

# The Practical Guides

7th Edition



AUSTRALIAN DENTAL ASSOCIATION INC.



# The Practical Guides

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Published by the Australian Dental Association Inc  
PO Box 520  
St Leonards NSW 1590  
Australia

First published 1982  
Second edition 1985  
Third edition 1989  
Fourth edition 1993  
Fifth edition 1996  
Sixth edition 2000  
Seventh edition 2006  
Seventh edition amended September 2009

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ISSN 1833-9883

## Preface to the First Edition

In 1964, the Australian Dental Standards Laboratory, then named the Commonwealth Bureau of Dental Standards, published eight *Practical Guides to the Successful Use of Dental Materials*. They proved to be extremely popular and continue to be in demand. However, since that time the practice of dentistry has developed and changed significantly. To fulfil the obvious need, it was decided to revise and increase the scope of the Guides and in association with the Tariffs, Instruments, Materials and Equipment Committee of the Australian Dental Association to produce them in booklet form for wide distribution to dentists and ancillary professions.

The objective of the booklet is to provide essential information for carrying out successful and safe dentistry and is aimed at dentists, dental therapists, dental nurses, technicians, retailers and manufacturers. While certain sections are especially applicable to one or more of these groups, the dentist should be familiar with all of this booklet since he is ultimately responsible for the treatment of the patient. It is hoped that it will find a place in every dental surgery and laboratory to provide readily accessible information. Emphasis is placed on practical points – for detailed explanations or reasons, compositions, definitions, etc, textbooks given in Further Reading should be consulted.

The TIME Committee and the Editors would welcome comments on this issue of the Guides and suggestions for subjects for inclusion in future issues.

**D R Beech**  
**H F Atkinson**

*March 1982*

## Preface to the Seventh Edition

The Seventh Edition represents a significant expansion of its predecessor, while maintaining the loose-leaf format. The 'A' Series Guides have been updated by the Infection Control Committee, the 'B' Series by the Special Purpose Committee on Drugs and Therapeutics, and the 'C', 'D' and 'E' Series by the Dental Instruments, Materials and Equipment Committee. Incorporated in this edition are the 'Guidelines for Good Practice'. These appear as the 'F' Series.

Dental therapeutics and resuscitation will be dealt with in a new publication due for release in early 2007.

**M J Tyas**

*August 2006*

## Acknowledgements

The Editors wish to acknowledge the generous contributions of more than 40 of our colleagues in the compilation of the Guides over the past 24 years. Their expertise and commitment to detail have enhanced the quality and credibility of the Guides. The Editors also wish to thank all those who have made comments and suggestions to improve the Guides.

## Notes

- Always read and follow the manufacturer's instructions
- Consider reporting side effects or unsatisfactory performance of drugs, materials or equipment to the Therapeutic Goods Administration ([www.tga.gov.au/problem/index.html](http://www.tga.gov.au/problem/index.html)).

For advice and information on dental products, contact:  
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## PRACTICAL GUIDES TO INFECTION CONTROL

Strict adherence to recommended infection control protocols forms the cornerstone of modern, safe dental practice. There are documents which are considered mandatory to achieve this aim. In some States or Territories, possession of these documents at the practice premises or availability via the internet is a requirement of the relevant Dental Board. It is the responsibility of individual practitioners to acquaint themselves with their State Dental Board's mandatory Regulations and Rules with regard to infection control in dentistry.

### A WRITTEN PRACTICE PROTOCOL

Every practice must have a specific written protocol which forms the 'how-to' of running the infection control requirements of that practice. It also helps members meet occupational health and safety and training requirements. This protocol can be written in conjunction with an infection control consultant or a commercially available document can be modified to meet the needs of the particular practice. Alternatively members can modify the various available pro forma manuals or CD-ROMs. Ask your ADA branch for details on what is available and applicable in your State/Territory.

### SUGGESTED REFERENCE DOCUMENTS

#### **Australian Government, Department of Health and Ageing**

'Infection control guidelines for the prevention of transmission of infectious diseases in the health care setting', January 2004, endorsed by the Communicable Diseases Network Australia (CDNA), the National Public Health Partnership and the Australian Health Ministers' Advisory Council. An electronic version of this document is available from [www.health.gov.au](http://www.health.gov.au). Particular interest to dental practice is under Part 5, Section 34 – Dental practice.

#### **Standards Australia**

AS/NZS 4187:2003

Cleaning, disinfecting and sterilizing reusable medical and surgical instruments and equipment, and maintenance of associated environments in health care facilities

AS/NZS 4815:2001

Office-based health care facilities not involved in complex patient procedures and processes – Cleaning, disinfecting and sterilizing reusable medical and surgical instruments and equipment, and maintenance of the associated environment

These documents may be purchased online from

[www.saiglobal.com/shop/Script/search.asp](http://www.saiglobal.com/shop/Script/search.asp)

or by telephoning SAI Global Ltd on 131 242 for the address of the State office or for credit card purchase.

#### **ADA (Victorian Branch)**

Systematic Operating Procedures Manual – [www.adavb.com.au](http://www.adavb.com.au)

To support the above reference documents the ADA Inc Infection Control Committee publishes articles for the *News Bulletin* highlighting matters of current importance. These and other references of note are either listed or available on the ADA website for members – [www.ada.org.au/\\_home.asp](http://www.ada.org.au/_home.asp).

The following articles have been collated to assist members and their staff with understanding key issues, establishing protocols and complying with Statutory Authorities.



## A1 – IMMUNIZATION FOR DENTISTS AND INFECTIOUS DISEASE STATUS

### KEY POINTS

It is recommended that dental health care workers be immunized against: hepatitis B, measles, mumps, rubella, varicella, influenza and maintain immunization against diphtheria, tuberculosis and tetanus. Additional considerations for immunization may include poliomyelitis, pneumococcal disease, hepatitis A, meningococcal disease and typhoid. Dental health care workers who practise exposure-prone procedures should know their own potential blood-borne virus status.

Like many health care workers, dentists are at risk of exposure to many common vaccine preventable diseases (VPDs) through contact with patients. In addition, they may be exposed to VPDs in the communities in which they live and travel to, and so vaccine recommendations must take into account the risk of exposure for all VPDs for the individual. Of course, a dentist's personal state of health may require additional vaccines to protect against infections which an average adult doesn't require.

Although most dentists will already be immune to the typical childhood VPDs from routine immunization or infection, it may be prudent to check your immunity by serology and vaccinate accordingly. VPD infections in adults tend to carry a higher mortality and morbidity, and it would be a shame to become a victim of something as ordinary as measles or mumps for want of immunization.

The US Department of Health and Human Services\* recommends all health care workers be immunized against hepatitis B, measles, mumps, rubella, varicella (currently only available in Australia through the TGA Special Access Scheme) and influenza. In addition, every adult should maintain diphtheria and tetanus immunization throughout life.

Depending on their individual health and situation, dentists should also consider immunization against poliomyelitis, pneumococcal disease, hepatitis A, meningococcal disease and typhoid. Regular surveillance for tuberculosis infection by skin testing may also be appropriate in some circumstances.

The Infection Control Committee has requested that members' attention be drawn to the recommendation that they be aware of their infectious disease status. In its publication 'Infection control guidelines for the prevention of transmission of infectious diseases in the health care setting' the CDNA notes that even without any legal or mandatory requirement for testing, 'HCWs [health care workers] who engage in exposure-prone procedures have an ethical and professional duty to consider their own potential blood borne virus status and should be encouraged to seek routine testing if they believe they are at risk from occupational or other exposures'.

\*Centres for Disease Control and Prevention. Immunization of Health-Care Workers: recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Hospital Infection Control Practices Advisory Committee (HICPAC). MMWR 1997;46(No RR-18).

### SUGGESTED REFERENCES

National Health and Medical Research Council. The Australian Immunisation Handbook. 8th edn. September 2003. (ISBN 0 642 822042)

Communicable Diseases Network Australia. Infection control guidelines for the prevention of transmission of infectious diseases in the health care setting. January 2004.

[www.immunise.health.gov.au](http://www.immunise.health.gov.au)

ADA (Victorian Branch). Systematic Operating Procedures Manual. [www.adavb.com.au](http://www.adavb.com.au)



## A2 – PREVENTION AND MANAGEMENT OF NATURAL LATEX ALLERGY IN DENTAL PRACTICE

### SUMMARY

- Natural latex allergy (NLA) may have serious consequences for dental staff and patients sensitized to natural rubber latex (NRL). Symptoms may manifest as delayed (type 4) hypersensitivity such as rash, conjunctivitis or rhinitis, which may then progress at some time to an acute allergic (type 1) anaphylactic reaction. Anaphylaxis may result in death.
- All patient medical histories must include questions about NLA and/or sensitivity to latex/rubber products.
- Suspected NLA in patients and staff must be treated as a serious medical issue and any testing deemed necessary must be carried out by a clinical medical allergist. Reports have shown that 15–17 per cent of health care workers may exhibit latex sensitivity.
- The use of powdered NRL gloves have the highest allergen levels and therefore the greatest risk of sensitization and allergic reaction. Powder-free NRL gloves and/or those listed as hypoallergenic are preferred for routine patient use.
- Those who report NLA must be treated (or at work, if health care worker) in a NRL-free environment. This means that non-latex gloves and dams are used and alternatives to rubber prophylaxis cups, rubber bite blocks, and rubber-based impression materials must be chosen. Additionally, anaesthetic carpules and solutions must be chosen to be free of latex rubber in their manufacture and be constructed so that latex does not contact the solutions in the bungs. Plungers of endodontic irrigant syringes must be latex-free. Staff protective face masks must not have latex rubber: tie on masks may be an alternative. Currently, gutta percha is not considered a problem for those with NLA.

### LATEX ALLERGY – AN UPDATE

Latex is the sap from the rubber tree, *Hevea brasiliensis*. As a material, it is comprised of proteins (5 per cent), rubber (cis-1,4-polyisoprene) and water (60 per cent). As will be discussed further below, allergenic latex compounds are present in NRL gloves, in addition to various stabilizers and polymerizing agents.

The latex protein content of NRL gloves can vary 3000-fold among manufacturers. Powdered NRL examination gloves have the highest protein content and allergen levels, because cornstarch particles absorb latex allergens (as well as bacteria from the skin), and then cause respiratory exposure to latex proteins when these particles become aerosolized during gloving and degloving. It has been shown that the protein/powder particles can remain in the air for up to 12 hours after changing gloves. Thus, powder-free gloves are preferred, to prevent release of these fine particles of latex materials into the breathing zone when gloving and ungloving.

NRL gloves which are rated as ‘hypoallergenic’ will have reduced levels of polymerizing or accelerating agents because of better washing and leaching treatments. The lowest levels of allergens (latex and other substances) will be in powder-free gloves that have undergone additional treatments such as washing and chlorination to remove or alter such allergens.

### Latex allergy in dental staff

#### Type 4

Dental staff can manifest a delayed (type 4) hypersensitivity reaction to latex proteins, which may then progress at some future time (with repeated exposure to latex) to an acute allergic (type 1) anaphylactic reaction. Symptoms of a type 4 reaction to latex may include conjunctivitis and rhinitis (as well as dermatitis), because of the degranulation of mast cells in these mucosal sites.

There are several routes of exposure which may have led to the latex allergy developing, such as:

- Inhalation of aerosolized latex proteins absorbed onto powder over an extended time. This route of exposure is probably the most significant for dental staff.
- Cutaneous absorption, by direct contact with gloves, particularly if the skin permeability has been increased by loss of normal surface lipids, or if the individual has severe dermatitis.
- Urogenital exposure, by urinary catheters and vaginal examinations.
- Other mucosal exposure, by rectal exams, dental procedures and surgery.
- Parenteral exposure, by intravenous lines.

An emerging latex sensitivity in a dental staff member is a serious health problem with major implications for their future working life. Should an individual develop a severe latex allergy, they will need to use non-latex gloves for all their work and will have to restrict their exposure to environments where latex proteins may be aerosolized. Skin testing by a clinical allergist can confirm a diagnosis of type 4 hypersensitivity. A test panel of suspected allergens is applied, and the result (the 'patch test') read from 1–3 days later.

#### *Type 1*

The most severe reaction to NRL glove materials is true latex allergy, where the eliciting antigen is a small latex protein (>30 kDa in size). A wide number of different latex proteins can be responsible for latex allergy, with seven of these linked to type 1 hypersensitivity, including heveamine, hevein and rubber elongation factor.

The clinical presentation of latex allergy is characteristic of rapid degranulation of mast cells and basophils, and may have an onset ranging from several seconds to 20 minutes. Symptoms and signs include:

- contact itching (urticaria, hives)
- flushing (redness)
- oedema (peri-oral or peri-orbital swelling)
- excessive lacrimation
- abdominal cramping and nausea
- bronchospasm (wheezing)

These may progress rapidly to full blown anaphylaxis (with tachycardia and dysrhythmias progressing to hypotension, collapse and cardiopulmonary arrest). Immediate medical management is essential. Milder reactions may be managed with corticosteroids (such as hydrocortisone) and antihistamines (for example diphenhydramine), while anaphylaxis will require life support as cardiac arrest can occur (both oxygen and adrenaline will be administered, with the latter as an intramuscular or intravenous injection).

Staff who are suspected of having developed latex allergy require expert assessment by a clinical allergist. This may involve both laboratory tests as well as skin tests. True allergy can be confirmed by a skin prick test (NOT a patch test) using panels of antigens from glove products. There will be a rapid response which is read instantly (in minutes). The positive control is a non-immunological agent which elicits mast cell degranulation, to give a 'wheal and flare' response. The prick test does pose the risk of severe reactions (and indeed even of anaphylaxis), and in the light of this there is increasing interest in various *in vitro* (laboratory) tests such as the radioallergosorbent test (RAST) which do not pose any risk to the patient. Such tests are safer and more convenient than the skin prick test, but have a lower sensitivity and specificity. A negative RAST result does not formally exclude allergy to NRL.

#### **Latex allergy in patients**

Several groups of patients are recognized to be at increased risk of latex allergy:

##### *Prolonged mucosal exposure to latex*

- neural tube defects and spina bifida
- sacral/lumbosacral agenesis
- urogenital abnormalities
- neurologically impaired bladder function
- frequent catheterization (especially urinary catheters)



- spinal cord injury
- neurosurgery
- cerebral palsy
- multiple major operations, particularly from early childhood

*Occupational exposure to latex (through wearing latex gloves)*

- health care workers
- rubber product workers
- hairdressers
- house cleaners
- emergency service personnel
- embalmers

*Individuals with atopy (an inherited tendency to develop allergic responses)*

- asthma, atopic enzema, allergic rhinitis (hay fever)
- myelodysplasia

*Patients with allergies to foods which share some antigens with latex*

- avocado, banana, kiwi fruit, chestnut
- potato, apricot, grape, papaya, passionfruit, pineapple, peach, cherry, tomato

All patient medical histories should include a question regarding latex allergy.

## IDENTIFICATION OF LATEX SOURCES

Latex sources in the dental practice should be identified so that exposure can be prevented.

These include:

- natural rubber latex gloves
- latex rubber dam
- gutta percha
- rubber base impression material
- relative analgesia masks
- blood pressure cuff tubing
- stethoscope tubing
- rubber stoppers on endodontic files
- rubber prophyl cups
- rubber bite blocks
- rubber orthodontic elastics

Other latex sources include:

*Medical products such as:*

- catheters and drains
- dressings and tapes
- tourniquets
- ECG pads
- oximeter probes
- airways used for general anaesthesia
- nasogastric tubes
- bellows of breathing bags
- plungers of disposable syringes

*Domestic products made from natural rubber, such as:*

- balloons
- condoms and diaphragms
- rubber bands
- rubber components of furniture, upholstery, tools and kitchen utensils

## LOCAL ANAESTHETIC SOLUTIONS

In relation to local anaesthetic solutions used in dentistry, manufacturers have introduced a range of measures to address the potential concern of latex proteins being released from the diaphragm or bung (plunger) of a local anaesthetic cartridge into the solution, thus

giving a systemic exposure to the patient when an injection is administered.

For example, all current (2005) Septodont local anaesthetic products have a bromobutyl bung rather than a latex bung, and employ a laminate design for the diaphragm so that the solution is in contact with bromobutyl rather than latex. Moreover, the latex used on the distal side of the diaphragm is treated so as to be free of proteins, which normally comprise 5 per cent of the material by volume.

According to a recent publication (Chin *et al.*, 2004), anaesthetic carpules manufactured by AstraZeneca contain no latex in the bung or diaphragm. Prilocaine hydrochloride with felypressin (Citanest with Octapressin) is known to be latex-free. It is noteworthy that while the medical literature provides some evidence that latex allergen can be released into pharmaceutical solutions contained within vials in contact with natural latex stoppers, there are no reports of studies or cases in which a documented allergy was due to the latex component of cartridges for dental local anaesthetic solutions. Consistent with this, in the recent case report of Chin *et al.*, no allergic reactions to latex occurred in a laboratory proven latex-allergic patient when either prilocaine with felypressin, or lignocaine hydrochloride with adrenaline were used.

### LATEX-FREE DENTISTRY

For patients or staff with a history of type 1 or type 4 reactions to latex, it is essential to have proper medical assessment and to then use a latex-free environment. For example:

- non-sterile non-latex gloves, such as Nitrile (Ansell Nitra-Tex), or neoprene for routine procedures
- sterile non-latex gloves, such as synthetic neoprene (Ansell Derma-Prene)
- non-latex rubber dam, such as Roeko Flexi-Dam
- latex-free face masks
- non-latex prophylaxis cups
- appropriate local anaesthetic solution (see below)
- silicone elastic bands

### RECOMMENDATIONS

To prevent the development of allergic reactions to latex, the following measures are recommended:

- Educate all staff regarding the clinical signs and symptoms of occupational skin disease and latex allergy.
- Use powder-free gloves with low extractable protein content routinely rather than powdered gloves.
- Ensure that any areas that may have become contaminated with latex glove powder are cleaned regularly by vacuuming using disposable bags (upholstery, ventilation ducts and plenums, cupboards, telephones, etc).
- Remove gloves slowly; do not 'snap' them off as this may release allergens into the atmosphere.
- Include a question regarding latex allergy on all new staff employment forms and on all patient medical histories.
- Consider referring patients or staff at high risk to true latex allergy to an allergist for assessment.
- Patients or staff with proven anaphylactic reactions to latex may need to wear a medical alert bracelet and carry self-injectable adrenaline (for example, Epi-needle containing 0.5–1.0 mg of adrenaline).
- Substitute latex-containing products with known latex-free products in the dental operatory for the treatment of any known or suspected latex-reactive patients.
- Treat latex-reactive patients as the first patient of the day to reduce the potential for exposure to latex proteins from glove powder in the air. Because gowns can also become contaminated with the same powder, disposable paper gowns should be worn when treating such patients. The dental surgery should be damp dusted immediately prior to the patient appointment to reduce aerosolized materials.

## FURTHER READING

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## A3 – PROCEDURES AND STRATEGIES TO REDUCE RISK OF INJURY IN DENTAL SURGERIES: PRACTICAL POINTS

### SUMMARY

A number of suggestions for the reduction of injury and exposure to blood-borne pathogens have been made. Many operators will have already established safe routines and techniques to eliminate sharps injuries and the associated risks of transmission of infection. Consistency in work practices and the routine adoption of safe working procedures and techniques are the surest methods for reducing the risk of injury and exposure to blood-borne pathogens.

Dental practice frequently involves the use of sharp instruments in invasive procedures, with exposure of clinicians to blood, saliva and exudates of patients, often under conditions of limited access and poor visibility.

The most common procedures in dentistry where sharps injuries to clinicians and their clinical assistants may occur are: cleaning up after a procedure; operative procedures involving burs; the administration of local anaesthetic; the disposal of local anaesthetic needles; the transfer of sharps between health care workers and some oral surgery procedures.

While there is a theoretical possibility of transmission of infection from patients to staff members with almost all clinical dental procedures where sharps are used, the probability of this occurring can be reduced considerably by use of techniques which avoid injury and prevent accidental injury during treatment. For sharps injuries, the blood-borne pathogens currently of most concern are the human immunodeficiency virus (HIV), hepatitis B (HBV) and hepatitis C (HCV). The practice must have a clear written protocol on the appropriate action to take in the event of sharps injuries and other blood or body fluid incidents involving either patients or staff members. It is essential to follow up any sharps injuries immediately with appropriate first aid, counselling and serology (for both the source/patient and staff member). Note that there are emergency contact numbers to provide information and advice for persons who have incurred an exposure to potential blood-borne pathogens. The information includes advice on prophylactic measures as well as follow up counselling. Dentists should keep the emergency numbers for injuries readily available.

Injuries to dentists or dental health care workers involving exposure to blood-borne pathogens may occur intra-orally or extra-orally. The majority of exposures are extra-oral and occur during clean up procedures. Injuries where the skin is punctured from burs left in handpieces whilst sitting in their cradles are a major component of extra-oral exposures, while intra-oral exposures are most often caused by local anaesthetic syringe needles, and sharp items such as instruments and matrix bands.

### SHARPS

It is recommended that sections 6.2, 14.1-14.2 and 33.2.4 of the CDNA Infection Control Guidelines be reviewed and used as a basis for a discussion within the practice of sharps management, with particular attention to the following points:

- Sharps **MUST** be handled with care at all times. (6.2, 14.1)
- Needles **MUST NEVER** be picked up with the fingers, nor the fingers used to expose and increase access for the passage of a suture in deep tissues. (33.2.4)
- Sharp instruments **MUST NOT** be passed by hand between staff members. (6.2, 14.1)
- Any single-use article or instrument that has penetrated the skin, mucous membrane or other tissue **MUST** be discarded immediately after use or at the end of the procedure, whichever is more appropriate. (16.2.4)

- The person who has used a sharp instrument **MUST** be responsible for its immediate safe disposal following its use. This **MUST** be at the point of use. (14.2)
- Disposable needle-syringe combinations, needles, scalpel blades, single-use razors and other sharp items **MUST** be discarded in a clearly labelled, puncture-proof container that conforms with AS 4031 or AS/NZS 4261 as appropriate. (14.2)

The following general points should be considered:

- To ensure that all risk items are identified, make a list of the types of sharps maintained in the practice (for example, instruments, scalpel blades, suture needles, glass local anaesthetic cartridges, glass vials, needles, matrix bands, wedges, burs, endodontic files, orthodontic and ligature wires and broken instruments). Distinguish between disposable sharps and re-useable sharps, such as instruments. Have a clear plan (ideally in writing) as to how each sharp is dispensed, used and disposed of, and discuss this at a meeting when all staff members are present.
- Review the circumstances of the sharps injuries which have occurred in the practice to identify factors which may have contributed to these incidents and to develop strategies for prevention. For example, are there problems with techniques, equipment, training or supervision?
- Plan procedures involving sharps so that all staff members are aware of their role and responsibilities. Where four handed dentistry is practised it is essential that strict regimens and protocols be established.
- Where circumstances are such that sharps, including needles and scalpels, have to be passed from operator and assistant then all sharps should be passed in a sterile tray or bowl, but never by hand.
- Only clean instruments should be passed from the assistant to the operator. Where it is necessary for contaminated instruments to be reused the operator should select them from their own working area, or they should be passed by use of a transfer tray.
- Ensure that the change-over procedure between patients starts with the removal of sharps from the working area (for example, starting with the bracket table) with tweezers. This should be done by the operator, who places them into a sharps container. An established cleaning plan will reduce exposure risk if sharps are inadvertently overlooked by the operator.
- Locate sharps containers close to the point of use. Dispose of sharps containers when three-quarters full, and do not overfill them.
- Remember that gloves have limited resistance to puncture injuries and develop porosities during use, particularly in the thumb and forefinger regions.
- Do not leave sharps in clinical gowns: check gowns carefully before sending to the laundry.

## **BURS**

Dental burs present a major hazard for sharps injury. Most injuries from burs are puncture wounds which occur on the hand or wrist when reaching past a bur in a handpiece in its holder attached to the dental bracket table.

### **Bur removal**

Burs should be removed from the handpiece as soon as drilling has been completed, or the handpiece (complete with bur) uncoupled and placed on the bracket table. Exposed burs retained in handpieces present an increased risk of injury to chairside assistants as they may be less aware of the presence of the contaminated bur than the operator.

### **Bur cover**

The use of a bur cover is an alternative to removal of burs from handpieces but presents problems of cleaning and sterilization. Use of a bur cover is less preferable than removal of burs.

### **Movement of staff**

Whilst it is necessary for the burs to remain in the handpiece only the operator should need to be in close proximity to the handpiece. Clinical staff moving in reach of and reaching over

handpieces containing burs are at risk of sustaining a bur injury. This is particularly applicable to the low speed handpiece where the bur is more likely to be contaminated with blood and debris.

### **Flushing turbine handpieces**

Some high speed turbine handpieces require a bur (or blank) to be in place in order for the water lines to be flushed after use. The use of a well-established routine will reduce sharps injuries. When purchasing new high speed turbine handpieces, consideration should be given to purchasing those for which water lines can be flushed without needing a bur (or blank). Operators should be responsible for removing all burs from handpieces at the end of a procedure.

### **LOCAL ANAESTHESIA**

- Practise syringe handling procedures as part of ongoing staff education and training.
- Handle syringes with care — only one person should hold the syringe at any one time.
- Retract tissues before injection with a mouth mirror or retractor (not with the fingers).
- During injection, the assistant can stabilize the patient's head position to prevent lateral or other involuntary head movement.
- Keep hands and fingers away from the mouth while injecting.
- Where multiple carpules are required, the syringe should be reloaded whilst it remains in the hands of the dentist. If multiple injections are required then consider whether they could be given at the one time and with an adrenaline-containing solution, prolonging the time of anaesthesia and avoiding the need for re-injection.
- Remove needles with care. Use artery forceps or other holding devices instead of fingers. As an alternative, consider using a local anaesthetic system with a captive needle which does not require disassembly as the needle and carpule holder are disposed of as one unit.
- It is recommended to dispose of the needle immediately after analgesia. Should supplemental anaesthesia be required during the appointment, it is recommended that a new needle and carpule be used.

### **CONTROL OF THE ORAL ENVIRONMENT**

- Poor visibility and poor lighting are major factors in sharps injury. Use a headlight to improve illumination, in addition to operating lights. Battery operated or fibre-optic head lights are very useful for surgical, endodontic and periodontal procedures and will enhance efficiency as well as safety.
- Use rubber dam where feasible to reduce contamination of operating field.
- Use suction judiciously to maintain a clear field.
- For ultrasonic scalers, when not in use the tip should be rendered safe (for example, covered with a sheath or a cotton roll). Following the procedure the scaler tip should be flushed through by the operator who then removes it from the handpiece. If it is not feasible for the operator to carry out this procedure then the flushing and dismantling of the scaler should be given first priority when cleaning up, and this should be incorporated in cleaning routines as they are established.

### **ORAL SURGERY**

- Be aware of risk situations. Blood is present in the mouth from the surgical procedure, and there are several potential causes of injury: scalpels, elevators, wires, sutures, as well as exposed sharp edges of tooth or bone. Injuries such as puncturing of the fingers by wire are more likely to occur in a poorly lit confined space where visibility is further reduced by secretions such as blood and saliva.
- All clinical staff must wear protective glasses with side shields to prevent splash injuries to the eyes.
- The use of fingers as cautionary rests when performing dentoalveolar procedures should be avoided where possible. Do not position fingers below an elevator tip to prevent it slipping into tissues; rather restrict the downward displacement of the tip by positioning

the fingers above the tip of the instrument and then using a rotational rather than vertical movement.

- Do not suture 'blind' or attempt to find a suture needle in a vestibule by feel.
- In areas of limited visibility, use single sutures rather than continuous suturing. The needle can be cut from the suture after tissue penetration has been achieved fully, and the knot then tied using instruments and fingers.
- Ensure adequate retraction.
- Maintain a clear field and improve visibility by removing secretions such as saliva and blood with suction.
- Control bleeding during the procedure using ligation, cautery, coagulation or sutures.
- Use appropriate vasoconstrictors as indicated clinically.
- Minimize the use of wiring in awkward and inaccessible sites to reduce the possibility of sharps injury from cut wires.
- Use an experienced trained assistant for all oral surgical procedures.
- Where appropriate, use a custom-made scalpel blade removal device for detaching blades from handles. To reduce the risk of injury from removing scalpel blades, consider using fully disposable scalpels.
- Some operators prefer to wear orthopaedic gloves or two pairs of gloves for major oral surgical procedures.
- Each operator should maintain awareness of their own infectious disease status (HBV, HCV, HIV).

### **INSTRUMENT REPROCESSING**

- Remove gross deposits of blood, cements and other contaminants from instruments by wiping them at the chairside onto an adhesive-backed sponge. This will reduce the need for intensive cleaning by hand and thus reduce the risk to dental chairside assistants.
- To prevent residues of dental materials or blood drying onto instruments, if instruments cannot be cleaned immediately once they have left the chairside, place them in a holding solution (containing detergent).
- Clean conventional hand instruments using ultrasonic cleaners or thermal disinfectors, rather than by hand scrubbing.
- Use instrument cassettes or trays where possible during instrument processing to minimize the risk of sharps injuries to staff from handling instruments.
- Develop a clear policy on which sizes and types of burs and endodontic files are discarded after use.



## A4 – PROCEDURES AND STRATEGIES TO REDUCE AIRBORNE TRANSMISSION OF INFECTION\*

Diseases may be transmitted via the airborne (breathing) route. Airborne dissemination may occur by either airborne droplets or dust particles. Airborne transmission includes aerosols (colloidal particles in the gas) which may be generated during certain procedures, including manual washing of instruments or equipment, ultrasonic cleaners operated without close fitting lids in place and fast moving equipment such as dental drills and ultrasonic scalers. Micro-organisms carried in this way can be widely disbursed by air currents through ventilation or air-conditioning systems. Patients who are immunosuppressed for a variety of reasons are particularly vulnerable to infection caused by organisms which are spread in this manner.

Some of the principles governing the spread of airborne particles are discussed in Australian Standard AS 1386.1 entitled 'Cleanrooms and Clean Workstations. Part 1: Principles of clean space control'.

### AIRBORNE PARTICLES

Airborne particulate matter may be organic or inorganic, viable or non-viable. Most contaminated control problems concern the total (gross) contamination within the air. Airborne particles range in size from 0.001  $\mu\text{m}$  to several hundred micrometres.

Aerosolized particles tend to settle out at a rate depending on the size and density of the particle. For example, according to Stokes law, in a room 2.4 m high, a particle in the 50  $\mu\text{m}$  range would take less than 60 seconds to settle out while a particle in the 1  $\mu\text{m}$  range would take 15–20 hours to settle out in still air.

### PARTICULATE CONTROL

The allowable size of an airborne particle at a point within an area depends on the most critical dimensions and tolerances of the process to be performed at that particular point. At the same time, consideration must be given to the quantity of the particles of a given size that may be present at a particular point within the area. Since a definite relationship exists between the size of a particle and the time in which it may be airborne, as defined by Stokes, it is most meaningful to discuss airborne particles by quantity of a given size.

To further analyse the level of contamination control required, the source of the contamination should be considered. Basically, this is divided into external sources and internal sources.

#### External sources

For any given space, there exists the external influence of gross atmospheric contamination or air pollution which tends to find its way into all areas of our working environment. The external contamination is brought in primarily through the air-conditioning system which supplies the working place with outdoor ventilation make-up air. In addition to the air-conditioning system, external contamination can infiltrate through doors, windows and cracks within the structure. The contamination introduced to the process is controlled primarily by the type of filtration utilized and the pressurization of the room.

#### Internal sources

One of the greatest sources of internal contamination is people themselves. All people continually shed particles (viable and non-viable); the amount can vary from as few as several hundred particles per hour to hundreds of thousands of particles per hour, depending on the individual. Skin is constantly flaking off and generating particles in the 1  $\mu\text{m}$  range and exhaled breath contains large quantities of particles ranging in size from a

\*Reprinted from the ADA News Bulletin, November 1999.

submicrometre to several hundred micrometres. Thus, people can be considered the highest contributor of contamination within a typical clean room.

### FURTHER STATISTICS

The internally generated contamination is also caused through the activity of service equipment within the area necessary to the process. Contamination is generated by such products as pharmaceuticals and such solids as carbon and other dusts. Service equipment such as soldering irons, solder, flux instrumentation equipment, cleaning agents, cardboard cartons, etc, must also be considered as possible sources of contamination. Thermal effects on air circulation patterns should not be overlooked.

It should be stressed that every activity involving friction of surfaces also creates some type of contamination. For example, the simple act of writing with a pencil on a piece of paper generates an aerosol cloud of many thousands of very fine carbon particles and paper fibres. Even the movement of two pieces of metal together generates a certain amount of particulate matter which can be aerosolized to form a very fine metallic dust as an airborne contaminant.

Within any working environment a certain dynamic situation exists in the air.

Movement results from people working, machines in operation, fans blowing, motors rotating, and the like. All of these motions impart kinetic energy to the air and cause it to move at random velocities within the space. An example would be a person walking down an aisle or hallway, imparting kinetic energy to the air, causing air motion as the gas molecules are compressed in front of the person.

Fine particles are caught up in the random current within a room and are easily moved from one area of the room to another. This transfer of contamination via random air currents from one part of the room to another is known as cross-contamination and is a significant contributor to the contamination level at the worksite.

A resulting contamination build-up occurs within the space and reaches a plateau or steady-state condition. A plateau count of 0.5  $\mu\text{m}$  particles and larger would range anywhere from several thousand to several million particles in a typical manufacturing environment. During off-hours or lunch breaks, a noticeable reduction in the contamination level will occur.

In the dental surgery the most common cause of airborne aerosols is the high speed air rotor handpiece and the ultrasonic scaler. The aerosol produced may be contaminated with bacteria from saliva or viruses from the patient's blood.

Microdroplets about two to five microns in diameter are expelled from the respiratory tract of individuals by coughing, sneezing, singing, laughing or shouting. These microdroplets may contain viruses which cause upper respiratory tract infections, bacteria such as *Staphylococcus aureus* as well as mycobacteria.

*S. aureus* is present on the skin and in the noses of approximately 30–50 per cent of the general population. Nasal secretions contain a large number of bacteria which will contaminate the hands. Shedding of skin releases these bacteria both into the air and eventually they settle in dust. In addition the bacteria are shed from person to person by skin contact.

In many instances the strains of *Mycobacterium tuberculosis* are resistant to first and second-line anti-tuberculous agents, and in some instances the mycobacteria are resistant to all known agents, making a cure almost impossible in these patients. As many cases of early infection may remain undiagnosed for many months it is possible for these infected patients to attend dentists for routine treatment. Airborne invasive fungal infections are an increasing problem for patients suffering from immunodeficiencies. These organisms may cause severe systemic infections. In hospitals, opportunistic fungi such as *Aspergillus fumigatus*, *Candida albicans*, and other species have all been isolated from air samples from damp areas where equipment is stored in moist cardboard boxes.

In the dental surgery, all packaged and wrapped sterile instruments should be stored in a clean, dry place to ensure sterility is maintained and that the packaging is not damaged by contact with sharp objects. Semi-critical instruments for routine non-invasive dental procedures (for example, amalgam pluggers and excavators) should be stored to protect from environmental contamination. (See AS 4187 regarding storage of bagged sterile instruments.) In the dental surgery the major source of environmental contamination is airborne bacteria and viruses which settle on instruments, bracket tables, open drawers, etc.

An efficient and economical way to protect sterilized instruments from environmental contamination is to bag them prior to autoclaving and store in the unopened bag. Ideally, this applies to both instruments which must be sterile at the time of use and to those which need only be sterilized in between patients. In addition, it is recommended that cartridges of local anaesthetic be packed in bubble packs<sup>†</sup> and the packaging opened only at time of use for each individual cartridge.

<sup>†</sup>Cartridges of local anaesthetic packed in bubble packs are clean but may not be sterile.



## A5 – WASTE MANAGEMENT IN DENTAL RADIOGRAPHY\*

Radiographic waste that needs to be separated from regular waste consists of:

- contaminated waste (for example, film packets and barrier envelopes)
- clean solid waste (for example, lead foil from intra-oral film packets, old films and packaging material), and liquid waste (for example, used developer and fixer)
- liquid waste

### CONTAMINATED WASTE

Film packets and barrier envelopes that carry traces of blood, blood products or saliva need to be disposed of in accordance with the guidelines for all contaminated and infectious clinical waste, that is, placed in yellow containers or plastic bags that are appropriately marked with the international bio-hazard symbol and collected and disposed of by a licensed operator.<sup>1</sup>

### CLEAN SOLID WASTE

Lead foil should be sold in bulk to a scrap metal dealer or disposed of through a licensed waste management service.<sup>2</sup>

Old films are unsuitable for disposal in landfills and should be disposed of via silver recovery firms.<sup>2</sup>

Packaging materials should be discarded in accordance with local council regulations.

### LIQUID WASTE

Regulations regarding the disposal of used developer and fixer solutions vary considerably. Some local authorities allow disposal of used developer through the sewer, whereas others forbid any such discharge. The primary reasons for concern are the pH and the concentration of silver.<sup>3</sup> Both depend upon the type of processor used, for example, systems for batch processing and systems with automatic replenishment of chemicals. Developer has a high pH, while fixer has a low pH; when combined the resulting effluent is approximately neutral and would, therefore, be within acceptable limits of most sewer codes. However, photographic chemicals are highly corrosive and can cause damage to copper pipes. Therefore PVC pipes are recommended.

Silver is only present in the form of silver thiosulphate complexes which are extremely stable and which have a low toxicity to aquatic species.<sup>4</sup> Silver concentrations depend upon the number of films processed and are in the order of 8–12 g/L in fixer and 0.2–0.3 g/L in wash water.<sup>2</sup> In water treatment plants these thiosulphate compounds are subsequently converted into silver sulphide which settles in the sludge. Both silver thiosulphate and silver sulphide are significantly less toxic than free silver ions (Ag<sup>+</sup>). The amount of free silver ions in waste fixer is extremely low and the environmental effect of waste fixer is therefore uncertain. However, some concerns still remain,<sup>4</sup> and as a result there are currently no uniform regulations for the disposal of these products in Australia.

In an attempt to standardize local regulations the Photographic and Imaging Council of Australia (PICA), through its Photographic Uniform Regulations for the Environment (PURE) division, has published a Code of Practice for liquid waste management.<sup>5</sup> In this Code radiography in dental practice has been categorized with medical diagnostic radiography. Some of the requirements and recommendations suggested by PURE and accepted by many water boards and sewerage authorities, for this category are:

- a trade waste water agreement, or approval or permit, from the local sewerage authority for discharge of photographic waste in the sewer;

\*Reprinted from the ADA News Bulletin, December 1999.

- if water is plumbed directly into the processor, a wash water limiter should be fitted to limit the incoming water to the times that processing occurs;
- treatment in an approved on-site silver recovery system, or collected for transport to an off-site approved treatment plant;
- fixer baths may be regularly tested with approved test strips to check the pH and silver concentration;
- a log book containing at least:
  - (i) quarterly test results for silver recovery systems
  - (ii) current PURE Data Sheet for the site
  - (iii) records of photographic waste liquid collections

To put the above requirements into perspective it is useful to estimate the amount of this type of waste generated in the average dental practice.

Processing of intra-oral films is usually done by means of processors that are not permanently connected to either the main water supply or the sewer system, and do not feature automatic chemical replenishment. The tank capacity of these units is in the order of 1–1.25 L. Assuming a weekly change of chemicals, the total weekly liquid photographic waste volume would not exceed 2.5 L in the average dental practice.

Extra-oral films are mostly taken and processed in medical X-ray facilities which use processors with automatic replenishment. A typical processor<sup>†</sup> used for this purpose has a replenishing rate for developer of 400 mL per square metre of film and for fixer of 600 mL per square metre.

