

## QUALITY GUIDELINES

# Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology

## European Society of Endodontology

### Abstract

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The assurance of the quality of a service rendered by a member of the dental profession is an essential feature of any system of peer review in dentistry. This document addresses two essential elements: (i) appropriateness of treatment modality and (ii) quality or level of treatment rendered. In revising these guidelines the European Society of Endodontology is responding to a public and professional need. In receiving care of a specialized nature such as endodontic treatment, patients need and deserve treatment that meets the standard of care

generally given by competent practitioners. The European Society of Endodontology has the expertise and professional responsibility necessary to assist the dental profession by instituting guidelines on the standard of care in the special area of Endodontics. In accepting this responsibility the European Society of Endodontology formulated treatment guidelines that are intended to represent current good practice. This document is the revised version of an earlier consensus report [*International Endodontic Journal* (1994) **27**, 115–24]. As there is not one single way of performing treatment, these guidelines have been formulated in broad terms.

**Keywords:** periodontics, standards, root canal treatment, vital pulp therapy, dental trauma.

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### Introduction

Endodontology is concerned with the study of the form, function and health of, injuries to and diseases of the dental pulp and periradicular region, their prevention and treatment; the principle disease being apical periodontitis, caused by infection. The aetiology and diagnosis of dental pain and diseases are integral parts of endodontic practice. The scope of the special area of dental practice known as endodontics is defined by the educational requirements for the training of a dentist, as described by the European Society of Endodontology in the undergraduate curriculum guidelines for Endod-

ontology (European Society of Endodontology 2001). Endodontic treatment encompasses procedures that are designed to maintain the health of all or part of the dental pulp. When the dental pulp is diseased or injured, treatment is aimed at preserving normal periradicular tissues. When apical periodontitis has occurred treatment is aimed at restoring the periradicular tissues to health: this is usually carried out by root canal treatment, occasionally in combination with surgical endodontics.

The scope of endodontics includes, but is not limited to, the differential diagnosis and treatment of oro-facial pain of pulpal and periradicular origin; prevention of pulp disease and vital pulp therapy; pulp extirpation and root canal treatment; root canal treatment in cases of apical periodontitis; (root canal) retreatment in case of post-treatment apical periodontitis; surgical endodontics; bleaching of endodontically treated teeth; treatment procedures related to coronal restoration by

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means of a core and/or a post involving the root canal space and/or endodontically related measures in connection with crown-lengthening and forced eruption procedures and treatment of traumatized teeth. As part of dentistry's main goal to maintain a healthy, natural dentition for the public, the aim of endodontic treatment is to preserve functional teeth without prejudice to the patient's health. Every dental practitioner is expected to be able to recognize and treat effectively pulpal and periapical injuries and diseases that are commonplace and within the skills acquired by graduates of dental schools in Europe (European Society of Endodontology 2001). The cases that are beyond an individual dental practitioner's means concerning diagnostic and/or technical alternatives should be referred to a colleague who has completed specialty training in Endodontology (European Society of Endodontology 1998) or to a colleague who has acquired the necessary expertise elsewhere.

### **History, diagnosis and treatment planning**

Many features of evaluation in Endodontics are common to all aspects of dental practice. These elements are herein abbreviated, yet included for the purposes of completeness.

#### **Medical and dental history**

Medical history should reveal any medical condition or medication which might influence diagnosis, e.g. sinusitis, neoplasia, or treatment which may be influenced by dental procedures; this should include allergy.

Dental history discovers factors that may be important for diagnosis and treatment planning. History of present complaint is recorded briefly and preferably in the patient's own words. Pain history is recorded to give information on the pain, but phrased to avoid leading questions. The questions may include: the nature, duration, site, periodicity, precipitating or relieving factors and associated symptoms.

#### **Clinical examination**

The patient should be examined both extra- and intra-orally and may also need to be checked for pyrexia and blood pressure.

#### *Extra-oral examination*

The practitioner should look for asymmetry, presence and extent of swelling in the head and neck region,

lymphadenopathy, presence of sinus tracts and presence of temporomandibular joint dysfunction.

#### *Intra-oral examination*

The practitioner should look for the standard of oral hygiene, condition of oral mucosa, presence of swellings and sinus tracts, condition of teeth present, periodontal condition, quantity and quality of restorative work.

