Received: 25 March 2024 | Accepted: 4 April 2024

DOI: 10.1111/aej.12848

Australian Endodontic Journal

INVITED ARTICLE

Guidelines for non-surgical root canal treatment

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Abstract

Guidelines were developed by the Australian Society of Endodontology Inc. with the intent to describe relevant aspects of contemporary evidence-based root canal treatment. The document aims to support clinicians by describing a Standard of Practice in the Australian context. The presented guidelines refer to Competence criteria and Quality standards for the main steps in root canal treatment. While the intent is not to replace individual clinical decision-making, it is envisaged that these periodically reviewable guidelines may help to improve clinical outcomes.

KEYWORDS

dentistry, endodontics, guidelines, root canal treatment, standard of practice

OPENING STATEMENT

The Australian Society of Endodontology Inc. (ASE) supports the provision of contemporary evidence-based care in dentistry, and specifically endodontics, to achieve best practice. To this end, the ASE has compiled this document describing the approach a competent practitioner may take in the following aspects of treatment:

- Diagnosis and case difficulty assessment.
- Access cavity preparation.
- Root canal preparation.
- Irrigation and medicaments.
- Root canal obturation.
- Restoration of endodontically treated teeth.
- Recall and outcome assessment.

The ASE serves as a trusted and credible source of information for non-specialist and specialist clinicians regarding various aspects of endodontics.

In this text, the ASE presents guidelines that illustrate contemporary practice standards for root canal treatment. The guidelines may further assist educational institutions and dental organisations in developing educational requirements.

The primary objective of endodontic treatment is to preserve the natural dentition through the prevention and/or treatment of pulpal and periradicular pathosis. The practice model in Australia is predicated on general dentists having the required knowledge and experience regarding endodontic treatment to perform most non-surgical root canal procedures on uncomplicated permanent teeth.

While integration with, and referral to, specialist endodontists is desirable in certain cases, it is acknowledged that

The guidance in this ASE statement is not intended to substitute for a clinician's independent judgement, in light of the conditions and needs of a specific patient.

referrals to specialist endodontists may not be practical in some geographic locations in Australia and other settings. This underlines the need for general dentists to understand and to practise within their competency to manage more complex cases, should they elect to treat these (Figure 1).

For the purposes of this statement and in line with the opinion of the Australian Dental Council, minimal competency for dental practitioners is defined as the ability to practise safely and effectively within the professions and their individual scope of practice, and who have an appropriate foundation for professional growth and development so that they can respond to diverse and changing health needs throughout their professional lives.

Despite similar primary dental educational curricula, disparities may exist in the levels of knowledge, competency and skill and clinical experiences of general dentists. Over the past two decades, there have been significant advances in technology, materials and endodontic treatment procedures. These include but are not limited to the use of an operating microscope, engine-driven nickel–titanium instruments, ultrasonics, enhanced irrigation technologies, digital radiography, cone-beam computed tomography and calcium silicate (bioceramic) materials. It appears that these changes, while in principle of benefit to patients, may have created a disparity in the quality of care provided by specialists versus general dentists for teeth with complex anatomy and morphology.