A reasonably sized medical facility may therefore generate a daily quantity of waste similar to or larger than the weekly quantity in dental practice. However, since there are more dental practices than medical radiography facilities, the collective burden on the environment arising from dental practice waste could be considerable and it is therefore appropriate to adopt a responsible attitude and to thoughtfully dispose of used photographic chemicals.

It is therefore recommended that dentists acquire the relevant regulations from their local water board and/or sewerage authority. If direct disposal via the sewerage system is not allowed and a permit cannot be obtained it would appear that, because of the small quantities involved, collection and disposal through an accredited disposal firm would be an economically viable method. Disposal in septic tanks, storm water drains etc is not acceptable.

<sup>†</sup> Agfa Curix 260, Agfa-Cevaert AG, München, Germany.  
Film size mm Developer mL Fixer mL

## REFERENCES

1. Industry Code of Practice for the Management of Clinical and Related Wastes. Australian and New Zealand Clinical Waste Management Industry Group (ANZCWMIG) and Environment Management Industry Association of Australia Ltd (EMIAA), 1998.
2. Waste Management Guidelines. Kodak Dental Radiography Series. Rochester, 1994.
3. Goaz PW, White SC. Oral Radiology – Principles and Practice, Chapter 7. St Louis: Mosby, 1992.
4. PURE Newsletter #17. The Photographic and Imaging Council of Australia, August 1999.
5. Photographic and Imaging Industry Code of Practice for Liquid Waste Management and Disposal. The Photographic and Imaging Council of Australia, 1997.

## A6 – PROCEDURES AND STRATEGIES FOR MONITORING AND VALIDATION OF STERILIZATION OF DENTAL INSTRUMENTS

### AUTOCLAVES

There are several types of steam-under-pressure sterilizers (autoclaves), for example, downward displacement, assisted air removal, and pre-vacuum ('Class B'). All autoclaves must meet the requirements of AS 2192, AS 1410 or AS 2182, and be operated according to AS 4187 and AS 4815. An autoclave used to produce wrapped items to be sterile at the time of use must have a dedicated drying cycle.

Regardless of the type of autoclave used, in order for steam under pressure to be effective for sterilizing, it must have a dryness fraction of 97 per cent and above, and not be superheated beyond 2°C of the saturated steam temperature. Steam which is 'wet' (that is, has a dryness fraction less than 97 per cent) is unsuitable for sterilization, and will result in wet instrument packs, while superheated steam will not condense evenly onto the surface of instruments and thus will not transfer the latent heat which is responsible for killing micro-organisms. This emphasizes the need for the thermocouples in autoclaves to be calibrated to the correct point.

Because load content and positioning influences air removal and steam penetration, correct loading of the autoclave chamber is essential to ensure sterilization. Efficient air removal from the chamber and the load will permit total steam penetration, and allow proper drainage of condensate. Additionally, correct loading will reduce damage to packs and their contents and maximize the efficient use of the sterilizer. To ensure air removal, hollow items should be tilted on edge in a draining position. Hollow items packed in pouches should be positioned with the opening against the paper and not the plastic. Similarly, laminate (paper-plastic) pouches should be loaded on edge with paper to laminate. Racks are useful for gaining adequate separation of packs in this 'toaster rack' configuration. If not in racks, these laminate pouches should be positioned flat in single layers with the paper surface downwards, and never stacked. Items should not touch the chamber walls.

As mentioned previously, some older types of autoclaves do not have a drying cycle incorporated into their design. Those units without a drying cycle are only appropriate for the sterilization of unwrapped items. It is expected that new autoclaves have a drying cycle and a printer for recording cycle parameters. It is no longer acceptable to crack open the door of the sterilizer to assist in drying of the load contents. Sterilizers which dry by simple mild heating of the chamber while the chamber door remains sealed can only provide reliable drying for small numbers of simple packs. Pre-vacuum autoclaves give the most reliable and efficient drying of instrument packs. They also provide a more effective method of air removal, which hastens steam penetration.

Newer models of bench-top sterilizers also have printout facilities for monitoring temperature and pressure (as applicable) and holding time. Existing, older-style bench-top sterilizers should be fitted with a mechanism to allow the observation and immediate transfer of information (for example, time at temperature, temperature, pressure) to an electronic data storage facility, rather than having to assign a staff member the onerous task of continuous cycle recording (at 10 second intervals), or following the expensive option of using an enzymatic or biological indicator with each cycle.

Modern autoclaves typically use single phase water systems, which do not recycle water between loads. Recycled water from previous cycles causes deterioration in the water quality for each successive cycle. Accumulated debris (and lubricants) in recycled sterilizing feed water may compromise sterility (for example, by causing the production of superheated steam). Thus, in an older autoclave which recycles water, the water reservoir should be

emptied, cleaned and flushed each week, then filled with a fresh supply of distilled or de-ionized water.

At the end of the autoclave cycle, a visual inspection is necessary to ensure that the necessary parameters were reached (by checking the printout) and that the chemical indicators in the load have undergone the required colour change.

Directly after the sterilizing process, items are very vulnerable to contamination by moisture or improper handling. Cooling items must not be placed on solid surfaces, as condensation from water vapour (which is still within the pack) may result. Similarly, if a plastic dust cover is used, the item must be allowed to cool before being placed in the dust cover.

## VALIDATION

The definition of sterility is *the state of being free from viable micro-organisms*. For an item which has been terminally sterilized, the theoretical possibility of there being a viable micro-organism present on or in the device must be *less than one in a million*. This probability is termed the Sterility Assurance Level (SAL).

Evidence that a device or instrument is sterile comes from the validation process, and from information gathered about the cycle parameters from printouts and chemical indicators. This comprehensive approach provides an assurance that all items which are used in surgical procedures have been treated to the SAL.

Validation is performed to assess the reliability of the sterilization process. The term validation refers to the total process, which comprises commissioning (installation qualification and operational qualification) and performance qualification (using physical and microbiological indicators). During the commissioning process, the installation technician will document and record a range of physical parameters, check the calibration of sensors and readouts, using measuring equipment certified by the National Association of Testing Authorities (NATA). The operational qualification will involve specific performance tests, for example, using process challenge devices and biological indicators, as well as thermocouples (to assess heat distribution if this is not known).

Performance qualification aims to establish that the minimum SAL of one in one million can be achieved, and this requires use of biological or enzymatic indicators placed inside the largest or most difficult pack to be sterilized, when located in the coolest part(s) of the sterilizer chamber (as identified from a heat distribution study, usually the drain at the lower rear aspect of the chamber). Biological or enzymatic indicators can be placed adjacent to temperature sensors within the chamber and packages. The location of chemical and biological indicators in a package should match its shape, for example three indicators in a rectangular-shaped pouch, and five indicators in a large square pouch (one in each corner and one in the centre). Reproducibility within acceptable limits is checked by using a minimum of three consecutive identical cycles as part of the validation process.

Thus, the test pack with multiple indicators must be prepared in triplicate such that one can be processed on each of three consecutive cycles. Typical biological indicators which can be used for validation are the Attest 1261P and Rapid Attest from 3M Corporation. Note that the Rapid Enzymatic Indicator (REI, previously termed RSI) cannot be used with 134°C downwards displacement autoclaves, however for an older autoclave which utilizes a holding temperature of 121°C and downwards displacement, REI indicators can be used satisfactorily.

Where the parameters are appropriate for the removal of air and the penetration of steam, all the autoclaved indicators should show no colour change. In other words, they should indicate complete killing of the spores or deactivation of the spore enzymes as appropriate. If there is a colour change, which signifies a failed test result, the holding time for the autoclave should be increased in increments of one or two minutes, and the entire validation procedure repeated, in order to establish the minimum time required.



The results of the validation process must be recorded. The information should include:

- the date of the test
- the brand and type of packaging system tested
- the type of biological indicator used and the batch number. It is important to ensure prior to the validation process that the biological indicators to be used have not expired.
- the location and number of the autoclave (if there are multiple autoclaves in the practice)
- the name of the operator running the validation tests
- the exact parameters which have been validated

The analysis of the data obtained during validation will demonstrate that a given sterilization cycle in a particular autoclave will, or will not, render a specified load sterile. Validation is, therefore, related to the type of load and to its arrangement in the autoclave chamber. Because of this, validation should be repeated every time significant changes are made in the type of load or type of packaging. If there are no changes in these, performance requalification is still required at least annually.

### **ROUTINE MONITORING OF AUTOCLAVES**

Saturated steam is an efficient means for killing micro-organisms since it is able to quickly transfer heat energy onto the items which are being sterilized. As saturated steam condenses, this heat is transmitted onto the surface and the micro-organisms are inactivated by direct thermal effects. For sterilization to occur, the steam must be saturated. The correct level of saturation is achieved by conditions of pressure and temperature. If the appropriate temperature and pressure are not present, the steam will be dry in which case it will be superheated or it will be wet or supersaturated. Both of these impair the sterilizing process. Steam which is superheated is too dry and gives insufficient pressure, and thus poor penetration. Steam which is too wet, or which is a mixture of air and steam, gives too high a pressure and will not condense onto a surface.

Statistically, a sterilizing cycle is designed so that the opportunity for a micro-organism to survive is less than one in one million. It is now recognized that the range of parameters which affect the efficiency of steam sterilization go beyond the traditional parameters of temperature, time, steam saturation, steam purity and air availability to include a number of items which are not associated with the process, but rather the product. These include parameters such as bioresistance, which is the difference between various species of micro-organisms to steam sterilization; bioquantity, the amount of organisms which are present; bioshielding, which indicates the problem where an object has a very low permeability to air or steam; biostate, which refers to the biological state of the organism, for example, as a spore rather than as a vegetative organism; and thermodensity, which refers to the heat capacity of the object. A large and heavy instrument may require a considerable degree of heating to raise it to the sterilizing temperature, while a small object can be heated very quickly.

Sterilization cycle performance must be monitored routinely. For existing autoclaves without a printer, a biological/enzymatic indicator or a Class 4, 5 or 6 chemical indicator **MUST** be used with every load (AS/NZS 4187, section 8.6.1). If there is a printer, a chemical indicator of the same class may be included inside each packaged item. In all autoclaves, a Class 1 indicator (autoclave indicating tape or colour change dye) must be used on the exterior of a packaged item. The test frequency and other details relating to the use of indicators are specified in Table 7.1 of AS/NZS 4187.

It should be noted that additional tests are required for pre-vacuum autoclaves (for example, a daily process challenge device for assessing air removal such as the Bowie-Dick test or helix test, and a weekly air leak test), as detailed in AS 1410. The types of chemical indicators used will depend on the configuration of the autoclave. In a conventional downwards displacement or assisted air removal autoclave, these air leak and air removal tests are not required.

Key aspects of sterilization quality control include checking autoclave readouts for

temperature, time and other parameters at the end of every cycle, and using chemical indicators on a routine basis. Data for physical autoclave parameters can be easily obtained if the autoclave has a printout. It is expected that modern autoclaves will come with printing or data transfer capabilities. When selecting a printer, ink-based printouts are preferred to thermal printouts as there is less likelihood of degeneration and fading over time. Since it is necessary to keep printouts for a specified period (typically seven years), it is important that the readouts are still legible after this time. In contrast, the cycle log books (as explained below) should be kept indefinitely.

Performance data for every autoclave cycle must be recorded in a log book. The batch code on a packaged item must be able to be tracked back to a specific autoclave cycle entry in the log book. The log book entry for each cycle should document the following: the date; the sterilizer number or code (if there is more than one sterilizer within the practice); the cycle or load number on that day; the cycle parameters (time, temperature and pressure); the specific contents of the load, for example, packs, instrument cassettes; the batch number(s) in the load; the readout result of the printout; the readout result of the chemical indicator(s); the name or identification of the person who loaded and unloaded that cycle and who authorizes release of the load. There needs to be a record of the release of the items to allow traceability, recall of compromised items, and quality management, as well as for medico-legal purposes.

Log books and the related printouts should be maintained for at least seven years (as defined by State regulations). Printouts should be initialled by the staff member reviewing them. Retention of chemical indicators is not a substitute for a permanent record of a sterilizing process, because exposed chemical indicators may change with time and therefore are not a reliable record.

## CHEMICAL INDICATORS

Chemical indicators are designed to give information regarding the performance of the sterilizer during the holding phase of the sterilizing cycle. This holding phase is the time period during which the micro-organisms are inactivated. Chemical indicators are convenient to use, are relatively inexpensive, and provide immediate results. Because chemical indicators are type-specific, it is important to select these according to the autoclave parameters used in the dental practice. Special attention must be given to proper placement of chemical indicators within larger packs. They should be placed in areas which are most likely to entrap air. When a peel pouch is used, the indicator should be placed in such a way that it can be easily seen when the pouch is inspected.

Integrating chemical indicators can provide useful information on steam saturation, steam purity and steam availability. With regard to steam saturation, it is important to bear in mind that whether water exists as a liquid or as a gas is entirely dependent upon the temperature and the pressure. When the pressure is increased, the boiling point of water is elevated. In an autoclave, it is essential that the steam be very close to the phase change temperature or boiling point. If the temperature is higher than this, the steam is superheated and this impairs its ability for killing. There are several reasons for this. Firstly, when saturated steam comes into contact with a cooler object, such as an instrument, the steam changes immediately to liquid water and this phase change is associated with the release of a large amount of energy in the form of heat. This transferred heat rapidly increases the temperature of the object involved. Secondly, when the steam changes back to water, there is a dramatic reduction in size and this contraction pulls in yet more steam to replace that which has already changed to water. This process continues until eventually the entire load in the sterilizer has been raised to the same temperature as the steam. The third reason relates to the moistening effect. When steam changes to water, this moistens the organisms, which increases the kill rate. When steam is superheated, the temperatures fluctuate considerably around the chamber and consistent killing is not achieved. Transfer of heat is less, shrinkage of steam is less, and for these three reasons, superheating of steam is a problem.

Class 6 chemical indicators can show the presence of superheated steam. The problem of superheated steam can also be detected by placing a range of thermocouples throughout the autoclave chamber, but this is not a practicable method in a dental practice.

The purity of steam is an important parameter in effective autoclaving. Pure steam is pure water in a gaseous phase. Any impurities in steam could be of a liquid form, for example, droplets of water or fog, or they may be of a gaseous nature, for example, entrapped air. Solid impurities in steam, such as particles of rust or instrument coatings, can also occur. When small amounts of air are present in steam as an impurity, this has little effect provided the air is mixed thoroughly with the steam and the amount of air is very low, for example, less than 1 per cent. If the air is present at a level beyond this, the air does not readily mix with the steam, but remains rather compressed by the steam into pockets of air which are cool. Cool air pockets, which may be caused by an overcrowded chamber, incorrect wrapping, incorrect positioning, or incorrect use of packaging materials, are a very common cause of failed autoclaving in downwards displacement autoclaves.

Air pockets occur less often in pre-vacuum autoclaves, and indeed a Bowie-Dick test is used to detect the presence of air pockets in a test pack. When water droplets or fog are present as an impurity in the steam, materials inside the sterilizer may become wet. The presence of a very small amount of entrained moisture, for example, less than 2 per cent, is beneficial since this reduces the tendency of the steam to otherwise superheat.

The third parameter of steam availability is affected by instrument factors of which the most common is a clogged filter in the steam line itself. It is important to remember that chemical indicators have specified performance limitations according to the class of the indicator. Where instruments are intended to be sterile at point of use, then a high level emulating indicator is required in each instrument pack. While AS 4187 permits chemical indicators between Classes 4 and 6 to be used for such a purpose, it is the author's personal view that a Class 6 indicator is preferable because of its ability to provide additional information on steam quality which is not provided by Class 4 and 5 indicators.

The performance of different types of chemical indicators can be summarized as follows:

- A **Class 1** indicator, also called a process indicator, is located on the outside of a package to show whether the item has been exposed to a sterilizing cycle. Examples of Class 1 indicators include inks which change colour which are incorporated into the paper of an autoclave bag or pouch, and tape with diagonal stripes which is used to either seal packs or as a specific indicator.
- A **Class 2** chemical indicator is used to measure the effectiveness of air removal. This is also known as a process challenge device.

With a pre-vacuum autoclave, an air removal test such as a helix test or Bowie-Dick test must be run each day to test the ability of the vacuum pump system to remove air adequately. The procedure for running a Bowie-Dick test can be described simply as follows:

1. The Bowie-Dick test is used for the very first cycle of the morning, once the auto-clave has been warmed to its normal operating temperature. No other items are loaded into the chamber for this test.
2. The Bowie-Dick test pack can either be made or can be purchased already configured.
3. The test pack is placed horizontally onto a perforated tray above the chamber drain, at least 100 mm from the door.
4. At the completion of a vacuum cycle, the pack is removed and the test sheet removed from the centre of the test pack. This is unfolded and the colour change on the indicator tape on the inside of the pack is compared with that provided by the manufacturer. Where there is an uneven colour change, this indicates problems in air removal and steam penetration which must then be further investigated. The Bowie-Dick test should show a consistent colour change across all areas of the test pack. The results of the test need to be recorded into the autoclave log book and signed off by the operator.

- A **Class 3** chemical indicator is a single parameter indicator with a fairly poor accuracy. A typical Class 3 indicator has an accuracy of 2°C only, and is only used with dry heat sterilizers.

Class 4, 5 and 6 indicators are multi-parameter.

- A **Class 4** indicator provides a graded response with a gradual colour change. It has an accuracy of 2° in temperature and 25 per cent in terms of time.
- A **Class 5** indicator is sometimes called a Biological Emulator because it is timed to change colour at the kill point for spore tests, which is 1.8 minutes at 134°C. These have a tolerance of 1° on temperature and 15 per cent on time.

A Class 5 chemical indicator offers no safety margin as this indicator is designed to show a pass at a point that is well before the desired cycle parameters have been achieved. At a temperature of 134°C this is 3.5 minutes. It is at this point that the probability of residual viable organisms remaining is less than one to a million (the sterility assurance level).

- A **Class 6** chemical indicator is sometimes referred to as an Emulating Cycle Verification Indicator, and several common products are used for this purpose, such as Titems TST and Brownes TST. These indicators have a narrow transition period with a 5 per cent tolerance on time and 1° tolerance on temperature. They change colour at 3.5 minutes at 134°C at the sterility assurance point. These indicators will not show a colour change if the temperature is 1° below. They also provide indication on the quality of the steam through bubbling of the laminate on the indicator of the steam if too wet, and producing a brown colour if the steam is too dry or superheated.

It is essential that the chemical indicator which is used is certified to international standards. Class 6 chemical indicators are certified to ISO11140-1. They are labelled to indicate the specifications, for example, 134°C for 3.5 minutes or 120°C for 15 minutes.

In instruments intended to be sterile at point of use, a chemical indicator may be included in each pack or pouch. While the standard specifies that this can be a Class 4, 5 or 6 indicator, as mentioned earlier Class 6 indicators are preferred because of their much tighter tolerance on the conditions of steam, temperature and time. A typical Class 6 indicator will give a colour change at 134° for 3.5 minutes at the correct level of steam dryness. The colour change expected for these indicators is both marked on the strip itself and is also provided on a reference chart from the manufacturer.

## BIOLOGICAL INDICATORS

Biological monitoring of sterilization is based on the use of highly heat resistant spores such as those from *Bacillus stearothermophilus*. The logic here is that these spores provide a greater challenge to the steam sterilizing process than will be the case with the organisms present on cleaned instruments. This overkill phenomena is fundamental to the probabilistic definition of sterilization which is used by manufacturers and regulators. This is the sterility assurance level (SAL) mentioned earlier.

The intention of chemical tests is to provide information on the process associated variables. In contrast, biological indicators provide some information on product associated variables in steam sterilization. Because of the probabilistic nature of autoclaving, chemical indicators which can give a parallel, or indeed go beyond biological indicators, are very useful, and it is these types of indicators which are now becoming commonly used in dental practice.

## A7 – TRACKING OF DENTAL INSTRUMENTS

The revision of the NHMRC CDNA Infection Control Guidelines and the related Australian Standards 4815 and 4187 in recent years has introduced the concept of tracking instruments used in certain clinical procedures (such as surgical procedures), *back to a particular autoclave cycle*. The requirement for tracking is specified in section 3.5 of the new NHMRC guidelines. It is important to stress that tracking is not the same as *tracing*, which refers to being able to identify which individual instruments have been used on a particular series of patients.

The underlying logic for tracking is based on the Spaulding classification system, which describes the risk that instruments may transmit infections to patients during clinical procedures according to the site where those instruments are to be used. Contact sites for instruments are classified as critical, semi-critical or non-critical. Instruments that contact sterile tissue (critical sites) are the highest risk, while instruments used on intact non-sterile mucosa (semi-critical sites) have lower risk, and instruments that contact only intact skin (non-critical sites) pose the lowest risk. Thus, an instrument which is used in clinical practice to intentionally enter or penetrate a sterile tissue, cavity or the bloodstream is classified as critical, and clearly instruments used for surgery in the dental office would fall into this classification.

### WHAT TO TRACK

As specified in sections 4.4 and 6.4 of the new national guidelines, all instruments and equipment used in critical sites:

- must be sterile at the point of use;
- must be packaged;
- must be processed in an autoclave with a dedicated drying cycle using validated cycle parameters; and
- must be able to be tracked back to a specific autoclave cycle.

Thus, reusable instruments used for the following procedures require tracking:

- oral surgery, including routine extractions, soft tissue procedures and surgical removal of teeth
- oral and maxillofacial surgery
- implant surgery
- periodontal surgery, including the use of electrosurgery
- endodontic surgery

These situations represent critical procedures in which deliberate (intentional) surgical entry to sterile tissues occurs. Any instrument that is used to enter tissue that would be sterile under normal circumstances must be sterile at the point of use.

### WHAT NOT TO TRACK

Instruments which come into contact with intact but non-sterile mucosa are regarded as semi-critical, and this includes instruments used in routine dentistry such as in restorative procedures. The same is true for instruments which are not intended to enter sterile tissues but may do so accidentally during a procedure (for example, a curette used for root planing). Instruments used in semi-critical procedures need to be sterilized between patients but do not need to be tracked back to an autoclave cycle. Routine dental instruments, while not required to be sterile at the point of use, must still be autoclaved between patients.

### HOW TO TRACK

The three key elements of tracking are:

- a batch number system;

- a comprehensive log of autoclave cycles which includes batch numbering data; and
- a simple means for recording batch information on patient records.

Because tracking refers to instrument packs or sets, rather than individual instruments, there is a clear logic in re-assessing the inventory of instruments used for surgical procedures. It will generally be more efficient to combine several instruments into a set, rather than to keep isolated instruments in separate pouches. Moreover, in a smaller dental practice where few critical procedures are undertaken, there may be improved efficiency by autoclaving the surgical instrument sets from the day together in the one load (which must employ a drying cycle).

Batch numbers can be a simple sequence of numbers, such as that produced from a labelling gun, or can be combinations of a number sequence with codes for the date and the autoclave number (if the practice has several autoclaves). For example, 05-12-03-A-07 would indicate that the pack was processed on 5 December 2003, in autoclave A, and was the seventh batch of that particular day.

Batch information can be recorded on a pack using non-soluble permanent marker ink or adhesive labels. Commercial labelling guns such as those used in supermarkets can be used, provided that the adhesive and the ink tolerate autoclaving. Alternatively, solvent-based felt-tipped marking pens, and rubber stamps with ink can be used for labelling packs prior to sterilization with information regarding the contents of the pack, and the batch data required for tracking. It is not necessary to place an expiry date on packs, since the modern concept of expiry dates relates to events rather than a specific time. Pencils, water-based markers and ball type pens should not be used for labelling packs as these may compromise pack integrity. Similarly, packs should not be labelled after sterilization as this may also compromise the integrity of the pack.

At the time of the clinical procedure, batch number information must be recorded into the treatment record section of the patient's chart, along with the usual details regarding the clinical procedure itself. It is the responsibility of the clinician to record the batch numbers for critical items in the patient's record when writing up the notes for the procedure.

An alternative to handwritten recording of batch information into the patient's chart is the use of a segmented (piggyback) adhesive label system, where part of the label is peeled off the pack at the time of setting up for the procedure, and placed directly under the day's entry on the patient's chart. A variety of commercial label systems and labelling guns are available. Some labelling systems include a Class 1 chemical indicator on the label, which changes colour in response to exposure to heat. This provides a useful visual guide that the item has been processed, and would be in addition to the Class 1 indicator already included on the pack.

The final component of tracking is a comprehensive log of autoclave cycles, which includes information on the batch numbers in various loads. An entry into this log is made for all autoclave cycles, even those which do not include any packs of critical instruments. It is this log that provides the necessary written documentation of sterilization. The log comprises a book with ruled columns, and the following headings:

- Autoclave identification code (if there are several units in the practice)
- Date
- Time
- Cycle parameters (wrapped, unwrapped, etc.)
- Nature of the load (numbers of packs, instrument cassettes, etc.)
- Batch numbers of packs included in that load (if any)
- Result of the autoclave readouts or printout for that cycle
- Result of the chemical indicators (Class 1, 4, 5 or 6) used in the cycle
- Identification of the person who has checked the autoclave readouts and chemical indicator result, and who authorizes release of the load for use.

Data for physical autoclave parameters can be obtained easily if the autoclave has a

printout. All new autoclaves have printing or data transfer capabilities. When selecting a printer, ink-based printouts are preferred to thermal printouts as there is less likelihood of degeneration and fading over time. Since it is necessary to keep printouts for a specified period (typically seven years), it is important that the readouts are still legible after this time.

Chemical indicators which change colour when proper sterilizing conditions have been achieved must be used on packs and pouches of critical items. Examples of so-called process indicators (Class 1 chemical indicators) include inks which change colour which are incorporated into the paper of an autoclave bag or pouch, and tape with diagonal stripes which is used to either seal packs or as a specific indicator.





## A8 – WATER FOR AUTOCLAVES

Regardless of the type of autoclave used in a dental practice, in order for steam under pressure to be effective for sterilizing, it must have a dryness fraction of 97 per cent and above, and not be superheated beyond 2°C of the saturated steam temperature. Steam which is 'wet' (that is, has a dryness fraction less than 97 per cent) is unsuitable for sterilization, and will result in wet instrument packs, while superheated steam will not condense evenly onto the surface of instruments and thus will not transfer the latent heat which is responsible for killing micro-organisms.

Older types of autoclaves typically employ simple water systems in which water from previous cycles is recycled by condensation of steam at the end of a cycle. Accumulated debris (and lubricants) in this recycled feed water may compromise the performance of the autoclave by causing superheated steam to be produced. Because of an inevitable deterioration in water quality over successive cycles with reuse, it is essential that the water reservoir in such autoclaves is drained completely, cleaned and flushed every week, and then filled with a fresh supply of distilled or de-ionized water (*not* tap water).

Many modern autoclaves use a two tank water system, with a storage tank on the top of the chamber for 'feed' water, and a tank below the chamber for 'dump' water. The latter normally has a waste hose connection. Because these autoclaves do not recycle water between loads, they require a substantial supply of distilled or de-ionized water each working day (typically four or more litres). It is therefore necessary to maintain a sufficient quantity of appropriate water for refilling the autoclave as part of the inventory of the sterilizing room.

The use of tap water, 'spring water', ground water, rain water or bore water in autoclaves is contraindicated, since inorganic materials in these waters (such as salts of calcium, magnesium and aluminium) will build up rapidly as a mineral 'scale' in the water and steam lines of the autoclave, and impair the flow of water and steam through the pipes. Distilled or de-ionized water have low levels of these inorganic impurities. Supplies of de-ionized water can be obtained commercially, as this water is also used for steam irons and lead-acid batteries. Water can be also be de-ionized 'on site' using reverse osmosis units. The level of inorganic ions in the exit water from these units can be tested by measuring the electrical conductivity of water. Water with greater levels of inorganic ions is more conductive. If reverse osmosis units are employed, it should be remembered that the membrane cartridges will need to be replaced on a regular basis to ensure proper operation of the unit.



## A9 – PROCEDURES AND STRATEGIES TO ASSURE SAFE STORAGE OF STERILE INSTRUMENT PACKS

Clean instrument storage should occur in a clearly defined area, which is protected from the vapours, splashing or aerosols produced during equipment washing, ultrasonic cleaning and reprocessing, or from clinical procedures or handwashing. Practically, this means that the storage of sterilized items should often be outside the sterilizing room environment.

Drawers or sealed containers are preferred for storage of sterile wrapped items because they allow the contents to be seen easily, and are generally located at a height so that the contents can be both easily seen and easily turned over with the most recently processed items being placed towards the back of the drawer. It is important that the area used to store sterile items be as far as possible physically from any sources of splash or contamination. This means it cannot be near the sink in the sterilizing room. If the area used for storage is too small, too high, crowded or awkward, then problems will occur in terms of correctly accessing the items. The chance of penetration of a sterile pouch by an item will be increased in such situations.

For routine dental instruments, protection from contamination by aerosols and environmental contamination can be achieved by storage in bags, covering instruments with an impermeable material, storage in closed drawers, or storage in dedicated covered containers. To facilitate environmental cleaning and prevent contamination, all packaged sterile items should be stored at least 250 mm above floor level. Similarly, sterile items should be stored at least 440 mm from ceiling fixtures to allow unrestricted airflow and to prevent heating and degradation of the packaging material by lighting or direct sunlight.

For sterile packaged items, it is essential that the packs be dried by the autoclaving process and that they be maintained in an environment which is clean, dry, and free of sharp objects that may damage the packaging. Thus, the autoclave which is used must dry package sterile items as part of the cycle before unloading, and not produce damp packages at the end of the cycle. This means that packaged items should only be processed in an autoclave that has a built-in drying cycle. Bench top sterilizers that do not have a built-in drying cycle are NOT appropriate for the sterilization of wrapped items, but can be used for non-critical unwrapped items. Pre-vacuum steam sterilizers are best for the sterilization of packaged loads.

During storage, events which can lead to a breach in the packaging and therefore contamination of the contents of a pack include the following:

- Over-handling of the pack, for example through excessive transferring from one place to another, or during rotation of instrument packs. It is good practice to rotate packaged instruments so that those with the latest expiry dates are placed at the rear of the storage drawer or cabinet.
- Moisture contamination of the pack. If a dry instrument pack is placed on a wet bench top, or is wet by splashing of water, other liquids or by aerosols, the pack must be deemed to be contaminated and unsterile. The contents cannot be used for a procedure, but must be cleaned and re-sterilized.
- Penetration. If during handling any instruments break through the surface of the pack or pouch, this breaches the protection of the pack, and the contents must be regarded as unsterile.

For the above reasons, it is important that wrapped instruments are stored in a clean dry area, and are subjected to minimal handling before use. Unwrapped instruments (that is, instruments in trays) must be stored in a clean, dry, dust-free environment, and must be separated from any possible contamination from the chairside. This can be achieved using large plastic bins with close fitting lids, which can be fitted to eliminate environmental and aerosol-based contamination.

When an instrument pouch intended for use in a surgical procedure is about to be used, the outer wrapping of the package should be checked to make sure there are no holes or tears in it. When the package is opened, and if a Class 6 indicator has been used, it should then be checked. If the pouch has a clear plastic side, this check can be done without opening the instrument pack. If there is any doubt that sterility was obtained during processing, the items should be considered contaminated and not used during a procedure.

## A10 – DENTAL UNIT WATERLINES

### PREAMBLE

- The dental community's attention has been drawn to contamination of dental unit waterlines (DUWL) over recent years. The presence of bacteria in waterlines has been recognized since 1957, however, at the time it was not considered that the numbers and types of micro-organisms were sufficient to present a significant health problem.
- All DUWL become contaminated. While the organisms are derived primarily from the water supply (such as the reticulated community water supply), retrograde contamination, that is, from the delivery end of the waterline, can also occur. The contamination of DUWL is a phenomenon related to laminar flow in small bore tubing (where the flow in middle of tubing is rapid, while the peripheral flow is nearly zero). These conditions allow the deposition and growth of a layer of heterotrophic mesophilic bacteria (somewhat akin to dental plaque in terms of its structure) known as a biofilm. Bacteria can break off the biofilm and can be expressed in the water delivered from the dental unit. Measurement of the level of bacteria in water exiting from a dental unit (colony forming units per millilitre or CFU/ml) gives an estimation of the level of biofilm present in DUWL.
- New anti-retraction valves can become coated with biofilm and this can lead to their failure under conditions of use.
- World Health Organization standards for potable water are in the range 100–500 CFU/ml, with coliforms (such as *E. coli*) less than 1 CFU/100 ml. Dialysis standard is 200 CFU/ml. Exit water from DUWL has been measured in the range from 0–18,000,000 CFU/ml, with variations according to the type and age of dental unit and the use of biofilm reduction measures.
- DUWL contamination is increased by:
  - use of municipal supply which does not conform to microbial contamination standards
  - heating water in the dental unit (such as for the triple syringe)
  - water stagnation overnight or weekend
  - failure to implement measures to reduce biofilm accumulation

A useful discussion paper regarding current water standards in Australia is the NHMRC's 'Microbial Indicators of Water Quality'.

### RISK

- The existence of a possible hazard is not automatically synonymous with unacceptable risk.
- Dental biofilms may contain such organisms as *Klebsiella*, *Nocardia*, *Moraxella*, *Serratia spp.*, *Pseudomonas spp.*, non-tuberculous mycobacterium and *Legionella spp.* These organisms can pose problems for immunocompromised patients, which represent an increasing proportion of today's dental patients. Elevated rates of seropositivity to legionella have been noted for some dental health care workers (up to 50 per cent in one study), indicating occupational exposure.
- DNA sequencing technology has been used as evidence in US court cases with patients claiming illness from contaminated DUWL.
- Current understanding of the risk is that there is negligible risk for a healthy patient, and there may be some risk, as yet not quantifiable, for an immunocompromised patient.

### CURRENT STATUS

- The American Dental Association (AmDA) released a statement on DUWL on 13 December 1995. The key finding is stated here:  
*"Water Quality Improvement: Dental unit water systems currently designed for general dental practice are incapable of delivering water of an optimal microbiological quality. The*

*Council recommends an ambitious and aggressive course to encourage industry and the research community to improve the design of dental equipment so that, by the year 2000, water delivered to patients during non-surgical dental procedures consistently contains no more than 200 CFU/ml of aerobic mesophilic heterotrophic bacteria at any point in time in the unfiltered output of the dental unit; this is equivalent to an existing quality assurance standard for dialysate fluid that ensures the fluid delivery systems in haemodialysis units have not been colonized by indigenous waterborne organisms."*

- The AmDA Council recognizes DUWL quality to be essentially a problem of equipment design for manufacturers to resolve in consultation with the dental profession.
- The 'Infection Control Guidelines for the prevention of transmission of infectious diseases in the health care setting January 2004' of the Communicable Diseases Network of Australia (CDNA) discusses water quality and waterlines in section 35.5 – 'Management of Water Quality and Aspiration'.

*"A hierarchy of water quality is required for dentistry. Water used for surgical procedures should be sterile; water used for mouth rinsing should be of potable standard. Water required for irrigation for tooth preparation and ultrasonic scaling should be of no less than potable standard. Biofilm in dental unit waterlines is an unknown hazard. It is prudent to treat immuno-compromised patients using water in which the number of colony forming units [CFU] per mL is less than 200. CFU levels can be measured using commercially available test strips.*

*Air and water lines should be flushed for a minimum of two minutes at the start of the day and for 30 seconds between patients. For dental units equipped with an independent water supply, the manufacturer's instructions must be closely followed for disinfection procedures.*

*All dental equipment that supplies water to the oral cavity must be fitted with non-return valves. Routine maintenance of non-return valves is necessary to ensure their effectiveness. Manufacturers should be consulted to establish an appropriate maintenance routine."*

- The Centres for Disease Control and Prevention (CDC) in the US released new infection control guidelines – 'Infection Control in Dental Health-care Settings' – in 2003 in which they now recommend:

*"For routine, non-surgical procedures, dental treatment water should meet standards set by the Environmental Protection Agency [EPA] for safe drinking water [that is, no more than 500 CFU/mL]"*

- Correctly managed, current protocols can deliver water of <200 CFU/ml. Generally, they are operator-dependent and complex, and many of them require a separate water supply not connected to the municipal system. Compliance will prove to be a significant issue in the continuing success of these processes. Examples of such protocols are:
  - 0.2 micron point of use, inline barrier filters, changed daily
  - disposable check anti-retraction valves for use with filters
  - chemical disinfection (for example, with continuous injection of hydrogen peroxide or intermittent sodium hypochlorite)
  - electrochemically activated water
  - autoclavable and disposable tubing
  - daily draining and purging
  - flushing lines between patients and an extended flush at the beginning of a session
  - electric silver-ion continuous treatment

## RECOMMENDATIONS

- That ADA members be informed of the concern associated with DUWL contamination and of the measures which at present can be taken to minimize this problem, so they can assess the risk to their own patients and adopt those measures they consider appropriate for their own practice.
- That ADA members be made aware that DUWL contamination is primarily a problem of equipment design for manufacturers to resolve.

- That ADA members follow current recommendations, as outlined in 35.5 of the CDNA Infection Control Guidelines and stated above.
- That ADA members bear in mind current AmDA recommendations, particularly when purchasing new equipment.
- That ADA members consider the simple commercial systems available to test the quality of their dental unit water on a regular basis (such as Millipore) or use the services of a diagnostic pathology laboratory.
- That ADA members consider the retro-fitting options available with some of the systems.
- That ADA members be made aware that this current ADA Position Statement is in an area of changing knowledge and technology.
- That ADA members be made aware that the current situation is well summarized in an article from the November 1999 issue of JADA, 'Dental Unit Waterlines: Approaching the Year 2000', which says, in part:

*To date, there is no published evidence of a serious public health risk from biofilm-contaminated dental unit water. Most of the microorganisms found in dental unit water are gram-negative, heterotrophic bacteria that have little potential to cause disease in immuno-competent people. However, we must continue our awareness that the presence of high levels of opportunistic organisms may overload the defence systems of immuno-compromised patients and occupationally exposed dental staff members.*

*Despite the lack of evidence of adverse health effects, contact of a patient's open wound, mucous membranes or body cavity with water of poor microbiological quality simply is inconsistent with patient expectations of modern dentistry.*

*There remains the need for continued research efforts to evaluate the risk of biofilms in dentistry as new technology, research and data become available.*

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## A11 – CLEANING ENDODONTIC ROTARY INSTRUMENTS

Reamers, files and broaches used in endodontic treatment are single use and not used for other patients. Alternatively, reuse endodontic instruments which have been cleaned according to a verifiable cleaning regime. Two such verifiable procedures have been described and are based on the process of Parashos P, Linsuwanont P, Messer HH. *'Effective cleaning protocols for rotary nickel-titanium files'*. Aust Endod J 2003;29:23-24.

Two cleaning regimes for reusable endodontic instruments were described:

### Method 1

1. Insert files into a scouring sponge soaked in 0.1% chlorhexidine gluconate aqueous solution immediately after use at the chairside;
2. Clean the files using 10 vigorous in-and-out strokes in the sponge;
3. Place the files in a wire mesh basket and immerse in an enzymatic cleaning solution for 30 minutes;
4. This is followed by a 15 minute ultrasonification in the enzymatic cleaning solution; and
5. Rinse in running tap water for 20 seconds.

### Method 2

1. Insert files into a sponge soaked in 0.1% chlorhexidine gluconate aqueous solution immediately after use at the chairside;
2. Place the files into an endodontic file stand that allows ready access to the file flutes for brushing with a fine bristle brush. Files should be scrubbed for 20 strokes and rinsed for 30 seconds under running water;
3. Completely immerse the files in a glass beaker in 1% NaOCl for 10 minutes, followed by ultrasonification in the same solution for five minutes; and
4. Rinse copiously under running water and then proceed to sterilization.