### **Diagnosis**

The cause of the patient's complaint should be identified. Some or all, of the following diagnostic tests may be applied: palpation, mobility test, percussion, periodontal examination, occlusal analysis, testing for possible cracked teeth, pulp sensitivity tests, transillumination, selective local anaesthesia, radiography (normally by using the paralleling technique and a beam guiding device for good reproducibility), colour matching and sinus tract exploration. It may be necessary to take radiographs from more than one angle, sometimes supplemented with bitewing and occlusal plane radiographs. Some patients may have to be recalled at periodic intervals to compare some of the examination data from one time interval to another to make an accurate diagnosis of the onset, progression or arrest of a certain process. At times it is advisable to obtain radiographs from previous practitioners to have a clearer understanding of the progress of a condition (as it presents to the clinician at a given time). This is the case especially where previous root canal treatment has been carried out.

### **Treatment planning**

Treatment should be planned for those teeth that are functionally or aesthetically important and have reasonable prognosis. Procedures to maintain pulp health are described in 'Management of the vital pulp'.

#### *Indications for root canal treatment*

Root canal treatment may be carried out on all patients where other dental procedures may be undertaken. Specific indications are

- 1 An irreversibly damaged or necrotic pulp with or without clinical and/or radiological findings of apical periodontitis.
- 2 Elective devitalization, e.g. to provide post space, prior to construction of an overdenture, doubtful pulp health prior to restorative procedures, likelihood of

pulpal exposure when restoring a (misaligned) tooth and prior to root resection or hemisection.

#### *Contra-indications for root canal treatment*

- 1 Teeth that cannot be made functional nor restored.
- 2 Teeth with insufficient periodontal support.
- 3 Teeth with poor prognosis, uncooperative patients or patients where dental treatment procedures cannot be undertaken.
- 4 Teeth of patients with poor oral condition that cannot be improved within a reasonable period.

#### *Indications for root canal retreatment*

- 1 Teeth with inadequate root canal filling with radiological findings of developing or persisting apical periodontitis and/or symptoms.
- 2 Teeth with inadequate root canal filling when the coronal restoration requires replacement or the coronal dental tissue is to be bleached.

#### *Indications for surgical endodontics*

- 1 Radiological findings of apical periodontitis and/or symptoms associated with an obstructed canal (the obstruction proved not to be removable, displacement did not seem feasible or the risk of damage was too great).
- 2 Extruded material with clinical or radiological findings of apical periodontitis and/or symptoms continuing over a prolonged period.
- 3 Persisting or emerging disease following root canal treatment when root canal retreatment is inappropriate.
- 4 Perforation of the root or the floor of the pulp chamber and where it is impossible to treat from within the pulp cavity.

#### *Contra-indications for surgical endodontics*

- 1 Local anatomical factors such as an inaccessible root end.
- 2 Tooth with inadequate periodontal support.
- 3 Uncooperative patient.
- 4 Patient with a compromised medical history (as mentioned in 'Contra-indications for root canal treatment').

## **Records**

It is essential to make adequate records of the patient's complaint, history and treatment plan so that treatment may be carried out to a proper standard and reviewed. Additionally, it allows other operators to take over treatment if required. Further, records are essen-

tial for medico-legal reasons. These guidelines are limited specifically to record keeping in relation to endodontic treatment.

## **The following should be recorded**

Presenting symptoms, history of the present complaint with a dental history related to this, results of clinical examination and sensitivity tests, report on radiographs taken, diagnosis and treatment plan.

## **Informed consent**

Where there are alternative treatments or special problems, these should be explained and discussed with the patient along with the likely prognosis and recorded. It is good practice to provide the patient with written information. It should be recorded that the patient has agreed to the treatment and to the cost.

## **Record of treatment**

The following should be recorded: use of local anaesthesia, method of rubber dam isolation, notable findings (e.g. cracks or iatrogenic defects), working length of canals and their reference points, size to which canals are prepared, preparation technique, volume and concentration of irrigation used, dressing applied, type of temporary restoration, medication prescribed including analgesics and antibiotics (where indicated), root filling material, sealer and technique, number of radiographs, reports on radiographs taken, complications (e.g. iatrogenic incidents) and advice on final restoration or type of restoration (in case treatment is not performed by a specialist).