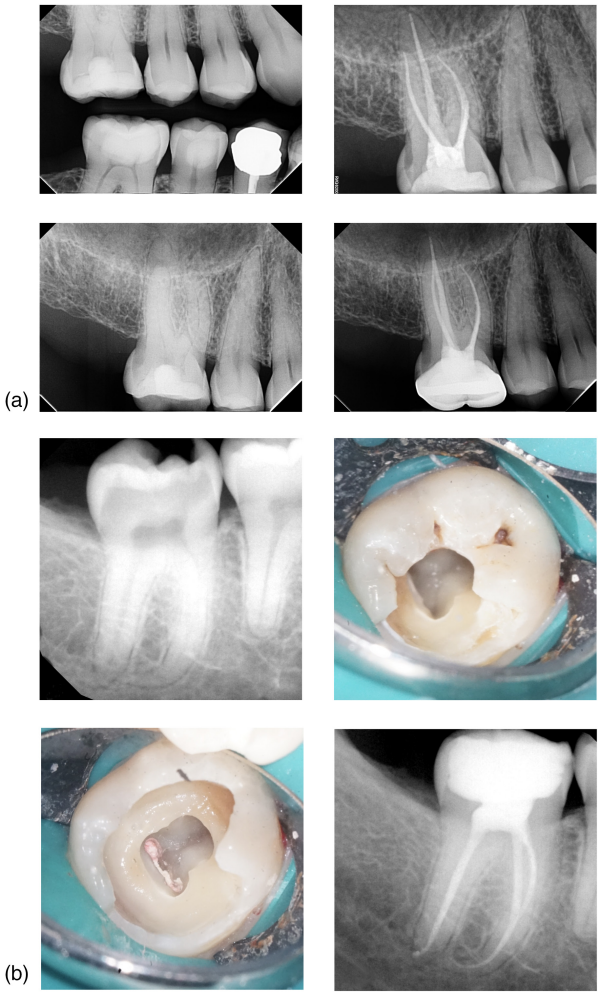

FIGURE 1 Two cases with molar root canal treatments. Note specifically radiographic assessment with periapical radiograph and one bitewing in (a) and appropriate length and width while preserving dentine (a, b). Cases courtesy of (a) Dr. Oliver Pope (Melbourne) and (b) Dr. Ahmed Salman (Denver, CO, USA).

The effect of these developments on the standard of clinical practice remains unknown. Currently within Australia, general dentists perform most non-surgical endodontic procedures overall and certainly most uncomplicated anteriors and premolars.

Educational considerations for both general dental students and specialists in training have been described recently for the Australian context. However, it was felt that a clear description of process and outcome quality was needed to guide continuous and indeed life-long learning. Self-evaluation is a critical component of life-long learning. Any clinician should be able to critically evaluate their competency as diagnosticians and practitioners to identify and act upon areas that require additional educational experiences. Based on this evaluation, each practitioner must be able to determine their skill and learning to determine when the patient should be referred to the appropriate specialist for consultation/treatment.

Methods of traditional education and the emphasis on facts are changing. Information technology has transformed the dental profession and placed emphasis on the importance of the evidence-based practice model. Contemporary methods of education focus on problem-solving and critical thinking skills, stress professional interactions as well as the benefits of multidisciplinary and interdisciplinary care.

The scope of endodontics in dental practice includes:

- Differential diagnosis and treatment of pain and/or swelling of pulpal and/or periapical origin.
- Urgent/emergency treatment of pain and/or swelling to include the pharmacologic use of antibiotics, anti-inflammatory agents, analgesic drugs and incision for drainage of localised abscesses.
- Urgent/emergency management of traumatic injuries to the dentoalveolar structures.
- Vital pulp treatment including pulp capping, and pulpotomy procedures.
- Non-surgical root canal treatment for the permanent dentition.
- Bleaching of discoloured teeth.
- Treatment procedures such as post and/or cores involving the root canal space.

INTENT

General dentists should provide endodontic treatment consistent with contemporary standards, their knowledge, clinical experience and technical skills. The standards of practice are constantly changing based on new evidence and technology. It is the responsibility of all practitioners to be life-long learners to meet contemporary standards.

These guidelines describe contemporary principles of non-surgical endodontics, supported by evidence. It is the intent of this document to detail relevant aspects of evidence-based care that relate to process and outcome quality consistent with an acceptable *Standard of Practice*, with the final aim of supporting clinicians in their clinical practice.

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DIAGNOSIS AND CASE DIFFICULTY ASSESSMENT

Purpose

An endodontic diagnosis is crucial for driving the treatment plan and assists with the determination of the prognosis. This assessment includes the identification of the aetiology of pulpal and periapical conditions. Subsequently, the clinician must determine case difficulty and potential risks to consider when proceeding with treatment or if referral of the patient to a specialist is more appropriate. Moreover, periodontal and restorative aspects must be considered.

Rationale/Summary

Dental practitioners have the legal and ethical responsibility for the decisions made to provide the patient with advice or carry out endodontic treatment and must assess their level of training and competency prior to doing so. Recognising and understanding the case difficulties prior to treatment will either prevent or reduce adverse outcomes for the patient and reduce the risk of dentolegal problems for the dental practitioner. If dental practitioners encounter a case that is beyond their capabilities to diagnose or manage, then they should refer the patient in a timely manner to an endodontist for further management.

Timely referral not only expedites a course of care but could also help to reduce the risk of pain, swelling or spread of infection associated with untreated endodontic pathosis. That said, it is not possible to predict the occurrence/severity of an exacerbation in the presence of asymptomatic apical periodontitis. If the patients' needs require management by specialists in other fields, this should be identified early, and the patient should be referred appropriately.

Competence criteria/Quality standards

- Documented definitive endodontic diagnosis, using contemporary terms for both pulpal and periapical diagnoses.
- Integration of patient, dental and pain histories with the clinical and radiographic examination, supported by specific tests (e.g., thermal pulp test) as indicated to arrive at diagnosis.
- Case difficulty assessment as well as self-assessment for competency before carrying out endodontic treatment.