This information is from the ADA Victorian Branch Systematic Operating Procedures Manual.

NOTE: Occupational Health and Safety guidelines must be observed to minimize the risk of injury during any procedure involving manual cleaning of sharp instruments.



## A12 – THE DENTAL LABORATORY

### DEALING WITH LABORATORY WORK

It is important to remember that infection control does not stop at the chairside. Any items or materials placed in a patient's mouth that are subsequently removed and processed elsewhere can be considered biologically contaminated and must be handled in a safe manner. Everyone concerned in the provision of dental treatment should be aware that there is a small but significant potential for transmission of infection when dealing with dental laboratory work.

It is also essential that staff are protected from accidental exposure to contaminated material. As it is impossible to guarantee that an impression is perfectly clean and free of blood and saliva many of the items generated in the clinic cannot be rendered biologically safe. If there are residues of blood and saliva on an impression and this impression is poured by someone with a cut on their hands and no barrier protection then the risk of developing an infection from a blood-borne virus such as hepatitis C does exist. It is a very small risk but there must be protocols for handling these items at every step, both at the dental surgery and at the laboratory.

In simple terms clinicians should ensure that the work is as clean as it can possibly be and there should be a protocol for transfer of items to and from the dental surgery to the laboratory. Dentists and managers of dental laboratories need to liaise with each other so that all are aware of infection control procedures.

Infection control against blood-borne viruses is based on the premise that in order for a person to be infected ALL of the following three conditions must be present:

- A susceptible host, that is anyone who is exposed to body fluids containing HIV, hepatitis C virus or hepatitis B virus (for anyone who has not been vaccinated against HBV or who does not have HBVAB)
- A virus with sufficient virulence (infectivity) and dose (numbers) to cause infection.
- A portal through which the virus may enter the host, that is, a break in the skin or sharps injury

To prevent cross-infection or transmission of infection only ONE of the above conditions needs to be eliminated.

In addition to blood-borne viruses, laboratory work should also be clean so that it is not contaminated with cold or influenza viruses, candida or bacteria such as staphylococci.

Although the risk of cross-infection is low from dental laboratory work, it is still essential that the basic precautions outlined below are followed when handling laboratory work:

- Appropriate personal protective equipment must be worn: that is, protective glasses at all times and masks and gloves as indicated.
- Develop safe work practices and risk management protocols to reduce the risk of sharps injuries.
- Contaminated work is separated from clean work.
- All items entering the laboratory area should be cleaned using a suitable agent before they are worked on.

### SENDING WORK TO THE LABORATORY

- All work going to the laboratory must be washed with detergent and water, rinsed with clean water and then inspected to ensure that it is free of blood or visible foreign matter, for example, denture adhesives.
- The work should be placed in a plastic bag and sealed and labelled.
- If sealed items are transferred in laboratory boxes the boxes should be wiped with detergent and water prior to being reused.

- Of note some States or health authorities may require additional disinfection of laboratory work. It should be acknowledged that many impression materials will react chemically with disinfectants resulting in a changed product and that some disinfectants, although suitable for use with dental materials, may have occupational hazards associated with their use (for example, glutaraldehyde). It is extremely difficult to contract infection from a clean item. If not cleanable then barrier protection should be invoked.
- Implantable items  
All work which requires a specific cleaning or sterilizing procedure prior to insertion in the clinic must have appropriate instructions supplied for that processing procedure.

### **Clinic lathe area / Laboratory area**

Where laboratory items are adjusted in a dedicated area within the surgery, attention needs to be paid to ensuring cross contamination does not occur. The area should be prepared and maintained for single patient use procedures.

This means that fresh pumice, new arbor bands and clean mops, clean brushes and preferably sterilized burs or at the minimum heat disinfected burs must be used for each item of work (patients).

### **LATHE AREA**

Fresh pumice, new arbor bands and clean mops, clean brushes and sterilized burs must be used for each patient's work.

#### **Lathes**

- Place bib inside lathe bucket with the plastic surface facing upwards.
- Place pre-measured pumice in denture cup.
- Add tap water to the dry pumice mix with a wooden spatula.
- Place brush / mop inside lathe bucket ready for use.

#### **After use**

- Place used mop / brush in 'dirty' collection bucket.
- Discard used pumice and container and bib from lathe bucket in waste container.
- Wipe out lathe bucket if visibly soiled.

#### **Procedure for cleaning / disinfecting lathe mops**

- Rinse lathe mops thoroughly to ensure removal of pumice.
- Wash lathe mops in very hot water with detergent. Rinse well in clear water.
- Mops should soak in near boiling or boiling water for five minutes. Boilers may be used.

OR

- Sterilize cleaned mops by placing flat on sterilizer tray or in 'toast rack'.

OR

- Items may be washed and disinfected in an instrument washer thermal disinfectant.
- If necessary treat lathe mops by rinsing in fabric softener which keeps mops soft and deodorized.
- Squeeze excess moisture from mops.
- Place mops on 'toast rack' for drying.
- Place clean mops in tray ready for next use.
- Disintegration of the plastic or leather centre insert may occur. Providing the centre is not over stretched, the mop will generally still fit onto the lathe without the insert.

### **Procedure for laboratory / lathe area motors, handpieces and burs situated in a clinic lathe area**

- Work to be rinsed with detergent and water and rinsed prior to using the handpiece.
- New exam gloves to be worn.
- Pre-sterilized bur to be placed in handpiece.

#### **Cleaning**

- Laboratory motor and handpiece to be wiped with a damp cloth impregnated with detergent and water.

- Wipe detergent residue away with a damp wipe. Do NOT over wet the handpiece and motor.

Burs are to be cleaned and sterilized after each patient's work completed.

## **INFECTION CONTROL MEASURES FOR USING ON-SITE LABORATORY FACILITIES AND FOR WORKING IN A DENTAL LABORATORY SITUATION**

There should be specific areas for incoming work ready for decontamination and for laboratory work which should be cleaned and sealed.

Dentists using laboratory facilities for adjustment of appliances, dentures, or any work from the clinic, must clean the item before using equipment. The work being adjusted needs to be treated as for incoming work, that is, it should not contaminate new work or dirty clean surfaces. It is imperative to ensure that saliva or blood contaminated work does not contaminate new work in preparation or work benches and models.

Incoming items can be cleaned by washing carefully with a slightly alkaline or neutral detergent.

Some items may be cleaned by immersion in an ultrasonic cleaner or in an acid bath.

If the incoming laboratory work cannot be adequately cleaned without damaging the work then all procedures carried out on that work should follow protocols for single patient use, for example, fresh pumice, clean mop, and sterilizing burs after use on the item.

### **Cleaning items in an ultrasonic cleaner**

- Ultrasonic cleaners must be degassed and tested regularly with the foil test to ensure that they are functioning properly.
- Items to be cleaned should be placed in an immersion basket for the required time.
- The time required to clean an item will obviously depend the amount of contamination present.
- Cleaned items should then be rinsed under warm running water and dried before being taken to the laboratory area.
- If the item has been grossly contaminated it may be necessary to change the ultrasonic solution after using it.

### **Cleaning items in an acid bath**

An acid bath is a very effective way of cleaning laboratory work. Note that acids are hazardous materials and must be handled carefully according to the following principles:

- The acid bath is made up of concentrated hydrochloric acid diluted 1:1 (that is, 50 mL acid added slowly to 50 mL water) placed in a closed glass container. When diluting acid to 1:1 mix, always add acid slowly to water.
- The lid should only be removed for work to be immersed.
- The closed glass container should be kept in a fume cupboard.
- Protective apron, glasses and heavy-duty gloves should be worn.
- Tongs should be used to add dentures and appliances to the acid bath.
- Items should be soaked for a minimum of 60 seconds.
- Work should be rinsed in water following immersion in acid bath.
- Bicarbonate of soda can be placed around the beaker containing acid, to absorb fumes from the acid.
- Disposal of acid – dilute by 100 per cent with water then flush down sink with copious amounts of water.

### **Infection control protocols for the dental laboratory**

- Areas for incoming and outgoing work will be clearly identified in laboratory.
- Hands MUST washed before starting work.
- Technicians MUST develop work practices to isolate contaminated work from clean work, that is, all work must be clean before placed on workbench.

- Impressions
  - Wash models with detergent and water and rinse.
- Decontamination of work
  - Old work (repairs, dentures for adjustment / grind in: If suitable for acrylic items and for removal of gross organic debris), items can be soaked in an ACID BATH for a minimum of sixty seconds and then rinsed with detergent / water. If unable to adequately clean items then old items (such as existing dentures requiring repair) need to be processed separately from new work.
  - New work must be washed with detergent and water and rinsed in running water.

## B GUIDES – PRACTICAL GUIDES TO DENTAL THERAPEUTICS

These Guides are currently under review and will be incorporated in the forthcoming joint publication between the Australian Dental Association and Therapeutic Guidelines (due for release in early 2007).





## C GUIDES – PRACTICAL GUIDES TO DENTAL EQUIPMENT

- C1 Installation of anaesthetic gas equipment
- C2 Anaesthetic gas hygiene
- C3 Electrodental equipment
- C4 Lasers
- C5 Use and maintenance of visible curing lights



# C1 – INSTALLATION OF ANAESTHETIC GAS EQUIPMENT

## 1 LOCATION OF MANIFOLDS AND CYLINDERS

- 1.1 When the number of cylinders and manifolds has been determined, an accessible site location should be selected and approved by the supplier in accordance with Australian Standard 2896-1991.
- 1.2 The site should have a firm and level base.
- 1.3 The site position should be such that damage will not occur from vehicles and other traffic but permit easy access for cylinder exchange.
- 1.4 The installation should preferably be outside the building, and never in the surgery.
- 1.5 House cylinders and manifolds outside the building in a shaded, well ventilated, lockable metal cabinet, in which the temperature will not exceed 45°C.
- 1.6 Keep cylinders and manifolds well away from any combustible material (oils, paint, paper, wood, etc).
- 1.7 Inside installations should be at least 6m from flammable and combustible materials such as those listed above.
- 1.8 Safety devices should vent outside the building for all inside installations.
- 1.9 Manifolds must be fitted with an automatic changeover system with both local and surgery warning signals which indicate low levels of oxygen.
- 1.10 Connections to surgery outlets should be made through approved fittings, which include reducing valves and pipelines.
- 1.11 Cylinders must be chained to the wall or otherwise secured from falling over.
- 1.12 Gas lines should be colour coded for easy identification: royal blue for nitrous oxide, white for oxygen.

## 2 MAINTENANCE AND SERVICING

- 2.1 Never grease or oil any valve, gauge or fitting.
- 2.2 Shut off the supply at the cylinders overnight.
- 2.3 For longer periods of shutdown, completely depressurize the system.
- 2.4 Use only the cylinder valve keys or handles supplied. The extra torque from the use of spanners may permanently damage valve seats and spindles. (Most cylinders are now fitted with non-removable keys.)

## 3 WARNINGS

- 3.1 Gas escaping under high pressure at high velocity may cause enough frictional heat to melt plastic hoses and cause an explosion of combustible material.
- 3.2 Never connect plastic hose directly to a cylinder. Reducing valves must be attached at the cylinder outlet.
- 3.3 Never allow oil, grease or waxy substances such as furniture polish to come into contact with any manifold, surgery outlet or other equipment. Oxygen and nitrous oxide are strong oxidizing agents and react violently with oils, greases, etc.
- 3.4 Never improvise fittings; use only approved equipment.
- 3.5 Never use a cylinder of oxygen to operate any surgical equipment (for example, handpieces or packers).
- 3.6 Check new installations for cross-connections and other faults before use.

## **FURTHER READING**

Atkinson HF. Dental installations of medical gas units. Current Note No. 67. Aust Dent J 1988;33:153.

Standards Australia. AS 2896-1998: Medical gas systems – Installation and testing of non-flammable medical gas pipeline systems.

Standards Australia. AS 2896-1998/Amdt No.1-1999: Medical gas systems – Installation and testing of non-flammable medical gas pipeline systems.

## C2 – ANAESTHETIC GAS HYGIENE

### 1 EQUIPMENT

- 1.1 Cylinders and gas lines must be installed by qualified personnel, and comply with Australian Standard 2896-1991. (See also Guide C1)
- 1.2 Equipment must be checked for leaks at installation and regularly thereafter. Leakage on both the high pressure and low pressure sides of the machine should be tested.
- 1.3 A regular equipment maintenance program must be initiated.
- 1.4 The use of a scavenging system is mandatory. An active system is preferred to a passive one.
- 1.5 Scavenged gases must be vented to the outside of the building via gas-tight lines. Such lines must not be vented in a position where re-entry of gases into the building may occur (for example, near windows or airconditioner or air compressor intakes).
- 1.6 Ensure the nasal hood fits as closely as possible to the patient's face. This will make calibration of gases easier due to lack of ingress of diluting air, reduce the volume of gases required and reduce the amount of expired gas escaping to the surgery environment.
- 1.7 Annual checks for surgery nitrous oxide and volatile anaesthetic agent levels are recommended for practices which use these agents daily. The air should be sampled from the breathing zone of the staff member.
- 1.8 Patient-to-patient cross-infection through inhalation sedation may be prevented by using disposable or single-patient nasal hoods or by using autoclavable scavenging hoods.

### 2 TECHNIQUE

- 2.1 Nitrous oxide anaesthetic or sedation techniques should only be used when clinically indicated for clinical, psychological or general medical reasons.
- 2.2 The period of use should be as short as possible.
- 2.3 The gas flow rate should be as low as possible.
- 2.4 Mouth breathing and conversation with the patient should be minimized.
- 2.5 The nitrous oxide should not be turned on until after the hood is applied.
- 2.6 The breathing bag should not be over-inflated. An over-inflated bag cannot monitor breathing. It also causes waste and pollution.
- 2.7 Oxygen should be administered until the patient indicates that all sedation symptoms have gone or, in the case of general anaesthesia, until the anaesthetist is confident the patient is recovering uneventfully.

### 3 ANCILLARY EQUIPMENT

- 3.1 Mouth suction must be vented to the outside of the building via gas-tight lines. Actively scavenging nasal hoods are now available.
- 3.2 Air circulation in the surgery should be designed to minimize anaesthetic gas concentrations.
- 3.3 Room airconditioning should not be of the recirculatory type (that is, air must vent to the outside).
- 3.4 Room ventilation is necessary but it must not be relied upon to reduce occupational exposure.

## **FURTHER READING**

Standards Australia. AS 2496-1995: Breathing attachments for anaesthetic machines for human use.

Standards Australia. AS 2896-1991: Medical gas systems – Installation and testing of non-flammable medical gas pipeline systems.

National Health and Medical Research Council. Dental anaesthetic gases – hazards and hygiene. Report presented at the National Health and Medical Research Council's 98th Session, October 1984. Canberra: AGPS, 1984.

Guidelines on Conscious Sedation for Dental Procedures – Australian and New Zealand College of Anaesthetists and the Royal Australasian College of Anaesthetists Review PS21 (2003).

## C3 – ELECTRODENTAL EQUIPMENT

### 1 PURCHASE AND INSTALLATION

- 1.1 Ensure the safety of electrodental equipment at the time of purchase by obtaining evidence of compliance with safety standards, either Australian Standard 3200 series or International Electrotechnical Commission 60601.1 series.
- 1.2 Ensure safe installation by complying with Australian Standard 3003-2003: Electrical installations – Patient treatment areas of hospitals and medical and dental practices. The Standard is not retrospective.

### 2 INSPECTION AND MAINTENANCE

- 2.1 Carry out regular inspection and checking of equipment for correct functioning and possible damage to plugs and connections.
- 2.2 Service electrodental equipment regularly either by following the manufacturer's recommendations or by arranging a service contract.
- 2.3 There may be occupational health and safety requirements in some States.

### 3 SAFETY IN USE

- 3.1 Read and follow the manufacturer's instructions regarding installation, calibration, maintenance and associated precautions. The instructions should be available on site.
- 3.2 Follow the requirements of Australian Standard 2500-1986: Guide to the safe use of electricity in patient care.
- 3.3 Electrosurgery devices must comply with Australian Standard 3202.2.2-1992: High frequency surgical equipment.

### 4 SPECIAL RISKS

- 4.1 The dental patient may not react normally to electric shock because of anaesthesia or because posture may inhibit mobility.
- 4.2 Additional electrical hazards exist when placing metal instruments in the mouth since the normal skin resistance is bypassed.
- 4.3 Ventricular fibrillation can result if currents from faulty electrodental equipment pass through the heart.
- 4.4 Increased electrical risks exist in the presence of fluid (for example, water cooling to the bur, saliva).
- 4.5 Severe burns can occur from faulty or incorrectly applied electrosurgical equipment, aggravated by the thinness of the oral mucosa.
- 4.6 Be aware of hazards from electromagnetic radiation. Induction casting machines, electrosurgical equipment and ultrasonic scalers can interfere with cardiac pacemakers by generating electromagnetic fields.

### FURTHER READING

Standards Australia. AS/NZS 2500:2004. Guide to the safe use of electricity in patient care.

Standards Australia. AS/NZS 3003:2003. Electrical installations – Patient treatment areas of hospitals and medical, dental practices and dialyzing locations.

Standards Australia. AS/NZS 3200.1.2:1999. High frequency surgical equipment.

Standards Australia. AS/NZS 3200.1:1998. Medical electrical equipment – General requirements for safety.

Standards Australia. AS 3859:1991. Effects of currents passing through the human body.

Wardlaw DA. Electrical safety in the dental surgery. *ADA News Bulletin*, December 2005, p. 17.





## C4 – LASERS

### 1 DEFINITION AND PRINCIPLE OF OPERATION

The word 'laser' is an acronym for the phrase 'light amplification by stimulated emission of radiation'. The effect was predicted by Einstein in 1916 and demonstrated by Maiman in 1960. Lasing occurs when laser-active atoms are raised from a ground state to excited states by absorption of electromagnetic energy. If the excited atoms are in a suitably designed cavity, they can be stimulated to emit electromagnetic photon energy and return to the ground state. The emitted energy has a specific wavelength (is monochromatic), is coherent (the wave fronts are in step) and is collimated (the beams are parallel). These qualities allow laser energy to be focused on a very small area to produce an extremely high energy density over this area.

Laser light does not occur in nature and it may interact with living tissues, even at low energy levels, in ways which have not been observed previously.

### 2 LASER TYPES AND DELIVERY SYSTEMS

2.1 Lasers are now available which are based on solids (including semi-conductors), liquids or gasses, and can emit laser light ranging from the ultra-violet to the far infra-red, at energies of a few milliwatts to several hundred watts, continuous or pulsed. Thus a complete laser description should specify its emission wavelength, the energy of the emitted beam, whether the beam is continuous or pulsed and, if the latter, the shape, duration and repetition rate of the pulses.

2.2 To use a laser effectively it must be possible to deliver its energy conveniently and efficiently to the target material. For most medical and dental applications, convenient delivery of the beam is important.

For wavelengths from visible up to the near-to-middle infra-red, a flexible optical fibre can deliver the energy. For far infra-red wavelengths, a less convenient hollow wave guide or articulated arm has been necessary. However, developments in fibre technology and fibre tip attachments now permit delivery of those far infra-red wavelengths which can remove enamel, dentine, bone, dental caries and calculus.

### 3 INTERACTION WITH ORAL TISSUES

Laser energy interacts with oral tissues and dental materials photo-chemically, photo-thermally, photo-mechanically, photo-electrically, or a combination of these. The type of interaction depends primarily on the target tissue (tissue optical properties, tissue-laser absorption characteristics), the laser wavelength and, to a lesser extent, the energy density delivered and the mechanism of its delivery. With current dental lasers, the interaction with oral structures is primarily photo-thermal.

If the energy is absorbed at the surface of hard or soft tissues, the surface is vaporized or ablated. If the energy is absorbed less effectively, the beam penetrates to cause coagulation in soft tissues and thermal damage (melting or crazing) in hard tissues. At high energies, all soft tissues are carbonized and hard tissues melted or crazed.

Some wavelengths are highly absorbed in water. For example, the Erbium YAG laser causes rapid vaporization of water and the resulting micro-explosions disintegrate enamel and dentine (photo-thermo-mechanical effects), thus cutting or ablating them. With the carbon dioxide laser, the energy absorbed by water molecules generates heat, which can then cut, vaporize and ablate soft tissue.

## 4 LASERS FOR DENTAL USE

Lasers which emit wavelengths from ultra-violet to far infra-red, at low to very high energy levels, are available for commercial and industrial use. Several types are currently available for dental use. Some manufacturers now offer dual wavelength lasers which extends their clinical usefulness for a modest increase in cost.

### 4.1 Argon lasers (wavelength 488 and 514 nm)

4.1.1 These lasers provide separate or combined blue and green wavelengths at adjustable energy levels, delivered by an optical fibre. The blue wavelength cures light-curing composite and other resins in a few seconds. The green wavelength is absorbed strongly by haemoglobin and the beam cuts or coagulates vascular soft tissue very effectively. Some laser wavelengths approximate the absorption spectrum maxima of some tooth stains (for example, Tetracycline). These lasers can be very effective for rapid tooth bleaching.

### 4.2 Diode lasers (range 600–1000 nm)

4.2.1 '*Lower level Diodes*' (630–670 nm) lasers. These deliver red (visible) wavelengths at energy levels up to 200+ mW. These lasers are said to promote healing and reduce pain and swelling (Biostimulation or Bio-modulation). Apparent beneficial results with lower energy (5–10 mW) lasers are probably placebo effects. They can be used to assist diagnosis of primary fissural and proximal dental caries through the interaction of laser induced fluorescence. They can also be used to photo-activate chemical dyes for dentinal surface disinfection.

4.2.2 '*Surgical Diode*' (800–980 nm) lasers. These diode lasers are a recent technical development and can provide gated, pulsed, fibre-optic delivery and high power (1–15 watts). They interact with oral tissues similarly to NdYAG lasers but are more compact, convenient and cost much less. In conjunction with photo-absorbing bleaching gel, they offer the dentist the possibility of photobleaching. When these lasers deliver energy level at below 0.5 watts, they can be used for biostimulation.

### 4.3 Neodymium/Yttrium-Aluminum-Garnet (NdYAG) lasers (1064 nm)

NdYAG lasers produce invisible, near infra-red light, delivered by an optical fibre. This wavelength is best absorbed by pigmented oral soft tissue and thus is effective for haemostasis and in managing vascular lesions. It is also useful for desensitisation, pulpal anaesthesia and root canal disinfection.

### 4.4 Holmium/Yttrium-Aluminium-Garnet (HoYAG) lasers (2140 nm)

HoYAG lasers generate infra-red light at a frequency which is strongly absorbed by water and is delivered by an optical fibre. The strong absorption makes this laser very effective for oral surgery (especially TMJ operations), haemostasis and wound debridement. Cost is similar to NdYAG lasers.

### 4.5 Erbium/Yttrium-Aluminium-Garnet (ErYAG) lasers (2940 nm)

ErYAG lasers produce infra-red light which is extremely strongly absorbed by water. The beam is delivered by a hollow wave guide or, alternatively, by an optical fibre. This laser is very effective for cutting soft tissue, bone and tooth structure but provides very little haemostasis. Its outstanding dental application is the cutting of carious or sound enamel and dentine to leave an etched and smear-free surface suitable for direct bonding. A film of water sprayed on the tooth absorbs the laser energy and the microexplosion of the water molecules induce the fragmentation of the dental hard tissue. Cavity preparation is painless in most cases, and pulp temperature rise is minimal. With a built-in 'auto-feedback' safety device, this laser can be used for dental calculus removal. Used carefully for short periods this laser can selectively remove dental caries. Some manufacturers offer versions of ErYAG which incorporate another laser (for example, NdYAG or Carbon Dioxide).

### 4.6 Erbium Chromium/Yttrium, Scandium, Gallium, Garnet (ErCrYSGG) lasers (2780 nm)

ErCrYSGG laser light is strongly absorbed by water but relatively less than Er:YAG light. The mechanism of absorption of the laser energy and its dental applications are

similar to those of the ErYAG laser. Its advantage over the Er:YAG laser is that it has a somewhat better haemostatic ability.

#### **4.7 Carbon Dioxide lasers (10,600 nm)**

This laser delivers far infra-red wavelength light via a hollow, thin, flexible wave guide or articulating jointed arm delivery system. This wavelength is strongly absorbed by water and thus cuts, vaporizes and debulks soft tissue extremely effectively. It also provides excellent haemostasis and has been the gold standard medical surgical laser for many years. An attachment is now available which sweeps the laser beam over the target area to provide controllable ablation of such lesions as leucoplakia and lichen planus.

#### **4.8 Potassium Titanyl Phosphate lasers (KTP)**

This laser has an emission wavelength of 532 nm, which is exactly half the 1.064 micron (frequency doubled) wavelength of the Nd:YAG laser, in the visible (green) region of the electromagnetic spectrum. Therefore, no aiming visible beam is required for guiding. This laser energy is highly absorbed by haemoglobin, melanin and chelate compounds. The soft tissue penetration is similar to the argon laser (1–2 mm). It transmits through water and has fiberoptic capability. It is a useful tool for cutting, vaporizing and coagulating tissues, gives a dry operating field, and thus combines the benefits of Nd:YAG and CO<sub>2</sub> lasers. The high power solid state light output makes these lasers very effective for rapid tooth bleaching.

### **5 LASER ADVANTAGES AND DISADVANTAGES**

5.1 Advantages: In surgical applications, the lack of tissue contact and high temperature during laser/tissue interaction reduce wound infection and post-operative pain and the intrinsic coagulation reduces or eliminates bleeding and reduces pain, tissue shrinkage and scarring during healing. The rapid curing of VLC resins improves productivity and maximizes material strength. The effective and painless removal of caries and preparation of cavities, with no local anaesthesia or vibration, improves productivity and patient acceptance of treatment.

5.2 Disadvantages: The equipment, its consumable parts and its servicing and maintenance are expensive. Currently available handpieces present no difficulties with sterilization between patients. Operator and staff training and changes in surgery arrangement and operation may be required to obtain maximum benefit from this new technology.

### **6 FUTURE DEVELOPMENTS**

As more manufacturers enter the field, the cost of lasers will decrease. Lasers with dual wavelength outputs for little extra cost are already available, and three or even more wavelengths should be available soon. Lasers which can be turned over a wide range of output wavelengths would be ideal for dentistry and should be available in a few years' time. High power solid state lasers offer a great cost saving and are already available.

Improved laser systems, laser handpieces and fibre tip attachments and increasingly sophisticated technological developments can be expected in the future. These can be expected to increase the acceptance of lasers in clinical dentistry. Applications such as screening for oral cancers, endodontic post and root filling removal, caries prevention and management, implant osseous surgery, metal welding and other applications not yet in general use can be expected in the future.

### **7 RECOMMENDATIONS**

Dentists whose major activity is cosmetic and adhesive dentistry should investigate the time-saving and thus productivity increase accompanying laser purchase. Dentists whose practices have significant numbers of patients with caries should consider trialling a laser to decide whether it would improve their delivery of dental care and attract dental-phobic patients.

Any dentist thinking about acquiring a laser should first consult with colleagues who use one, and also undertake postgraduate courses on laser science and laser safety before signing a purchase or lease agreement. Laser safety is paramount. There should be no compromises in implementing safety protocols in clinical dentistry. Just a few injuries arising from careless laser use may hold back the acceptance of this important advance in dental health care delivery.

The Australian/New Zealand Standard (AS/NZS 4173:2004) classifies laser products according to the beam arrangements, power output and the hazard potential. Laser systems with a power output greater than 0.5W are classified as Class 4 Operators of these lasers, plus assistants and patients must be protected from unintended or accidental eye or skin exposure to direct or scattered radiation during laser use. All Class 4 laser operators and team members working within the designated operating zone must hold proof of training which complies with the requirements of the local legislation. The A/NZ standard also stipulates the safety requirements for the operating room.

## C5 – USE AND MAINTENANCE OF VISIBLE CURING LIGHTS

### 1 GENERAL

- 1.1 Visible light with a wavelength of approximately 470 nm is used to cure a range of restorative, lining and temporary materials.
- 1.2 Efficient curing depends on the correct wavelength, sufficient intensity of the light and adequate curing time.

### 2 USE

- 2.1 A curing time of 40–60 seconds is appropriate for each 2 mm thick increment of universal shade resin composite. Some of the more recent lamps may allow shorter curing times, however the possibility of excessive heat production should be considered.
- 2.2 Darker shades, microfilled composites and curing through enamel require longer curing times and/or smaller increments of material.
- 2.3 A minimum of 400 mW/cm<sup>2</sup> of radiant light intensity is required for all units including the final stage of those with a ramped cure. The light output diminishes with age and use as a result of deterioration of the components.
- 2.4 An intensity reading should be taken with a suitable radiometer when the unit is new or has been recently repaired. A warm-up period of five minutes is recommended before a radiometer reading is taken.
- 2.5 The light intensity should be checked daily thereafter to determine any change in intensity.
- 2.6 If the light intensity is:
  - 400 mW/cm<sup>2</sup> or greater, cure for 40–60 seconds per increment
  - 230–400 mW/cm<sup>2</sup>, increase the curing time
  - less than 230 mW/cm<sup>2</sup>, do not use the curing light
- 2.7 If the curing light has a fan, it must be allowed to complete its cooling cycle without interruption following use.
- 2.8 Do not use a double adapter or powerboard when connecting the light unit to a power source.
- 2.9 When operating the curing light, always protect the eyes of the assistant and dentist with the appropriate shield.

### 3 MAINTENANCE

- 3.1 If the intensity of the light output decreases, check the components for signs of deterioration.
- 3.2 For halogen curing lights:
  - Efficiency of the bulb diminishes with time, sometimes caused by a black or white deposit on the bulb. The average lifespan is approximately 30 hours.
  - The reflector surfaces can become pitted, whitened or blackened, which will reduce light emission from the curing tip.
  - The filter can become cracked, blistered or pitted. This allows the emission of unnecessary wavelengths which do not contribute to curing, but cause heat and glare.
  - Keep the fan and grid clear of debris and dust to allow efficient operation.
- 3.3 For LED curing lights:
  - Never place the handpiece in the charger without its battery. Damage to the light will result.
- 3.4 Curing light handpieces are not sterilizable and caution should be taken if wiping them to prevent disinfectant penetrating the mechanism.

- 3.5 The light guide tip may become contaminated with deposits of cured resin composite which require removal by polishing.
- 3.6 The light guide can become damaged or contaminated by autoclaving which can be rectified by polishing. Follow the manufacturer's instructions.
- 3.7 Check for broken fibres within fibre optic cables, or fractures of the light guide, by holding the end of the light guide to a light source.

## D GUIDES – PRACTICAL GUIDES TO CLINICAL MATERIALS

- D1 Enamel etching
- D2 Bonding to dentine
- D3 Cavity lining and base materials
- D4 Resin-based filling materials
- D5 Glass-ionomer (polyalkenoate) filling materials
- D6 Amalgam
- D7 World Health Organization consensus statement on dental amalgam 1997
- D8 Recommendations on dental mercury hygiene
- D9 Luting cements
- D10 Impression materials
- D11 Orthodontic wires
- D12 Orthodontic elastics
- D13 Mouthguards
- D14 Implants
- D15 Regulation of dental products
- D16 Radiographic examination of dental patients
- D17 Processing of radiographs and causes of X-ray image imperfections
- D18 Provisional (temporary) restorations





## D1 – ENAMEL ETCHING

- 1 Use phosphoric acid between 20–50 per cent (m/m).
- 2 Accurate placement of etch can be achieved by using a gel delivered from a syringe with a fine bore needle.
- 3 Use a matrix strip to protect adjacent teeth from being etched.
- 4 Avoid exposing dentine to acid unless it is part of a dentine bonding system. Protect dentine with calcium hydroxide or glass-ionomer lining. Some calcium hydroxide linings are not acid resistant so use one which can withstand acid exposure (see Guide D3), or cover with glass-ionomer first.
- 5 Do not apply the acid for longer than 30 seconds. If the characteristic matt-white surface is not evident after washing and drying, apply fresh acid for a further 30 seconds and repeat until successful. The appearance of a well defined matt-white surface is a good visual guide as to whether the enamel has been etched satisfactorily.
- 6 Fluoridated enamel is more difficult to etch than unfluoridated enamel.
- 7 Gel etchants are as effective as liquid etchants.
- 8 Wash thoroughly with excess water to remove acid and precipitates.
- 9 Ensure the air supply is dry and free from oil. (Check by blowing gently on a mirror or paper tissue.) A small hairdryer or a chip-syringe (squeeze bulb blower) is useful. Triplex syringes should be checked regularly for oil or water contamination of the air supply.
- 10 If the etched surface is contaminated with anything other than water (for example saliva), it must be re-etched for 10 seconds. Rubber dam is desirable to prevent contamination.
- 11 Surfaces from which an acid-etch restoration has become detached can be re-etched and the newly applied resin will bond to the existing resin tags in the enamel surface. If re-etching is not effective, cut the enamel surface back and re-etch.
- 12 Unfilled monomer adhesives can improve the reliability of obtaining a bond if the composite cannot be applied with pressure. Do not remove the unpolymerized surface layer from the adhesive, as this is necessary for bonding to the composite. Adhesive also helps to avoid air entrapment on pitted/hypoplastic enamel.
- 13 Acid etch bonds are as strong as tooth structure and composite restorative material. Pins are not necessary if the cavity is surrounded by 1 mm of enamel, and can be aesthetically and functionally undesirable.
- 14 Failure due to deficiencies in technique occurs soon after placement.
- 15 Avoid a thin section of restorative material (flash) on unetched enamel, as this will tend to flex and peel away, leading to leakage and staining.
- 16 An enamel bevel is recommended if additional retention is required, or if it is necessary to blend the shade from composite to enamel. However, bevels in stress-bearing areas should be avoided, for example occlusal surfaces.



## D2 – BONDING TO DENTINE

- 1 Dentine adhesive systems, glass-ionomer cements and resin-modified glass-ionomer cements may be used to enhance bonding of resin composite to dentine.
- 2 Laboratory data on bond strength and microleakage tests are not reliable indicators of clinical performance.
- 3 Do not rely on dentine bonding alone for retention; create additional mechanical retention (undercuts, etching of enamel) where possible.
- 4 Follow the manufacturer's instructions on usage, and do not mix different manufacturers' systems. Primers, conditioners and adhesives from different manufacturers are not interchangeable.
- 5 Never condition/etch the dentine surface longer than the time specified by the manufacturer.
- 6 Acid treatment of dentine will not necessarily result in pulp damage, provided a marginal seal can be obtained.
- 7 Avoid desiccation of acid-treated dentine after washing.
- 8 Place and cure composite incrementally to minimize the stress of polymerization contraction on the dentine bond.
- 9 Use the manufacturer's recommended resin composite.
- 10 Dentine bonding agents tend to be less successful on older patients and where the dentine is sclerosed.
- 11 Dentine bonding is less successful when bonding to deep dentine approximating the pulp as the surface tends to remain wetter.
- 12 Laboratory data indicate that conventional, 'single-bottle' and self-etching/priming bonding systems are equally effective with regard to bond strength. Comparative clinical efficacy has yet to be demonstrated.
- 13 Glass-ionomer cement may be preferable in obtaining a bond between resin composite and dentine (see Guide D3).



## D3 – CAVITY LINING AND BASE MATERIALS

### 1 GENERAL

- 1.1 Lining and base materials are placed beneath restorative materials to protect the pulp against:
- bacterial microleakage, which is likely to occur with most filling materials;
  - thermal insult, particularly transfer through metallic restorations; and
  - chemical toxicity, which may be a possibility with some resin-based materials.
- 1.2 Many materials may cause irritation if placed on exposed pulp tissue compared with placement on dentine. If a pulp exposure is known or suspected then a two-stage lining or base should be prepared with calcium hydroxide or Ledermix\* cement (see 5.2) in the region of the pulpal tissue and a glass-ionomer cement, chosen for its sealing properties, over the capping agent.

### 2 CALCIUM HYDROXIDE

- 2.1 This is primarily used for promoting bridging of pulp exposures with reparative dentine. It is used when a small, uncontaminated pulp exposure is known or suspected, and if the pulp is otherwise thought to be healthy.
- 2.2 Due to its high pH of 12, calcium hydroxide cement is bactericidal and is useful in the treatment of deep carious lesions.
- 2.3 Setting or non-setting calcium hydroxide pastes may be used. The setting cement has higher strength but less calcium ions are available.
- 2.4 Self-cure and light-cure setting types are available but should be assumed to be soluble with time and therefore should be used sparingly and in thin layers. All calcium hydroxides are best overlaid with a second material (for example, glass-ionomer) for protection against dissolution.

### 3 MODIFIED ZINC OXIDE-EUGENOL CEMENT (ZOE)

- 3.1 This is primarily used for therapeutic purposes in the treatment of active caries or in the treatment of reversible pulpitis.
- 3.2 Because most ZOE formulations hydrolyse and become soft with time, they are not recommended for bases to provide support to a permanent restoration.
- 3.3 Eugenol-containing cements should not be used under resin-based restorative materials because they may prevent complete setting or cause softening or discolouration of the resin.
- 3.4 Glass-ionomer cements (not resin-modified) are tolerant of eugenol-containing cements and may be used as an intermediary between ZOE and resin restoratives.

### 4 GLASS-IONOMER (POLYALKENOATE) CEMENT

- 4.1 Glass-ionomer cement has a number of desirable properties including:
- good protection against microleakage;
  - fluoride release;
  - low solubility;
  - good biocompatibility; and
  - moderate strength for restoration support.
- 4.2 Glass-ionomer is the material of choice for use beneath resin composite restorations (direct or indirect) and can be used beneath other materials. It is an ideal 'dentine replacement' material while resin composite is the 'enamel replacement' material. This forms the basis of the 'Sandwich Restoration'.

\*Cyanamid GmbH, Lederle Pharmaceuticals Division, Wolfstatshausen, Germany

- 4.3 Dentine should be conditioned according to the manufacturer's instructions prior to placement.
- 4.4 Glass-ionomer may be etched prior to composite placement to provide increased adhesion for the adhesive resin bonding.

## **5 OTHER CEMENTS**

- 5.1 Zinc phosphate cement mixed as thickly as possible is suitable for use under metallic restorations and as a second barrier against microleakage. Its use has largely been replaced by the glass-ionomer cements.
- 5.2 Cements containing corticosteroids, for example Ledermix, are effective in alleviating the symptoms of reversible pulpitis in the first days after placement. They have poor strength under restorations. Ledermix cement contains eugenol and should not be used directly under resin-containing materials.

## **6 VARNISHES**

- 6.1 Varnishes may provide temporary partial protection against chemical and bacterial irritants but dissolve in time.
- 6.2 Use varnishes with spherical amalgams only and apply as several thin coats.
- 6.3 Do not use varnishes under glass-ionomer or composite restorations.

## D4 – RESIN-BASED FILLING MATERIALS

### 1 INTRODUCTION

1.1 Resin-based filling materials generally consist of a resin matrix, filler particles, interfacial coupling agents and polymerization initiators. They are usually classified by filler particle size.

#### 1.2 Resin matrix

The resin matrix acts to bind the filler particles together. It is usually a dimethacrylate monomer, for example, Bis-GMA. Other common matrix resins are urethane dimethacrylate (UDMA) and tricyclodimethacrylate (TCDMA).

#### 1.3 Filler particles

1.3.1 The filler particles are essential in order to provide dimensional stability to the soft resin matrix, to reduce the polymerization shrinkage, decrease the coefficient of thermal expansion and increase the hardness.