## **Review**

The outcome of the treatment should be reviewed periodically and recorded (see 'Assessment of outcome of endodontic treatment').

## **Infection control**

The operator and dental nurse should wear gloves and use an aseptic technique. All instruments used within the oral cavity should be sterile, have been decontaminated and sterilized or disinfected where sterilization is not possible. The tooth should be isolated with rubber dam. The tooth to be treated and rubber dam should be disinfected prior to entering the pulp cavity.

## Management of the vital pulp

### Prevention of pulp damage

Recommending and encouraging the use of measures to prevent caries, traumatic injuries and other physical or chemical damage to the teeth. The appropriate early treatment of carious lesions and traumatic injuries may contribute to the maintenance of pulp health. Cavity preparations should be kept as small as possible. Effective water-spray cooling and light pressure should be applied during cutting procedures. Exposed dentinal tubules should be covered with material(s) that protect(s) the pulp from additional injury and permit(s) healing and repair. Restorations should be bonded to tooth structure.

### Treatment procedures for reversible pulp damage

The viability of the pulp should be assessed and, if satisfactory, the tooth may be selected for pulp treatment.

**1 Indirect pulp capping (stepwise excavation of caries):** defined as a procedure in which a pulp is covered with a protective dressing or cement placed over a thin partition of remaining dentine or slightly softened dentine which if removed, might expose the pulp. This procedure is performed when, macroscopically, the pulp is not exposed. Infected softened carious dentine should be removed, thus leaving a layer of slightly softened, presumed noninfected, dentine overlying the pulp. After washing and drying, the cavity is covered with material(s) that protect(s) the pulp from additional injury and permit(s) healing and repair. This should be performed as a two-stage procedure, with the second stage to remove remaining softened dentine being completed within 6 months.

**2 Direct pulp capping:** defined as a procedure in which the pulp is covered with a protective dressing or base placed directly over the pulp at the site of exposure. This procedure may be performed when the pulp is exposed through noninfected dentine and the tooth has no recent history of spontaneous pain and a bacteria-tight seal can be applied. The tooth should be isolated to prevent contamination. The cavity should be washed with a sterile, nonirritating solution and gently dried. The exposure site and surrounding dentine should be covered with material(s) that protect(s) the pulp from additional injury and permit(s) healing and repair. An overlying restoration with a bacteria-tight seal is required to prevent infection. An observation period

of at least 1 year is necessary to evaluate the pulp condition of such a tooth confirmed by radiological examination and sensitivity tests. Indirectly fabricated gold alloy and ceramic restorations are not advised before pulp health has been determined.

### Treatment for irreversible pulp damage

**1 Pulp amputation:** defined as a procedure in which a part of an exposed vital pulp is removed usually as a means of preserving the vitality and function of the remaining part. This procedure is specifically indicated when the pulp of a tooth with incomplete root formation is exposed. It is also performed in some instances in primary teeth and as an emergency procedure before root canal treatment in permanent teeth. The tooth should be isolated to prevent contamination. Damaged and inflamed pulp tissue should be removed gently, preferably by using a high-speed bur under cooling with sterile water or saline. The pulp should be amputated at a level corresponding to the assumed depth of tissue damage. Where the superficial part of the pulp is removed, it is termed 'partial pulpotomy', whereas when it involves the entire coronal pulp it is termed 'coronal pulpotomy'. This level may be determined as the level where after amputation bleeding can be stopped by simple means such as applying a cotton pellet saline-soaked for several minutes. Shreds of tissue and dentine debris are removed by irrigation and haemorrhage is controlled. The amputated pulp and surrounding dentine is covered with material(s) that protect(s) the pulp from additional injury and permit(s) healing and repair.

**2 Pulpectomy:** defined as a procedure in which the total pulp is removed and which is followed by root canal treatment (see 'Root canal treatment'). This procedure may be performed when the pulp is considered to be irreversibly inflamed or when (part of) the pulp cavity is needed for retention of a restoration. Devitalization or chemically modifying the pulp should not be undertaken with materials containing toxic components as there are no indications for this approach.

### Root canal treatment

Root canal treatment is carried out when the pulp is nonvital or has been removed to prevent or treat apical periodontitis. The purpose of root canal treatment is either to maintain asepsis of the root canal system or to disinfect it adequately.