Considerations and clinical approach

An endodontic diagnosis cannot be formed from a single piece of information, but requires a clinician to collate the necessary information systematically to arrive at a probable conclusion. The medical and dental history and the patient's presenting complaint will allow the clinician to form a provisional diagnosis. Following that, all the relevant information from the clinical and radiographic examination along with the results of the appropriate diagnostic tests will then be collated to confirm the diagnosis.

Examination procedures relevant to endodontic diagnosis and treatment plan development

Chief complaint. History of symptoms (if any)
Medical and dental history. History of dental trauma (if any)
Clinical examination—extra-oral and intra-oral examination
Radiographic examination may include periapical radiograph(s), maxillary or mandibular occlusal radiograph, bitewing(s), limited FOV cone-beam computed tomography
Clinical tests may include percussion, palpation, thermal/electric pulp testing, mobility, periodontal probing, transillumination, tooth slooth

Diagnostic quality periapical radiographs are the standard in root canal treatment (see Figure 1). However, more recently limited field of view (FOV) cone-beam computed tomography (CBCT) has been used in cases where a diagnosis cannot be made based on periapical films alone.

Some indications for the use of limited FOV CBCT are complex anatomy, dental trauma, teeth presenting with root resorption or developmental anomalies and for assessment/decision-making in root canal retreatment.

The Dental Board of Australia has published a reflective practice tool for dental practitioners to assess their scope of practice and to consider whether continuing professional development will be required. Also, there are various case difficulty assessment forms or apps that are available online such as the Endodontic Case Difficulty Assessment form and guidelines for desktop, the AAE Endo Case App for mobile devices and the British Endodontic Society EndoApp.

What not to do during case assessment

- Initiate root canal treatment without a documented diagnosis or assessment of restorability.
- Initiate root canal treatment in a case exceeding personal competence level.
- Initiate root canal treatment simply based on radiographic findings, such as the presence of a periapical radiolucency.
- Initiate root canal treatment without informing the patient of the diagnosis, case difficulty level and relevant complications and risks.
- Initiate root canal treatment in a complex case without informing the patient of the option of consulting a specialist.
- Use non-diagnostic terms in dental records.

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ACCESS CAVITY PREPARATION

Purpose

An access preparation from the coronal tooth structure is essential to reach the internal anatomy of the tooth and forms the first step in non-surgical endodontic treatment.

Rationale/Summary

An ideal access cavity should allow unhindered entry to the complete root canal anatomy without excessive destruction of tooth structure. Wherever possible, the preservation of structural dentine optimises restorative outcomes. Conversely, inadequate access can lead to missed canals, undetected cracks, iatrogenic errors, inadequate cleaning, shaping and obturation and even failure of the root canal treatment. The access cavity should serve as a reservoir for an irrigant which will act as a disinfectant and lubricant, facilitating disinfection of the root canal system and allowing for the placement of a suitable interim restoration.

Competence criteria/Quality standards

- Isolation with dental dam.
- Unimpeded access to all canal orifices and into the root canal system.
- Minimal removal of tooth structure.
- Minimal structural damage to tooth structure.
- Appropriate size of the cavity, neither too small to hinder cleaning and shaping nor too wide to compromise the structural integrity of the tooth.
- Potential pre-operative referral to a specialist if root canal access is exceedingly difficult, for example with mineralised pulp space or in the presence of extra-coronal restorations.

Considerations and clinical approach

The pulp chamber is located in the centre of the tooth crown and resembles the shape of the crown unless there are physiological or pathological changes. A wide variety of access cavity designs have been suggested. Anatomical landmarks, particularly the CEJ, can serve as a reliable

guide to accessing the pulp chamber. Assessment of the long axis of the tooth is important as inclined teeth are prone to perforation whether the bur is not directed accordingly.

The access cavity preparation should be planned by visualising and analysing the tooth anatomy, clinical examination of hard and soft tissues around the tooth, along with radiographic examination of the pulp chamber to identify size, shape and any calcifications. Bitewing radiographs along with periapical radiographs at different horizontal angulations can help in planning the access; however, use of small FOV CBCT may add pivotal information about the internal anatomy of the tooth.

Appropriate coronal access provides a convenience form, in which the smallest possible dimensions of an access cavity are dictated by the precise location of canal entrances on the pulpal floor. The concept of a so-called straight-line approach to an orifice and further to the primary curvature of the root canal was adopted to minimise procedural errors during subsequent treatment procedures. However, a large access with divergent walls is not required for the use of contemporary flexible and fatigue-resistant root canal instruments.