1.3.2 The filler particles vary from 0.01–10 µm in diameter.

1.3.3 Common filler particles are crystalline quartz, pyrolytic silica, lithium aluminium silicate, borosilicate glass, boron glass and barium glass. All have high hardness, chemical inertness, and a refractive index and opacity close to that of tooth structure.

#### 1.4 Coupling agents

Coupling agents are used to help bond the resin matrix and the filler particles together. The most commonly used coupling agents are epoxy and vinyl silanes.

#### 1.5 Polyacid-modified resin composites (compomers)

1.5.1 Compomers contain an acid resin and glass-ionomer powder filler. The dominant setting reaction is by light polymerization of the resin component. No acid-base reaction occurs until approximately two weeks later when the material absorbs water, resulting in ionization of the acid resin.

1.5.2 Compomers release fluoride, but at a lower level than glass-ionomer cements.

1.5.3 Since compomers are basically resin composites, they usually require a dentine bonding agent for bonding to dentine.

### 2 SELECTION

2.1 Microfill composites, consisting of pyrolytic silica filler of mean diameter 0.04 µm, are used mainly in anterior approximal and cervical restorations, because they can be polished to a high gloss.

2.2 Small particle composites, with a mean filler particle size of 0.5–5 µm, are indicated for incisal edge and posterior approximal restorations. They cannot be polished as highly as the microfill composites, but they have higher strength for occlusal and incisal contact areas.

2.3 Hybrid composites, with a mixture of pyrolytic silica and small particle fillers, are also indicated for occlusal, incisal edge and posterior approximal restorations. They provide a compromise of polishability and strength for most restorative applications.

2.4 ‘Flowable’ composites, with a lower filler content than those above, can be used as a fissure sealant and as a repair material for small discrepancies at the margin of restorations.

2.5 ‘Packable’ composites have a higher viscosity with slightly improved physical properties. They should however not be ‘packed’ like an amalgam as stress and tearing of the composite may occur.

2.6 ‘Nano-filled composites’ contain very small ( $10^{-9}$  m) particles for increased translucency and polishability and are an alternative method of incorporating fillers.

### 3 CAVITY PREPARATION

- 3.1 As much tooth structure as possible should be preserved and sharp internal line angles should be avoided because resin composite does not easily flow in to these areas.
- 3.2 Posteriorly, centric stops should be kept on sound tooth structure wherever possible.
- 3.3 A round ovoid box design is advocated for posterior approximal preparations. Extension of the approximal box as for amalgam is not necessary.
- 3.4 A 0.5 mm bevel can be placed on non-load bearing margins and on the gingival margins when enamel is available. A butt finish is preferable on the cavo-surface margin, in order to give bulk to the material and reduce the chance of micro-fractures in this area.
- 3.5 A marginal seal is difficult to obtain when the margin is on dentine or cementum. A better seal may be obtained by using a glass-ionomer restorative material as a base and extending it out to the margin.

### 4 REQUIREMENTS FOR MATERIAL PLACEMENT

- 4.1 Where possible use a rubber dam to avoid saliva/moisture contamination of the cavity preparation and material.
- 4.2 A eugenol-free lining such as glass-ionomer should be used. Anecdotally, this also reduces the amount of post-operative sensitivity that can occur with posterior resin composites.
- 4.3 A self-cure glass-ionomer lining can be etched if necessary to enhance the interfacial bond. However, unetched glass-ionomer lining is preferred as it avoids the possibility of acid damage to the lining.
- 4.4 A resin-modified glass-ionomer lining does not require etching.
- 4.5 The enamel should be etched for a minimum of 20–30 seconds. Precise placement is essential, and the use of a fine needle and syringe is recommended.
- 4.6 A thorough 60-second rinse should be given in order to remove the retentive etching gel and precipitated calcium phosphate.
- 4.7 Thorough drying of the etched enamel with water and oil-free air is essential. The air-line can be assessed for water and oil contamination by blowing onto a mirror, a tissue or the back of the glove.
- 4.8 Anteriorly, use a mylar matrix with wedging, prior to the placement of the unfilled resin or bonding agent. This prevents blocking of the approximal space with cured unfilled resin.
- 4.9 An unfilled resin should be applied immediately to the dried etched enamel and to the lining to aid retention, adaptation and to minimize leakage and marginal staining. If rubber dam has not been applied, it is essential to maintain good isolation of the etched surface and frequently blow with air until the unfilled resin is applied in order to minimize contamination from the moist atmosphere in the mouth. This should not be done for dentine adhesive bonding.
- 4.10 Resin bonding to dentine is achieved by etching the surface to demineralize it then infiltrating this collagen-rich surface with a low viscosity resin. The resultant layer is termed the 'Hybrid Layer'. (Refer to the section on bonding)
- 4.11 Ensure that pooling of the unfilled resin does not occur by blowing lightly prior to curing.
- 4.12 The unfilled resin should be light cured following the manufacturer's instructions, and for at least 10 seconds.

### 5 MATRIX PLACEMENT

- 5.1 Posteriorly, a transparent matrix may be used as this allows more thorough light curing of the cervical areas in approximal boxes. However, burnishing to optimize the contact area and obtaining good anatomical contour is not possible.
- 5.2 A metal matrix may be easier to pass through a tight contact. When this is used it is important to give additional light curing in the cervical area following removal of the matrix.



- 5.3 Firm, early wedging should be done, especially posteriorly, to offset the polymerization shrinkage of the resin composite at the contact area, and to avoid cervical excess.
- 5.4 Interproximal contact areas may be improved by 'pre-wedging', use of 'dead-soft' matrix bands and use of separation (sectional) rings such as the Sectional Matrix (3M-ESPE) or the Bitine Ring (Palodent).

## **6 PLACEMENT OF RESIN COMPOSITE**

- 6.1 The chair light must be directed away from the patient's mouth in order to ensure there is no premature polymerization of the material.
- 6.2 When possible, a syringe delivery system should be used in order to accurately place the material.
- 6.3 The first layer should not exceed 2.0 mm in depth. Incremental build-up and polymerization of the resin composite will reduce the stresses of polymerization shrinkage and consequent gap formation at the margin.
- 6.4 The resin composite should be packed with a smooth instrument. Minimal pressure is needed, and the application instrument may be lightly coated with an unfilled resin to avoid 'pull back'. Ideally, an instrument coated with titanium nitride and designed for use with resin composite should be used.
- 6.5 While different shades of composite may be mixed to produce accurate colour match, care must be taken to ensure an even mix with no bubbles. Alternatively, layering of shades and use of enamel and dentine shades will minimize porosity in the composite.

## **7 LIGHT POLYMERIZATION**

- 7.1 When curing the resin composite, the light source should be as close to the material as possible.
- 7.2 Polymerization shrinkage is probably the greatest problem associated with resin composite, especially when used in large cavities.
- 7.3 The amount of shrinkage is proportional to the degree of polymerization. Resin composites have a volumetric shrinkage of approximately 2.0–4.8 per cent.
- 7.4 When the light is directed onto the material, there is a rapid setting reaction. Stress relief flow is very restricted. High light curing intensity means that polymerization is rapid, resulting in high stress within the set material. It may be beneficial to have a low light intensity at the start of the curing process, possibly enhancing marginal adaptation of the material in less than ideal bonding situations. This is referred to as Ramp curing.
- 7.5 Several techniques which might enhance the adaptation at the cervical margin are:
  - increasing the cervical bonding area by using good dentine bonding agents, or a glass-ionomer;
  - using small increments of low viscosity/flowable resin composites at the cervical floor; and
  - using directional light curing.
- 7.6 Always use adequate filtering of the intense light for eye protection during light curing (orange filter for visible blue (470 nm) light).
- 7.7 Always cover excess dispensed resin composite with an orange cover so that ambient light will not polymerize the surface layer.

## **8 FINISHING AND POLISHING**

- 8.1 Finishing can be accomplished with fine diamond burs, 12- or 30-bladed tungsten carbide burs, or discs. A No. 12 Bard Parker scalpel is useful for approximal trimming.
- 8.2 Polishing can be done with silicone cups and points or with fine aluminium oxide impregnated discs.
- 8.3 A final polish of posterior restorations can be delayed for 24 hours, which seems to enhance surface durability of the resin composite.

## **9 STORAGE**

- 9.1 Follow the manufacturer's instructions. If stored in the refrigerator, allow time for the material to reach room temperature before opening, to avoid condensation that may affect the material and allows the material to 'flow' more easily.
- 9.2 Always check the date of manufacture or expiry date before using.

## D5 – GLASS-IONOMER (POLYALKEONATE) FILLING MATERIALS

### 1 GLASS IONOMERS, GENERAL

- 1.1 Keep the field free from moisture and contamination. Rubber dam is recommended for complex cases.
- 1.2 Glass-ionomer cements are not irritating to the pulp, therefore a lining is required only if there is less than 0.25 mm of remaining dentine. If necessary use a quick-setting calcium hydroxide lining and cover only the area closest to the pulp.
- 1.3 To ensure retention by adhesion, dentine and enamel must be free of organic matter such as plaque and saliva. This can be achieved by 'conditioning' with polyacrylic acid; follow the manufacturer's instructions. Do not use phosphoric acid etchant.
- 1.4 Wash the cavity thoroughly and dry, but do not dehydrate. Adhesion is best to freshly cut surfaces; prevent contamination with blood or saliva. In the case of non-carious lesions, clean lightly with a slurry of pumice and water. **Do not use** a proprietary prophylaxis paste.
- 1.5 Using a matrix will allow application of a degree of pressure during placement, as well as develop the initial contour and lead to a smooth surface, thus minimizing the need to polish.

### 2 CONVENTIONAL GLASS-IONOMERS, MANUAL MIX

- 2.1 Keep the bottles closed as much as possible. This is especially important for liquids containing a polycarboxylic acid, to avoid loss of water, and for powders containing a dehydrated polycarboxylic acid which may absorb water and initiate setting.
- 2.2 Discard any liquid remaining after all the powder has been used.
- 2.3 Aqueous polycarboxylic acid may gel after some months on the shelf. It can be returned to a more fluid state by standing the bottle in water at 60°C for approximately 15 minutes and agitating from time to time. Allow it to return to room temperature before use.
- 2.4 Never chill the liquid if it contains a polycarboxylic acid because the liquid may gel and become unusable. However, it is possible to extend the working time by mixing on a glass slab with a reduced temperature. If the polycarboxylic acid is dehydrated and incorporated in the powder, then the liquid and the slab can both be chilled safely, but the powder should not be chilled because condensation may occur in the bottle.
- 2.5 Powders and liquids from different manufacturers are not interchangeable.
- 2.6 Use the powder:liquid ratio recommended by the manufacturer and proportion the components carefully using the system provided. (Weighing is the most accurate means of proportioning.)
- 2.7 When dispensing the liquid ensure the orifice is free of deposits then hold the bottle vertically. If the liquid is viscous invert the bottle in two stages: turn to horizontal first and allow the liquid to flow into the region of the nozzle without entrapping an air bubble; and finally turn to the vertical and dispense the drop.
- 2.8 Mix with a plastic, agate, or chrome-cobalt ('stellite') spatula on a clean, dry, smooth surface.
- 2.9 Use a small area of the slab for mixing, to minimize loss of water and wastage.
- 2.10 Initially add two-thirds of the powder to the liquid and spatulate for 10 seconds, then add the remainder of the powder.

- 2.11 Fold the powder into the liquid and do not over-spatulate. The object is to wet the surface of each particle but not to break up the particles any more than is necessary.
- 2.12 Use the entire length of the spatula blade in a linear 'stropping' motion, alternately spreading and gathering the mix. Complete the mix within a total time of 30 seconds.
- 2.13 The finished mix should be a smooth, uniform paste with a glossy surface and free of dry powder. The texture will vary from one product to another but generally the fresh mix should not slump on the slab.

### **3 CONVENTIONAL GLASS-IONOMER, CAPSULE MIX**

- 3.1 Capsulation is the safest and most reliable form of dispensing.
- 3.2 Mechanical mixing in a capsule is strongly recommended for standard, reliable, long term results.
- 3.3 Do NOT store capsules in a refrigerator. Store at room temperature.
- 3.4 Take care to follow the manufacturer's directions when activating and mixing the capsule. Each system has its own instructions.
- 3.5 The setting time can be reduced by adding 2-3 seconds to the recommended mixing time, and extended by mixing 2-3 seconds less than the recommended mixing time.

### **4 CONVENTIONAL GLASS-IONOMER, FINISHING/POLISHING**

- 4.1 The type II.1 aesthetic restorative auto-cure cement is vulnerable to damage both by loss of water or by exposure to water for up to 60 minutes after mixing (depending on the product). If this occurs, there will be a serious loss of aesthetics and the cement may take on a crazed, white, opaque appearance.
- 4.2 Protect the cement immediately after initial set, that is after removal of the matrix, by applying a waterproof sealant. The most effective sealant is a very low viscosity, single component, light-activated resin enamel bond (supplied by some manufacturers). Petroleum jelly ('Vaseline') will wash off rapidly and varnishes such as copal varnish are not waterproof and must not be used.
- 4.3 After the initial set and placement of the protective coating, excess and over-contoured cement can be removed by the careful use of a scalpel or bur, cutting from restoration to tooth. Carry out a minimum of adjustment at this time and reseal. The best aesthetic results will be achieved if contouring is delayed for 24 hours.
- 4.4 The restoration can be completely contoured and polished after 24 hours using fine diamonds under air/water spray.

### **5 CONVENTIONAL GLASS-IONOMER, HIGH POWDER:LIQUID RATIO (ALSO KNOWN AS 'PACKABLE', 'VISCOUS', AND 'HIGH STRENGTH' PRODUCTS)**

- 5.1 It is strongly recommended that these products always be used in their capsulated form. Effective hand mixing is difficult.
- 5.2 Preparation and mixing of the capsules are the same as Section 3.
- 5.3 These products can be finished and polished wet immediately after the manufacturer's stated setting time
- 5.4 Dehydration must be prevented at all times, so cover with a resin sealant if the restoration is likely to be exposed to air for any length of time after placement.

### **6 RESIN-MODIFIED GLASS-IONOMERS**

- 6.1 Resin-modified glass-ionomer cements may be self-cure only (e.g., luting cements) or dual-cure (e.g., restorative cements).
- 6.2 It is strongly recommended that these products are always used in their capsulated form. Proper hand mixing is difficult.
- 6.3 Preparation and mixing of the capsules are the same as Para 3.

- 6.4 The instructions for the dual-cure cements are the same as for the self-cure cements, except in regard to setting. Use all the criteria as set out in Section 1 above for successful placement. True dual-cure cements will set initially through light activation followed by chemical setting of any cement that is not cured by the light activation.
- 6.5 The depth of light-curing through a relatively translucent cement is approximately 3 mm, but this will be influenced by both the proximity and the intensity of the activator light.
- 6.6 Exposure to the curing light for 20 seconds should be regarded as the minimum, and a further 20 seconds is recommended, as it is not possible to overexpose.
- 6.7 After light activation, the cement will immediately be sufficiently stable to contour and polish with fine diamonds at intermediate high speed **under air/water spray**, although chemical setting will continue.
- 6.8 It is not necessary to cover the cement with a sealant to maintain the water balance, but the application of a low viscosity resin seal may provide a smoother surface finish.

## D6 – AMALGAM

### 1 SELECTION OF AMALGAM

- 1.1 Choose alloys to suit the planned technique. Spherical amalgams generally offer less resistance to packing pressure.
- 1.2 If a fast setting amalgam is required, choose one that provides this as supplied rather than substantially varying the mixing time or mercury:alloy ratio at the chairside.
- 1.3 Most high-copper (or gamma-2 free) amalgams give superior clinical performance compared with low-copper (gamma-2 containing) amalgams and are less dependent on operator technique.
- 1.4 Ensure compatibility of alloys with powder dispensers. The particle size varies considerably.

### 2 MERCURY:ALLOY RATIO (Refer to Guides D7 and D8 before handling mercury)

- 2.1 Choose a mercury:alloy ratio that does not require removal (squeezing out) of excess mercury between mixing and condensation.
- 2.2 Use a minimal initial mercury content consistent with satisfactory plasticity.
- 2.3 Spherical alloys require less initial mercury than alloys containing lathe-cut particles.
- 2.4 Single-use (disposable) pre-dosed capsules provide a better seal against mercury loss during mixing than reusable capsules.
- 2.5 Check the accuracy of volume dispensers from time to time.

### 3 MIXING

- 3.1 Use mechanical amalgamators. Mechanical mixing is faster, more reproducible and offers substantially better mercury hygiene than is provided by hand mixing.
- 3.2 A high-energy amalgamator is best (approximately 4000 Hz). The mix should be completed in 3–20 seconds, depending on mixer and alloy.
- 3.3 Check the amalgamator periodically for slipping drive belts, defective forks and incorrect timer.
- 3.4 A cold amalgamator may result in incorrect mixing.
- 3.5 Avoid under-mixing or excessive over-mixing. Slightly extended mixing time may improve initial plasticity but may hasten setting.
- 3.6 Sufficient plasticity of the mix when placed into the cavity is most important. The mix loses plasticity and becomes dry as it sets. Inadequate plasticity at placement may result in inferior adaptation at margins and walls, reduced strength and increased corrosion and tarnish.
- 3.7 Capsule size affects mixing time and efficiency, as does the use of a pestle.

### 4 HANDLING

- 4.1 Do not touch amalgam with bare hands.
- 4.2 Use an amalgam carrier to convey the mixed amalgam to the cavity.
- 4.3 Do not allow moisture to contact the amalgam before placement into the cavity is complete. Contamination by water will increase tarnish and porosity and may cause delayed expansion.
- 4.4 Correctly proportioned machine-mixed amalgams do not require mulling or expression of mercury before condensation.
- 4.5 Use multiple mixes for large restorations. The plasticity and strength of the amalgam are rapidly reduced by a delay in packing.
- 4.6 Small increments are required for hand and mechanical condensation.
- 4.7 Remove as much mercury as possible from the restoration during packing. The quality of the amalgam increases with a decrease in residual mercury.
- 4.8 Good condensation is essential for successful amalgam restorations. After packing

- each layer, use the largest practicable condenser to bring mercury-rich alloy to the surface and remove it before adding the next increment.
- 4.9 Rigidly confine the amalgam with properly formed and firmly wedged matrices.
  - 4.10 Mechanical condensers can produce more consistent results with less effort, but may be unsuitable with spherical alloys. Avoid ultrasonic condensing. Ensure effective suction while using a mechanical condenser, to improve mercury hygiene.
  - 4.11 An initial (pre-carve) burnish, immediately after condensing, can further reduce the residual mercury content and improve adaptation at the margins.
  - 4.12 Do not carve deep grooves. These may reduce the bulk of amalgam at the margin, enhance the marginal fracture and lead to fracture under loading.

## **5 FINISHING**

- 5.1 Mastication should not occur on high-copper amalgam restorations for at least two hours (low-copper amalgams require significantly longer).
- 5.2 Restorations should be finished not less than 24 hours after placement, to remove marginal excess (flash), improve contour and tarnish resistance, and facilitate cleaning by providing a smooth surface. Polishing to achieve a highly reflective surface is not desirable, for reasons of mercury hygiene.
- 5.3 Use wet polishing to minimize release of mercury vapour and heating of the amalgam surface. Dry polishing can raise the temperature high enough to decompose the amalgam matrix and release significant quantities of mercury vapour and may permanently damage the pulp.

## D7 – WORLD HEALTH ORGANIZATION CONSENSUS STATEMENT ON DENTAL AMALGAM 1997\*†

### **PREAMBLE**

Dental caries (tooth decay) is a common oral disease and its prevention is in accord with the main mission of the World Health Organization (WHO). In spite of great success in the prevention of dental caries, caries in need of restoration still occur. In these cases, diseased tissue should be removed and teeth restored with appropriate material(s). Dental amalgam, a combination of mercury and silver based alloys, is widely used as a dental restorative material. While the current weight of evidence suggests that dental restorative materials, including dental amalgams, are considered to be safe and effective, concerns have been expressed about the health effects of mercury in amalgam. Following an evaluation of a large amount of sometimes conflicting evidence from diverse sources, WHO offers the following consensus statements on dental amalgam.

### **THE USE OF DENTAL AMALGAM**

Dental amalgam is a frequently used material for restoring decaying teeth. It has been used successfully for more than a century and its quality has improved over the years. Amalgam restorations are durable and cost-effective; they are, however, not tooth-coloured. While much research has been devoted to the development of dental restorative materials, there is currently no direct filling material that has the wide indications for use, ease of handling and good physical properties of dental amalgam. The restorative materials currently available as alternatives to dental amalgam significantly increase the cost of dental care.

### **SAFETY OF DENTAL AMALGAM**

Dental amalgam restorations are considered safe, but components of amalgam and other dental restorative materials may, in rare instances, cause local side effects or allergic reactions. The small amount of mercury released from amalgam restorations, especially during placement and removal, has not been shown to cause any other adverse health effects.

Because of concerns over the adverse effects of mercury, some patients, with or without symptoms, may request the removal of their amalgam restorations. While there have been a number of case studies and informal reports, no controlled studies have been published demonstrating systemic adverse effects from amalgam restorations. At present, there is no scientific evidence showing that general symptoms are relieved by the removal of amalgam restorations. Therefore, after a comprehensive oral examination and appropriate dental treatment, these patients should be considered for referral to other health care professionals for diagnosis and treatment if symptoms persist.

### **OCCUPATIONAL RISK TO ORAL HEALTH PERSONNEL**

A potential health risk to oral health personnel from mercury exposure exists if working conditions are not properly organized. The application of proper mercury hygienic requirements together with monitoring of mercury vapours in the work environment in dental clinics will significantly reduce mercury exposure.

### **ENVIRONMENTAL CONCERNS**

Mercury used in dentistry may contaminate the environment via the disposal of waste products from dental clinics. Equipment is available to collect metallic waste generated

\*Also approved by the FDI World Dental Federation General Assembly, Seoul, Korea, September 1997.

†Under revision in 2006.



during dental amalgam placement and removal. Appropriate collection and recycling technology is also available to reduce mercury pollution of the environment, including pollution from crematoria.

#### **PUBLIC OPINION AND MASS MEDIA**

Today, there is considerable exchange of information on dental amalgam around the world. For environmental reasons, some countries are restricting all uses of mercury, including dental amalgam. Due to publicity in the mass media, however, the situation in those countries which have undertaken restrictive action is often misinterpreted, leading to numerous inquiries about the safety of dental amalgam and a demand for removal of amalgam fillings.

The current weight of evidence is that contemporary dental restorative materials, including dental amalgam, are considered to be safe and effective. However, adverse biological reactions to the materials do occasionally occur and they must be treated on an individual basis. WHO recognizes the importance of the continued monitoring of the safety and effectiveness of all dental restorative materials.

## D8 – RECOMMENDATIONS ON DENTAL MERCURY HYGIENE\*†

- 1 All personnel involved in the handling of mercury should be trained with respect to the potential hazards of mercury vapour and the necessity for observing good mercury hygiene practices.
- 2 All personnel should know the potential sources of mercury vapour in the dental surgery, that is: spills; open storage of amalgam scrap; open storage of used capsules; trituration of amalgam; placement, polishing or removing amalgam, heating of amalgam-contaminated instruments; leaky capsules and leaky bulk mercury dispensers. They should also be aware of the proper handling of amalgam waste and environmental issues.
- 3 All dental personnel should work in well-ventilated spaces, with fresh air exchanges and outside exhaust. If the spaces are airconditioned, the airconditioning filters should be periodically replaced.
- 4 The dental surgery atmosphere should be periodically checked for mercury vapour. Monitoring should be considered in case of mercury spill or suspected spill, or when there is a reasonable concern regarding the concentration of mercury vapour in the surgery. Monitors may be of the dosimeter type. Mercury vapour analysers (hand-held monitors often used by industrial hygienists) which give rapid readout may also be used. They are especially useful for rapid assessment after a spill or cleanup.
- 5 Do not carpet dental surgeries. Non-absorbing, easy to clean surfaces such as continuous seamless-sheet flooring carried up the walls are preferred.
- 6 Use pre-capsulated alloy whenever possible. It eliminates the possibility of a bulk mercury spill and also eliminates a mercury dispenser as a source of leaks.
- 7 If bulk mercury is used, minimize the amount of mercury stored. Mercury should be stored in unbreakable, tightly sealed containers, in a well-ventilated place away from any source of heat.
- 8 Mercury and amalgam equipment should be used only in areas that have impervious and suitably lipped surfaces, so that spilled mercury or excess amalgam is confined and recovery facilitated. Care should be taken in handling liquid mercury to minimize the possibility of spills (for example, use a funnel when mercury is being dispensed into an amalgamator; place a lipped tray under the mercury dispenser).
- 9 If pre-capsulated alloys are not used, the removal of excess mercury prior to placement should be minimized by selecting an appropriate alloy:mercury ratio.
- 10 Only capsules that remain sealed during amalgamation should be used.
- 11 An amalgamator with a completely enclosed arm should be used. The amalgamator should comply with ISO7488.
- 12 Single-use capsules from pre-capsulated alloy should be recapped, if possible, after use. Used capsules should be placed in a container with a tight lid, or in plastic bags. If reusable capsules are used, they should be reassembled after use.
- 13 A mercury dispenser, if used, should be handled with care and periodically checked for mercury leakage.
- 14 The mercury dispenser orifice should be examined after use for residual mercury. Any mercury droplet remaining should be disposed of as described in recommendation 19.
- 15 A no-touch technique should be used with mercury and amalgam at all times.
- 16 Ultrasonic condensers should not be used.
- 17 High-volume evacuation should be used during placement or removal of amalgam.
- 18 All amalgam scraps should be salvaged and stored in a tightly closed container. If the scrap is stored dry, then mercury vapour can escape into the room air when the container is opened. If the scrap is stored under photographic fixer solution, then special disposal of the fixer may be necessary.

\*FDI Statement approved by the FDI General Assembly, Barcelona, Spain, October 1998.

†Under revision in 2006.

- 19 Any spilled mercury should be cleaned up immediately by suitable means. Small amounts of mercury may be formed into amalgam by triturating with alloy powder and the resultant scrap added to the scrap container. Droplets may be picked up using an adhesive tape or a hypodermic syringe. Commercial mercury spill cleanup kits may also be used to manage spills. After a spill cleanup, the area should be well ventilated, preferably through open windows. The airconditioning or heating unit should be shut down during this period to minimize distribution of mercury vapour throughout the building. In countries which have regulations regarding major spills, these regulations should be followed.
- 20 Avoid heating of mercury or amalgam or any equipment used with amalgam. Instruments contaminated with amalgam should be cleaned to remove the amalgam contaminant before heat sterilization or heat disinfection.

#### **SUPPLEMENTARY COMMENTS ON MERCURY AND AMALGAM**

- i. Water spray should be used in conjunction with high volume evacuation when removing old amalgam restorations.
- ii. Masks and gloves should be worn by dentists and dental assistants during placement and removal of amalgam restorations.
- iii. Caution should be exercised regarding removal of amalgams by lasers. There are limited data available on the effectiveness of various types of laser and on the release of mercury vapour.
- iv. Needless removal of amalgam restorations should be avoided. Guidelines on indications for amalgam removal have been published.\*
- v. Readily accessible amalgam traps should be incorporated into dental units in order to collect mercury and amalgam.  
*Note:* In addition, some local authorities may require the installation of amalgam separators which may be required to comply with current international standards.
- vi. When removing amalgam waste collected by traps, protective clothing, including gloves and masks, should be worn. The waste collected should be placed in a sealed container and disposed of as toxic waste.  
*Note:* It may be possible to return amalgam scrap for refining.\*\*
- vii. Exposed skin which has been contaminated with mercury or with unset amalgam should be washed thoroughly with soap and water.
- viii. Mercury urinalysis should be considered if persistent or excessive exposure to mercury is suspected.

\*Tyas MJ, Anusavice KJ, Frencken J, Mount GJ. Minimal intervention dentistry – a review. *Int Dent J* 2000;50:1-12.

\*\*SDI Limited, 5-9 Brunson St Bayswater VIC 3153. Phone: 1800 337 003.

## D9 – LUTING CEMENTS

### 1 PRESENTATION

- 1.1 A range of cements is available which may set by a chemical, light or dual cure mechanism.
- 1.2 Cements may be in supplied or pre-dosed capsules, paste syringes or as a hand mixed powder and liquid.
- 1.3 Capsulated and self-mixing syringe tips may be preferred over hand mixed cements as mixing ratios and mixing procedures can be more controlled and this is critical to clinical success.

### 2 PRECAUTIONS FOR OPERATOR-DISPENSED CEMENTS

- 2.1 Keep the bottles closed. Gain or loss of small amounts of water from the liquid will reduce the quality of the cement and may alter its setting time.
- 2.2 Discard deteriorated or old liquid, particularly if it becomes cloudy or crystals appear. Do not use a small quantity of liquid that has been left standing in the bottle or if the liquid becomes very viscous.
- 2.3 The surface on which the cement is mixed must be clean, smooth and dry. The cement should preferably be mixed on a cool glass slab, but not below the dew point. With a mixing pad, use a fresh sheet for each mix.
- 2.4 Use a stainless steel spatula only for cements containing zinc oxide (zinc phosphate and polycarboxylate). To avoid cement discolouration, a plastic, agate or cobalt-chrome (stellite) spatula should be used for mixing glass-ionomer and resin cements.

### 3 MIXING OF CEMENTS

- 3.1 For powder:liquid cements, use the liquid dropper correctly. To dispense uniform drops, hold the bottle or dropper such that the orifice is parallel to the mixing surface, and ensure the orifice is free from deposits. Let the drop form by gravity. Do not squeeze the plastic bottle.
- 3.2 Proportioning by mass is more accurate than by volume. Some form of measure should be used. Briefly agitate the powder to give consistent powder density for volume dispensers.
- 3.3 Use a small area of slab or pad for mixing. The smaller area will minimize water loss and wastage of material.
- 3.4 To prolong working time use a cool mixing slab.
- 3.5 The rate of addition of powder to liquid can be important. Different techniques are required for the different cements.
- 3.6 Standardize the mixing procedure.
- 3.7 Use as thick a mix as possible, commensurate with seating the restoration. The physical properties of the set cement improve with higher powder loadings. Gain thickness of mix by maximal powder incorporation, not by partial setting.
- 3.8 Never add liquid to a mix which is too thick – start a new mix.
- 3.9 For capsulated cements, ensure capsule is properly activated to ensure all liquid combines with the powder.
- 3.10 Mixing times vary dependent on type of automated mixer – follow the manufacturer's recommendation.
- 3.11 Be prepared to abandon an unsuitable mix of cement.
- 3.12 Be prepared to read the instructions – they are usually excellent.

**4 CEMENTATION PROCEDURE**

- 4.1 Clean the crown before cementation with either sandblasting or an organic solvent or both. (See Section 9 for special considerations)
- 4.2 Clean the tooth with pumice and water.
- 4.3 Dry but do not desiccate the tooth.
- 4.4 Prepare the gingival sulcus with retraction cord if needed, to prevent contamination of the exposed cement.
- 4.5 Check the crown on the tooth to ensure it can be fully seated before cementation. Tight or binding crowns will need adjustment prior to cementation.
- 4.6 Some form of cement release is essential for full seating. Dental laboratories usually apply at least 30 µm (three coats) of die spacer during construction of the restoration.
- 4.7 Mix the cement and apply with a brush or applicator to the restoration. Cover the entire preparation with cement and immediately place the crown with a modest force. If the crown appears to seat badly, remove and reseal quickly. Maintain this force for 30 seconds, and then hold the crown still until the cement has set.
- 4.8 Remove excess cement and protect the margins with varnish or resin if recommended by the manufacturer.
- 4.9 Recheck the occlusion.

**5 ZINC PHOSPHATE**

- 5.1 Zinc phosphate cement is useful where the properties of slow set and final high modulus are required.
- 5.2 These cements have a low pH initially so consider whether an agent should be used to reduce pulpal damage (for example, varnish).
- 5.3 Incorporate the powder incrementally. Add small proportions initially and spatulate each portion thoroughly. Mixing should take no more than 90 seconds.

**6 POLYCARBOXYLATE**

- 6.1 Infrequently used but may be used for single units. The low modulus of the set cement may result in plastic flow.
- 6.2 Complete the mixing within 30 seconds. Incorporate the full amount of powder with a 'folding' action as quickly as possible and spatulate vigorously.
- 6.3 The correctly mixed unset cement appears viscous, but will flow when the crown is cemented. A low viscosity mix will have a low powder:liquid ratio and poorer physical characteristics.
- 6.4 Seat the restoration as soon as possible after mixing and not later than 90 seconds after the commencement of mixing.
- 6.5 The cement must be cleaned up either before gross setting or after complete setting. Intermediate removal will pull out tags of material from under the margin.
- 6.6 To reverse the gelling which may occur with liquids containing polycarboxylic acid, warm the container to approximately 60°C and manipulate and shake.

**7 REINFORCED ZINC OXIDE-EUGENOL / ETHOXYBENZOIC ACID (EBA)**

- 7.1 Eugenol cements should not be used with resins.
- 7.2 EBA cements containing quartz or alumina tend to be viscous and give relatively thick films. A powder:liquid ratio of up to 3:1 is required, with the powder being incorporated incrementally. Use as soon as possible after mixing, seat the castings firmly and maintain pressure for as long as possible.
- 7.3 These cements can take several days to reach their ultimate strength, so masticatory forces should be avoided for as long as possible.

**8 GLASS-IONOMER (POLYALKENOATE)**

- 8.1 This cement is versatile, with good mechanical properties and moderate translucency.
- 8.2 The cement has a low viscosity phase after mixing and then a snap set. Place as quickly as possible as the development of the high viscosity phase must not occur before complete set. The brittle set facilitates excess removal.
- 8.3 Protect cement at the margin. Varnish, vaseline or unfilled resin may be used to prevent moisture contamination.
- 8.4 Fluoride release from these cements provides an additional therapeutic benefit.
- 8.5 Capsule systems are often supplied in individual foil wrappers to reduce effects of humidity. Only remove the capsule from the foil wrapper just before use.
- 8.6 These cements are chemical set only.

**9 RESIN-MODIFIED GLASS-IONOMER**

- 9.1 The resin addition provides an improvement in physical properties compared with conventional glass-ionomer cements, with low solubility and some improved adhesion to tooth structure.
- 9.2 These cements may be totally chemical set with a self cure resin component or they may have a light cure resin component.
- 9.3 Cavity conditioners may be required prior to cementation.
- 9.4 Water sorption may cause slight expansion of these cements which has been reported to crack some all-ceramic restorations.
- 9.5 Capsule systems are often supplied in individual foil wrappers to reduce effects of humidity. Only remove the capsule from the foil wrapper just before use.

**10 RESIN CEMENTS**

- 10.1 Resin cements are insoluble with high toughness.
- 10.2 The potential for adhesion to dentine and restorative materials (silanated porcelain, oxidized metal) suggests possibilities for non-geometric retention.
- 10.3 Resin cements may be chemical cure, light cure, dual cure or a combination (for example, light and chemical cure).
- 10.4 Filler loading of resin cements varies from substantial (>70% mass/mass) to minimal. The incorporation of filler particles increases cohesive strength of material and reduces polymerization shrinkage. Film thickness may be altered depending on the filler particles size.
- 10.5 A range of shades and opacities is available for aesthetic restoration cementation. Tints and shade modifiers can also be incorporated into many of the light and dual cure materials.
- 10.6 Clean up may be difficult due to the toughness of the resin.
- 10.7 Removal of restorations may be extremely difficult if the bond has remained strong.

**11 TEMPORARY CEMENTS**

- 11.1 Avoid using eugenol-containing temporary cements if final cementation will be with resin-based cement. Residual eugenol may remain on the tooth surface after removal of the temporary and affect the set of the permanent resin cement.
- 11.2 Non-eugenol temporary cements are available.
- 11.3 Remove residual temporary cement with ultrasonics or cavity cleanser. Cavity conditioner or solvent may be used to clean the preparation. All residual temporary cement must be removed.
- 11.4 Take care using glass-ionomer, resin-modified glass-ionomer or resin cements as temporary cements as bonding to tooth structure may make removal difficult.



## D10 – IMPRESSION MATERIALS

### 1 ELASTIC IMPRESSION MATERIALS

#### 1.1 Alginate (irreversible hydrocolloid)

- 1.1.1 The water:powder ratio must be correct – always use the measures provided. Shake the container prior to use to ensure uniformity of the contents. Always add the powder to the water.
- 1.1.2 Use water at the recommended temperature for uniform and predictable setting characteristics.
- 1.1.3 Mix for the correct time as recommended by the manufacturer. Undermixing may result in areas of unmixed material and overmixing will break up the setting gel.
- 1.1.4 Spatulate vigorously against the side of the bowl to produce a smooth, creamy paste with minimal entrapped air.
- 1.1.5 Good retention to the tray is essential. Perforated or 'rim-lock' trays are suitable, or use the adhesive recommended by the manufacturer.
- 1.1.6 Use a reasonable bulk of alginate. The layer of alginate should be thick enough to prevent tearing during removal over undercuts and to ensure maximum elastic recovery.
- 1.1.7 Use the manufacturer's stated setting time as a minimum. Extra time in the mouth improves tear strength and elastic properties.
- 1.1.8 Remove the impression with a firm but controlled rapid action, first breaking the peripheral seal. Avoid rocking movements which may permanently deform and/or tear the set material.
- 1.1.9 Rinse the impression under gently running water to remove any saliva, blood or mucus. The impression may be disinfected by immersion in 0.5 per cent hypochlorite solution for up to 15 minutes. Rinse the impression in running water before pouring stone.
- 1.1.10 Some alginate/model combinations may produce a rough or soft model surface. Modern alginates usually do not require surface treatment but, when recommended by the manufacturer, the appropriate solution should be used. When there is evidence of incompatibility, change either the alginate or the model material.
- 1.1.11 Pour the model as soon as practicable to minimize dimensional changes due to loss or gain of water. If the impression cannot be poured immediately, cover with damp gauze, place in a plastic bag, seal, and pour within 30 minutes.
- 1.1.12 Avoid incorporating air bubbles in the model by flowing the stone progressively into the impression. Fill the impression to the limits of the tray only. To avoid distortion, do not invert the impression until the stone is nearing its initial set. Add a base from a fresh mix of stone.
- 1.1.13 Remove the model within 1–2 hours of pouring. Alginate loses water over time and tends to harden, which could damage the model. There can also be an interaction between the alginate and the stone which can cause a friable stone surface.

#### 1.2 Agar (reversible hydrocolloid)

- 1.2.1 Three thermostatically controlled conditioning baths are highly recommended for successful use of agar impression materials. Heat as recommended in the boiling tank until uniformly liquid and then store at the recommended temperature.
- 1.2.2 Transfer the material from the storage bath to the tempering bath shortly before use. The tempering time will depend on the bulk of material and the temperature difference between the baths.
- 1.2.3 For direct injection, hold the syringe material at the recommended storage temperature. Using tray material in the syringe may give better results with less risk of tearing.
- 1.2.4 Use a rigid water-cooled tray to avoid distortion during removal. Allow a minimum thickness of 3 mm of material.



- 1.2.5 Smooth the surface of the material prior to insertion in order to ensure clear reproduction of detail.
- 1.2.6 Cool the tray in the mouth with circulating water at 20–22°C for at least five minutes.
- 1.2.7 Pour the model immediately after removal of the impression. Observe 1.1.9-13.
- 1.2.8 Placing the impression in 1 per cent potassium sulphate solution for up to 15 minutes may improve the quality of the model.