### Preoperative radiograph

A preoperative radiograph showing at least the full root(s) and approximately 2–3 mm of periapical region, must be examined prior to treatment.

### Local anaesthesia

The need for local anaesthesia should be considered and given as appropriate.

### Preparation of tooth

All caries and defective restorations should be removed and, if necessary, the occlusion adjusted and the tooth protected against fracture. The tooth should be capable of being restored and isolated and the periodontal status should be sound or capable of resolution.

### Isolation of tooth

Root canal treatment procedures should be carried out only when the tooth is isolated by rubber dam to: prevent salivary and bacterial contamination, prevent inhalation and ingestion of instruments and prevent irrigating solutions escaping into the oral cavity.

### Access cavity preparation

The objectives of the access cavity preparation are to: remove the roof of the pulp chamber so that this chamber can be cleaned and good visibility of the canal orifices can be obtained, enable root canal instruments to be introduced into the root canal(s) without undue bending, offer sufficient retention for a temporary restoration and conserve as much sound tooth tissue as possible that is compatible with the above.

### Determination of working length

The objective of determining the working length is to enable the root canal to be prepared as close to the apical constriction as possible. The location of the apical constriction normally varies between 0.5 and 2 mm from the radiographic apex. Recommended methods are electronic and radiographic.

#### *Electronic*

Electronic devices measure the length of the root canal accurately in most cases. The working length should normally be confirmed radiographically.

#### *Radiographic*

The instrument should be equipped with some form of length indicator and be of sufficient size so that its tip can be clearly identified on the radiograph. A radiograph is then taken which should show the instrument and the apex with minimal distortion. The desired working length is determined. If the distance between the tip of the instrument and the desired working length is  $>3$  mm, the working length of the file is adjusted and a further radiograph taken. It may be necessary to take more than one working length radiograph.

### Preparation of the root canal system

The objectives of preparation are to: remove remaining pulp tissue, eliminate microorganisms, remove debris and shape the root canal(s) so that the root canal system can be cleaned and filled. The use of magnification and additional sources of light facilitate identification of root canal anatomy. The requirements should be: the prepared canal should include the original canal, the apical constriction should be maintained, the canal should end in an apical narrowing and the canal should be tapered from crown to apex. Preparation should be undertaken with copious irrigation. The final length of the preparation should not be reduced by treatment.

### Irrigation

The objectives of irrigation are to: eliminate microorganisms, flush out debris, lubricate root canal instruments and dissolve organic debris. The irrigant solution should preferably have disinfectant and organic debris dissolving properties, whilst not irritating the periradicular tissues. The irrigant solution should be delivered in copious amounts as far up the canal as possible without risking extrusion beyond the foramen. This can be performed with a syringe, ensuring that the solution is allowed to escape freely into the pulp chamber and is not delivered with excessive force. The solution may also be delivered by ultrasonic or sonic systems.

### Inter-appointment medication

The objectives of inter-appointment medication are to prevent growth and multiplication between visits of microorganisms left in the canal system despite cleaning. They should be used following proper cleaning and irrigation and to support the tissue-dissolving effects of irrigating solutions. This stage is rarely necessary after

pulpectomy and root canal preparation of a tooth with a vital pulp. An effective temporary restoration is essential to prevent contamination of the canal system between visits. The requirements of an inter-appointment disinfectant are: have long-lasting disinfectant action, be biocompatible, be removable and be nondamaging to tooth structure or the restorative material.

### **Filling of the root canal system**

The objectives are: to prevent the passage of microorganisms and fluid along the root canal and to fill the whole canal system, not only to block the apical foramina but also the dentinal tubules and accessory canals. Materials used to fill the root canal system should be: biocompatible, dimensionally stable, able to seal, unaffected by tissue fluids and insoluble, nonsupportive of bacterial growth, radiopaque, and removable from the canal if retreatment needed.