Removal of all existing restorations is recommended where feasible, to facilitate visualisation of any existing cracks or defects beneath the restoration. All caries must be removed before gaining access into the pulp chamber. The access cavity is complete when coronal dentine does not impede access to instrumentation of the root canals.

What not to do during access cavity preparation

- Leave residual caries beneath existing or defective restorations.
- Prepare the access cavity too small or too large (overextension into the walls or floor of the pulp chamber).
- Inadequately remove pulp stones or other mineralisations.
- Excessively sacrifice dentine or perforate the pulp chamber floor.
- Create damage to the pulpal floor obscuring root canal orifices.

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ROOT CANAL PREPARATION

Purpose

The objective of root canal preparation is to facilitate the disinfection and obturation of the root canal space. Preparation develops a tapered shape from the orifice to provide apical resistance form during obturation.

Rationale/Summary

Root canal preparation allows the removal of canal content and penetration of irrigation solutions into the apical and lateral spaces of the root canal system. Preparation errors such as ledges and perforations can significantly reduce clinical outcomes (see Figure 2). Based on available irrigation needles and canal diameters, a certain minimum canal size (e.g., size 25 with apical 0.06 taper) is desirable for irrigation dynamics and antimicrobial effect. Removal of canal content, microorganisms and biofilm, require direct and prolonged contact of irrigants with the canal wall.

Competence criteria/Quality standards

- Conscious determination and maintenance of an exact apical endpoint (working length) and restricting canal preparation to the confines of the root canal space.
- Ability to predictably enlarge canal spaces to mechanically remove vital or necrotic tissues and microorganisms, providing effective space for antimicrobial solutions and intracanal medicaments and the insertion

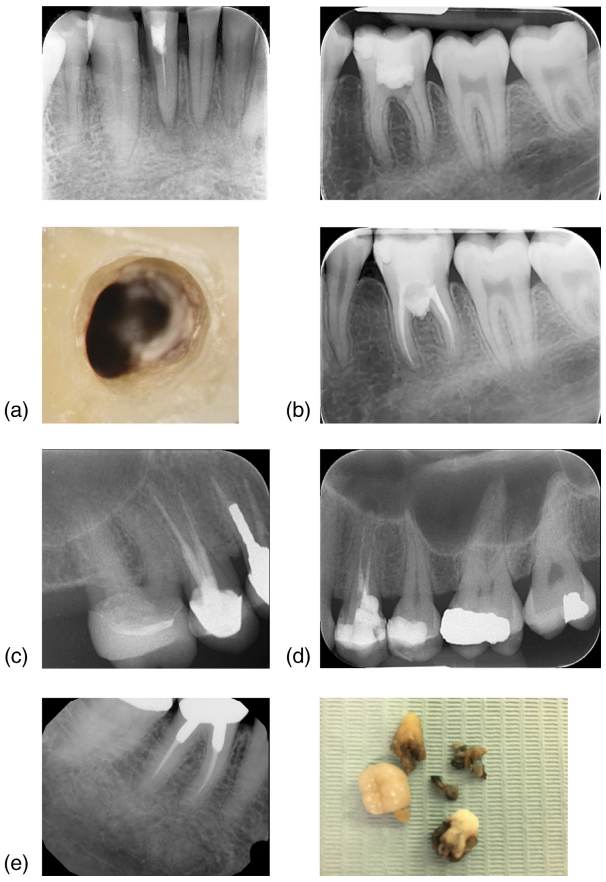

FIGURE 2 Some of the procedural errors in root canal treatment that should be avoided to maximise clinical outcomes. (a) Lateral perforation of a mandibular anterior, radiographic and clinical view. (b) Perforation into the furcation of a mandibular molar. (c) Over-preparation into the middle root canal third, possibly by Gates Glidden drills. (d) Over-enlarged and misaligned access cavity. (e) Restoration with disregard to dentine preservation and subsequent fracture. Images courtesy of Dr. Kiran Kumar (Brisbane; a), Dr. Giampiero Rossi-Fedele (Adelaide; b, c, d), and Dr. Ove Peters (Brisbane; E).

and compaction of obturation materials to the determined working length.
- Selecting instruments and treatment sequences that minimise damage to radicular structures.
- In-depth understanding of the development of procedural errors and ways to avoid these.
- Patient-oriented decision-making and candid communication when recognising procedural errors.