## **2 ELASTOMERIC IMPRESSION MATERIALS**

### **2.1 Polysulphides, silicones and polyethers**

- 2.1.1 Use an 'auto-mix' system if possible. These systems have significant benefits in cost-effectiveness and quality of mix.
- 2.1.2 Thoroughly mix the components if using a hand-mix system. When components are of different colours, the presence of streaks indicates inadequate mixing.
- 2.1.3 High temperatures decrease the working and setting times, while cooling the materials prolongs the working time. Storage of materials in a refrigerator will prolong the working time.
- 2.1.4 The lubricating powder used on some gloves can inhibit the setting of some silicone materials.
- 2.1.5 Use a rigid tray to avoid distortion during removal.
- 2.1.6 Chlorhexidine mouthwash can improve pre-operative gingival health.
- 2.1.7 Retraction of the gingivae is essential for a useful impression of cavity and/or crown preparations.
- 2.1.8 Avoid using epinephrine (adrenaline) cords because of the risk of systemic absorption.
- 2.1.9 A putty-wash technique is not recommended due to the high force needed for placement and the possibility of elastic deformation of either the tray or the impression.
- 2.1.10 Use heavy-body for the tray, and either medium-body or heavy-body for the syringe. Medium-body and heavy-body materials give adequate surface detail and higher tear strength than light-body. Light-body also slumps more readily, which can result in voids and distortions that are difficult to detect. It is critical to time the mixing of the impression materials – immediately the material is syringed into the mouth, the tray should be placed. This may mean that mixing for the tray material should start 10–20 seconds before mixing the syringe material.
- 2.1.11 Rinse the sulcus with water if an astringent agent is used as this may inhibit the set of the material.
- 2.1.12 The use of a syringe to place the material into a clean, dry, appropriately wide sulcus is highly recommended. Ensure the tip is fine enough to encircle the margin without being lifted, or a void can result. Do not overfill the syringe as the resulting length may be greater than your handspan.
- 2.1.13 Do not expect the seating force to fill the sulcus with material, as voids can often result.
- 2.1.14 Use the method of retention to the tray recommended by the manufacturer. The layer of adhesive should be thin and be allowed to dry before the impression material is placed in the tray.
- 2.1.15 Allow additional thickness in special trays for the more rigid impression materials (particularly polyether and some addition-cured silicones) to aid removal of the impression from deep undercuts.
- 2.1.16 Ensure the material is set before removal. Check the set by feel. Leaving the impression in place for a few minutes after apparent setting will improve the elastic properties of the material.
- 2.1.17 Break the peripheral seal and remove the impression carefully but rapidly.
- 2.1.18 Clean the impression thoroughly. Rinse off any blood, saliva or mucus under gently running tepid water. Disinfect the impression.
- 2.1.19 Pour the model 15–20 minutes after removal of the impression from the mouth since elastomeric impression materials can sometimes take this length of time to recover after removal over undercuts.
- 2.1.20 Additional silicone should be left for 45–60 minutes before pouring to allow any gas to evolve.

- 2.1.21 Some elastomeric impression materials can be electroplated to give a harder, more abrasion-resistant die. Damage to dies can be countered by the use of multiple dies.
- 2.1.22 Keep polyether impressions dry as they absorb water and swell. They may be disinfected but should be allowed to dry again before the model is poured.



## D11 – ORTHODONTIC WIRES

### 1 STORAGE

In general, shelf life is not critical for orthodontic wires but it is prudent to instruct staff to follow the usual good practice of placing new stock to the rear of the storage cupboard. This is particularly important with some of the very high tensile wires because of age embrittlement.

### 2 SELECTION AND USES

#### 2.1 Stainless steel (18 per cent chromium, 8 per cent nickel ('18/8' alloy))

- 2.1.1 The greater the hardness or tensile strength of a wire, the more difficult it is to bend without fracture.
- 2.1.2 Spring-hard 0.6 mm and 0.8 mm diameter is used for clasps and springs for removable appliances.
- 2.1.3 Spring-hard 0.8–1 mm diameter is used for labial arch wires in removable appliances.
- 2.1.4 Braided wires, round or rectangular, are used with fixed appliances. They exert light forces and a long range of deflection for initial levelling and alignment. In some brackets, friction can be significant.
- 2.1.5 Stranded wires provide more force than braided wires.
- 2.1.6 High tensile resilient wires, round or rectangular, range in size from 0.009 in diameter (round) to 0.025 x 0.025 in (rectangular). Small diameter wires are usually used for aligning and levelling. Larger diameter round wires are used for arch form control, while rectangular wires are used for torquing.
- 2.1.7 Dead soft wires are used for ligation.

#### 2.2 Nickel titanium (up to 50 per cent nickel content)

- 2.2.1 These wires are suitable initial aligning wires. They are very flexible and have good springback with light force delivery over a long distance.
- 2.2.2 They are difficult to form and are thus available as preformed arches in various sizes and in round and rectangular configurations.

#### 2.3 Titanium molybdenum (TMA)

- 2.3.1 These are used as working and/or finishing wires.
- 2.3.2 They are formable to a degree and are available as preformed arches in various sizes in round and rectangular configurations.

### 3 DIFFERENTIAL USE

- 3.1 Heavier wires may be used as guide wires, base wires and labial bows to which other wires are attached.
- 3.2 Active tooth moving wires should apply low forces to the periodontal ligament. In particular, torquing forces should be minimal to reduce the incidence of root resorption.
- 3.3 The active forces should be measured and the torquing forces in particular should be less than 25 g per anterior tooth.

### 4 MANIPULATION

- 4.1 Use the fingers to bend wires, not the beaks of the pliers. Hold the wire some distance from the plier beaks so the wire provides its own stress breaking.
- 4.2 Beware of pliers with rough, jagged or serrated beaks which may damage the wire surface.
- 4.3 Avoid the use of three-pronged pliers.
- 4.4 Bend around the square beak of the pliers rather than the round beak. This is especially important for the more brittle wires.

- 4.5 If wires consistently break, polish the beaks of the pliers with an impregnated rubber wheel, particularly if the pliers have tungsten carbide inserts.
- 4.6 Try to avoid acute bends in the wires.

## 5 COILS

- 5.1 The diameter of a helical coil should be four times the diameter of the wire used.
- 5.2 Position the coil so it unwinds to deliver its force.
- 5.3 The 'arm' and 'leg' should be tangential to the coil rather than coming off radially, in order to reduce unwanted stresses and the possibility of distortion due to stress relaxation.

## 6 HEAT TREATING WIRE

- 6.1 Many wires come in the optimum heat-treated condition. Others, such as the cobalt-chromium types, may be heat-treated after forming. This is usually done with an attachment to an orthodontic welder.
- 6.2 Wires are softened by hard soldering, brazing and, in particular, welding.
- 6.3 Annealing can be useful for softening the ends of wires, for example, in order to bend the ends of the wire to reduce mucosal irritation.
- 6.4 Polishing the wire vigorously in one direction a number of times in order to smooth and clean the surface does provide heat. Although this is not heat treatment per se, it may be one stratagem if breakage during fabrication is common. A household scourer provides minimal abrasion and does not remove too much of the critical outer layer.
- 6.5 Straight wires may exhibit creep after forming into arch wires. This applies more to the pulse-straightened wires than to the spinner-straightened wires. Return to a straighter form by creep or hysteresis can produce cross-bites, and stress release before placement in the mouth is therefore necessary.

## 7 REDUCTION IN CROSS-SECTION

- 7.1 Electrolytic polishing requires a specific apparatus, but may be done in the laboratory.
- 7.2 Centreless grinding requires round and rectangular sections of the same wire. Wires must be ordered as required.

## 8 ALLERGIES

- 8.1 Nickel sensitivity includes reactions to solders and nickel titanium wires and has been well documented. No reactions to stainless steel orthodontic appliances alone have been documented.
- 8.2 A history should be taken to explore irritations, rashes or itchiness related to non-gold jewellery, especially earrings where ears have been pierced, watch bands and finger rings. Most reactions during orthodontic treatment are not initial sensitization reactions.
- 8.3 Soldered appliances and nickel titanium wires may cause gingival inflammation and angular cheilitis. In more severe cases the reactions may extend to rashes and irritation on and inside the lips and around the mouth. In the most severe cases erythematous reaction may include the face, neck and upper torso, extremities and especially previously sensitized sites adjacent to watch bands and earrings.

## 9 FRICTION

- 9.1 Friction between a bracket and an arch wire is an issue whenever a tooth is moved by sliding along an arch wire because of its effect on anchorage.
- 9.2 Friction is determined by two factors:
  - the coefficient of friction of the two surfaces in contact; and
  - the total force between surfaces, that is, force per unit area.
- 9.3 Stainless steel wires have the lowest coefficient of friction, followed by  $\alpha$ -titanium, nickel titanium, and TMA ( $\beta$ -titanium).
- 9.4 The bracket surface and bracket design may be more critical than the type of wire. For instance, self-ligating brackets which don't bind the wire as a wire ligature would, result in less friction.

## D12 – ORTHODONTIC ELASTICS

### 1 STORAGE

Elastics have a limited shelf life and should be stored in the dark in a cool, dry place.

### 2 USES

- 2.1 Elastic bands are used for inter-arch mechanics with fixed appliances, retraction of maxillary incisor (overjet) and in conjunction with removable appliances.
- 2.2 Elastomeric chains are used for intra-arch mechanics to close spaces with fixed appliances.
- 2.3 Modules are used to engage arch wires into fixed brackets. They are also used as separating elastics, fitted between teeth to create space prior to fitting bands.
- 2.4 Threads, solid and tubular, are used to tie ectopic or displaced teeth to arch wires.

### 3 SELECTION

#### 3.1 Elastic bands

- 3.1.1 Elastic bands are supplied in a range of diameters and thicknesses to provide a variety of forces. For tooth movement, light forces are recommended (approximately 100 mg), with the aim of ‘tickling’ the periodontal ligament and stimulating osteoclastic activity.
- 3.1.2 Selection is based on the span of the stretched elastics and the inherent friction within the fixed appliance.
- 3.1.3 Elastics worn intra-orally deteriorate more quickly and should be changed daily.

#### 3.2 Elastic chains

- 3.2.1 Elastic chains may be open loop or closed loop, reflecting the size of the link between each circle of elastic.
- 3.2.2 Open loop provides less force per unit of stretch than closed loop, and is recommended for space closing.
- 3.2.3 Elastomeric chain elastics are available in different colours.
- 3.2.4 The force to be delivered should be checked before final attachment. Force delivery and strength varies with colours and between products from manufacturers. In general, colouring pigments reduce elasticity.
- 3.2.5 Change elastic chains every four to six weeks.
- 3.2.6 Coloured chains especially deteriorate with prolonged shelf life.

#### 3.3 Modules

- 3.3.1 A small range of diameters and thicknesses is available.
- 3.3.2 Selection is based on bracket size and depth of the tie wings.
- 3.3.3 Modules are available in different colours, but there is little clinical difference between the colours.

#### 3.4 Separating elastics

- 3.4.1 Separating elastics are fitted between tooth contacts. Once fitted, they are visible above the contact area across the marginal ridge.
- 3.4.2 A contrasting colour (blue) should be used.
- 3.4.3 Keep full documentation of placement and note numbers when removing prior to fitting bands.
- 3.4.4 These elastics can be displaced and impact subgingivally below the contact area and there is a risk that orthodontic bands can be fitted over them.
- 3.4.5 Radio-opaque separating elastics are available.

## **4 STRETCHING**

- 4.1 The force decay rate of elastics is rapid over the first 24 hours.
- 4.2 All elastics should be stretched 75–100 per cent before engagement to provide a more even force delivery over time.

## **5 ALLERGIES**

- 5.1 Dentists should be aware of the potential for an anaphylactic reaction to latex.
- 5.2 Other less severe reactions are quite common. A careful history should be taken, including questions about itching, rash or rhinitis following contact with objects containing latex such as balloons, hot water bottles, latex gloves or dental rubber dam. Sensitized persons can react to latex incorporated in their clothing such as socks.
- 5.3 Many products are now made from non-latex materials, including orthodontic elastics.

## D13 – MOUTHGUARDS

This Guide has been withdrawn.

Readers are referred to the Standards Australia handbook *HB 209-2003 Guidelines for the fabrication, use and maintenance of sports mouthguards*.

The handbook is available for purchase from SAI Global Ltd on behalf of Standards Australia:

Online: [www.saiglobal.com.au/shop/Script/search.asp](http://www.saiglobal.com.au/shop/Script/search.asp)

Telephone: 13 12 42

Fax: 1300 65 49 49

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## D14 – IMPLANTS

### 1 INTRODUCTION

- 1.1 Dental implants, when defined by the accepted host-implant interface of osseointegration (osteointegration), are now considered a mainstream discipline in dentistry. Significant clinical research information is available to provide longitudinal confidence in the application of these alloplastic tooth substitutes to clinical situations of failed or missing teeth for carefully selected patients.
- 1.2 Although any dental restoration has an intrinsic aesthetic value, the use of implant-borne prostheses delivers a quantum improvement in comfort and function for the patient, often eliminating the need for removable prostheses or involvement of the natural dentition in conventional fixed prosthodontics. The reduced dental intervention means these treatments may be viewed as conservative treatment options.
- 1.3 The clinician must decide whether to provide these services as there are significant costs associated with training and clinical practice and a level of activity is required to gain confidence and to be a financially viable practice option. Referral is the appropriate action if the clinician declines to offer these services.

### 2 PATIENT MANAGEMENT

- 2.1 The restorative dentist will spend many hours with the patient and assumes the responsibility for achieving the desired clinical outcome and ensuring the long-term review and maintenance of the restoration and its peri-implant health.
- 2.2 The restorative dentist must provide the patient with a full review of all viable treatment options for the particular clinical situation. This should include a description of the operative technique(s) involved, an 'evidence based' review of the longevity of the options, and a discussion of the costs to the patient.
- 2.3 Consultation with a suitably trained surgical implant clinician is undertaken to discuss with the patient the surgical procedures required. This covers the clinical venue, a review of the medical status, the preferred method of anaesthesia, any associated grafting and a summary of any risks that may be foreseen.
- 2.4 'Informed consent' should be confirmed in a written form signed by both parties.

### 3 CLINICAL MANAGEMENT

- The restorative dentist must take the responsibility for the design of the prosthesis including the number and distribution of the implants, their position and angulation. They should support the surgical colleague by attendance at surgery or by provision of a surgical guide.
- 3.1 Surgical considerations of the proposed treatment should be discussed prior to surgery and modifications to the treatment plan be made in response to the surgical clinical assessment and any further investigative radiological studies, for example, CT scan. It is not acceptable for the implant to be placed in a compromised position because 'that was where the bone was'.
  - 3.2 Surgical techniques of bone grafting, osteotomies, ridge expansion, osseodistraction, sinus or nasal lining lifts and membrane augmentation may be used to optimize the bony structure to ensure optimal implant placement.
  - 3.3 Assessment of any existing prostheses worn by the patient to ensure they will be satisfactory for ongoing use during the surgical phase of implant management may include:
    - provision of new dentures if the patient is edentulous
    - study casts with a wax-up of the proposed restoration
    - a suitable radiological review of the possible implant sites, using periapical and orthopantomogram views

- in those areas of the mouth where vital anatomic structures exist, tomographic or computerised tomographic studies may be indicated
- provision of a surgical guide for implant positioning, or computer-generated guide template

3.4 Surgical management may be undertaken by the restorative dentist, if appropriately trained, or may be referred to a colleague with that expertise.

3.5 Surgical management – timing options:

- Immediate implant placement. At the time of extraction, the socket is cleared of fibrous tissue and the site surgically prepared to accept the implant. The advantage may be the improved maintenance of the buccal alveolar bone and the need for only the single surgical procedure.
- Delayed immediate implant placement. If there is a disseminated-cellulitis emanating from peri-dental pathology, a delay of up to eight weeks may be indicated before implantation. Epithelial regrowth over the socket will enable simple primary closure if a dual-stage surgical protocol is preferred.
- Deferred implant placement. Following six to nine months of healing, bony fill of the extraction site has occurred, though loss of the bony buccal architecture and the subsequent loss of soft tissue support may compromise the aesthetic outcome in the anterior maxillary sites.

3.6 Surgical procedures may be:

- Single-stage surgical procedures. The implant is placed and a healing abutment is added to maintain a perimucosal opening.
- Two-stage procedures. The implant is placed and buried subperiosteally. In three to six months, a further surgical procedure exposes the implant interface and a healing abutment is placed.

3.7 Restorative management:

The final phase of treatment involves the construction of the restoration. Clinical management at this time will consist of impression procedures, selection of appropriate abutment hardware, and fabrication of the restoration in the dental laboratory, followed by delivery to the patient.

3.8 Restorative options:

- Immediate loading. Studies now show that, in very carefully selected circumstances, restorations may be placed at the time of implant placement in limited regions of the jaws. This requires a very stable screw-shaped implant of adequate length that can be placed with a defined torque value for the particular implant.
- Delayed immediate loading. Some implant systems advocate cautious loading at eight weeks post-implantation.
- Delayed loading. The conservative option is to wait three to six months, depending on the bone quality/quantity, the implant length and the implant surface morphology before restoring to function.
- Long-term follow-up and review are required as with conventional crown and bridge prosthodontics. The treating restorative practitioner and patient must be aware of this from the outset.

## 4 IMPLANT SYSTEM SELECTION

4.1 This is often the result of recommendation by experienced colleagues and should be supported by attendance at university-based or non-commercially aligned implant dentistry society continuing education programs. Training seminars offered by the various implant system distributors are recommended once an overview of the discipline of implant dentistry has been acquired.

4.2 The literature associated with a particular implant system should be carefully studied and assessed prior to use of the system, as all manufacturers claim various benefits for their coatings and surfaces. Many claimed “improvements” lack substantiation, and may only be supported by short-term clinical trials, of limited validity.

4.3 Technical backup, laboratory suitability and quality of manufacture should also be taken into account when selecting an implant system.

- 4.4 It is important to be aware there is always the risk of some failure with implant therapy due to surgical, prosthetic or implant factors. The literature supports the clinical experience that implant restorations are efficacious treatments, though survival statistics vary in the various regions of the jaws.
- 4.5 Implant survival may be compromised by:
- the quantity and quality of available host bone
  - host factors such as metabolic disorders (e.g., untreated diabetes) and medications (e.g., bisphosphonates)
  - the technical design features of the prostheses including the type, dimension, number and distribution of the implants and the biomechanical influences on the prosthesis in the oral environment
  - the experience of the clinicians involved, patient selection factors, home care and the regularity of attendance for review

## 5 SUMMARY

The concept of osseointegration has introduced the dental implant as a viable alternative to conventional prosthodontic procedures for tooth replacement. Proper clinical management of implant cases requires a thorough basic dental understanding with further training for success. Dental implants present an alternative to, rather than a replacement for, other prosthodontic options.

The suitability of each case for implant usage can only be determined on its individual merits. The practitioner who is interested in implant dentistry would be well advised to undertake a training course prior to deciding whether implant management should be incorporated as part of their routine dental practice.

*Revision carried out by Dr G. Clausen - 15.6.2008*

*Approved at 3.7.2008 SCHED Meeting*



## D15 – REGULATION OF DENTAL PRODUCTS\*

### 1 GENERAL REQUIREMENTS

- 1.1 Legal controls apply to many dental products, through the provisions of the Therapeutic Goods Act 1989, Therapeutic Goods Regulations 1990, Therapeutic Goods (Medical Devices) Regulations 2002, and associated Therapeutic Goods Orders (TGO). Such dental products are considered to be therapeutic goods, and include medical devices and medicines.
- 1.2 Therapeutic products must be included by their sponsors in the Australian Register of Therapeutic Goods (ARTG) before supply or use in Australia.
- 1.3 The sponsor is the Australian manufacturer, importer or exporter. If there is more than one importer or exporter, all must place their product on the ARTG.
- 1.4 Individual dentists or groups of dentists who import or export regulated products directly are regarded as sponsors.
- 1.5 It is the legal responsibility of the sponsor to ensure the product is included in the ARTG.
- 1.6 Sponsors must report to the Therapeutic Goods Administration any adverse affects including death or serious injury to patients or users associated with the use of dental products.
- 1.7 Dentists risk prosecution and professional indemnity insurance may be compromised if the Act is breached.
- 1.8 If in doubt obtain advice from the Therapeutic Goods Administration (TGA) on: toll free 1800 141 144 for medical devices, toll free 1800 020 653 for medicines, or visit the TGA website at: [www.tga.gov.au](http://www.tga.gov.au).

### 2 MEDICAL DEVICES REGULATORY SYSTEM

- 2.1 The medical devices regulatory system is based on:
  - a set of risk-based classification rules by which medical devices are classified into one of five categories: Class I, Class 1 Sterile, Class 1 Measure (low risk), Class IIa (low-medium risk), Class IIb (medium-high risk), Class III (high risk), and Active Implantable Medical Device (high risk);
  - a set of essential principles for safety and performance that must be met by all medical devices;
  - conformity assessment procedures used to demonstrate medical devices conform with the essential principles;
  - a requirement for all manufacturers of medical devices to have a quality management system in place for the manufacture of medical devices; and
  - ongoing post-market monitoring requirements for all devices, which includes mandatory reporting of serious adverse events.
- 2.2 All products that fit the definition of a medical device have to be included in the ARTG.
- 2.3 Examples of dental products by class are:

#### Class I

Dental impression materials, hand-held dental mirror, dental patient chair, dental curing light, examination gloves, materials for removable prosthesis, syringe tips for the delivery of dental materials, rubber dam, rubber dam clamps, cotton rolls, gauze, wedges, waxes, retraction cord, matrix bands, matrix band holders, impression trays, bite registration devices and materials, reusable hand instruments, amalgam separators

\*This is a guide only to the interpretation of the Therapeutic Goods Act 1989 and associated legislation. It does not diminish the responsibility of any parties in fulfilling their legal obligations.

The assistance of the Office of Devices, Blood and Tissues of the Therapeutic Goods Administration in preparing this information is acknowledged.

### **Class 1 Measure**

Perioprobes, gauges

### **Class 1 Sterile**

Sterile gauze, sterile cotton roll, sterile cotton pellets

### **Class IIa**

Dental filling materials and pins, dental alloys, ceramics and polymers, powered dental drill, X-ray film, orthodontic wire, fissure sealants, dental aspirator tips, lining materials, gutta percha, materials for fixed prosthesis, orthodontic materials and devices for intra-oral use, temporary filling materials, material for custom-made temporary prosthesis, non-absorbable suture material, etchant, paper points, attachments to handpieces-burs-mandrels-polishing discs, single use hand instruments, air/water syringes, supply units, pulp testers, ultrasonic scalers and attachments

### **Class IIb**

Diagnostic X-ray sources, non-absorbable sutures, YAG lasers, transendodontic implants, non-resorbable bone substitutes, electrosurgical units

### **Class III**

Absorbable sutures, collagen, medicated pulp capping, biologically coated implants, resorbable bone substitutes, medicated short-term relining materials, medicated surgical packs, resorbable sutures, medicated retraction cord

- 2.4 All classes of medical devices have to be included in the ARTG. Applications for inclusion of devices in the ARTG can be sent using the TGA's web-based electronic lodgement system, the Device Electronic Application Lodgement system (DEAL). DEAL allows sponsors to manage and lodge applications remotely from an internet-capable personal computer through a secure transmission system. It includes online access for sponsors to view all the regulatory information about their products, including the full ARTG entry.

## **2.5 Standards**

- 2.5.1 All medical devices are required to meet the essential principles for quality and safety. One way to demonstrate that devices meet the essential principles is the use of Medical Device Standards Orders (MDSOs), which reference international standards. While MDSOs are non-mandatory, compliance with the relevant MDSO will lead to an automatic presumption that the device meets the relevant essential principles.
- 2.5.2 Electrically powered dental equipment is required to meet standards for electrical safety and electromagnetic compatibility. State/Territory electricity authorities may have additional requirements.
- 2.5.3 Radiography equipment must be included in the ARTG. State/Territory laws may also apply to the regulation of radiography equipment.

## **3 OTHER PRODUCTS REQUIRING INCLUSION IN THE ARTG**

Medicines and medicine-containing products, for example local anaesthetic, retraction cord impregnated with a medicament and topical fluoride.

- Products of biological origin, for example freeze-dried bone and collagen.
- Disinfectants and sterilants. TGO Nos. 54/54A/54B – Standard for disinfectants and sterilants apply.

#### 4 ACCESS TO UNAPPROVED PRODUCT

There are four mechanisms by which individuals can gain limited access to unapproved medical devices in Australia:

- use in clinical trials;
- via the Special Access Scheme (SAS);
- through an authorized prescriber; and
- by personal importation.

The operation of the four mechanisms remains the same under the new medical devices regulatory system, with the exception of the SAS, where a new mechanism of notification of use of unapproved products in patients with life-threatening illness has been introduced. These changes align the operation of the SAS for medical devices with that already existing for medicines.

#### 5 FURTHER ADVICE

Further advice on the regulatory system for therapeutic goods may be obtained from the Therapeutic Goods Administration, Office of Devices, Blood and Tissues, PO Box 100, Woden ACT 2606. Phone toll free: 1800 141 144 for medical devices, toll free 1800 020 653 for medicines or visit the TGA website at: [www.tga.gov.au/devices/devices.htm](http://www.tga.gov.au/devices/devices.htm).

Note: This is a guide only to the interpretation of the *Therapeutic Goods Act* 1989 and associated legislation. It does not diminish the responsibility of any parties in fulfilling their legal obligations.

The assistance of the Office of Devices, Blood and Tissues of the Therapeutic Goods Administration in preparing this information is acknowledged.





## D16 – RADIOGRAPHIC EXAMINATION OF DENTAL PATIENTS

Modern dentistry relies very much upon the usage of ionising radiation. It is used for diagnostic purposes and in many cases it also assists clinicians in the execution of treatment plans. It should, however, be remembered that each exposure of living tissue to ionising radiation results in a transient or permanent biological change at cellular level of that tissue. This biological change has the potential to become manifest as a somatic stochastic and/or genetic effect. Although the individual doses in dental radiography are, generally speaking, low (ref. Table 3), the number of radiographs taken is often high, as is the number of individuals exposed. The overall population dose resulting from dental radiography is therefore significant. Besides, as the doses of ionising radiation are cumulative, individuals can receive substantial doses from dental radiography during their lifetime. It follows that general principles of radiation protection should be applied in order to keep these doses As Low As Reasonably Achievable (the ALARA principle). Every exposure to ionising radiation must therefore be justified: that is, there must be an expectation that the nett benefits to the patient outweigh the possible risks. Once the decision has been made that a radiological examination is indeed justified, the procedure must be optimised so that the patient receives the lowest possible dose.

### 1 JUSTIFICATION

As far as the diagnostic usage is concerned the National Health and Medical Research Council's Code of Practice for Radiation Protection in Dentistry states:

*"The nature and extent of an actual or a suspected dental condition, its early detection, treatment and response to treatment shall be the primary determining factors in submitting the patient to radiographic examination. Radiology shall not be used as a substitute for a clinical investigation, and therefore radiography shall not be undertaken until a clinical examination has been performed."*<sup>1</sup>

It is ultimately the responsibility of the dentist to make a decision, in the light of the clinical circumstances, as to the radiation exposure to which the patient should be subjected. Before undertaking any radiological examination, the dentist should study the relevant previous radiographs of the patient.

The American Dental Association and the US Department of Health and Human Services have published a matrix with selection criteria for dental radiographic examinations. These recommendations are set out in Table 1. They are always subject to clinical judgement and should therefore be used in the context of a review of the patient's needs and medical/dental history.<sup>2,3,4,5</sup>

## GUIDELINES FOR PRESCRIBING DENTAL RADIOGRAPHS

The recommendations in this chart are subject to clinical judgement and may not apply to every patient. They are to be used by dentists only after reviewing the patient's health history and completing a clinical examination. Because every precaution should be taken to minimize radiation exposure, protective thyroid collars and aprons should be used whenever possible. This practice is strongly recommended for children, women of childbearing age and pregnant women.

TYPE OF ENCOUNTER	PATIENT AGE AND DENTAL DEVELOPMENTAL STAGE				
	Child with Primary Dentition (prior to eruption of first permanent tooth)	Child with Transitional Dentition (after eruption of first permanent tooth)	Adolescent with Permanent Dentition (prior to eruption of third molars)	Adult, Dentate or Partially Edentulous	Adult, Edentulous
<b>New patient*</b> being evaluated for dental diseases and dental development	Individualized radiographic exam consisting of selected periapical/occlusal views and/or posterior bitewings if proximal surfaces cannot be visualized or probed. Patients without evidence of disease and with open proximal contacts may not require a radiographic exam at this time.	Individualized radiographic exam consisting of posterior bitewings with panoramic exam or posterior bitewings and selected periapical images.	Individualized radiographic exam consisting of posterior bitewings with panoramic exam or posterior bitewings and selected periapical images. A full mouth intra-oral radiographic exam is preferred when the patient has clinical evidence of generalized dental disease or a history of extensive dental treatment.		Individualized radiographic exam, based on clinical signs and symptoms.
<b>Recall patient*</b> with clinical caries or at increased risk for caries**	Posterior bitewing exam at 6–12 month intervals if proximal surfaces cannot be examined visually or with a probe.	Posterior bitewing exam at 6–12 month intervals if proximal surfaces cannot be examined visually or with a probe.	Posterior bitewing exam at 6–12 month intervals if proximal surfaces cannot be examined visually or with a probe.	Posterior bitewing exam at 6–18 month intervals	Not applicable
<b>Recall patient*</b> with no clinical caries or not at increased risk for caries**	Posterior bitewing exam at 12–24 month intervals if proximal surfaces cannot be examined visually or with a probe.	Posterior bitewing exam at 12–24 month intervals if proximal surfaces cannot be examined visually or with a probe.	Posterior bitewing exam at 12–24 month intervals if proximal surfaces cannot be examined visually or with a probe.	Posterior bitewing exam at 18–36 month intervals	Not applicable
<b>Recall patient*</b> with periodontal disease	Clinical judgement as to need for and type of radiographic images for the evaluation of periodontal disease. Imaging may consist of, but is not limited to, selected bitewing and/or periapical images of areas where periodontal disease (other than non-specific gingivitis) can be identified clinically.	Clinical judgement as to need for and type of radiographic images for the evaluation of periodontal disease. Imaging may consist of, but is not limited to, selected bitewing and/or periapical images of areas where periodontal disease (other than non-specific gingivitis) can be identified clinically.	Clinical judgement as to need for and type of radiographic images for the evaluation of periodontal disease. Imaging may consist of, but is not limited to, selected bitewing and/or periapical images of areas where periodontal disease (other than non-specific gingivitis) can be identified clinically.	Posterior bitewing exam at 24–36 month intervals	Not applicable
<b>Patient</b> for monitoring of growth and development	Clinical judgement as to need for and type of radiographic images for the evaluation and/or monitoring of dentofacial growth and development	Clinical judgement as to need for and type of radiographic images for the evaluation and/or monitoring of dentofacial growth and development	Clinical judgement as to need for and type of radiographic images for the evaluation and/or monitoring of dentofacial growth and development	Usually not indicated	
<b>Patient</b> with other circumstances including, but not limited to, proposed or existing implants, pathology, restorative/endodontic needs, treated periodontal disease and caries remineralization	Clinical judgement as to need for and type of radiographic images for evaluation and/or monitoring in these circumstances.	Clinical judgement as to need for and type of radiographic images for evaluation and/or monitoring in these circumstances.	Clinical judgement as to need for and type of radiographic images for evaluation and/or monitoring in these circumstances.		

\* Clinical situations for which radiographs may be indicated include but are not limited to:

**A. Positive historical findings**

1. Previous periodontal or endodontic treatment
2. History of pain or trauma
3. Familial history of dental anomalies
4. Post-operative evaluation of healing
5. Remineralization monitoring
6. Presence of implants or evaluation for implant placement

**B. Positive clinical signs/ Symptoms**

1. Clinical evidence of periodontal disease
2. Large or deep restorations
3. Deep carious lesions
4. Malposed or clinically impacted teeth
5. Swelling
6. Evidence of dental/facial trauma
7. Mobility of teeth
8. Sinus tract ('fistula')
9. Clinically suspected sinus pathology
10. Growth abnormalities
11. Oral involvement in known or suspected systemic disease
12. Positive neurologic findings in the head and neck
13. Evidence of foreign objects
14. Pain and/or dysfunction of the temporomandibular joint
15. Facial asymmetry
16. Abutment teeth for fixed or removable partial prosthesis
17. Unexplained bleeding
18. Unexplained sensitivity of teeth
19. Unusual eruption, spacing or migration of teeth
20. Unusual tooth morphology, calcification or colour
21. Unexplained absence of teeth
22. Clinical erosion

**\*\* Factors increasing risk for caries may include but are not limited to:**

1. High level of caries experience or demineralization
2. History of recurrent caries
3. High titers of cariogenic bacteria
4. Existing restoration(s) of poor quality
5. Poor oral hygiene
6. Inadequate fluoride exposure
7. Prolonged nursing (bottle or breast)
8. Frequent high sucrose content in diet
9. Poor family dental health
10. Developmental or acquired enamel defects
11. Developmental or acquired disability
12. Xerostomia
13. Genetic abnormality of teeth
14. Many multi-surface restorations
15. Chemo/radiation therapy
16. Eating disorders
17. Drug/alcohol abuse
18. Irregular dental care

## 2 OPTIMISATION

Once it has been established that a radiographic examination is indicated, the procedure needs to be optimised. The principle of optimisation is to keep the individual dose as low as is reasonably achievable and to keep the number of individuals exposed as low as possible. Set out below are a number of practices that will assist in complying with the requirement of optimisation.

2.1 The number of exposures to be made in the examination should be the minimum necessary to obtain the required diagnostic information. The desirability of 'full mouth' periapical radiography is now held to be less than was formerly considered necessary. In many instances, a panoramic radiograph, when necessary supplemented with periapical and/or occlusal radiographs, will provide more information and a lower radiation dose than a full-mouth periapical series (ref. Table 3). However, it is recognized that when optimum detail is required a full-mouth periapical series is justifiable (for example, at the start of extensive oral rehabilitation).

2.2 Certain procedures administer relatively high doses to radiosensitive organs, which may be particularly hazardous in children. Hence, radiographs such as oblique-lateral jaw and vertex (true maxillary) occlusal should only be taken if no alternatives are possible.

### 2.3 Exposure during pregnancy

#### 2.3.1 Pregnant patients

With regard to performing radiological procedures on women of reproductive capacity, the National Health and Medical Research Council's Code of Practice for Radiation Protection in Dentistry<sup>1</sup> states:

*"The National Health and Medical Research Council recommends that precautions be adopted in radiological procedures involving exposure to the lower abdomen and pelvic regions of women of reproductive capacity to ensure that the radiation dose received is as low as possible, and particular care should be taken to avoid the irradiation of the foetus whenever practicable. When radiography of an area remote from the foetus is needed, such as in dental radiography, this can be undertaken with negligible dose to the foetus at any time during pregnancy if proper collimation is used and the equipment is properly shielded. There is no need on radiation protection grounds to defer dental radiography during pregnancy."*

However, in a recently published epidemiological study it is suggested that an association may exist between radiation exposure of the thyroid during pregnancy and low birth weight.<sup>6</sup> Application of a thyroid collar when exposing female patients of reproductive age, whenever possible, seems therefore prudent.

#### 2.3.2 Pregnant staff

If a member of the dental staff is pregnant, then the foetus should be afforded the same level of protection as a member of the public, which is set at 1 milli-Sievert per year, averaged over five years. Where the recommended radiation safety procedures (see section 2.5.2) are followed, the effective doses typically recorded by dental staff are such that it should not normally be necessary to modify work practices during pregnancy.

### 2.4 Technique

Faulty technique is a frequent cause of increased radiation exposure. Accuracy in exposing and processing radiographs will ensure maximum diagnostic yield.

If contrast and density of films is not consistent with the usual results obtained, exposure should not be increased in an attempt to compensate. Processing deficiencies, such as cold or exhausted developer, are more likely to be the cause of such problems (see Guide D17).

The X-ray film with the highest speed available, consistent with the detail and contrast required, should be used (see section 2.8.2). As part of an extra-oral image receptor

system, rare earth intensifying screens are highly recommended.

Methods which enable the operator to standardize radiographic techniques should be used whenever practicable. For periapical radiography the paralleling technique is in many cases superior to and easier to standardize than the bisecting of the angle technique.

An important quality assurance tool is to maintain a register of reject radiographs. This register should contain the occasions on which the required diagnostic information could not be obtained and the remedial action taken, if any. Regular analysis of such an inventory can provide valuable information regarding the need for equipment maintenance, additional training, etc.

## **2.5 Radiation shielding**

### **2.5.1 Patient shielding requirements**

Patients should be shielded from unwanted radiation. Proper shielding includes the use of 'lead aprons' with an attenuation coefficient equivalent to at least 0.25 mm of lead. Use other appropriate shields according to the geometry of the site.

Special attention should be given to shielding the thyroid gland of female patients of reproductive age<sup>6</sup> and children. For cephalometric and orthopantomographic examinations application of a thyroid shield is usually not possible. Legal requirements are in force in various States and Territories.

### **2.5.2 Shielding dental personnel**

Dental personnel should be properly trained in radiation protection procedures. Protection by the use of a proper operator position<sup>7</sup>, distance, fixed protective shields and other means of personnel shielding should be understood and implemented.

During the exposure, the patient must remain within the field of vision of the operator. Therefore, lead glass has to be frequently incorporated in permanent protective shields or doors.

Under no circumstance must the operator or any member of the dentist's staff be occupationally exposed to the useful beam during a radiographic exposure. Neither the operator nor any member of the dentist's staff must hold patients during radiographic examinations. When there is a need to hold a child or an incapacitated patient, restraining devices should be used.

If parents or other people are required to assist, they must be provided with protective aprons and be positioned so as to avoid being exposed to the useful X-ray beam. One person must not regularly perform these duties.

Personal radiation exposure monitoring, for example by means of a film badge, is useful for checking the adequacy of radiation protection. It can be used to document the occupational doses of the wearers, especially when the wearer is accidentally exposed, and to disclose inadequate or improper radiation protection practices.

It may be obligatory in some States and Territories to wear monitors until it can be shown that the occupational dose of the wearers is either zero or negligible. Personal monitors must not be worn when the wearer is undergoing any medical or dental radiography as a patient.

### **2.5.3 Other**

The construction of rooms in which radiographs are taken should be such that people outside the room are not exposed to radiation in excess of 1 milli-Sievert per year averaged over five consecutive years.

No exact figure as to the required wall thickness can be given in the context of these guidelines, as it is dependent upon a number of variables:

- the distance between the wall and the radiation source;
- the nature and occupancy factor of the area to be shielded;

- the sort of radiation, primary beam or stray radiation, to be attenuated by the wall;
- the amount of time the primary beam is directed at the wall;
- the workload of the X-ray machine (maximum exposure time per week);
- the maximum kilo-voltage of the X-ray machine; and
- the building materials used.

Calculations for shielding requirements must be carried out by appropriately qualified people (for example, radiation safety officers). Advice should be obtained from the State or Territory radiation safety authority.

There should be no-one in the useful X-ray beam other than the patient.

People not involved in the examination should not be permitted to remain in the room while the exposure is made.

## 2.6 Transfer of patients

It should be recognized that a patient transferring from one practitioner to another might be exposed to unnecessary radiation if the relevant radiographs are not made available to the new practitioner. In the case of digital images, a hard copy or a written report should be made available if the new practice is not equipped to read the digital images.

## 2.7 Equipment

### 2.7.1 Radiography with conventional films

The apparatus used must conform to Australian Standard/New Zealand Standard 3200.2.201:2000, and may not be modified. Filters and collimation devices may not be removed, nor may their characteristics be changed. An open cylindrical aiming device limiting the focus-skin distance to not less than 200 mm must be used and not the short pointed cone. A chart with exposure variables for various projections and areas must be permanently attached to or near the machine.