The root canal filling should consist of a (semi-) solid material in combination with a root canal sealer to fill the voids between the (semi-) solid material and root canal wall. Sealers containing organic materials such as aldehydes are not recommended. Filling should be undertaken after the completion of root canal preparation and when the infection is considered to have been eliminated and the canal can be dried. In some cases it might be recommended that prior to filling, the completion of root canal preparation is verified by taking a radiograph with the root canal instrument(s) (or filling cones) inserted to the full working length. The end-point of the inserted instrument (or cone) and the apex should be visible on this verification radiograph. The quality of filling should be checked with a radiograph. This radiograph should show the root apex with preferably at least 2–3 mm of the periapical region clearly identifiable. The prepared root canal should be filled completely unless space is needed for a post. The prepared and filled canal should contain the original canal. No space between canal filling and canal wall should be seen. There should be no canal space visible beyond the end-point of the root canal filling.

The tooth should be adequately restored after root canal filling to prevent bacterial recontamination of the root canal system or fracture of the tooth.

### **Surgical endodontics**

Surgical endodontics is performed when intracanal approaches are technically difficult or impractical. The

following are standard sub-procedures: incision and drainage, apical surgery, other surgical endodontic procedures and extraction with replantation. Pre-surgical planning is necessary.

#### **Incision and drainage**

The objective is to release exudate that is entrapped within tissue and cannot be drained through the root canal or as an emergency treatment prior to starting root canal treatment in cases of fluctuant swelling. Anaesthesia should be obtained. An incision is made into the fluctuant swelling and drainage established. If microbial sensitivity testing is to be carried out, aspiration of contents of the swelling should be performed prior to incision. A drain may be positioned in the incision wound. The tooth is then, or shortly thereafter, isolated and the root canal(s) prepared. If no drainage can be obtained and there are systemic effects from the infection, the use of antibiotics may be considered.

#### **Apical surgery**

##### *General principles*

Suitable anaesthesia is obtained. An appropriate surgical flap design is chosen and the mucoperiosteum, handled with minimal trauma, is reflected. Bone overlying the lesion is then removed, the appropriate procedure (see below) is performed and the flap is replaced and then sutured. A postoperative radiograph is then taken. Advice is given on post-operative care.

##### *Exploratory surgery*

The objective of exploratory surgery is to diagnose an endodontic problem that cannot be diagnosed in any other way. It is necessary to reflect a flap to examine the area, e.g. for a longitudinal root fracture. Appropriate treatment is then carried out.

##### *Periradicular curettage*

The objective of curettage is to remove diseased tissue and/or foreign material from the alveolar bone in the apical or lateral region surrounding a pulpless tooth. The procedure is rarely used alone and only when the root canal system has been considered satisfactorily disinfected and filled.

##### *Biopsy*

The objective of biopsy is the surgical removal of a tissue specimen for microscopic examination. It is

performed if there is any doubt as to the cause of a periradicular lesion. The tissue is immediately placed into a transport medium or suitable fixative.

#### *Root-end resection*

The objectives of root-end resection are to: remove a part of the root which could not be disinfected or/and filled with a root canal filling material and the contents of which may have caused or maintained inflammation and facilitate access for creation of a root-end preparation for a root-end filling. The root tip should be resected with little or no bevel. The procedure is rarely used on its own and only when the root canal system has been considered to have been satisfactorily treated and well filled.

#### *Root-end preparation and filling*

Root-end preparation is performed after root-end resection. It should follow the outline of the canal system and be in the axis of the canal(s). The objective of the root-end filling is to fill the root-end cavity and seal any path from the root canal to the periradicular tissues. A filling material is placed in the root-end cavity. The requirements for materials are as listed in 'Filling of the root canal system'. Amalgam is no longer the material of choice.

### **Other surgical endodontic procedures**

#### *Repair of perforation*

The objective of repair of a perforation is to prepare, disinfect and fill the defect in the lateral aspect of the root with a filling material.

#### *Root resection*

The objective of root resection is to remove an entire root or roots from a multirooted tooth without the removal of the corresponding part of the crown. The indications include periodontitis, root fracture or where it is impossible to carry out root canal treatment or root-end resection, and signs and symptoms are present.

#### *Tooth resection*

The objective of tooth resection is to cut off from a multirooted tooth an entire root or roots with the associated coronal tooth structure. The indications are similar to those of root resection. Root and tooth resection usually necessitate root canal treatment of all remaining roots, preferably before the commencement of the surgical procedure.