Considerations and clinical approach

Generalisations may be made regarding tooth anatomy and morphology, although ***each tooth is unique***. Because morphology is variable, there can be no standardised apical canal preparation size or width. Rather, canal shaping is dictated by the initial canal size, the irrigation regime and the obturation technique employed. A minimum canal size is currently required for mechanical debridement and to place antimicrobial solutions into contact with the root canal system. Of note, care must be taken that apical canal enlargement is not done at an excessive expense of coronal dentine, where in molars and premolars the radicular wall thickness toward the furcation is in some sections 1.0 mm or less. Based on studies of apical anatomy, the ideal apical point of termination of root canal preparation, also known as working length, has been established empirically to be 0.5 to 1.0 mm from the radiographic apex. Historically, working lengths have been determined with periapical radiographs, however, it is recommended that an electronic apex locator is used in conjunction with verifying radiographs to determine the working length.

In root canal treatment of teeth with vital pulp tissue (irreversible pulpitis and elective treatment procedures), complete removal of pulp tissue and creating space for obturation materials is sufficient. With infected pulpal necrosis, root canal walls are often covered with a polymicrobial bacterial biofilm, extending into secondary anatomy such as fins, isthmuses, accessory canals and possibly dentinal tubules. In that condition, the antimicrobial efficiency of the overall procedure is paramount. Neither hand files nor rotary/reciprocating instruments have been shown to completely debride a root canal system. Mechanical enlargement of the canal space dramatically decreases the presence of microorganisms present in the canal and creates a channel for the delivery of biocidal agents but cannot render the canal system sterile.

Therefore, the use of antimicrobial irrigants is essential in addition to mechanical preparation techniques.

What not to do during canal preparation

- Overextend working length and thereby over-enlarge the apical foramen.
- Use excessively large files in a curved canal with the result of various preparation errors.
- Work in a dry canal.
- Prematurely use larger files, resulting in canal straightening.
- Overuse and overwork files, risking file fracture.

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IRRIGATION AND MEDICAMENTS

Purpose

The primary purpose of using root canal irrigants is to treat and prevent the recurrence of infection and biofilms within the root canal system. Irrigation also aims to provide lubrication for mechanical canal preparation, flush debris out of the canal, dissolve organic tissue remnants and remove the smear layer.

Rationale/Summary

Optimising the removal of bacteria at the time of root canal obturation is associated with an increased likelihood of successful root canal treatment in infected cases. Instrumentation does not contact all aspects of the canal and biofilms can remain in inaccessible areas such as fins, lateral canals and isthmuses. Thus, irrigation is needed to complement mechanical preparation to achieve effective disinfection of the root canal system. Endodontic irrigation also removes the smear layer created during instrumentation. This is advocated as the smear layer can harbour microorganisms and prevent the penetration of antimicrobial agents and sealers into the dentinal tubules. Finally, irrigation is required to dissolve organic material in the form of vital or necrotic pulp and the organic components of biofilms.

Intracanal medicaments (e.g., antimicrobial or anti-inflammatory pastes) are used when endodontic treatment is completed over multiple appointments. Several factors, including operator-related considerations, may influence the decision whether or not to employ a single-visit approach.

Competence criteria/Quality standards

- Utilisation of dental dam (mandatory in root canal treatment).
- Use of a side-vented needle that does not bind in the canal.
- Avoidance of excessive pressure during irrigation.
- Placement of irrigants and medicaments within the confines of the root canal.
- Understanding of safety, efficacy, usage features and interactions of all materials used.

Considerations and clinical approach

Currently, the use of sodium hypochlorite (NaOCl) is considered essential to endodontic irrigation because it is the only irrigant that both disinfects and dissolves organic material. Thus, NaOCl should be used as the primary irrigant during canal preparation and refreshed regularly. Smear layer removal is most frequently achieved by an approximately 1-min rinse with EDTA, following canal preparation in the presence of NaOCl. After the use of EDTA, a final antimicrobial rinse is often used and NaOCl is typically used for this purpose.

Safe irrigation is achieved by placing a side-vented needle, without binding, 1–2 mm from the working length. The irrigation needle is then gently moved in alternate coronal-apical movements while introducing irrigants slowly and without pressure. All materials used in a root canal should have limited toxicity, be non-allergenic and non-staining and be compatible with other endodontic materials, while maintaining the mechanical integrity of the tooth. It is worth noting that currently there is no perfect endodontic irrigant. However, the attributes of an ideal irrigant can be described, as in the table below.

Attributes of an ideal irrigant

Effectiveness in core functions—broad spectrum antimicrobial action, including biofilm disinfection and dissolution in areas of complex canal anatomy, removal of smear layer and dissolution of vital and necrotic pulp.

Tooth factors—non-staining, maintenance of tooth mechanical properties, compatibility with dental materials, lubrication during instrumentation, flushing of debris.

Safety—non-toxic, non-caustic, non-allergenic, non-irritant to periapical tissues.