### 2.7.2 Digital equipment

Several digital imaging systems are available for intra-oral and extra-oral radiography. These systems employ sensors to replace conventional films on silver-halide base and should require less exposure than E-speed film. No Australian Standard covering digital equipment for dental radiography is as yet available. The most important systems are:

- direct systems, employing charge-coupled devices (CCD); and
- indirect systems, employing photostimulable phosphors (PSP).

These systems differ in properties such as image processing, image quality, patients' acceptability of sensors, range of image receptor sizes and cost.

Some other aspects to be aware of are:

- Some digital systems for intra-oral radiography have radiation sensors significantly smaller than conventional films which may limit their use to the imaging of a relatively small area, thus diminishing the dose reduction advantage due to a larger number of exposures being required to cover the area under investigation. The choice of the imaging system should result in a nett dose benefit to the patient.
- Exposure times for digital intra-oral radiography are significantly lower than for conventional films and practitioners using both digital and conventional image receptors should carefully check exposure settings before initiating the exposure.
- Care should be taken to ensure that the equipment is set up correctly with respect to the exposure. Some systems automatically compensate for exposure errors without the user being aware of this. It is therefore possible that patients are routinely overexposed if the initial set-up has not been properly conducted.
- A record should be kept of all exposures made using digital equipment in the form of a hard copy of the image, a written diagnostic report or a computer record with appropriate back-up.

## 2.8 Some technical parameters

### 2.8.1 Radiation dosage

Even with optimum collimation, many parts of the patient's body will receive some radiation during dental radiography. In humans, typical gonad doses are  $8.63 \times 10^{-4}$  to  $8.63 \times 10^{-3}$  mGy (0.1–1 mR) following one intra-oral radiograph, depending primarily on the beam direction (lower and upper teeth respectively), when using optimum beam size and filtration. However, these figures can be lowered appreciably to less than  $8.63 \times 10^{-5}$  mGy (0.01 mR) simply by using a protective apron or neck shield.

### 2.8.2 Speed of intra-oral films

Currently, films available in Australia are of speed group D, E or F. Films of group E are approximately twice as sensitive as those from group D and F-speed films require only a quarter of the exposure of D-speed films. Films of groups E and F generally possess adequate image qualities for normal diagnostic purposes and are therefore recommended. Practitioners still using D-speed films should consider switching to E or F-speed films. Films with speed less than that of group D must not be used. Films should comply with ISO3665: Photography-intraoral radiographic film – Specification, 1996, which has been adopted as a collateral Australian Standard.

Table 2 contains the various film sizes and their indications.

FILM SIZES	DIMENSIONS (mm)	APPLICATIONS
0	22x35	<ul style="list-style-type: none"> <li>• Periapicals of deciduous teeth</li> <li>• Bitewings of deciduous teeth</li> </ul>
1	24x40	<ul style="list-style-type: none"> <li>• Periapicals of permanent incisors and canines</li> <li>• Bitewings of mixed dentitions</li> </ul>
2	31x41	<ul style="list-style-type: none"> <li>• Periapicals of premolars and molars</li> <li>• Bitewings of permanent dentitions</li> <li>• Occlusal views of very small children</li> </ul>
3	27x54	Use not recommended
4	57x76	Occlusal views of children and adults

**Table 2: Film sizes and their applications**

Double film packets for all intra-oral film sizes are available and should be used when it is expected the radiographs will be used by others (for example, for legal or specialist consultation).

### 2.8.3 Filtration

The aluminium equivalent of the total filtration of the useful beam should not be less than 1.5 mm for the customary dental X-ray machine operating at up to 70 kV (peak).

### 2.8.4 X-ray beam diameter and focal spot-skin distance

With respect to dental X-ray machines for intra-oral radiography, the maximum dimension of the X-ray field at the open end of the beam applicator must not be more than 60 mm, and the focal spot-to-skin distance must not be less than 200 mm.

Rectangular beam collimators with dimensions equal to those of periapical films are now available. Use of these collimators in conjunction with certain film holders greatly reduces the radiation dose to the patient and they are therefore highly recommended (see Table 3).

Note: The National Health and Medical Research Council's Code of Practice for Radiation Protection in Dentistry<sup>1</sup> gives comprehensive recommendations for work practices and technical standards.



### 3 COMMUNICATION WITH PATIENTS REGARDING RADIATION DOSAGES

In illustrating to patients the magnitudes of the dosages involved in dental radiography, the numbers of days of exposure to natural environmental background radiation which are equivalent to the bone marrow dose from dental X-rays as presented in Table 3 can be quoted.

EXAMINATION	EFFECTIVE DOSE (mSv)	EQUIVALENT PERIOD OF NATURAL BACKGROUND RADIATION <sup>1</sup>
2 bitewings, 70 kV, 200 mm FSD <sup>2</sup> , rectangular collimation E-speed film	0.002	8.8 hours
2 bitewings, 70 kV, 200 mm FSD <sup>2</sup> , round collimation, E-speed film	0.004	17.5 hours
Dental panoramic, rare-earth intensifying screens	0.007	1.3 days
Dental panoramic, calcium-tungstate intensifying screens	0.014	2.6 days
Skull	0.1	2.6 weeks
Computed tomography: head	2	1 year
Chest	0.02	3.4 days
Air travel <sup>3</sup> : New York to Paris (7 hrs 25 min) Melbourne to Perth (4 hrs)	0.05 0.009	9 days 1.5 days

**Table 3: Typical doses from some dental and medical radiographic examinations as well as air travel** (After: Australian Radiation Protection and Nuclear Safety Agency: Draft Code of Practice and Safety Guide for Radiation Protection in Dentistry (in preparation)).

1. Natural background radiation is approximately 2 mSv per year in Australia

2. X-ray tube focus to skin distance

3. The radiation dose during air travel is due to increased exposure to cosmic radiation

The above quoted doses for dental radiography are small when compared with the total amount of background radiation received during the patient's lifetime of, say, 25,000 days. However, these figures are not intended to encourage 'routine' radiography<sup>8</sup> for the following reasons:

- It is assumed that there is no radiation dose threshold to induce stochastic effects (for example, cancer induction and genetic effects).
- Radiation doses are thought to be cumulative.

In determining the desirability of a radiographic examination, therefore, the following ground rule must always be applied:

*The decision to make a radiographic examination rests upon a professional judgement of the benefits which accrue to the total dental health of the patient as opposed to any biological effects which might be caused by the radiation.*<sup>1</sup>

Wall and Kendall<sup>9</sup> state that the risk of fatal malignancy amounts to 0.33 cases per million for two-bitewing examinations and 1.3 cases per million for orthopantomogram examinations. It has been shown that these figures are significantly age-dependent.<sup>10</sup> It would appear that where dental or medical indications exist (ref. Table 1), the risks resulting from not proceeding with the radiographic examination could be higher than the risk involved in taking the radiograph(s).

### 4 STATE LEGISLATION

Practitioners must be aware of the legislative requirements of the State or Territory in which they practise.

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## D17 – PROCESSING OF RADIOGRAPHS AND CAUSES OF X-RAY IMAGE IMPERFECTIONS

### 1 PROCESSING

Intra-oral film packets must be free of blood, blood components and saliva when brought into the darkroom or daylight processor. Packets made from a smooth vinyl type material can be wiped off with a suitable disinfectant. This procedure is, however, inappropriate for packets made of an uneven or paper material. In all cases, the use of special individual envelopes is preferred and highly recommended. The most frequently used film sizes can be purchased pre-packaged in barrier envelopes.

#### 1.1 Darkroom

- 1.1.1 There must be no extraneous light. Check for leaks by isolating yourself in the darkroom for at least 10 minutes.
- 1.1.2 Use the safelight illumination prescribed by the film manufacturer. The instructions should specify power of bulb, type of filter and distance from working area. Never use general purpose ruby bulbs. Films for extra-oral use require different safelights to films for intra-oral use.
- 1.1.3 Test the safelight illumination by exposing a partly unwrapped film for a period of time at least equal to that required for unpacking as many films as can be processed simultaneously and mounting them on hangers. On development, there should be no difference in density between the exposed and the covered side of the film.

#### 1.2 Developing

- 1.2.1 To avoid chemical contamination use clean utensils, benches and work areas. Ensure your fingers are absolutely clean and dry when handling films. Always handle films by the edges.
- 1.2.2 Use the solutions recommended by the film manufacturer.
- 1.2.3 Minimize oxidation of developer by using a floating lid in the tank or simply by covering the surface of the developer fluid with cling wrap.
- 1.2.4 Dispose of solutions at regular intervals. Do not wait until films come out underdeveloped. Record the date of mixing and the number of films developed. Solution quality can be checked using a standard exposure of an aluminium step wedge or other standard object.
- 1.2.5 Manufacturer's time and temperature specifications must be followed strictly.
- 1.2.6 After the prescribed developing time, rinse for about 20 seconds to prevent chemical fogging of the film and contamination of the fixing solution.

#### 1.3 Fixing

- 1.3.1 Check the quality of the fixer solution regularly. A film should be clear in two minutes (no safelight required during this test). The use of old solution will result in staining of the films.
- 1.3.2 Fix for the manufacturer's recommended time, otherwise staining may occur.

#### 1.4 Washing and drying

- 1.4.1 Films should be rinsed in *running* water for 30 minutes after completion of fixing.
- 1.4.2 Do not touch the wet emulsion surface.
- 1.4.3 Films should be dried in a dust-free area.
- 1.4.4 Films should be properly mounted and filed.

#### 1.5 Waste disposal

- 1.5.1 Contaminated waste such as barrier envelopes should be separated from other waste and discarded with other contaminated waste.
- 1.5.2 Clean solid waste such as old films and lead foil should be separated from other waste and disposed of in accordance with local council requirements.
- 1.5.3 Liquid waste such as exhausted developer and fixer should be disposed of in accordance with the regulations of the local water board (see Guide A7).

**1.6 Processing machines**

- 1.6.1 Apply the above principles to the use of processing machines.
- 1.6.2 Check frequently for light leaks, particularly in the sleeves.
- 1.6.3 Place the machine as far away as possible from the main light source. If transparent ruby daylight covers are used, they should be covered with an opaque material when processing takes place.
- 1.6.4 Meticulous maintenance of processing machines is crucial for obtaining optimum results, and the manufacturer's recommendations must be strictly followed.

**2 IMPERFECTIONS****2.1 Pale image (low density)**

- 2.1.1 Inadequate processing can cause a pale radiograph. This may be due to insufficient developing time or temperature, exhausted developer, or over fixing resulting in bleaching of the film. Inadequate processing procedures should be ruled out before measures are taken to increase the exposure.
- 2.1.2 Under-exposure resulting in low density may be due to an inaccurate timer, a wrong timer setting or a faulty switch contact.

**2.2 Dark image (high density)**

- 2.2.1 Inadequate processing resulting in a dense image is usually caused by an incorrect time-temperature relationship.
- 2.2.2 Over-exposure can also cause a dense image. There are agents which can reduce the density of over-exposed radiographs.
- 2.2.3 If the film has too high a base density (fog), then the image will be too dense and will lack contrast.

**2.3 Fog**

- 2.3.1 Age fog is caused by films used after their expiry date.
- 2.3.2 Inadequate storage conditions can result in fog. If the film is in a sealed metal foil pack, the main hazards are heat (store between 10°C and 23°C) and stray X-radiation (store in a lead-lined box).
- 2.3.3 Chemical fog is caused by inadequate darkroom procedures such as wrong time-temperature relationship and poor quality, poorly mixed or impure developer. A very small quantity of fixer spilled into the developer will gradually deteriorate the developer, resulting in an increase of the base fog and a reduced contrast of processed films. When spillage occurs, clean the tank immediately and prepare fresh developer.

**2.4 Handling artefacts**

- 2.4.1 Dark lines are usually caused by bending of the film. Under very dry atmospheric conditions rapid removal of film from its paper wrapping may cause static electricity discharges which also become visible as dark lines.
- 2.4.2 Dark stains visible on the processed film may be caused by touching the emulsion of unprocessed films with certain latex gloves. Contamination of films with some fluorides during processing may also result in black spots on films.
- 2.4.3 White spots can be caused by air bubbles clinging to the film during developing. Agitate gently during developing to prevent this. Fixer splashes prior to processing will also give white patches.
- 2.4.4 Wet film emulsion is extremely susceptible to mechanical damage. Therefore, handle films during processing with the utmost care.
- 2.4.5 Reticulation (a web-like appearance) is caused by thermal stress when the film is transferred between solutions of greatly differing temperatures.
- 2.4.6 Yellowish-green stains on newly processed films indicate that fixing has been incomplete. The cause is usually a depleted or too cold fixer solution (see 1.3.1). As these stains contain residual AgBr, they will become black after some time.
- 2.4.7 Brown stains occurring after storing films for longer periods indicate that the washing process has been incomplete. These stains are caused by oxidation of residual chemicals in the emulsion.

**FURTHER READING**

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## D18 – PROVISIONAL (TEMPORARY) RESTORATIONS

### 1 DEFINITION

A restoration placed for a limited period, from several days to several months, and sometimes one to two years. It is designed to maintain tooth integrity and position until a permanent restoration can be placed.

Provisional restorations are also used as a repair of a fractured or compromised restoration, or as a substitute restoration while a permanent restoration is being fabricated in a dental laboratory. They are also invaluable in evaluating aesthetic and occlusal changes prior to placing the final restoration.

Provisionalisation is necessary to protect the pulpodental complex from bacterial, mechanical and thermal stimuli. It stabilises the proximal and opposing teeth relationship, and also provides an acceptable function.

### 2 CHARACTERISTICS OF AN IDEAL PROVISIONAL MATERIAL

- Easy to use
- Easy repair
- Fast setting
- Low exothermic reaction
- No reaction with impression materials

### 3 CHARACTERISTICS OF A PROVISIONAL RESTORATION

- Protect hard and soft tissues (e.g., exposed dentine to prevent sensitivity)
- Stabilises the tooth
- Has a good marginal seal
- Has good aesthetics
- Has good fracture and wear resistance
- Biocompatible
- Does not affect the final restoration
- Resists chemical degradation

### 4 PROVISIONAL RESTORATIONS CAN BE CATEGORISED AS:

#### 4.1 Intracoronal Provisional Restorations

- Zinc oxide based and/or Zinc oxide non-eugenol based materials
- Glass-ionomer based
- Polycarboxylate

#### 4.2 Pre-formed Provisional Crowns

- Polycarbonate Crowns
- Metal Alloy Crowns  
(Aluminium, Anodised Aluminium, Stainless Steel, Ni-Cr)

#### 4.3 Custom-fabricated Provisional Crowns

- MMA-like products. self-cured.  
(MMA/PMMA, IBMA/PBMA, EMA/PEMA)\*
- Epimine-Imine products. self-cured.
- Bis-Acryl, Bis-Methacryl, Bis-GMA products. self-cured, dual-cured, visible light-cured.\*
- Restorative resin composite

\*The compressive strengths and flexural strengths of MMA/PMMA are less than those of the Bis-Acryl/Bis-Methacryl materials.

The most popular systems are the Bis-Acryl or Bis-Methacryl products.



## 5 INTRA-CORONAL PROVISIONAL MATERIAL

The contamination of cavity surfaces by temporary cements (with or without eugenol) has been shown to affect the subsequent bonding procedures of the final restoration.<sup>1</sup> It is therefore imperative that all remnants of the cement are removed. This is often more difficult with the intra-coronal preparations, because of access, than the extra-coronal preparations.

## 6 EXTRA-CORONAL PROVISIONAL MATERIAL FOR CROWN AND BRIDGES

- Polymethyl methacrylate (PMMA) is strong, has good wear resistance, and good aesthetics. However it has disadvantages:
  - o Polymerisation shrinkage can affect fit
  - o Polymerisation exotherm could damage the pulp
  - o Free monomer may cause pulp and tissue damage
- Polyethyl methacrylate (PEMA) shrinks less than PMMA. There is also less heat release. However aesthetics are not as good as PMMA.
- Bis-Acryl Composites produce less heat and shrinkage than PMMA and Polyethyl methacrylate, and therefore give a better marginal fit. The material is brittle, and difficult to add to. There is a Bis-Acryl temporary crown material that is mouldable in its uncured state, and can be adapted to the tooth preparation margins and proximal contacts prior to curing.

Polymerisation shrinkage occurs after fabrication, with the amount of shrinkage depending upon the material used. The dimensional changes will affect the fit of the temporary restoration. The discrepancies in fit may not give the protection that is required. A recent study<sup>2</sup> suggests that Monomethacrylates were associated with smaller discrepancies than Dimethacrylates. Most of the shrinkage occurs in the first 30 minutes after fabrication, so trimming of the fitting surface of the crown should be delayed until this time has passed.

## 7 INTERIM AND TEMPORARY RESTORATION IN ENDODONTIC TREATMENT

The aim of the interim and temporary restoration is to prevent the ingress of bacteria during and after treatment,<sup>3</sup> until a permanent restoration can be placed.

There are two terms used for the materials:

- Interim restoration: This is the restoration placed after the caries or fracture of the previous restoration has been eliminated. This restoration remains in place until the end of endodontic treatment.
- Temporary/Provisional restoration: This is the restoration placed within the access cavity. The most common materials used in this situation are Cavit, IRM, GIC and RMGIC. They are often used in a double seal technique with combinations of the above materials.

## 8 CONCLUSION

The provision of quality Provisional Restorations is necessary for predictable results. There is a large range of materials and techniques for short term, medium term and long term temporisation. Treatment planning for temporisation is also essential, in that the correct material should be used to give optimum results.

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## E GUIDES – PRACTICAL GUIDES TO LABORATORY MATERIALS

- E1 Porcelain
- E2 Porcelain laminate veneers
- E3 Porcelain fused to metal
- E4 Plaster, stone and diestone
- E5 Wax patterns / waxes for other purposes
- E6 Investing and casting of dental crown and bridge alloys
- E7 Investing, casting and finishing of base metal partial dentures
- E8 Avoidance of casting defects
- E9 Acrylic denture base and repair resins
- E10 Resilient liners and tissue conditioners
- E11 Soldering



## E1 – PORCELAIN

### 1 CONVENTIONAL DENTAL PORCELAIN

#### 1.1 Dies

- 1.1.1 Use a diestone in order to obtain the most dimensionally accurate dies.
- 1.1.2 Electroformed dies offer the hardest surface, but they are usually not as accurate as those made from a diestone.
- 1.1.3 Soaking the dies in water after separating into sections will help to eliminate brittle chipping when trimming the margins.

#### 1.2 Matrix for porcelain build up

- 1.2.1 Porcelain can be built up in layers on a single or twin platinum foil matrix, or on a refractory die.
- 1.2.2 Undercuts should be blocked out with a material such as cyanoacrylate gel or an acrylic resin prior to foil adaptation in order to avoid distortion of the foil on removal.
- 1.2.3 Maximum accuracy must be obtained when adapting the platinum matrix, and the foil should not move on the die. Precision is essential in the final burnishing of the foil because residual faults will be reproduced in the crown.
- 1.2.4 Anneal the foil prior to porcelain build up in order to help burn out remaining debris that may cause bubbling in the porcelain.
- 1.2.5 Refractory die material may be poured under vibration directly into vinyl polysiloxane or polyether impression.
- 1.2.6 The casting should not be left in the mould for longer than recommended by the manufacturer because the material changes with time.
- 1.2.7 Firing the refractory die before applying porcelain will eliminate gases and help to stabilize the die.
- 1.2.8 Thoroughly soak the die in the recommended conditioning solution before porcelain application. Saturating the die material prevents it from drawing moisture from the porcelain and also colours the die, which allows the thickness of the porcelain to be estimated.

#### 1.3 Mixing and building the porcelain

- 1.3.1 Do not use metal instruments for mixing. Mix porcelain powder with binder on a clean glass slab using a clean glass mixing rod.
- 1.3.2 The mix should be creamy and capable of being transferred in small amounts without excessive flow. Do not over-stir as this can incorporate air bubbles. Gentle tapping on a hard surface can help to eliminate entrapped air bubbles.
- 1.3.3 Avoid drying out during condensation as this can cause the condensed powder to crack. Do not build porcelain at high room temperature.
- 1.3.4 Avoid air spaces in the powder bed as these will resist the flow of binder liquid and the mix will not condense easily.
- 1.3.5 Use high quality brushes to apply and condense the porcelain. Wash the brush frequently in distilled water to cleanse the bristles and maintain a fine point.
- 1.3.6 Do not over-vibrate – this causes slumping of the porcelain. Absorb excess binder liquid with lint-free gauze.

#### 1.4 Firing

- 1.4.1 Dry the 'green' crown slowly to eliminate all water vapour or binder liquid before the porcelain enters the hot zone of the furnace otherwise cracking may occur.
- 1.4.2 A rapid firing cycle should not be used as it may cause the surface skin to seal before internal pores (air spaces) are eliminated.
- 1.4.3 Do not prolong vacuum-firing at maturing temperature otherwise the porcelain may blister or 'bloat' due to internal porosity.

- 1.4.4 Break the vacuum while the crown is in the hot zone of the furnace. The dense surface skin will then hydraulically compress any residual air bubbles left in the ceramic.
- 1.4.5 Vacuum-firing will not remove large air bubbles left by faulty condensation.
- 1.4.6 Maximum translucency will be maintained with fewer bakes.
- 1.4.7 For aluminous core porcelain, higher strength will be obtained by firing in normal atmosphere once the maturing temperature is reached. Air-firing at 1100°C for 15–20 minutes produces the best result.

## 1.5 Glazing

- 1.5.1 Do not glaze under vacuum.
- 1.5.2 Pre-heat the crown in the muffle entrance in order to avoid thermal shock.
- 1.5.3 High glazing temperatures may cause slumping or porcelain, obliteration of fine detail and colour loss.

## 1.6 Intra-oral repair

- 1.6.1 Minor fractures can be replaced temporarily using a proprietary porcelain repair kit.
- 1.6.2 Mechanical retention may be essential for long-term success.
- 1.6.3 Great care must be taken to avoid contact with soft tissues if a porcelain etching agent such as hydrofluoric acid gel is used in the mouth. Rubber dam must be used.

## 2 OTHER CERAMIC SYSTEMS

There are numerous ceramic systems available with applications including all ceramic crowns, anterior and posterior, ceramic bridges, and bonded ceramic restorations such as veneers, inlays and onlays. Broadly, these systems fall into the following categories:

- Castable glass ceramics
- Press formed ceramics
- High purity alumina and zirconia ceramics

Many of these commercial systems have specific instructions for both fabrication of restorations and clinical usage of the material. Particularly in the case of bonded ceramic restorations such as veneers, inlays and onlays, cementation materials and surface treatment protocols vary depending on the ceramic substrate to be bonded. For detailed instruction it is essential to refer to the manufacturer's technical manual.

## E2 – PORCELAIN LAMINATE VENEERS

The fabrication and provision of porcelain laminate veneers is highly technique-sensitive and close liaison between the dentist and the dental technician is needed.

### 1 PREPARATION OF FITTING SURFACE

- 1.1 The recommendations made in Guide E1 also pertain to porcelain laminate veneers. However, correct preparation of the fitting surfaces is essential for long-term retention.
- 1.2 Fitting surfaces must be roughened by etching in order to obtain the strongest possible bond. The bond strength of the porcelain laminate veneer to the enamel surface depends upon the degree of etch of the fitting surface of the veneer. This in turn depends on the etchant exposure time. The etch will give more opacity to the porcelain laminate veneer, which is useful when the tooth to be veneered has deep discolouration.
- 1.3 The porcelain must be thoroughly washed to remove all traces of etchant and abrasion grit. Use high purity solvents to avoid surface residues on drying.
- 1.4 When using a resin-based luting agent, apply a silane coupling agent to the clean and dry fitting surfaces in order to obtain the strongest possible bond. If a chemical silane (not heat-cured) is used, do not use alcohol or acetone to clean the silanated surface because this will adversely affect the bond strength.
- 1.5 When trying-in the restoration for clinical evaluation, the restoration should be either:
  - Non-etched and non-silanated. In this case try-in paste can be used, and subsequently the restoration returned to the laboratory for etching and silane application prior to cementation; or
  - Etched and silanated. Once try-in is complete the try-in paste can be removed, the restoration cleaned (with acetone or alcohol), a silane coupling agent then reapplied, and then cementation can proceed.



## E3 – PORCELAIN FUSED TO METAL

- 1 Aim for a clean, homogeneous casting. Tapered sprues should be attached so they fan out from a central reservoir, allowing an uninterrupted flow of metal.
- 2 Use at least 50 per cent new metal for every casting. The casting process causes depletion of the base metal components involved in bonding.
- 3 Gas evolution can result in porous castings – do not veneer or reuse these porous castings.
- 4 Clean the casting by blasting with 50 µm aluminium oxide grit. Clean with a solvent such as acetone or alcohol before applying the opaque. High purity solvents should be used, otherwise surface residues will be left on drying.
- 5 Do not finish gold alloys with organic-bonded stones or rubber wheels which may contaminate the surface. Ceramic-bonded, tungsten carbide or clean diamond stones should be used.
- 6 Mechanical retention of porcelain is aided by high pressure air-blasting with 25–70 µm aluminium oxide grit. Ensure surface contours are not significantly altered or regions of stress concentration created (for example, sharp corners).
- 7 Chemical etching of the surface of the casting with strong acids immediately prior to porcelain application is highly undesirable, as oxides and base metal components which contribute to the bonding may be removed. Ultrasonic cleaning in distilled water for 5–10 minutes is usually sufficient.
- 8 Take care not to contaminate the casting with the fingers or grease, wax, detergents, etc.
- 9 Use rapid firing cycles when firing the opaque to prevent the formation of a thick oxide layer. Use black ceramic firing trays to speed thermal conductivity.
- 10 Use the minimal number of bakes of dentine and enamel porcelain to minimize the risk of chromium ions, if present, in the alloy reaching the interfacial porcelain to form chromium oxide. Repeated firing can often cause shade changes.
- 11 Repeated firing cycles, low firing temperatures and an insufficiently rapid cooling rate may raise the coefficient of thermal expansion of the porcelain to a point where cracking occurs.





## E4 – PLASTER, STONE AND DIESTONE

### 1 STORAGE AND USAGE

- 1.1 Store in moisture-proof resealable containers in a dry place. Reseal container immediately after use.
- 1.2 Purchase a product with the desired setting time.
- 1.3 When an abrasion resistant surface is required, use a diestone.
- 1.4 For all working casts, use a dental stone.
- 1.5 Use a plaster-stone mix for denture flasking. For a given consistency, the strength is reduced in proportion to the amount of plaster in the mix and vice versa.
- 1.6 Properties may deteriorate significantly after the use-by date.

### 2 MIXING

- 2.1 Use the correct water:powder ratio. Weigh the powder. Weigh or use a measuring cylinder for the water.
- 2.2 The less water required for mixing, the greater the strength. The water:powder ratios by mass are usually in the ranges: 0.45–0.55 for plaster; 0.30–0.35 for stone; and 0.20–0.26 for diestone. The compressive strengths of plaster, stone and diestone are roughly in the ratio 1:2:3.
- 2.3 A thinly mixed stone will be weaker than a thickly mixed plaster, since the strengths are dependent on the water:powder ratio.
- 2.4 Do not use excessively thick mixes as these may not adequately reproduce detail and will give greater expansion.
- 2.5 Spatulate so that air is not incorporated. Sift the powder into the water, vibrating the bowl gently.
- 2.6 Remove air from the mix using vibration and vacuum mixing.
- 2.7 Mechanical spatulation gives more consistent results than hand mixing. Specify the amount of mixing and use consistently.

### 3 MAKING THE MODEL

- 3.1 See Guide D10 for previous treatment of the impression, which should be clean and free from excess water.
- 3.2 Flow model material progressively into the impression with moderate vibration in order to avoid entrapment of air.
- 3.3 Be careful not to distort the impression during pouring of the model. Fill the impression and support it by the tray only. Do not invert. Add the base when set.
- 3.4 Certain hydrocolloid impression materials are incompatible with some gypsum products, resulting in a powdery model surface. The best solution is to change one of the materials. Alternatively, soak impression in 2%  $K_2SO_4$  solution for five minutes and then remove excess solution.
- 3.5 Set plaster and stone are slightly soluble in water. Do not use excess hot water for wax elimination. Prolonged treatment with water will cause erosion. Soak dry models in water saturated with powdered gypsum from the model trimmer.
- 3.6 Borax solution hardens the surface of plaster but not of stone.
- 3.7 Gypsum models dried below 45°C have a greatly increased strength. Higher temperatures adversely affect the strength.
- 3.8 Plaster and stone are brittle materials. Sudden knocks may cause chipping or fracture. If dry models come into contact with hot water, cracking may result.
- 3.9 Diestone models can be steam-sterilized with some loss of strength.



## E5 – WAX PATTERNS / WAXES FOR OTHER PURPOSES

### 1 SOFTENING

- 1.1 Select a wax with the appropriate softening range: Type 1 (soft) for indirect patterns (approximate softening range 30–40°C); Type 2 (hard) for direct patterns (approximate softening range 40–45°C). While the choice is not critical, Type 2 waxes are preferred for direct pattern taking in the mouth because of a flow requirement of less than 1 per cent at 37°C, but this is now a relatively uncommon procedure in modern restorative dentistry.
- 1.2 Heat the wax uniformly and slowly. Variations in temperature within the wax during manipulation will cause distortion of the pattern. Use of a wax annealing oven or bath at 40°C is recommended prior to heating above the flame.
- 1.3 Do not pass the wax through the flame. Hold the wax above the visible flame for uniform heating and never allow the wax to run.

### 2 PATTERN PREPARATION

- 2.1 Keep a steady pressure on the wax until it is firm – this will minimize inaccuracies due to contraction during hardening. Apply pressure for one to two minutes.
- 2.2 Limit subsequent melting and additions – this causes areas of residual stress in the wax which may lead to distortion.
- 2.3 Eliminate residual stress by placing in water at 37°C for five minutes and then correct the margins if necessary.
- 2.4 Do not rapidly chill the pattern before removal as this may cause distortion. Slow cooling is best.
- 2.5 Polish the surface of the pattern by rubbing towards the margins with, for example, cotton wool moistened with cold, soapy water.

### 3 SPRUING

- 3.1 The number, size and position of the sprues must be chosen to ensure the smooth passage of the alloy and elimination of porosity during casting.
- 3.2 Wax sprues are preferred to prevent damage to investment.
- 3.3 Where metal sprues are used, tubular sprues give better adhesion to the pattern and less wax distortion than solid sprues since they hold less heat.
- 3.4 Synthetic resin sprues with a higher melting or ignition temperature than the wax can block the sprue hole and drive the wax into the investment during burnout.
- 3.5 Coat metal or plastic sprues with wax for easy withdrawal and removal before burnout.
- 3.6 Use sprues ranging from 2.5–3 mm diameter.
- 3.7 Use a sprue with an effective length of about 6 mm. The thickness of the investment above the top of the pattern should be 6–10 mm to give adequate strength while still allowing passage of air from the mould during casting. For large and intricate patterns, vents to within this distance may be required.
- 3.8 Attach the sprue at the thickest section. Metal may solidify while passing through restricted areas and prevent filling of the mould.
- 3.9 Use a reservoir up to 2 mm from the pattern with sprues thinner than the section of the casting to which they are attached in order to minimize or prevent shrinkage porosity in the casting.
- 3.10 Multiple sprues are necessary for large patterns. Thick sections separated by thin sections should be individually sprued. Follow the alloy manufacturer's instructions.
- 3.11 Select a crucible former with a shape which allows a smooth flow of metal into the mould.

## 4 PRECAUTIONS

- 4.1 Wax patterns have a high coefficient of thermal expansion. Significant contraction takes place in a wax pattern on cooling from mouth temperature to room temperature.
- 4.2 Wax patterns distort by release of residual stress. Place indirect patterns in water at 37°C for five minutes and check for distortion prior to investing.
- 4.3 Invest direct wax patterns immediately. If this is not possible, store in a cool place such as a refrigerator (not in the freezer compartment). Allow pattern to return to room temperature before investing.

## 5 OTHER WAXES

Apart from their use for casting of crowns and bridges, waxes find considerable use both in the clinic and the dental laboratory. Uses include registration of jaw relations (including some waxes which are loaded with copper or aluminium particles), additions to impression trays, and wax patterns for trial dentures. For the successful handling of these waxes a number of general principles need to be observed.

- Dental waxes tend to soften or melt at between 45 and 50°C.
- Waxes usually solidify at or above mouth temperature but may be plastic enough that, if care is not taken, distortion can occur during manipulation and removal from the mouth.
- Trial dentures should not be left in the patient's mouth for extended periods as warpage may occur and artificial teeth may be dislodged.
- After removal from the mouth, waxes should be washed in running cold water, sanitised and stored in cold water until needed in the dental laboratory.
- Waxes have a high coefficient of thermal expansion, so dimensional changes are to be expected as they cool from mouth to room temperature.
- Waxes for casting patterns are formulated to burn out of casting investments leaving no residue other than carbon, while laboratory or modelling waxes are formulated so that they can be completely eliminated from gypsum moulds when flushed with near boiling water.

## E6 – INVESTING AND CASTING OF DENTAL CROWN AND BRIDGE ALLOYS

### 1 SELECTION OF MATERIALS

#### 1.1 Investment

- 1.1.1 Use thermal, hygroscopic or rapid burnout techniques according to personal preferences.
- 1.1.2 Use phosphate-bonded investments for alloys with melting temperatures above 1080°C. Do not use gypsum-bonded investments with high fusing alloys.
- 1.1.3 All alloys may be cast in phosphate-bonded investments.
- 1.1.4 Investments for rapid burnout techniques may be used. Compliance with manufacturer's instructions is crucial for successful casting.

### 2 INVESTING THE PATTERN

- 2.1 Clean the pattern and paint with a wetting agent, removing any excess. Use the correct wetting agent for vacuum investing.
- 2.2 Line the casting ring with a dry liner about 1 mm thick and immerse in water, allowing excess to drain off. Do not compress the wet liner.
- 2.3 Exact proportioning of powder and liquid is essential. Weigh the powder and measure the liquid by volume.
- 2.4 Paint the pattern with investment, using a fine brush. To avoid entrapment of air bubbles, use mild vibration. Do not dust with dry powder. The painted pattern must not dry out before the ring is filled and investing completed.
- 2.5 Vacuum investing and mechanical spatulation equipment will give more uniform results with improved surface quality. Ensure the liner is fully wet otherwise it will absorb liquid under the vacuum, thus altering the powder:liquid ratio.
- 2.6 Pressure investing allows investment to set under pressure, eliminating bubbles and producing a good surface finish. Follow investment manufacturer's recommendations for the duration of this treatment as excessive time may reduce setting expansion.
- 2.7 Hygroscopic expansion may cause distortion with some complex patterns because variations in cross-section may cause local variations in expansion.

### 3 HEATING THE MOULD

- 3.1 Use a furnace fitted with a pyrometer and check the pyrometer annually.
- 3.2 The investment must be wet at the commencement of burnout because the steam prevents molten wax from penetrating the investment. Heat with the sprue facing down to allow wax to escape.
- 3.3 Allow the investment to expand and build up strength by waiting at least one hour after setting before heating. Use a constant time interval between investing and commencing heating. Mould expansion may vary with this interval.
- 3.4 Place the mould in the cold furnace sprue down and heat to the middle of the manufacturer's recommended range. Overheating may lead to decomposition of the investment and a defective casting.
- 3.5 Do not heat (except for 3.9) the mould too quickly otherwise spalling or cracking may occur.
- 3.6 Ensure good furnace ventilation during the early stages of burnout to prevent buildup of flammable or noxious fumes.
- 3.7 Use the manufacturer's recommended heating rates and mould temperatures.
- 3.8 Approximate mould temperatures and heating rates are:
  - Thermal expansion techniques: heat cristobalite investment to 250°C, hold for 30 minutes, heat to 550–650°C over 60 minutes, hold for 30–60 minutes; heat quartz investment to 600–700°C over 60–90 minutes, hold for 30–60 minutes.

- Hygroscopic techniques: heat to 500–550°C, hold for 1–2 hours.
  - Phosphate-bonded investments: heat slowly to 200–250°C, hold for 30–60 minutes, raise to 950–1000°C, hold for 30–60 minutes. Allow extra time for large rings and extra rings in the furnace.
- 3.9 Special investments are available allowing rapid heating by placement of the mould in a hot furnace.

#### **4 MELTING AND CASTING**

- 4.1 Methods that heat the mould and melt the alloy separately are preferred.
- 4.2 Do not mix alloys. Add new metal to each melt. Melting degrades alloy, and new metal reduces this effect. Addition of 50 per cent new metal is recommended. Buttons, sprues and recasts should be thoroughly cleaned before re-melting.
- 4.3 For torch melting, use the pale blue (reducing) zone in a gas flame to cover the alloy. The pale blue zone surrounds the bright blue central zone.
- 4.4 Induction melting is the preferred method.
- 4.5 Sprinkle a little flux on the alloy at red heat just before casting. Do not use borax or boracic acid. With all forms of melting, avoid prolonged heating and overheating.
- 4.6 Allow the mould to bench-cool until the button turns black when observed in subdued light, then quench in water to disintegrate the investment.

#### **5 PICKLING AND CLEANING**

- 5.1 Alloys cast in gypsum-bonded investments can be pickled.
- 5.2 With gold alloys, use 50 per cent hydrochloric acid or 10 per cent sulphuric acid in water. *Always add acid to water.* Other alloys should be sandblasted.
- 5.3 Renew pickling solution frequently as it will become contaminated with use.
- 5.4 Pickling should be carried out in a fume cabinet or a well-ventilated room.
- 5.5 Do not heat the casting and drop into acid. Place the casting in a porcelain pickling dish, add acid to cover, replace lid and heat. Wash the casting when free from oxide. Use only fresh solutions and do not handle castings in acid with metallic instruments.
- 5.6 Alloys cast in phosphate-bonded investments can only be cleaned by sandblasting. When sandblasting grit is used for alloys, do not reuse for fused ceramic.
- 5.7 To avoid excessive removal of metal, use only equipment and the abrasives recommended. To avoid damage, protect fine margins when sandblasting.
- 5.8 When grinding, polishing or sandblasting, protect the eyes and use air extraction to prevent inhalation of dust and particles.
- 5.9 Hydrofluoric acid may be necessary for alloys for fused ceramics. Use the following precautions with hydrofluoric acid and its fumes:
- use a well-ventilated fume cupboard;
  - do not heat the acid;
  - wear eye protection and protective gloves;
  - use only plastics containers and instruments and if any part of the body comes into contact with hydrofluoric acid, wash immediately under running water (washing alone may not stop the action of the acid and an injection of calcium gluconate may be required).

Burns caused by this acid require special treatment at your nearest casualty department. Alternatively, less active products are available.

## E7 – INVESTING, CASTING AND FINISHING OF BASE METAL PARTIAL DENTURES

### 1 DUPLICATING

- 1.1 Use duplicating flasks which provide an even thickness of material around the cast.
- 1.2 To control the effect of shrinkage, pour duplicating material at the recommended temperature and cool the flask from the base.
- 1.3 To avoid permanent distortion of the duplicating material, remove the cast with a controlled rapid movement.
- 1.4 To avoid dimensional change, pour cast immediately.
- 1.5 For the best cast surface using phosphate-bonded investments, ensure the surface of the duplicating material is free from excess moisture. For gypsum-bonded investments, treat the surface of the duplicating material with an accelerator (for example 2 per cent potassium sulphate solution).