### **Extraction with replantation**

The objectives of extraction with replantation are to: remove the tooth intentionally from its socket, carry out normal surgical root-end procedures extraorally and replant the tooth. This indication is relevant when nonsurgical root canal treatment is not possible or has not been successful and when surgical endodontics *in situ* is not advisable.

### **Assessment of outcome of endodontic treatment**

The primary purpose of outcome assessment is to monitor healing or development of pulpitis or apical periodontitis. Clinical and radiographic follow-ups at regular intervals for a minimum observation period of 1 year are desirable, but longer may be required where healing is incomplete or there is a history of trauma. A favourable outcome may be reversed if infection or reinfection occurs.

### **Assessment of direct pulp capping and pulp amputation**

Direct pulp capping and pulp amputation should be assessed no longer than 6 months postoperatively and thereafter at regular intervals. The following findings indicate favourable outcome: normal response to pulp sensitivity tests (when feasible), absence of pain and other symptoms, radiological evidence of dentine bridge formation, radiological evidence of continued root formation in immature teeth, absence of clinical and radiographic signs of internal root resorption and apical periodontitis.

### **Assessment of outcome of root canal treatment**

Root canal treatment should be assessed at least after 1 year and subsequently as required. The following findings indicate a favourable outcome: absence of pain, swelling and other symptoms, no sinus tract, no loss of function and radiological evidence of a normal periodontal ligament space around the root.

#### *Root canal treatment has an uncertain outcome*

If radiographs reveal that a lesion has remained the same size or has only diminished in size, the outcome is considered uncertain. In this situation it is advised to assess the lesion further until it has resolved or for a minimum period of 4 years. If a lesion persists after

4 years the root canal treatment is usually considered to be associated with post-treatment disease.

*Root canal treatment has an unfavourable outcome*

This occurs when

- 1** The tooth is associated with signs and symptoms of infection.
- 2** A radiologically visible lesion has appeared subsequent to treatment or a pre-existing lesion has increased in size.
- 3** A lesion has remained the same size or has only diminished in size during the 4-year assessment period.
- 4** Signs of continuing root resorption are present.

In these situations it is advised that the tooth requires further treatment.

*Exception* An extensive radiological lesion may heal but leave a locally visible, irregularly mineralized area. This defect may be scar tissue formation rather than a sign of persisting apical periodontitis. The tooth should continue to be assessed.

### Assessment of surgical endodontics

Surgical endodontics should be assessed after 1 year and subsequently as required. The following findings indicate a favourable outcome: absence of pain, swelling and other symptoms, satisfactory healing of soft tissue, no sinus tract, no loss of function and radiological evidence of repair of apical periodontitis including reformation of the periodontal ligament space. It should be noted that occasionally a radiolucent area, 'surgical defect' or 'scar', may persist. If there is a persisting lesion after 1 year, it should be followed up for 4 years (see 'Assessment of outcome of root canal treatment').

### Secondary sources of compromised treatment outcomes

Factors that may lead to new disease and thus jeopardize endodontic treatment include, e.g. recurrent caries and coronal leakage, caries extending into the root canal or furcation, root fracture, root perforation or extending marginal periodontitis.

### Traumatic injuries

Traumatic injuries may have an effect on dental hard substances, the pulp and the periodontium. Therefore, often a multidisciplinary approach is needed in

diagnosis and treatment. These quality guidelines mainly focus on the endodontic component of dental trauma.

In addition to the regular medical and dental history, other information is required such as photographs and the type, time and location of the accident. Depending on previous vaccinations the patient may require immunization against tetanus, if a wound or replanted tooth has been contaminated with soil. More than one tooth may be affected by different types of injury. The practitioner carrying out endodontic treatment may not have seen the patient at the time of injury.

### Crown infraction

An incomplete fracture of the enamel, which may extend into dentine, without the loss of tooth substance. Usually no treatment is indicated.

### Crown fracture

#### *Uncomplicated*

A fracture of enamel or enamel and dentine without pulp exposure. Enamel fractures may require selective grinding of the incisal edge only and/or restoration. When a fragment can be repositioned, it should be bonded in place. Fractures of enamel and dentine require coverage of the exposed dentine as soon as possible for protection against the oral environment.

#### *Complicated*

A fracture of enamel and dentine that exposes the pulp.