Cost—low purchase price, rapid action, stable in storage.

Reprinted with permission from Wright PP. Continuous chelation in endodontics with a focus on the novel chelator clodronate. PhD Thesis, The University of Queensland; 2020.

The following applies to the use of irrigants and medicaments in root canal treatment:

Sodium hypochlorite (NaOCl)

- Concentrations of up to 6% are currently available in Australia.
- NaOCl has a pH of 12 or higher and is inactivated in contact with EDTA.
- NaOCl has broad spectrum antimicrobial action and can dissolve biofilms.

EDTA

- Following the use of EDTA, a subsequent rinse of NaOCl should be brief due to a potential erosive effect of NaOCl when used following a demineralising agent such as EDTA.
- EDTA is used as a neutral to slightly alkaline solution at a concentration of 15% or 17%; commercially available products in Australia may contain cetrimide.
- A 1-min rinse with 17% EDTA is sufficient to remove the smear layer.

Chlorhexidine (CHX)

- Allergic reactions have been reported.
- CHX poorly removes biofilm, has limited effectiveness against Gram-negative organisms and no tissue-dissolving ability.
- CHX is mostly used at a concentration of 2%.

Calcium hydroxide

- $Ca(OH)_2$ may be used as a paste in multiple visit treatments.
- High pH has been implicated in canal disinfection and may aid in the dissolution of pulp remnants.
- $Ca(OH)_2$ may cause nerve damage and tissue necrosis when extruded beyond the apex.

What not to do during irrigation

- Extrude NaOCl beyond the apex under pressure; extrusion can cause severe swelling and ecchymosis.
- Alternate NaOCl and EDTA irrigation cycles.
- Allow NaOCl to contact CHX, in which case a toxic brown-orange precipitate will form.
- Use local anaesthetic or other non-active irrigation solutions.
- Allow CHX and EDTA to come into contact, in which case a white precipitate will form.

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ROOT CANAL OBTURATION

Purpose

Root canal obturation aims to minimise space in the root canal system after the removal of canal contents. This reduces the ability for any remaining microorganisms to persist and has a positive role in the long-term outcome of endodontic treatment.

Rationale/Summary

Root canal obturation should, as completely as possible, fill the entire root canal system and provide a barrier that prevents nutrients, oral microorganisms and their by-products from reaching residual microorganisms and the periapical tissues. Typical obturation materials include gutta-percha (GP) and a sealer (cement). There are several techniques in clinical use that allow the placement of root canal filling materials to the working length, for example cold lateral compaction, vertical compaction and carrier-based obturation. All filling materials and techniques are associated with the potential for marginal penetration of oral microorganisms.

Competence criteria/Quality standards

- Root canal system completely filled with obturation material.
- Void-free filling material contained within the confines of the root canal system.
- Use of techniques and materials appropriate for each case and clinician's skill level.
- Sound technical quality of root canal filling demonstrated with radiographs that show all relevant details.

Considerations and clinical approach

The best obturation results are obtained when obturation terminates within 0–1 mm from WL and is well compacted. Overfill is related to potential damage of sensitive tissue such as the inferior alveolar nerve. Filling of accessory canals may occur but is not predictable. In the absence of a clinically applicable real-time method to assess the disinfection of the root canal space, it is the clinician's responsibility to ensure all canals have been located and disinfected to the appropriate length prior to obturation. The presence or persistence of symptoms and signs of disease should also be considered prior to final obturation.

Several root canal filling techniques have been described; however, no technique is superior to another. The approach to filling the root canal system should be determined considering the root canal morphology, the skill of the operator and the available armamentarium. This process should whenever possible be considered prior to initiating the root canal treatment. Regardless of the technique used, the final fill should demonstrate no space between canal wall and the filling material and should be filled without voids to the predetermined working length. When considering the filling material, it is important for clinicians using GP cones as the filling material to be aware of the different tapers and the consequences to the fit and retention. The compaction of GP can be achieved using thermal or non-thermal compaction techniques. With the advent of engine-driven systems and their matching cones, there has been an increasing trend to use a single-cone technique. This technique considers the final root preparation to match the final file and hence the need for only a single matched cone. Care should be taken to complete single-cone obturation to the same clinical standards, for example regarding appropriate apical termination and sizing as is achieved with other obturation techniques, in particular in complex canal anatomies.

The role of the sealer is to fill minor spaces that cannot be filled with the core material. Recently, calcium silicate-based sealers have complemented the use of single-cone techniques.

Certain conditions, such as open apices, ledges, transportation of the canal or the proximity to anatomical structures, can make obturation difficult and pose a risk of extrusion of the filling material.