### 2 INVESTING THE PATTERN

- 2.1 Avoid contamination of base metals by correct burnout procedures. Carbon-free investments are recommended.
- 2.2 For gypsum- and phosphate-bonded investments, see Guide E5.
- 2.3 Silica-bonded investment solutions must be fresh and kept in a refrigerator. Discard when thickening is apparent.
- 2.4 For silica-bonded investments, provide overfill space on the ring using an extended liner. After filling, vibrate gently until gelled and then grind off overfill to remove impermeable gel skin.
- 2.5 Provide vents in silica-bonded investments to allow air to escape during casting.

### 3 HEATING THE MOULD

- 3.1 Use a furnace fitted with a pyrometer and check the pyrometer annually.
- 3.2 Heat the investment slowly to 200–250°C and hold for 30 minutes. Then raise to the recommended temperature, taking about one hour and holding for at least 30 minutes before casting.
- 3.3 Ensure good ventilation of the furnace environment during the early stages of burnout, in order to prevent buildup of flammable or noxious fumes.

### 4 MELTING AND CASTING

- 4.1 Do not overheat the metal.
- 4.2 Avoid contamination by carbon. If using oxyacetylene, ensure the torch is correctly adjusted. The crucible must be carbon-free.
- 4.3 If re-melting is recommended, use at least 50 per cent new alloy in each melt. Ensure used metal is thoroughly cleaned before recasting. Do not use scrap or alloy of unknown origin.
- 4.4 Place the hot mould in the casting machine when the metal is almost molten and cast as soon as ready.
- 4.5 Cool the mould slowly in air with the button down and do not quench since this may cause distortion and have an adverse effect on the properties of the alloy.
- 4.6 Use effective fume extraction when melting.



## **5 CLEANING AND FINISHING**

- 5.1 Sandblasting is necessary for effective removal of oxide investment coatings, using special grit.
- 5.2 When grinding or polishing, protect the eyes and use suction to prevent inhalation of dust and particles.
- 5.3 Electropolishing may be carried out to improve surface finish after polishing.
- 5.4 Beryllium is toxic and great care is necessary when melting or grinding beryllium-containing alloys in the dental laboratory. When an alloy contains beryllium, it should be so indicated on the label.
- 5.5 All fumes, dusts and particles are potentially dangerous, and efficient air extraction should be used at all times. Dust should be captured and not released into the atmosphere.

## E8 – AVOIDANCE OF CASTING DEFECTS

### 1 ROUGH CASTING SURFACES

- 1.1 Do not overheat the mould or the alloy or hold at temperature for longer than necessary otherwise the investment may break down.
- 1.2 Use an investment which produces a good surface finish.
- 1.3 Use a wetting agent on the pattern and vacuum invest or set under air pressure of 500 kPa (five times atmospheric) to eliminate air bubbles.
- 1.4 Avoid using excess wetting agent on the pattern as it weakens the surface of the investment.
- 1.5 Due to bubbling, some wetting agents are not suitable for vacuum investing.
- 1.6 The use of excessive casting force can damage the investment surface.

### 2 FINS ON CASTINGS

- 2.1 Fins on castings are caused by cracking of the investment.
- 2.2 Avoid building up the mould from two or more mixes with different powder:liquid ratios since they may have different coefficients of thermal expansion.
- 2.3 Do not heat the mould too rapidly (refer to the manufacturer's instructions), especially cristobalite investments.
- 2.4 Use a metal retaining ring around the investment where fins are a problem.

### 3 POROSITY

- 3.1 Irregular voids near the junction of the sprues and casting (shrinkage porosity) may arise from shrinkage of the alloy on cooling. This can be prevented by using thicker sprues attached to the bulkiest sections and by siting reservoirs close to the pattern.
- 3.2 Irregular voids in the surface of the casting may be caused by breakdown of the investment. Fragments of investment may be incorporated and may obstruct the flow of metal.
- 3.3 Spherical voids caused by dissolved gas evolution on solidification will occur to a greater extent if the alloy is overheated or heated for a prolonged period.
- 3.4 Back pressure porosity is caused by incomplete escape of air from the mould. Position the pattern 6–10 mm from the end of the ring or provide a vent on the casting next to the sprue.
- 3.5 Microporosity throughout the entire casting may arise if the temperature of the investment is too low or if the alloy has not been heated sufficiently. This is because solidification occurs too rapidly to allow progressive shrinkage.
- 3.6 Porosity just below the casting surface is thought to be caused by overheating the mould or the alloy. This may cause solidification to occur at the borders while the main bulk remains molten. Subsequently, there is a contraction toward the centre, causing voids just below the previously hardened surface.
- 3.7 Gas entrapment may occur as a result of turbulence due to poor sprue design or position, or excessive casting force.

### 4 CRACKING

Hot cracking may occur where excessive alloy and/or mould temperatures are used, or alloy is burnt or contaminated.

### 5 INCOMPLETE CASTINGS

- 5.1 Ensure the mould is heated to the correct temperature. A mould which is not hot enough will cause solidification before the metal has flowed to all parts of the cavity.
- 5.2 Ensure the metal is quickly heated to the correct casting temperature. Low

temperatures will cause rounded margins or miscasts and burnt metal will produce rough surfaces.

- 5.3 Ensure the ring is heated long enough to burn out residual carbon, as this can reduce the permeability of the mould. The removal of carbon is slow at the mould temperature recommended in hygroscopic expansion techniques (500°C), and heat soaking for at least one hour is desirable (see 3.4).
- 5.4 Too low a casting force or back pressure in the mould (see 3.4) will give an incomplete cast.
- 5.5 Prevent back pressure porosity by adding a vent to the casting next to the sprue.

## **6 POOR FIT OF CASTINGS**

- 6.1 Minimize distortion of the wax pattern by keeping it cool, taking care when removing it from the model, investing it as soon as possible, and placing it in a central position in the casting ring.
- 6.2 Ensure there is adequate lining material to allow mould expansion. Two layers may be necessary in some cases.
- 6.3 The expansion and contraction during fabrication must balance. Use a matched system. In particular, the expansion of the investment should accurately balance the shrinkage of the alloy on cooling. Ensure the investment is heated to the correct temperature.

## E9 – ACRYLIC DENTURE BASE AND REPAIR RESINS

### 1 MIXING

- 1.1 Use the correct powder:liquid ratio. Dispense the appropriate quantity of liquid into a mixing jar, then add the measured quantity of powder, gently tapping the jar to achieve saturation. Stir the mix thoroughly to blend the pigments.
- 1.2 Keep the mixing jar closed to reduce evaporation of monomer and prevent contamination. Do not add more powder when the surface again becomes wet.
- 1.3 Do not use thin mixes to increase working time, as excessive shrinkage and porosity may result. Cooling the mixing jar will extend the working time.
- 1.4 Modern rapid-cure resins tend to have extended working times.
- 1.5 Warmth will accelerate doughing time, but will also shorten the time the dough remains suitable for packing and may prevent satisfactory closure of the flask.

### 2 PACKING

- 2.1 Use a 50:50 stone and plaster mix for flasking, to provide sufficient strength while enabling the processed denture to be removed without damage.
- 2.2 **Separating agents**
  - 2.2.1 Plaster to plaster: sodium alginate solution or some soap solutions.
  - 2.2.2 Plaster to acrylic: sodium alginate solution (for best results with clear acrylic use tin foil).
- 2.3 Thoroughly clean the surfaces of the teeth to ensure good retention with porcelain and bonding of acrylic teeth to the denture base. All traces of wax must be removed by thoroughly flushing with clean, near-boiling water preferably containing a detergent.
- 2.4 Avoid contaminating the dough during kneading. Natural oil from tile fingers can adversely affect the properties. Use clean hands and hold between polyethylene sheets.
- 2.5 Pack the dough when it separates cleanly from the sides of the mixing jar.
- 2.6 During trial packing, close the flask slowly with moderate force, with a polyethylene sheet in place as a separator, to allow the dough to flow within the mould. Rapid closure will build up excessive pressure and may cause fracture of the mould and tooth movement.
- 2.7 If additional resin is required after trial packing ensure it is at the correct packing stage. At final closure, discard the polyethylene separating film. Before processing, the two parts of the flask must be in metal to metal contact.

### 3 PROCESSING

- 3.1 Acceptable methods of heat curing in water are:
  - heat the flask to 70°C and hold at that temperature for a minimum of eight hours (low temperature processing); or
  - heat the flask to 70°C for 90 minutes then place the flask in boiling water for 30 minutes.If the appliance has thick sections, it should be heated from cold to 70°C over a period of one hour followed by one of the above methods.
- 3.2 New rapid curing resins can be processed by placing the flasks in boiling water for 20–30 minutes. However, if there are thick sections in the appliance being made, it is safer to place the flasks in water at 70°C for 30 minutes and then into boiling water for a further 20–30 minutes.
- 3.3 Low-temperature processing is preferred in order to minimize the risk of porosity in the resin, excessive residual stress and unacceptable dimensional change.
- 3.4 Cool the flask slowly after processing. Allow to cool to room temperature preferably in

the water bath or on the bench before opening. Fast cooling or opening before fully cooled may cause warpage.

- 3.5 Self-curing (cold processing) resins can be used for full dentures but the hardened resin is more flexible and not as strong as heat-cured resins. Porosity and colour stability may be problems.

#### **4 REPAIRS**

- 4.1 Determine and correct the cause of failure if the denture has fractured during function.
- 4.2 Dentures should be kept in water while awaiting repair to minimize distortion and crazing during repair procedures.
- 4.3 Use a cold-cure resin to minimize warpage.
- 4.4 Process in a water pressure vessel to minimize porosity. Allow at least five minutes at 40°C under the appropriate pressure (200–300 kPa).
- 4.5 Careful preparation of the repair area is essential. Prepare the joints with a medium taper and smooth but not highly polished rounded edges. Sharp edges give rise to stress concentrations and possible refracture. Allow a minimum gap of 2 mm between the prepared edges.
- 4.6 Absolute cleanliness is vital for effective bonding. Eliminate any traces of wax by using near-boiling water containing a detergent. Paint the prepared edges sparingly with monomer immediately prior to packing.
- 4.7 Crazing is caused by the relief of stress after the application of a solvent such as methyl methacrylate. Stress may be present as a result of large temperature changes, inserts (porcelain teeth, clasps) or drying.
- 4.8 Restrict the application of repair resin and monomer to the repair area, to avoid crazing.

#### **5 FINISHING AND STERILIZING**

- 5.1 Use wet grinding and polishing to prevent overheating. Make up slurries of pumice and polishing agents with water or dilute non-phenolic disinfectant solution. Local overheating can cause burning of the surface and warpage.
- 5.2 Store the denture in water at all stages of the preparation and until insertion in the mouth. A dilute solution of mild disinfectant may be used. Acrylic resins may be safely sterilized in Milton's solution diluted 1:1 with water. A minimum 10 minutes soaking is required.
- 5.3 Work in well-ventilated areas and wear eye protection.

#### **6 OTHER TECHNIQUES**

##### **6.1 Microwave processing**

- 6.1.1 Acrylic resins can be processed using microwave energy, and although some products have been developed for this purpose, normal heat cured resins can be used.
- 6.1.2 Never use standard metal flasks and clamps if microwave processing is to be employed. Polyester flasks and polycarbonate bolts and nuts are made for use in this procedure. However, it may be safe to process partial dentures onto metal frameworks or clasps, providing none of the metal is exposed from within the investing gypsum.
- 6.1.3 Except for the plastics flasks, standard flasking, boil out and packing procedures are used, but the polycarbonate bolts and nuts should be tightened while the flask is under pressure in a standard bench clamp. Tightening the nuts when the flask is not in the bench clamp will probably result in shearing of the bolt.
- 6.1.4 Processing time will depend on the power of the microwave unit and the number of flasks placed in the microwave oven. Refer to the guidelines provided by the flask manufacturer for suggested times and energy levels (often 5–10 minutes at 500 watts). Some experimenting may be needed to find the best conditions for complete processing. Longer times are not harmful.
- 6.1.5 Always let the flask cool completely to room temperature before deflasking the processed denture.

**6.2 Injection moulding**

- 6.2.1 Injection moulding procedures are available but, because of the cost of the moulding equipment, such processing is usually restricted to commercial dental laboratories.
- 6.2.2 It is claimed that dentures produced by injection moulding techniques fit more accurately, but this may only be anecdotal rather than being scientifically evaluated.



## E10 – RESILIENT LINERS AND TISSUE CONDITIONERS

### 1 RESILIENT LINERS

- 1.1 Resilient (soft) liners are elastomeric materials used on the fitting surfaces of dentures. Current materials are either silicone elastomers, plasticized higher methacrylate polymers or hydrophilic polymethacrylates.
- 1.2 Indications for use are sharp or irregular ridges, bilateral undercut tuberosities and tissue defects, particularly when the overlying mucosa is thin and non-resilient.
- 1.3 Before resorting to the use of soft liners, evaluate all possible alternatives to overcome the prosthetic problems; for example, surgical modification of the supporting bony structures, polishing the surface of a conventional rigid base etc.
- 1.4 Laboratory-processed products are preferable to mouth-processed products.
- 1.5 Most products can be processed with the original denture base or added subsequently. Secure attachment of silicone liners is more difficult to achieve than for other types and these materials are best processed with the original denture.
- 1.6 Use a 2–3 mm thickness of resilient liner and finish to a butt joint between hard and soft materials; avoid feather edging.
- 1.7 Care must be taken when substituting hard denture base material with a resilient liner that the rigid denture base is not reduced in cross-section to such an extent as to predispose to fracture of the denture.
- 1.8 Review the patient regularly for deterioration of the liner. All resilient liners have a limited life and may harden, lose attachment, support fungal growth or develop calculus deposits.
- 1.9 Exposure to strong oxygenating denture cleansers may result in the rapid deterioration of some resilient liners.

### 2 TISSUE CONDITIONERS (FUNCTIONAL IMPRESSION MATERIALS)

- 2.1 Tissue conditioners are intended to help denture-bearing tissues recover from injury caused by ill-fitting dentures, and can also be used as temporary relining materials (particularly during rapid resorption after immediate denture construction), in the construction of cleft palate appliances and during reconstructive surgery.
- 2.2 Tissue conditioners remain soft for several days and shortly after placement are mouldable enough to flow to accommodate tissue changes. Most products consist of higher polymethacrylate polymers with a plasticizer and ethyl alcohol.
- 2.3 Allow sufficient thickness to accommodate the anticipated alterations in the soft tissue and in no case less than 0.5 mm. A scalpel, scissors and/or a warm wax knife can be used to trim excess material.
- 2.4 Patients should be recalled for frequent checking, often every week. Adjustment of occlusion and vertical dimension, and, if considered necessary, replacement of the soft liner, should be undertaken at each visit.
- 2.5 These materials harden in a relatively short time (weeks) and may cause tissue irritation if not renewed regularly. It is important to emphasize to the patient the necessity of frequent replacement of the liner and the need to substitute with a more permanent material.
- 2.6 When used as a functional impression material, pour the model as soon as possible after removal from the mouth. Some clinicians prefer to use a wash of free-flowing zinc oxide-eugenol impression paste over the functional impression material for the final impression.





## E11 – SOLDERING AND WELDING

- 1 Use only the solder and flux recommended for the alloys being joined.
- 2 Wear safety goggles and protective clothing, as molten flux can cause corrosive and heat burns.
- 3 Perform all soldering in a well-ventilated area. Toxic fumes are given off by some solders and fluxes.
- 4 Clean surfaces completely with tungsten carbide burs. Do not use rubber wheels or similar abrasive agents which may leave organic residues. Do not rely on the flux to clean the surfaces.
- 5 Coat all of the surfaces to be soldered with an even layer of flux.
- 6 Keep flux away from ceramic by applying a protective coating.
- 7 Use a solder which melts at a higher temperature than that to be used for a subsequent soldering or ceramic application.
- 8 Use the smallest flame that will heat the work to the fusion temperature of the solder and cause it to run. Heat the entire appliance first, then focus near the gap area to raise it to soldering temperature.
- 9 Use a fine needle-type flame for orthodontic work. Heat and solder only the areas to be joined.
- 10 Orthodontic soldered joints on stainless steel are likely to fail by corrosion and work-hardened wires will be softened to some degree. Keep heating to a minimum. Alternatively, use Elgiloy.
- 11 Heat gently and uniformly until the flux has dried in order to avoid spattering.
- 12 Use a neutral or slightly reducing flame and heat parts gently and uniformly.
- 13 For furnace soldering, set the temperature as recommended by the solder/flux manufacturer or 15–30°C above the melting point of the solder. Remove from the furnace as soon as the solder runs.
- 14 Do not quench. Quenching may cause cracking or warping.
- 15 Remove all flux after soldering by soaking in hot water and careful brushing. An ultrasonic cleaner may be used. Be certain to remove all flux as some fluxes contain toxic ingredients or may cause corrosion.
- 16 Laser welding may also be considered as an alternative to conventional soldering procedures, and is most applicable to metals such as titanium and cobalt-chromium.
- 17 Specialized laser welding equipment is required, and welding is performed in an inert gas atmosphere.
- 18 Correct treatment and chemical cleanliness of the metal surfaces to be joined is just as important as it is in soldering.
- 19 Weld depth, and hence penetration, is sensitive to applied current, which in turn needs to be accurately calculated for the metal used, and cross-sectional area of the objects to be joined.
- 20 As heating is particularly localized with laser welding this can allow denture repairs to cast frameworks without the need to strip the acrylic resin superstructure.
- 21 The above characteristic also reduces overall thermal distortion that can occur when soldering large metallic structures, such as implant frameworks.

*Revision carried out by Dr G. Clausen – 14.7.2008*



## F GUIDES – GUIDELINES FOR GOOD PRACTICE

- F1 Patient information and records
- F2 Consent for care in dentistry
- F3 Emergencies in dental practice
- F4 Conscious sedation for dental procedures



## F1 – PATIENT INFORMATION AND RECORDS\*

### 1 WHY MAKE RECORDS?

- A record of each encounter with a patient is an essential part of the practice of dentistry, which improves diagnosis, treatment planning, case management and fees control.
- Accurate records assist efficient and complete delivery of care in the event of another clinician assuming that patient's treatment.
- Patient records may be used in a forensic role for patient identification.
- Patient records form the basis for retrieval of treatment details in the case of a dispute or the requirement to provide evidence. It is desirable that such details provide an adequate contemporaneous record that obviates the need for any later, and possibly questionable, assumptions that a dentist's 'usual practices' were followed in a specific case.
- Personal details (besides health information) are needed for satisfactory business management of a patient. This record should include the name of the person or entity responsible for payment for the treatment.

#### **Features which make health information special include:**

- Confidentiality of collection. Health information is collected in a situation of confidence and trust in the context of a dentist/patient relationship and may be of a sensitive nature.
- Sensitivity of information. Some health information is highly sensitive and can include details about an individual's body, lifestyle and practices which are particularly intimate or which may, if improperly disclosed, be misused.
- Duration of retention (see part 5). Health information may be required long after it has ceased to be needed for the original episode of care and treatment.

### 2 WHAT CONSTITUTES RECORDS?

- Notes made by clinicians and staff
- Completed written medical history
- Consent documents
- Copies of correspondence about the patient
- Radiographs, tracings, measurement
- Diagnostic casts
- Special test findings
- Photographs
- Records of financial transactions

### 3 STANDARDS FOR RECORD KEEPING

**Records must comply with statutory requirements and should include the following information about the individual:**

- Name, birth date, address and telephone (facsimile) contacts of the patient
- Gender of the patient
- If the patient is under 18 years of age, the name and address of a parent or guardian
- An adequate medical history which is updated regularly
- The date of every visit and appointment made which the patient failed to attend

\*Legislation on this topic will differ between States and Territories. Reference should be made to such legislation. What is set out here is general information on the topic.

**Records should also include where appropriate:**

- A description of the presenting complaint, relevant history, clinical findings, diagnosis, treatment options and treatment plan agreed to
- Advice given to the patient\* on:
  - Treatment options
  - Pre- and post-operative instructions
  - Likely outcomes
- Any treatment undertaken. Notes should include detail about the material used, variation from your usual technique and comments on the procedure. The detail should reflect the complexity of seriousness of potential sequelae.
- Any treatment advice that the patient was unwilling to accept
- Drugs prescribed (quantity, dose, instructions)
- Drugs administered (dose)
- Consents obtained for treatment (see part 7)
- Unusual sequelae to treatment reported by the patient
- Estimates or quotations for fees
- Relevant comments by patients on concerns over offered treatments
- Any comments or complaints by patients about treatment provided
- Annotations made by staff following telephone conversations etc

All comments should be couched in objective, unemotional language.

It is desirable that the treating dentist does not delegate responsibility for the accuracy of medical and dental information to another person.

Records should be legible and abbreviations standard ones. They should be readily understood by any third party (particularly another dentist) accessing the file.

Where corrections are necessary, liquid paper products or erasable pens should not be used. Corrections should be undertaken by the person striking out the incorrect words and rewriting the correct words. If the document is being rewritten the original document should be kept as a reference.

**Computer records**

The principles applying to handwritten records also apply to computer records. Computer records should be time logged and, if codes are used, they should be readily convertible to conventional language.

Other desirable features pertaining to computer records are:

- a dental practitioner's records must show who made each entry and when it was made;
- it must not be possible for entries to be changed without trace, that is, there must be an audit trail;
- there should be security procedures such as access being available only by password;
- there must be a standard procedure for entering treatment record data that is recorded in an office manual or memorandum to the practitioner's staff; and
- there must be adequate computer back up systems in place.

**4 STORAGE AND SECURITY OF RECORDS**

It is the responsibility of the dentist and staff to keep in confidence information derived from a patient. Information should only be divulged from a patient in accordance with relevant legislation and Australian Standard 44100.

Appropriate arrangements should be made for the adequate physical security of patient records.

\*References hereafter to 'patients' should be read as 'patients and where applicable, their custodial parent(s) or guardian(s) or duly authorised person.'

## 5 RETENTION OF RECORDS

The retention of records must comply with statutory requirements but, as a general rule, with the possible exemption of diagnostic casts, all records should be kept for at least seven years after the date of the final entry.

Records relating to the treatment of minors should be retained for at least seven years after the minor has attained majority.

If records are released for whatever reason, dental practitioners should obtain an acknowledgment receipt and also retain copies for their own records. In the case of radiographs, if it is a contentious issue a copy should be kept.

It is a reasonable alternative that diagnostic casts be given to the patient and regarded as a patient held record.

## 6 ACCESS TO RECORDS

Patients need access to the information in dental records for a variety of reasons. Some move to a new town or suburb and need to consult a new dentist. Others may have compensation cases lodged with the courts, where their medical/dental condition and treatment are central issues. Some patients simply want to understand what is wrong with them and to fully understand the treatment they have had or intend to have.

It is preferable that the information should be provided in a report, and not simply by sending a copy (never an original) of the records. A report written for the express purpose of the request may be far more helpful than the records themselves.

Records remain the property of the practitioner. In some jurisdictions, regulations entitle patients to view or obtain copies of their records.

In some jurisdictions, regulations entitle patients to obtain copies of any radiographs and records, or a report of their treatment, at their own expense.

## 7 CONSENT RECORDS

The issue of consent is currently under scrutiny by law reform commissions, the National Health and Medical Research Council, various other government, statutory and community bodies and the media. In order to practise in a legally defensible and professionally responsible manner, a practitioner must assist patients to make well informed decisions about treatment procedures.

- By action of consulting a dentist, consent for examination is implied.
- Implied consent would usually pertain for minor and familiar procedures.
- For more complex procedures a more formal consent (which may be verbal or written) is required.
- Mere agreement by a patient does not fully satisfy the requirement of consent. For this to be valid, some information about the proposed procedure must be provided and the patient must understand what it is he or she is consenting to.

In all situations it is necessary to keep careful, clear records. Disclosure of information and subsequent oral consent (which suffices for the vast majority of dental procedures) should be listed in the clinical notes. For major treatment, either in terms of invasiveness or expense, written consent forms acknowledging that the nature, implications and risks of the proposed procedure have been explained, may provide substantial evidence that the information was given and consent granted.

Adopted as a Code of Practice by Federal Council, 17-18 April 1997.  
Adopted as Guideline for Good Practice by Federal Council, 11-12 November 1999.





## F2 – CONSENT FOR CARE IN DENTISTRY

In order to practise in a professionally responsible manner, dentists must assist patients to make well informed decisions about treatment procedures.

This discussion paper deals with some essential principles in this process.

- 1 THE FUNDAMENTALS OF CONSENT FOR TREATMENT IN DENTAL PRACTICE**
  - 1.1 By the action of consulting a dentist a patient's consent for examination is implied.
  - 1.2 Strictly speaking, however, no further service should be provided without the **express consent** of the patient, although with regular patients who only require relatively minor and familiar maintenance procedures, implied consent would usually pertain.
  - 1.3 Oral consent is sufficient for most dental treatments; but for procedures such as general anaesthesia and major oral and maxillofacial surgery **written consent** is needed and this consent should include contingency consent to cover unforeseen eventualities.
  - 1.4 Mere agreement by a patient does not fully satisfy the requirement of consent. For this to be valid, some information about the proposed procedure(s) must be provided and the patient must understand what it is to which he or she is consenting.
- 2 THE NATURE OF CONSENT FOR TREATMENT**

Essentially, an informed decision about treatment has four elements:

  - 2.1 Sufficient relevant and accurate information on which to base a decision**

This might include explanations of:

    - 2.1.1 The proposed treatment plan (indicating to what extent it depends upon established versus new or controversial procedures) and its cost.
    - 2.1.2 Likely prognosis, outcomes and benefits.
    - 2.1.3 Possible complications, side-effects and material risks inherent in the treatment.
    - 2.1.4 Possible alternative treatments and cost options.
    - 2.1.5 Likely consequences of no treatment.
    - 2.1.6 Any other aspects requested by the patient.
  - 2.2 Comprehension of the information**

A clinician can contribute to this by:

    - 2.2.1 Use of simple language.
    - 2.2.2 Allowing adequate time for questions.
    - 2.2.3 Taking into account such factors as cultural differences and language comprehension.
  - 2.3 Legal competence to make personal decisions**

Relevant considerations are:

    - 2.3.1 As a general rule, consent for treatment of minors, the intellectually disabled or others not considered legally competent to make decisions on their own behalf, should be obtained from a parent, guardian or attorney (as appropriate) who must be provided with the same amount of information as would be required for adult consent.
    - 2.3.2 Mature minors may validly consent to treatment. In New South Wales there is statutory provision for the consent of a minor over the age of 14 years. In other jurisdictions the common law position is that consent to treatment may be given by a minor provided that there is understanding of its nature. Nevertheless, it is prudent to seek parental consent whenever it is possible to obtain it, to avoid misunderstanding and conflict, notwithstanding the legal position.
    - 2.3.3 Substitute decision-making processes are also needed for adults incapable of providing consent. Subject to relevant legislation the following are appropriate:
      - If possible, follow an advance health directive, for example, refusal of blood transfusions by some religious groups.

- Follow the direction of a guardian appointed by a guardianship and administration tribunal.
- Obtain consent from an attorney appointed under an enduring Power of Attorney.
- Obtain consent from the statutory health attorney or the adult guardian who is an officer appointed by a State/Territory Government to make consent decisions if there is no other appropriate attorney.

2.3.4 In an emergency, when immediate intervention is necessary to preserve life or prevent serious harm, it may not be possible to provide information.

## 2.4 Absence of coercion

It is important that:

- 2.4.1 Consent is voluntarily given.
- 2.4.2 No misleading information is offered.
- 2.4.3 Ample time is allowed for decision.
- 2.4.4 The patient's option to refuse or withdraw at any stage from treatment is understood, even though such treatment is aimed to be in the best interests of the patient and failure to have it may be harmful.

## 3 POSSIBLE CONSEQUENCES OF NOT OBTAINING CONSENT FOR TREATMENT

Two areas of the law are relevant: trespass to person and negligence.

3.1 If invasive treatment is provided without patient consent to the general nature of the procedure, then a practitioner may be sued for the tort of battery, and damages claimed for trespass to person – unless the failure to obtain consent is justified by necessity: for example, in an emergency. However, the role of the law of trespass in the area of 'informed consent' is limited. Consent to a procedure is not usually negated by being obtained without disclosure of associated risks and possible alternative treatments.

3.2 The most applicable sanction for failure to disclose this sort of information lies in the tort of negligence.

It is accepted that a practitioner's general duty to act reasonably includes a duty to provide adequate information, particularly in relation to risks and hazards. If something goes wrong then the practitioner may be exposed to liability for damages in negligence.

A negligent act is usually found or alleged to have occurred in the procedure itself. However, a failure to provide information about the procedure and associated risks may also amount to negligence.

For action in negligence on the latter score to succeed, two points must be established:

- (a) that failure to disclose the information was unreasonable; and
- (b) that this failure was a cause of harm to the patient.

The measure of reasonableness in relation to information-giving is akin to the standard of care required in relation to diagnosis and treatment, viz. that of an 'ordinary careful and competent practitioner of the class to which the practitioner belongs'.

To satisfy the second element (causation), the patient must establish both that he or she would not have consented to the treatment had proper disclosure been made and that injury was suffered due to the treatment.

At present it is not easy for the plaintiff/patient to establish any, let alone all of these things, especially causation. Actions in negligence are often unsuccessful. The mere fact of treatment without consent will not be regarded as compensatable injury. However, this may undergo change as the law in medical negligence evolves further, particularly in the areas of:

- determining the weight that is to be accorded evidence derived from standard practice; and
- assessing whether risk was material, that is, whether it would have influenced a reasonable person in the position of the patient in deciding whether to accept the procedure in question.

## 4 PRACTICAL CONSIDERATIONS FOR DENTISTS

### 4.1 Quality of communication

It is not a main purpose of this paper to engage in much discussion on the separate subject of communication in dental practice. Nevertheless, in the present context it must be kept in mind that good communication lies at the heart of successful dentist/patient relationships, whilst poor communication is likely to engender apprehension, dissatisfaction, suspicion and possible litigation.

Communication skill has many aspects. Practitioners may require improved ability in listening and feedback techniques, avoidance of technical language, or understanding of negotiation, decision-making, behavioural processes and the needs of minority groups.

The effect of time spent on communication is less dependent on its quantity than its quality. Thus commitment to providing patients with ample basis for consent will not necessarily increase the cost of treatment, particularly if improvements in treatment efficiency or reductions in stress and anxiety for the patient follow better communication.

In explaining the nature of proposed treatment, communication can effectively be extended by use of diagrams, suitable pamphlets and other literature, photographs, videos and models. The cost of a proposed treatment plan is always an important aspect to be communicated.

### 4.2 Determining reasonable disclosure

Whilst the extent of information which should be given to patients will depend on the circumstances of each case, the courts have at least provided some guidance. Matters are material if they 'might influence the decisions of a reasonable person in the situation of the patient'. If, for example, a risk involves potential harm or injury so slight, or so unlikely to occur, that no reasonable person would be influenced by it, then that risk need not be discussed.

From a health provider perspective, however, it would usually be preferable for disclosure to be based not so much upon a hypothetical 'reasonable person' as on the circumstances and needs of the particular patient in question.

Relevant factors, especially in relation to risk, might include:

#### 4.2.1 *The nature of treatment*

More drastic treatment requires more information. There is clearly a difference between orthognathic surgery and plaque removal.

Most procedures carried out in general practice would be considered minor. However, an extensive treatment plan composed of numerous minor items will require elaboration, as will more costly or controversial items.

#### 4.2.2 *The magnitude and/or likelihood of possible harm*

Information about the possibility of serious harm should normally be given even if the chance of it occurring is slight. Similarly, information should generally be given if the potential harm is relatively slight but the risk of it occurring is great. Typical risks in general dentistry which may need to be mentioned include the possibility of nerve damage in oral surgery procedures, perforation or instrument breakage in endodontics, and crown and bridge failures. It is probably not necessary to discuss risks that are inherent in any operation, such as post-operative infection.

#### 4.2.3 *The personality, temperament and attitude of the patient*

More information must be given to those keen to have it for more than just reassurance, especially in response to specific questions. On the other hand, it is not necessary to force information on a patient who is prepared to leave all decisions to the service provider. On occasions, albeit rarely in dentistry, it would be considered justifiable not to volunteer certain information if there are reasonable grounds for believing that the patient's health or welfare might be seriously harmed by being given the information.

#### 4.2.4 *The patient's level of understanding*

Without it being necessary to cross-examine a patient to ascertain understanding, information-giving should be influenced by some appraisal of the patient's intelligence and apparent understanding, and made in the light of the simplicity or complexity of the proposed treatment. Seeking some feedback from the patient may give an indication of his/her comprehension.

### 4.3 **Permanent records**

In all situations, it is necessary to keep careful, clear records. Disclosure of information and subsequent oral consent (which suffices for the vast majority of dental procedures) should be listed in the clinical notes.

For major treatment, either in terms of invasiveness or expense, written consent forms acknowledging that the nature, implications and risks of the proposed procedure have been explained may provide substantial, although still not entirely conclusive, evidence that information was given and consent granted. Whenever in doubt about whether a procedure is major or minor, written consent should be obtained. An appropriate alternative may be to have adequately written records of the information given, shown to and initialled by the patient.

### 4.4 **Potential controversies**

Dentists must take care always to mention any proposed use of treatments which, although considered standard, safe and minor procedures by the dental profession, might be regarded with some doubt by certain patients (for example, X-rays or amalgam fillings), so that these patients have the opportunity to request further information or decline such treatment modalities.

Procedures which have yet to receive general acceptance as standard or desirable practices, or which do not accord with mainstream dental opinion, necessitate the precaution in every case of ensuring that 'fully informed' consent is forthcoming.

### 4.5 **Less tangible items of treatment**

Genuine service should be free from any suspicion of overservicing. Consent for relatively minor procedures which might not be very apparent after completion, such as occlusal adjustment, recontouring of existing restorations or fissure sealants, especially if numerous, will often require fuller justification than more obvious items.

### 4.6 **Situations in which authority is not clear**

If a practitioner cannot be certain that consent is valid: for example, where there is conflict between parent and child, or where a child or other legally incompetent person is under the control of a person not normally authorised to give consent; then it would be unwise to proceed with treatment (except in the case of an emergency) until the situation is clarified.

### 4.7 **Treatment alternatives**

Where alternative treatments have been expounded, a dentist should accept the patient's preferred option within reason. For instance, few dentists would have problems about providing a partial denture rather than a bridge, or a complex amalgam rather than a full crown on the basis of the patient's informed decision. But it is usually better to decline giving a treatment of the patient's choice which, although included among discussed options, has been recommended against or declared

undesirable: for example, the provision of an immediate full denture rather than a recommended course of relatively simple conservative work. In the event of problems, it is preferable not to have acted contrary to one's own recommendation.

If any part of an accepted treatment plan is to be delivered by someone other than the dentist presenting it, such as another dentist or auxiliary within the practice, then the patient must be made aware of this in advance.

*The subject of consent is constantly under review by the legislature and courts. These guidelines have attempted to express views consistent with the law as at the date of their publication.*

Prepared by FT Widdop, July 15 1990. Adopted as a Resource Document by Federal Council, 30 October/2 November 1990. Published in the *News Bulletin*, February 1991. Adopted as a Code of Practice by Federal Council, 13-14 November 1997. Amended by Federal Council, 30 April/1 May 1998. Adopted as Guidelines for Good Practice by Federal Council, 11-12 November 1999. Issued as Guideline for Good Practice in *Resources Handbook*, July 2001. Amended by Federal Council, 7-8 April 2005 and reissued as Guideline for Good Practice in *Resources Handbook*. Insert in *News Bulletin*, June 2005.



## F3 – EMERGENCIES IN DENTAL PRACTICE

### INTRODUCTION

Dentists and their staff should be prepared for emergency situations which will occur at any time in their practices. These emergencies range from the minor such as the common faint (vaso-vagal syndrome) and hyperventilation, to the life-threatening such as cardiac arrest or anaphylaxis.

An Australian study (Chapman, 1997) showed that about one in seven dentists surveyed had had to resuscitate a patient, whilst an American study covering a 10 year period revealed that over 30,000 emergencies arose from a surveyed population of some 4,000 dentists (Malamed, 1992).

It is possible to over-prepare, however, and **it is the aim of this Guideline to be as simple as practicable** since over preparation without appropriate experience will be counterproductive and even dangerous (for example, excessive drugs and equipment).

### FIVE STEPS IN THE PREPARATION FOR EMERGENCIES

- Step 1. Medical history.
- Step 2. Assessment of patient/Recognition of cause of emergency.
- Step 3. Resuscitation – knowledge, training and practice.
- Step 4. Emergency drugs and devices.
- Step 5. Calling for medical assistance.

#### Step 1. Medical history

This aspect of practice is constantly covered and, therefore, will not be laboured but should include:

- a. Date of birth.
- b. Physician's name, telephone number and address.
- c. Past and present serious illnesses.

Prompts: Heart disease

(Ischaemic heart disease/congestive heart failure)

Blood pressure

Stroke

Rheumatic heart disease

Diabetes

Asthma

- d. Blood transfusion history.

Prompt: If positive: 'Are you being treated by a doctor at present?'

- e. Allergies to drugs, medicines, antiseptics.

Prompts: Penicillin

Local anaesthetic

Antiseptics

Latex

- f. Present medication.

Prompt: 'What medicine, pills, tablets or drugs are you taking or have you taken recently (in the last six months)?'

Where there is any doubt regarding the patient's medical status, the dentist should consult the patient's medical practitioner.

#### Step 2. Assessment of patient

The following conditions are recognized as the predominant causes of medical emergencies in dental surgeries.



The first five are stress related, that is, initiated or aggravated by emotional stress and stress minimization techniques can assist in the prevention of such conditions.

The conditions will exhibit a range of clinical features and the dentist should be vigilant regarding the patient's medical history and the circumstances which may have provoked the condition.

	CONDITION	CLINICAL FEATURES	TREATMENT / RESPONSE
1	Vasovagal syncope (fainting) approx. 40%	Faintness, weakness, pallor, sweaty skin, lowered pulse rate, hypotension	Lie horizontally, elevate feet, oxygen, monitor vital signs.
2	Hyperventilation approx. 30% (frequently confused with syncope)	Dyspnoea, rapid breathing, faintness, paraesthesia of extremities, palpitations	Encourage slower breathing, rebreath expired air with a paper bag.
3	Asthma (medical history)	Dyspnoea, cyanosis, audible wheezing	Reassure, use up to four metered doses of aerosol bronchodilator.
4	Angina pectoris (medical history)	Moderate to crushing central chest pain, radiating to left arm, neck or mandible	Stop treatment, place one glyceryl trinitrate tablet 0.6 mg under tongue or spray under tongue. Repeat dose in five minutes after first checking blood pressure and again after another five minutes if pain persists. If no improvement after 15 minutes, treat as acute myocardial infarction.
5	Acute myocardial infarction (medical history, e.g., angina pectoris, acute myocardial infarction, hypertension, diabetes)	Chest pain similar to angina but unrelieved by up to three glyceryl trinitrate tablets over 10 minutes. Suspect in anginal patient who says pain is much worse than usual, or if this is first ever episode of chest pain.	Call 000. Monitor vital signs, 100% oxygen. Dissolved aspirin tablet and one glyceryl trinitrate dose stat and one repeat in five minutes after check of blood pressure.
6	Cardiac arrest (medical history, especially angina and acute myocardial infarction)	Sudden unconsciousness, no breathing, no pulse	Irreversible brain damage in 3-5 minutes. Call 000 immediately. Initiate cardiopulmonary resuscitation, early defibrillation, oxygen.
7	Epilepsy (Grand-mal) (inquire as to control of condition, medication, last episode)	Sudden unconsciousness, temporary asphyxia and cyanosis in tonic phase, involuntary movement in limbs in clonic phase	Place in lateral position, protect from injury, monitor vital signs, oxygen, medical assistance.
8	Toxic effects from LA (rare)	1. Adrenaline toxicity – restlessness, throbbing headache, pallor, rapid full pulse, palpitations. 2. LA base toxicity – first CNS stimulation then depression with convulsions.	Basically supportive – effects should terminate rapidly.
9	Hypoglycaemia (history of insulin-dependent diabetes)	Slurred speech, altered behaviour, sweating, rapid pulse, apprehension, then loss of consciousness	Give orange juice, glucose drink or sugar lumps at first sign which will rapidly terminate event, i.e., loss of consciousness should never occur. If loss of consciousness occurs, will need parenteral therapy (glucose or glucagon).
10	Acute airway obstruction (choking)	Sudden asphyxia or dyspnoea cyanosis, violent coughing spasms, inability to catch breath	Try to remove cause – five back blows with patient leaning forward. If unable to remove, administer oxygen, transfer to hospital for bronchoscopy.
11	Severe allergic reaction (anaphylaxis) (NB. history of allergies)	Asthma-like symptoms (sneezing and dyspnoea), circulatory collapse, cardiac arrest, following drug administration	Call 000. Always check that respiratory distress not due to other causes. Adrenalin 1:1000 IM (1/2 ml). May need to repeat dose after five minutes. 100% oxygen. CPR if cardiac arrest occurs.