What not to do during root canal obturation

- Perform obturation if skill or armamentarium is not appropriate for the case.
- Disregard concerns regarding complete disinfection of the root canal system.
- Fail to protect vulnerable structures such as the inferior alveolar nerve.
- Ignore root canal anatomy when deciding upon a specific obturation technique.

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RESTORATION OF ROOT CANAL-TREATED TEETH

Purpose

The restoration of teeth after root canal treatment is essential to return a tooth to aesthetic and occlusal function and to prevent subsequent complications. A suitable restoration should be provided as soon as practically possible.

Rationale/Summary

Common causes of pulpal demise involve the destruction of dentine and enamel and loss of structural

integrity, which in turn make teeth more prone to endodontic and restorative complications. The long-term patient- and clinician-measured outcomes of root canal-treated teeth can be negatively affected by microbial (re) contamination, tooth fracture, recurrent caries and periodontal complications associated with a restoration of insufficient quality.

While an unsuccessful root canal treatment can be managed conservatively by retreatment, recurrent caries and tooth fracture are the most common causes of extraction of endodontically treated teeth. Obviously, the latter should be prevented as it constitutes an undesirable outcome for the patient and the operator.

Competence criteria/Quality standards

- Prompt placement of a definitive restoration whenever feasible.
- Consideration of conservative restorations (e.g., onlays and direct overlays instead of full coverage crowns).
- Replacement of previous restorations as required based upon clinical and radiographic assessment.

Considerations and clinical approach

Common causes of pulp pathosis include caries, traumatic dental injuries, tooth wear loss and operative procedures. The identification of the aetiology of pulpal complications and the planning of a final restoration is crucial during the diagnosis and treatment planning stages. It should be reiterated that the clinical and radiographic assessment of previous restorations is often insufficient to identify the cause of endodontic disease; therefore, the removal of restorations is recommended whenever feasible.

Restorative needs of the tooth in question and caries risk assessment should be part of the informed consent process and shared decision-making in endodontics. The type of final restoration should take into consideration several pre-operative and intra-operative factors. These include patient expectations (including costs and aesthetics), tooth function and occlusion. The unnecessary sacrifice of coronal tissues should always be avoided. Effective removal from the pulp chamber space of materials potentially causing discolouration or recontamination (e.g., root canal sealer, pulp remnants, and discoloured restorative materials) is mandatory, especially in aesthetically challenging cases. Anterior teeth often only require a direct restoration, whereas maxillary premolars and molars, specifically in cases of extensive loss of strategic tooth structure, benefit from receiving a suitable cuspal-coverage restoration. However, with intact marginal ridges and overall sufficient structure, a direct intra-coronal restoration should be considered also for posterior teeth. In the presence of extensive loss of coronal tissues, an extra-coronal restoration may also be required for anterior teeth. A case-by-case assessment is considered best practice (Figure 3).

Where possible onlays should be considered for posterior teeth, in preference to full crowns to preserve the tooth structure, place margins in favourable supragingival locations, optimise forces and allow options for future restorations. Occlusion and articulation should be considered when restoring root canal-treated teeth.

Timing for the provision of the final restoration should take into consideration several pre-operative and intra-operative factors. These include patient expectations, tooth function and occlusion, preoperative diagnosis and the ability to clean and fill the canals in proximity to the radiographic apical terminus by the operator. Extensive tooth loss (e.g., caries) and damage to marginal ridges render teeth more prone to fracture, making prompt restoration a necessity.

Overall, the provision of a definitive restoration as soon as practically possible is recommended. The timely provision of an adequate restoration for endodontically treated teeth is associated with positive clinician- and patient-measured outcomes, including the healing of apical periodontitis and tooth survival. An adequately restored tooth can be retreated, if necessary, however, a fractured previously root canal-treated tooth commonly presents several challenges for its retention and is lost often. When not able to clean and fill the root canal adequately and in the presence of apical periodontitis/symptoms, a direct composite resin restoration could be placed as an interim restoration.

The provision of intracanal posts and/or the placement of core materials should be carried out with dental dam isolation. If an indirect post technique is opted for, an adequate barrier using an appropriate material of choice to protect the root canal filling material is mandatory.

What not to do during the restoration of root canal-treated teeth

- Use a temporary material as a long-term restoration following the completion of root canal treatment.
- Delay a cuspal-coverage restoration for a root canal-treated tooth deemed at risk of fracture.
- Retain potentially discolouring materials in the pulp chamber space of aesthetically relevant teeth.
- Expose root canal filling materials in the absence of adequate isolation.