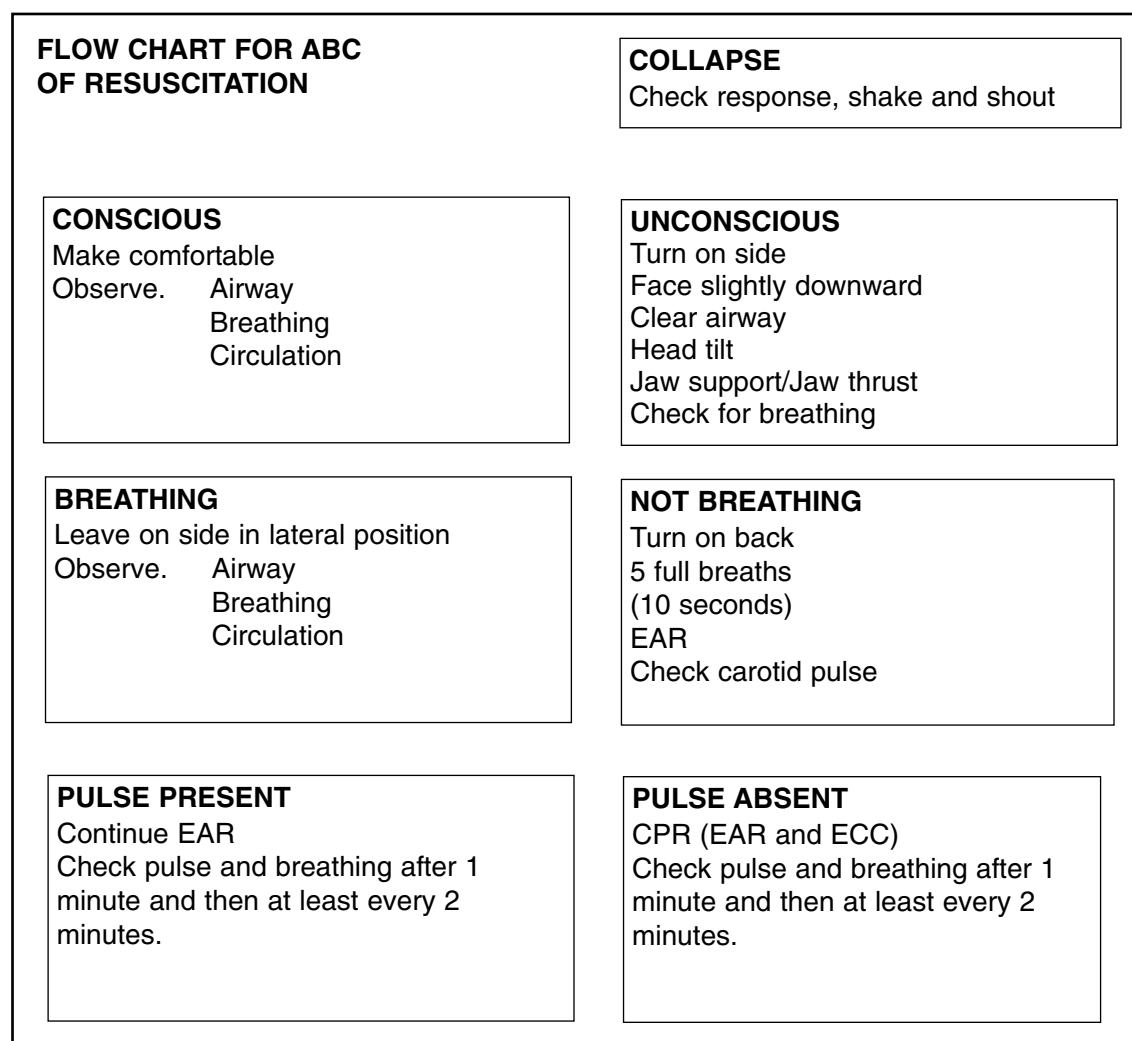
### Step 3. Resuscitation – knowledge, training and practice.

Further annual refamiliarization courses are recommended to maintain competence in basic life support (BLS).

All dentists should be competent in BLS resuscitation. That is, they should be able to assess breathing and circulation and to carry out effective expired air resuscitation (EAR) and cardiopulmonary resuscitation (CPR) if required. They should also encourage their staff to attend resuscitation courses and run practice drills with surgery staff. A wall poster can assist in retention of learnt techniques.

When an emergency is immediately life threatening such as complete laryngeal obstruction, cardiac arrest associated with acute myocardial infarction, or bronchospasm associated with anaphylaxis, there is no time for delay and an immediate diagnosis must be made and definitive treatment initiated.

A summary of BLS which follows is the recommended sequence for the management of collapse which involves care of **Airway, Breathing and Circulation (ABC of Resuscitation)**.



**EAR** - Expired Air Resuscitation

**ECC** - External Cardiac Compression

**CPR** - Cardiopulmonary Resuscitation (i.e., EAR and ECC)

#### Step 4. Emergency drugs and devices

There are four drugs which dentists should have on hand to assist management of medical emergencies. These are:

- Oxygen
- Oral glucose
- Adrenaline 1:1000
- Glyceryl trinitrate spray or tablets.

##### *Oxygen*

All surgeries should have an oxygen source which is easily transported to the patient. The simplest and safest way of administering oxygen to a non-breathing patient is via a pocket mask with a nozzle to which a low pressure oxygen line is connected. At a flow rate of 10L/minute this provides about 50% oxygen in the ventilated air. The mask should have an adjustable head strap. Oxygen-powered resuscitators are considered part of Advanced Life Support (ALS), however, because of the risk of gaseous distension of the stomach and consequent regurgitation, their use in the dental surgery is not recommended. It is now considered that these resuscitators require two operators.

##### *Oral glucose*

For insulin dependent patients who are exhibiting signs of hypoglycaemia, administration of orange juice, glucose or sucrose drinks or sweets in small amounts (50–100 ml) every five minutes, will rapidly raise the blood sugar level and reverse the situation.

##### *Adrenaline 1:1000*

When a severe anaphylactic allergic response is diagnosed, an injection of 0.3–0.5 mg (0.3–0.5 ml of 1:1000 solution) on to the tongue, floor of the mouth or other muscle is required. Adrenaline is available as a 1 ml 1:1000 solution in a pre-loaded syringe. Two such pre-loaded syringes should be kept, as the injection may need to be repeated.

##### *Glyceryl trinitrate tablets or spray*

Patients with a history of angina usually have their tablets with them and administer their usual dose sublingually. However, it is recommended that the dentist's emergency kit contain glyceryl trinitrate spray (which has a much longer shelf life than tablets) in case the patient does not have his/her glyceryl trinitrate (GTN) tablets.

#### Step 5. Calling for medical assistance.

Apart from the use of 000, it is appropriate for a dentist to make established links with his or her nearest medical practitioner or facility. Therefore, these should be displayed in a prominent place.

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## F4 – CONSCIOUS SEDATION FOR DENTAL PROCEDURES

At its meeting of 22-23 April 2004, the Association adopted the 'Guidelines on Conscious Sedation for Dental Procedures in Australia' as jointly approved by the Royal Australasian College of Dental Surgeons Inc and the Australian and New Zealand College of Anaesthetists in April 2003.

The ADA is grateful for permission from both the RACDS and the ANZCA to adopt their Guidelines – Review PS21 (2003).

### 1 INTRODUCTION

Sedation for dental procedures (with or without local anaesthesia) includes the administration by any route or technique of all drugs which result in depression of the central nervous system. The objective of these techniques is to produce a degree of sedation of the patient, **without loss of consciousness**, so that uncomfortable procedures may be facilitated. The drugs and techniques used should provide a margin of safety which is wide enough to render loss of consciousness unlikely. Loss of consciousness constitutes general anaesthesia and carries specific risks. These guidelines are not intended for very light techniques such as nitrous oxide/oxygen mediated sedation (see para 9).

These techniques are not without risk because of the:

- 1.1 Potential for unintentional loss of consciousness.
- 1.2 Depression of protective reflexes.
- 1.3 Depression of respiration.
- 1.4 Depression of the cardiovascular system.
- 1.5 Wide variety and combinations of drugs which may be used, with the potential for drug interactions.
- 1.6 Possibility of excessive amounts of these drugs being used to compensate for inadequate analgesia.
- 1.7 Individual variations in response to the drugs used, particularly in children, the elderly and those with pre-existing medical disease.
- 1.8 Wide variety of procedures performed.
- 1.9 Differing standards of equipment and staffing at the locations where these procedures may be performed.

It is important to recognise the variability of effects which may occur with sedative drugs, however administered, and that over-sedation, airway obstruction or cardiovascular complications may occur at any time. To ensure that standards of patient care are satisfactory, equipment and staffing of the area in which the patient is being managed should satisfy the requirements in the appropriate ANZCA Professional Documents.

### 2 GENERAL PRINCIPLES

- 2.1 The patient should be assessed before the procedure and this assessment should include:
  - 2.1.1 A concise medical history, examination (including blood pressure measurement), performance of appropriate investigations and identification of risk factors. The American Society of Anesthesiologists classification system is convenient for this purpose. (See Appendix 1)
  - 2.1.2 Informed consent for sedation as well as the planned procedure.
  - 2.1.3 Instructions for preparation for the procedure (**including the importance of fasting**), the recovery period, and discharge of the patient (including avoidance of driving, other dangerous activities, undertaking responsible business).

- 2.2 If the patient has any serious medical condition then the appropriate treating general medical practitioner and/or their specialist should be consulted prior to any planned treatment under sedation. If the patient is deemed to be seriously medically compromised then an anaesthetist should be present to administer sedation and to monitor the patient during the procedure.
- 2.3 The practitioner administering sedation requires sufficient knowledge to be able to:
  - 2.3.1 Understand the actions of the drug or drugs being administered.
  - 2.3.2 Detect and manage appropriately any complications arising from these actions.  
*In particular medical and dental practitioners administering sedation must be skilled in airway management and cardiovascular resuscitation.*
  - 2.3.3 Anticipate and manage appropriately the modification of sedative drug actions by any concurrent therapeutic regimen or disease process which may be present.
- 2.4 Techniques intended to produce loss of consciousness must not be used unless an anaesthetist is present.
- 2.5 A written record of the dosages of drugs and the timing of their administration must be kept as a part of the patient's records. Such entries should be made as near the time of administration of the drugs as possible. This record should also note the regular readings from the monitored variables.
- 2.6 Techniques which compensate for inadequate local analgesia by means of heavy sedation must not be used unless an anaesthetist is present.

### **3 STAFFING**

- 3.1 If an appropriately trained medical or dental practitioner is not present to administer sedation and monitor the patient, there must be an assistant present during the procedure, appropriately trained in observation and monitoring of sedated patients, and in resuscitation whose **sole** duty shall be to monitor the level of consciousness and cardio-respiratory function of the patient.
- 3.2 If at any time spontaneous respiration and/or protective reflexes are lost, or the patient does not respond to verbal commands or stimulation, both the proceduralist and assistant must devote their entire attention to monitoring and treating the patient until recovery, or until such time as another medical or dental practitioner becomes available to take responsibility for the patient's care.
- 3.3 If general anaesthesia or loss of consciousness is sought for the procedure, then an anaesthetist must be present to care exclusively for the patient.

### **4 FACILITIES**

- The procedure must be performed in a location which is adequate in size and staffed and equipped to deal with a cardiopulmonary emergency. This must include:
  - 4.1 An operating table, trolley or chair which can be readily tilted.
  - 4.2 Adequate uncluttered floor space to perform resuscitation.
  - 4.3 Adequate suction and room lighting.
  - 4.4 A supply of oxygen and suitable devices for the administration of oxygen to a spontaneously breathing patient.
  - 4.5 A self-inflating bag suitable for artificial ventilation together with a range of equipment for advanced airway management.
  - 4.6 Appropriate drugs for cardiopulmonary resuscitation and a range of intravenous equipment. (See Appendix II.)
  - 4.7 A pulse oximeter.
  - 4.8 Ready access to a defibrillator.

### **5 MONITORING**

All patients undergoing intravenous sedation must be monitored continuously with pulse oximetry and this equipment must alarm when certain set limits are

exceeded. There must be regular recording of pulse rate, oxygen saturation and blood pressure. According to the clinical status of the patient, other monitors such as ECG or capnometry may be required.

## 6 OXYGENATION

Degrees of hypoxaemia occur frequently during intravenous sedation without oxygen supplementation. Oxygen administration diminishes hypoxaemia during procedures carried out under sedation and should be routinely available.

Pulse oximetry enables the degree of tissue oxygenation to be monitored and must be used on all patients during sedation.

## 7 DRUGS USED FOR SEDATION

A variety of drugs and techniques are available for sedation. The most common intravenous agents used are small doses of a benzodiazepine (such as midazolam) for sedation and small doses of opioid (such as fentanyl) for analgesia. Even small doses of such drugs may result in loss of consciousness in some patients.

*Intravenous anaesthetic agents must only be used by an appropriately trained medical or dental practitioner, and titrated in doses which do not allow intended loss of consciousness. Continuous monitoring of consciousness by whatever means must be established. These agents must not be administered by the proceduralist without the presence of an appropriately trained assistant whose sole duty is to monitor the level of consciousness of cardio-respiratory function of the patient (see 3.1).*

## 8 TRAINING IN SEDATION FOR DENTAL PROCEDURES

An appropriately trained medical or dental practitioner should be present and be responsible for administration of sedation. The clinician is to be one of the following:

- 8.1 A dentist who has successfully completed relevant postgraduate training leading to an accredited qualification accepted by the relevant health authority. An example is the Diploma in Clinical Dentistry (Sedation and Pain Control) from the University of Sydney, or an equivalent course (as defined by the relevant regulating authority).
- 8.2 A medical practitioner with formal training at least equivalent to the Diploma in Clinical Dentistry (Sedation and Pain Control) from the University of Sydney, or training in accordance with ANZCA current professional requirements.
- 8.3 A specialist anaesthetist.

## 9 SPECIALISED EQUIPMENT FOR NITROUS OXIDE SEDATION

When nitrous oxide is being used to provide sedation, the following equipment requirements must be satisfied:

- 9.1 There must be a minimum oxygen flow of 2.5 litres/minute with a maximum flow of 10 litres/minute of nitrous oxide, or in machines so calibrated, a minimum of 30% oxygen. There must be the capacity for the administration of 100% oxygen.
- 9.2 The circuit must include an anti-hypoxic device which cuts off nitrous oxide flow in the event of an oxygen supply failure, and opens the system to allow the patient to breathe room air.
- 9.3 There must be a non-return valve to prevent re-breathing, and a reservoir bag.
- 9.4 The patient breathing circuit must provide low resistance to normal gas flows, and be of lightweight construction.
- 9.5 Installation and maintenance of any piped gas system must be according to appropriate standards.
- 9.6 Servicing of equipment and piped gases must occur on a regular basis and at least annually.
- 9.7 An appropriate method for scavenging of expired gases must be in use.
- 9.8 There must be a low gas flow alarm.
- 9.9 Risks of chronic exposure to nitrous oxide should be considered.

## DISCHARGE

The patient should be discharged only after an appropriate period of recovery and observation in the procedure room, or in an adjacent area which is adequately equipped and staffed. Oxygen must be available in any area used for patient recovery.

Discharge of the patient should be authorized by the practitioner who administered the drugs, or another appropriately qualified practitioner. The patient should be discharged into the care of a responsible adult to whom written instructions should be given. Transport should normally be by car.

Adequate staffing and facilities must be available in the recovery area for managing patients who have become unconscious or who have suffered some medical mishap. Should the need arise the patient must be transferred to appropriate medical care.

A number of ANZCA Professional Documents should be noted where appropriate, particularly the following:

- PS1 *Recommendations on Essential Training for Rural General Practitioners in Australia Proposing to Administer Anaesthesia*
- PS2 *Recommendations on Privileges in Anaesthesia*
- PS4 *Recommendations for the Post-Anaesthesia Recovery Room*
- PS6 *Recommendations on Minimum Requirements for the Anaesthesia Record*
- PS7 *Recommendations on the Pre-Anaesthesia Consultation*
- PS15 *Recommendations for the Perioperative Care of Patients Selected for Day Care Surgery*
- PS16 *Guidelines on the Standards of Practice of a Specialist Anaesthetist*
- PS18 *Recommendations on Monitoring During Anaesthesia*
- T2 *Recommendations on Minimum Facilities for Safe Anaesthesia Practice Outside Operating Suites*
- TE3 *Policy on Supervision of Clinical Experience for Vocational Trainees in Anaesthesia*

## APPENDIX I

The American Society of Anesthesiologists' physical status classification system\*:

Class I: A normal, healthy patient.

Class II: A patient with mild systemic disease.

Class III: A patient with severe systemic disease.

Class IV: A patient with severe systemic disease that is a constant threat to life.

Class V: A moribund patient who is not expected to survive without the operation.

*\*Excerpted from American Society of Anesthesiologists Manual for Anesthesia Department Organization and Management 2001. A copy of the full text can be obtained from ASA, 520 N Northwest Highway, Park Ridge, Illinois 60068-2573.*

## APPENDIX II

Emergency drugs should include at least the following:

- adrenaline
- atropine
- dextrose 50%
- lignocaine
- naloxone
- flumazenil
- portable emergency oxygen supply

## ANZCA Professional Documents

ANZCA Professional Documents are progressively being coded as follows:

TE – Training and Educational

EX – Examinations

PS – Professional Standards

T – Technical

POLICY – defined as ‘a course of action adopted and pursued by the College’. These are matters coming within the authority and control of the College.

RECOMMENDATIONS – defined as ‘advisable courses of action’.

GUIDELINES – defined as ‘a document offering advice’. These may be clinical (in which case they will eventually be evidence-based), or non-clinical.

STATEMENTS – defined as ‘a communication setting out information’.

***THIS DOCUMENT IS INTENDED TO APPLY WHEREVER ANAESTHESIA IS ADMINISTERED.***

*This document has been prepared having regard to general circumstances, and it is the responsibility of the practitioner to have express regard to the particular circumstances of each case, and the application of this document in each case.*

*Professional documents are reviewed from time to time, and it is the responsibility of the practitioner to ensure that the practitioner has obtained the current version. Professional documents have been prepared having regard to the information available at the time of their preparation, and the practitioner should therefore have regard to any information, research or material which may have been published or become available subsequently.*

*Whilst the Colleges endeavour to ensure that professional documents are as current as possible at the time of their preparation, they take no responsibility for matters arising from changed circumstances or information or material which may have become available subsequently.*

*Promulgated (as P21): 1990*

*Reviewed: 1992, 1996*

*Date of current document: February 2003*

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## APPENDIX 1

### Inspection, Service / Repair Request

To .....

Make of equipment/item .....

Serial No (*where applicable*) .....

Description .....

This item has been sterilized or disinfected by:

Autoclave ☐      Dry Heat ☐      Cold Sterilization ☐

in accordance with the manufacturer's instructions.

Signed ..... Position .....

Practice name and address .....

.....

Telephone ..... Fax .....

Email .....

#### Notes:

1. It is the responsibility of the practitioner to sterilize, where possible, all equipment prior to sending to serviceperson.
2. This confirmation is required to protect our staff under the Occupational Health and Safety Act and we thank you for your cooperation. If items returned for repair etc are not accompanied by this form, it may be considered necessary to disinfect/sterilize same before inspection, a service which may attract an additional charge separate to any other costs involved.
3. It is illegal to send contaminated items through Australia Post.
4. This form has been published by the Australian Dental Industry Association Inc in the interests of hygiene and health.

## APPENDIX 2

## Comparison Chart of Bur Sizes

ISO	English
005	4/0
006	3/0
007	2/0
008	0
009	1
010	2
012	3
014	4
016	5
018	6
021	7
023	8
025	9
027	10
029	11
031	12
033	13
035	14
037	15
040	16
042	17
045	18
047	19
050	20
055	21
060	22
065	23
070	24
075	25
080	26

The International Organization for Standardization (ISO) figure refers to the size of the bur head at the greatest diameter in tenths of a millimetre (eg 010=1 mm).

## APPENDIX 3

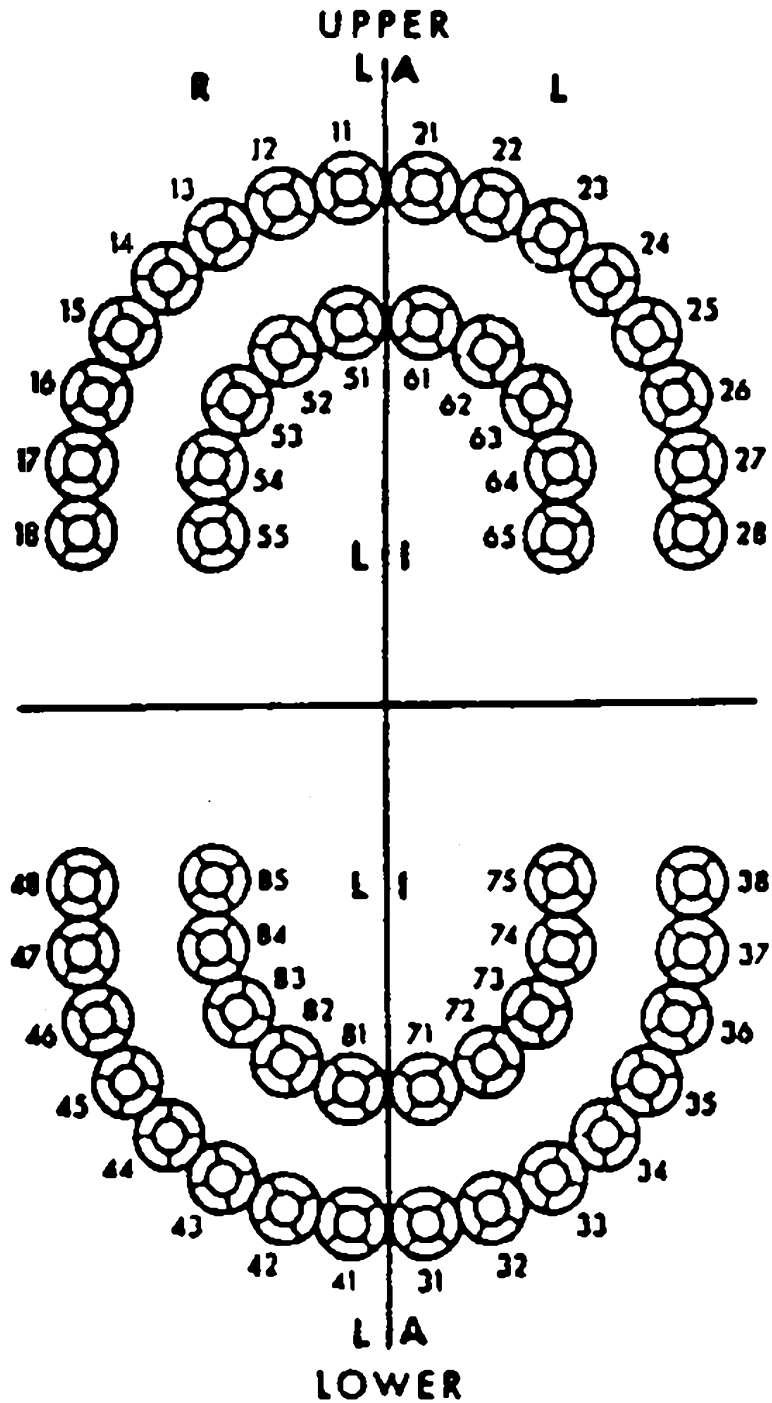
## Colour Code and Size Designation of Endodontic Files and Reamers

Standard size designation	Colour
010	Purple
015	White
020	Yellow
025	Red
030	Blue
035	Green
040	Black
045	White
050	Yellow
055	Red
060	Blue
070	Green
080	Black
090	White
100	Yellow
110	Red
120	Blue
130	Green
140	Black

The ISO standard size designation refers to the diameter of the tip in tenths of a millimetre (eg the smallest, 010, =0.10 mm, and the largest, 140, =1.40 mm).

## APPENDIX 4

FDI Two-digit Tooth Identification Chart



## APPENDIX 5

### Système International d'Unités (SI Units)

1 Some basic units		
Quantity	Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K
2 Some derived units		
Quantity	Name	Symbol
force	newton	N (=1 kg.m/s <sup>2</sup> )
power	watt	W (=1 J/s)
pressure	pascal	Pa (=1 N/m <sup>2</sup> )
temperature	degree Celsius	°C
volume	litre	L (=10 <sup>-3</sup> m <sup>3</sup> )
work, energy	joule	J (=1 N.m)
3 Some multiples of units		
Multiplication factor	Prefix	Symbol
10 <sup>6</sup>	mega	M
10 <sup>3</sup>	kilo	k
10 <sup>-3</sup>	milli	m
10 <sup>-6</sup>	micro	μ
10 <sup>-9</sup>	nano	n
4 Conversion factors		
Unit	SI equivalent	
ångström, Å	10 <sup>-10</sup> m	
*British thermal unit, Btu	1.055 kJ	
*calorie, cal	4.1868 J	
*dyne	10 <sup>-5</sup> N	
foot, ft	0.3048 m	
gram/cubic centimetre, g/m³	1000 kg/m³	
inch, in	25.4 mm	
*kilogram force/square centimetre, kgf/cm²	0.0981 MPa	
*kilogram force, kgf	9.81 N	
*ounce, oz	0.02835 kg	
*ounce, fluid, fl oz	28.41 mL	
*pound, lb	0.454 kg	
*poundal, pdl	0.1383 N	
*pound force, lbf	4.448 N	
*pound force/square inch, lbf/in² or psi	6.895 kPa	
rem	0.010 Sv	
square inch, in²	645.16 mm²	
*Approximate values.		

## APPENDIX 6

### International Standards TC 106 - Dentistry

#### **MATERIALS**

ISO 1563:1990

Dental alginate impression material

ISO 1564:1995

Dental aqueous impression materials based on agar

ISO 1567:1999

Dentistry -- Denture base polymers

ISO 1567:1999/Amd 1:2003

ISO 1942-2:1989

Dental vocabulary -- Part 2: Dental materials

ISO 1942-2:1989/Amd 1:1992

ISO 1942-2:1989/Amd 2:1992

ISO 3107:2004

Dentistry -- Zinc oxide/eugenol and zinc oxide/non-eugenol cements

ISO 3107:2004/Cor 1:2006

ISO 4049:2000

Dentistry -- Polymer-based filling, restorative and luting materials

ISO 4823:2000

Dentistry -- Elastomeric impression materials

ISO 4823:2000/Amd 1:2007

ISO 4823:2000/Cor 1:2004

ISO 6872:1995

Dental ceramic

ISO 6872:1995/Amd 1:1997

ISO 6873:1998

Dental gypsum products

ISO 6874:2005

Dentistry -- Polymer-based pit and fissure sealants

ISO 6876:2001  
Dental root canal sealing materials

ISO 6877:2006  
Dentistry – Root-canal obturating points

ISO 7491:2000  
Dental materials -- Determination of colour stability

ISO 7551:1996  
Dental absorbent points

ISO 9333:2006  
Dentistry -- Brazing materials

ISO 9693:1999  
Metal-ceramic dental restorative systems

ISO 9693:1999/Amd 1:2005

ISO 9917-1:2007  
Dentistry -- Water-based cements -- Part 1: Powder/liquid acid-base cements

ISO 9917-2:1998  
Dental water-based cements -- Part 2: Light-activated cements

ISO 10139-1:2005  
Dentistry -- Soft lining materials for removable dentures -- Part 1: Materials for short-term use

ISO 10139-1:2005/Cor 1:2006

ISO 10139-2:1999  
Dentistry -- Soft lining materials for removable dentures -- Part 2: Materials for long-term use

ISO 10271:2001  
Dental metallic materials -- Corrosion test methods

ISO 10271:2001/Cor 1:2005

ISO 10477:2004  
Dentistry -- Polymer-based crown and bridge materials

ISO/TS 11405:2003  
Dental materials -- Testing of adhesion to tooth structure

ISO 13716:1999  
Dentistry -- Reversible-irreversible hydrocolloid impression material systems

ISO 13897:2003  
Dentistry -- Amalgam capsules

ISO 13897:2003/Cor 1:2003

ISO 14233:2003  
Dentistry -- Polymer-based die materials

ISO 14356:2003  
Dentistry -- Duplicating material

ISO/TR 14569-1:2007

Dental materials -- Guidance on testing of wear -- Part 1: Wear by toothbrushing

ISO/TS 14569-2:2001

Dental materials -- Guidance on testing of wear -- Part 2: Wear by two- and/or three body contact

ISO 15841:2006

Dentistry -- Wires for use in orthodontics

ISO 15854:2005

Dentistry -- Casting and baseplate waxes

ISO 15912:2006

Dentistry -- Casting investments and refractory die materials

ISO 16408:2004

Dentistry -- Oral hygiene products -- Oral rinses

ISO 21606:2007

Dentistry -- Elastomeric auxiliaries for use in orthodontics

ISO 22112:2005

Dentistry -- Artificial teeth for dental prostheses

ISO 22674:2006

Dentistry -- Metallic materials for fixed and removable restorations and appliances

ISO 22794:2007

Dentistry -- Implantable materials for bone filling and augmentation in oral and maxillofacial surgery --  
Contents of a technical file

ISO 22803:2004

Dentistry -- Membrane materials for guided tissue regeneration in oral and maxillofacial surgery --  
Contents of a technical file

ISO 24234:2004

Dentistry -- Mercury and alloys for dental amalgam

## **EQUIPMENT**

ISO 1942-4:1989

Dental vocabulary -- Part 4: Dental equipment

ISO 1942-4:1989/Amd 1:1992

ISO 3964:1982

Dental handpieces -- Coupling dimensions

ISO 4073:1980

Dental equipment -- Items of dental equipment at the working place -- Identification system

ISO 6875:1995

Dental patient chair

ISO 7488:1991

Dental amalgamators



ISO 7493:2006  
Dentistry -- Operator's stool

ISO 7494-1:2004  
Dentistry -- Dental units -- Part 1: General requirements and test methods

ISO 7494-2:2003  
Dentistry -- Dental units -- Part 2: Water and air supply

ISO 7785-1:1997  
Dental handpieces -- Part 1: High-speed air turbine handpieces

ISO 7785-2:1995  
Dental handpieces -- Part 2: Straight and geared angle handpieces

ISO 8282:1994  
Dental equipment -- Mercury and alloy mixers and dispensers

ISO 9168:1991  
Dental handpieces -- Hose connectors

ISO 9680:2007  
Dentistry -- Operating lights

ISO 10637:1999  
Dental equipment -- High- and medium-volume suction systems

ISO 10650-1:2004  
Dentistry -- Powered polymerization activators -- Part 1: Quartz tungsten halogen lamps

ISO 10650-2:2007  
Dentistry -- Powered polymerization activators -- Part 2: Light-emitting diode (LED) lamps

ISO 11143:2008  
Dentistry -- Amalgam separators

ISO 11144:1995  
Dental equipment -- Connections for supply and waste lines

ISO 11498:1997  
Dental handpieces -- Dental low-voltage electrical motors

ISO 13294:1997  
Dental handpieces -- Dental air-motors

ISO 15606:1999  
Dental handpieces -- Air-powered scalers and scaler tips

ISO 21530:2004  
Dentistry -- Materials used for dental equipment surfaces -- Determination of resistance to chemical disinfectants

ISO 22374:2005  
Dentistry -- Dental handpieces -- Electrical-powered scalers and scaler tips

ISO/TS 22595-1:2006

Dentistry -- Plant area equipment -- Part 1: Suction systems

ISO/TS 22595-2:2008

Dentistry -- Plant area equipment -- Part 2: Compressor systems

ISO/TS 22911:2005

Dentistry -- Preclinical evaluation of dental implant systems -- Animal test methods

## **INSTRUMENTS**

ISO 1797-1:1992

Dental rotary instruments -- Shanks -- Part 1: Shanks made of metals

ISO 1797-1:1992/Amd 1:1997

ISO 1797-2:1992

Dental rotary instruments -- Shanks -- Part 2: Shanks made of plastics

ISO 1942-3:1989

Dental vocabulary -- Part 3: Dental instruments

ISO 1942-3:1989/Amd 1:1992

ISO 1942-3:1989/Amd 2:1992

ISO 2157:1992

Dental rotary instruments -- Nominal diameters and designation code number

ISO 3630-1:2008

Dentistry -- Root-canal instruments -- Part 1: General requirements and test methods

ISO 3630-2:2000

Dental root-canal instruments -- Part 2: Enlargers

ISO 3630-3:1994

Dental root-canal instruments -- Part 3: Condensers, pluggers and spreaders

ISO 3823-1:1997

Dental rotary instruments -- Burs -- Part 1: Steel and carbide burs

ISO 3823-2:2003

Dentistry -- Rotary bur instruments -- Part 2: Finishing burs

ISO 3823-2:2003/Amd 1:2008

ISO 6360-1:2004

Dentistry -- Number coding system for rotary instruments -- Part 1: General characteristics

ISO 6360-1:2004/Cor 1:2007

ISO 6360-2:2004

Dentistry -- Number coding system for rotary instruments -- Part 2: Shapes

ISO 6360-3:2005

Dentistry -- Number coding system for rotary instruments -- Part 3: Specific characteristics of burs and cutters

ISO 6360-4:2004

Dentistry -- Number coding system for rotary instruments -- Part 4: Specific characteristics of diamond instruments

ISO 6360-5:2007

Dentistry -- Number coding system for rotary instruments -- Part 5: Specific characteristics of root-canal instruments

ISO 6360-6:2004

Dentistry -- Number coding system for rotary instruments -- Part 6: Specific characteristics of abrasive instruments

ISO 6360-7:2006

Dentistry -- Number coding system for rotary instruments -- Part 7: Specific characteristics of mandrels and special instruments

ISO 7492:1997

Dental explorers

ISO 7711-1:1997

Dental rotary instruments -- Diamond instruments -- Part 1: Dimensions, requirements, marking and packaging

ISO 7711-2:1992

Dental rotary instruments -- Diamond instruments -- Part 2: Discs

ISO 7711-3:2004

Dentistry -- Diamond rotary instruments -- Part 3: Grit sizes, designation and colour code

ISO 7786:2001

Dental rotary instruments -- Laboratory abrasive instruments

ISO 7787-1:1984

Dental rotary instruments -- Cutters -- Part 1: Steel laboratory cutters

ISO 7787-2:2000

Dental rotary instruments -- Cutters -- Part 2: Carbide laboratory cutters

ISO 7787-3:1991

Dental rotary instruments -- Cutters -- Part 3: Carbide laboratory cutters for milling machines

ISO 7787-4:2002

Dental rotary instruments -- Cutters -- Part 4: Miniature carbide laboratory cutters

ISO 7885:2000

Sterile dental injection needles for single use

ISO 8325:2004

Dentistry -- Test methods for rotary instruments

ISO 9173-1:2006

Dentistry -- Extraction forceps -- Part 1: General requirements and test methods

ISO 9873:1998

Dental hand instruments -- Reusable mirrors and handles

ISO 9873:1998/Cor 1:2000

ISO 9997:1999  
Dental cartridge syringes

ISO 10323:1991  
Dental rotary instruments -- Bore diameters for discs and wheels

ISO 11499:2007  
Dentistry -- Single-use cartridges for local anaesthetics

ISO 13295:2007  
Dentistry -- Mandrels for rotary instruments

ISO 13397-1:1995  
Periodontal curettes, dental scalers and excavators -- Part 1: General requirements

ISO 13397-2:2005  
Dentistry -- Periodontal curettes, dental scalers and excavators -- Part 2: Periodontal curettes of Gr-type

ISO 13397-3:1996  
Periodontal curettes, dental scalers and excavators -- Part 3: Dental scalers -- H-type

ISO 13397-4:1997  
Periodontal curettes, dental scalers and excavators -- Part 4: Dental excavators -- Discoid-type

ISO 15087-1:1999  
Dental elevators -- Part 1: General requirements

ISO 15087-2:2000  
Dental elevators -- Part 2: Warwick James elevators

ISO 15087-3:2000  
Dental elevators -- Part 3: Cryer elevators

ISO 15087-4:2000  
Dental elevators -- Part 4: Coupland elevators

ISO 15087-5:2000  
Dental elevators -- Part 5: Bein elevators

ISO 15087-6:2000  
Dental elevators -- Part 6: Flohr elevators

ISO 15098-1:1999  
Dental tweezers -- Part 1: General requirements

ISO 15098-2:2000  
Dental tweezers -- Part 2: Meriam types

ISO 15098-3:2000  
Dental tweezers -- Part 3: College types

ISO 21533:2003  
Dentistry -- Reusable cartridge syringes intended for intraligamentary injections

ISO 21671:2006  
Dentistry -- Rotary polishers

## **ORAL CARE PRODUCTS**

ISO 11609:1995

Dentistry -- Toothpastes -- Requirements, test methods and marking

ISO 16409:2006

Dentistry -- Oral hygiene products -- Manual interdental brushes

ISO 20126:2005

Dentistry -- Manual toothbrushes -- General requirements and test methods

ISO 20127:2005

Dentistry -- Powered toothbrushes -- General requirements and test methods

ISO 22254:2005

Dentistry -- Manual toothbrushes -- Resistance of tufted portion to deflection

## **GENERAL**

ISO 1942-1:1989

Dental vocabulary -- Part 1: General and clinical terms

ISO 1942-1:1989/Amd 1:1992

ISO 1942-1:1989/Amd 2:1992

ISO 1942-1:1989/Amd 3:1993

ISO 1942-1:1989/Amd 5:1993

ISO 1942-5:1989

Dental vocabulary -- Part 5: Terms associated with testing

ISO 3950:1984

Dentistry -- Designation system for teeth and areas of the oral cavity

ISO 7405:1997

Dentistry -- Preclinical evaluation of biocompatibility of medical devices used in dentistry -- Test methods for dental materials

ISO 9687:1993

Dental equipment -- Graphical symbols

ISO/TR 13668:1998

Digital coding of oral health and care

ISO/TR 15300:2001

Dentistry -- Application of OSI clinical codification to the classification and coding of dental products

ISO/TR 15599:2002

Digital codification of dental laboratory procedures

ISO/TR 15599:2002/Cor 1:2003

ISO 16059:2007

Dentistry -- Required elements for codification used in data exchange

**IMPLANTS**

ISO 10451:2002

Dental implant systems -- Contents of technical file

ISO/TR 11175:1993

Dental implants -- Guidelines for developing dental implants

ISO 14801:2007

Dentistry -- Implants -- Dynamic fatigue test for endosseous dental implants