FIGURE 3 Clinical cases illustrating three different restorative treatment options for mandibular molar following root canal treatment: (A) direct composite resin overlay. (B) bonded ceramic onlay and (C) ceramic full crown restoration. Note: ideal contemporary access and preparations may preserve further pericervical dentine. Cases courtesy of Dr. Yoshi Shibata (Melbourne).

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RECALL AND OUTCOME ASSESSMENT

Purpose

Regular clinical and radiographic assessment following root canal treatment is essential to assess whether the procedure has led to the expected outcomes.

Rationale/Summary

Root canal treatment, like any other surgical procedure, does not always achieve all the desired outcomes. In fact, there is a high frequency of incidental findings confirming the presence of apical periodontitis in root canal-treated teeth globally. Systematically scheduling recall appointments allows for the identification of those cases and subsequently for shared decision-making between clinician and patient regarding the subsequent course of action.

Possible management options in the presence of disease include further monitoring, orthograde or retrograde retreatment and tooth extraction. The risks and benefits of these options should be discussed based on the best available evidence. Recall supports an understanding of treatment outcomes for the operator leading towards modification in the endodontic management of teeth.

Competence criteria/Quality standards

- Scheduling appropriate recalls following endodontic treatment.
- Follow-ups include clinical and appropriate radiographic examinations.
- Findings and associated options discussed with the patient.

Considerations and clinical approach

Root canal treatment is associated with various patient- and clinician-measured outcomes, including the resolution of symptoms, tooth survival and the presence of normal periapical radiographic findings. Optimal outcomes are not necessarily attained in all cases and case conditions may change over time; therefore, adequate recall is necessary.

In the absence of prearranged review appointments, patients may request a recall only when patient-measured outcomes are not achieved, in the presence of symptoms. Nonetheless, clinician-measured outcomes require intraoral examination, radiographic examination and the use of special tests. If the tooth in question has been treated by different operators (e.g., referral to an endodontist), an assessment of the provision of an adequate restoration is required. The recall schedule may vary depending on the pre-existing condition. A 6-month or 1-year recall with a radiographic examination is an option for follow-up; however, the schedule may be adjusted according to the clinical condition.

Recall is also important for the operator as it allows one to estimate their own 'success rate' and understand what 'works in his/her hands'. Reported outcome rates are not necessarily transferable to each individual practice setting. Recall allows the operator to identify needs for self-directed long-life learning when required.

Recall appointments should be planned upon completion of the root canal treatment and is the responsibility of the operator that has provided the treatment. If an issue is identified, this should be discussed with the patient and subsequent management should be arranged.

Possible options include further recall or intervention, with the decision based on shared decision-making and informed consent.

Recall following traumatic dental injuries has been described in the relevant Trauma Guidelines and are not the purpose of the present document.

What not to do in follow-up care

- Fail to organise recalls following the completion of root canal treatment.
- Use unsuitable radiograph(s) for comparison of treatment outcome.
- Neglect to share decision-making and informed consent when the desired outcomes are not obtained.
- Fail to assess the treatment outcomes and modify future management, if required.

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CONCLUDING REMARKS

These guidelines have been created to establish treatment standards in root canal treatment in Australia. They represent a consensus of expert opinion and are not construed to replace the individual clinician's assessment

and decision in a given clinical case. It is hoped, however, that similar to existing guidelines in the United States and Europe, the codification of standards will inform practising clinicians and, in the end, improve the outcomes of clinical treatment.

DATE OF ISSUE

These Guidelines were finalised on the 8th August 2022 and ratified by the ASE Education Subcommittee on the 1st November 2023.

DATE OF REVIEW

These guidelines will be reviewed regularly. If a new document is created, it will supersede this version

Version 1.0.

In addition to the reading lists included for each subtopic, the ASE Inc. supports the use of the following open access resources to guide dentists in their endodontic practice:

RESOURCES TO GUIDE PRACTICE

Duncan HF, Kirkevang LL, Peters OA, El-Karim I, Krastl G, Del Fabbro M. Treatment of pulpal and apical disease: the European Society of Endodontology (ESE) S3-level clinical practice guideline. Int Endod J. 2023;56:238–95.

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FUNDING INFORMATIONS

Open access publishing facilitated by The University of Queensland, as part of the Wiley - The University of Queensland agreement via the Council of Australian University Librarians.

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How to cite this article: Peters OA, Rossi-Fedele G, George R, Kumar K, Timmerman A, Wright PP. Guidelines for non-surgical root canal treatment. Aust Endod J. 2024;00:1–13. https://doi.org/10.1111/aej.12848