*Vital pulp, open apex* If the patient is seen up to several days after injury, pulp amputation should be performed (see 'Treatment procedures for reversible pulp damage'). The level of amputation should be in the most coronal pulp tissue, which is not inflamed and where haemorrhage can be easily controlled. The exposed dentine should be covered and a bacteria-tight seal applied. The pulp status should be monitored.

*Necrotic pulp, open apex* This requires the preparation of an access cavity, establishment of canal length, cleaning and minimal mechanical preparation of the canal supported by much irrigation (see 'Irrigation'). The canal is dried and filled with a material that permits healing and repair of the root-end and surrounding tissues, prevents bacterial contamination and can be easily removed; the access cavity is sealed. The development of an apical barrier should be monitored.



When an apical barrier has formed, the permanent root canal filling should be placed. An alternative treatment could include the intra-canal placement of an apical plug of a suitable material to produce a barrier between the canal and periapical tissues.

*Vital pulp, fully formed root* In cases where the patient is seen within 24 h, pulp amputation may be indicated (see 'Treatment for irreversible pulp damage'). In all other cases root canal treatment is indicated.

*Necrotic pulp, fully formed root* Root canal treatment is indicated (see 'Root canal treatment').

### **Crown-root fracture**

A fracture that involves enamel, dentine and cementum. The tooth needs to be assessed for restorability. Where it is restorable, treatment of pulp tissue in this situation is similar to the treatment of crown fractures (see 'Crown fracture'). It may be necessary to consider root extrusion and/or periodontal surgery.

### **Root fracture**

A fracture of dentine and root cementum involving the pulp. The pulp is damaged but not exposed to the oral cavity. Treatment is aimed at maintaining pulp vitality; this may include repositioning of the coronal part and placement of a splint attached to the injured and adjacent unaffected teeth. The splint should be maintained for approximately 3 weeks (longer in cases of great mobility) and allow optimal oral hygiene. If the coronal pulp becomes necrotic, that part of the canal should be treated endodontically. A root-end closure procedure (see 'Crown fracture') for this part may be considered. On those rare occasions where the apical part becomes necrotic this should also be treated; if root canal treatment of the apical part associated with apical periodontitis is impossible via the coronal part, the apical part of the root should be removed surgically.

### **Luxation**

These injuries have caused damage to the periodontal ligament and the alveolar bone; the greater the affected root area, the more the prognosis is reduced. Inflammatory root resorption is a sequel to pulp necrosis and infection. Ankylosis, the replacement of the root by bone, is a late complication and progressive. Cervical resorption is another possible complication.

### *Extrusive luxation*

A partial displacement of the tooth out of its socket without fracture of the alveolar bone. The tooth should be repositioned immediately. Correct position should be ensured and if the tooth is mobile the tooth should be splinted for up to 3 weeks with a slightly flexible splint that allows optimal oral hygiene and function of the tooth. The pulp status should be monitored in immature teeth. Teeth with closed apex should be treated endodontically (see 'Root canal treatment').

### *Lateral luxation*

Displacement of a tooth in a direction other than axially with comminution or fracture of the alveolar bone. The tooth should be repositioned immediately and further treatment performed as described in 'Extrusive luxation'.

### *Intrusive luxation*

Displacement of the tooth into the alveolar bone with comminution or fracture of the alveolar bone.

*Open apex* In cases of minor displacement no treatment should be undertaken as the tooth may re-erupt spontaneously. If the intrusion is severe orthodontic and orthodontic/surgical reposition should be considered. The pulp status should be monitored. Where signs of periradicular radiolucency or inflammatory root resorption are seen the necrotic pulp should be removed immediately, the tooth should be treated endodontically (see 'Necrotic pulp, open apex').

*Root formation completed* The tooth is repositioned orthodontically and/or surgically, the pulp should then be removed as soon as possible and the canal cleaned to prevent infection. The tooth should be treated endodontically (see 'Root canal treatment').

### **Minor fractures of the alveolar process associated with traumatized teeth**

Bony fragments should be repositioned and soft tissue wounds sutured as necessary. The teeth involved should be splinted to include at least one unaffected tooth on each side. The splint is left in place for up to 3 weeks.

### **Avulsion of the tooth (exarticulation)**

A displacement of the tooth out of its socket. The tooth should be replanted as soon as possible, by the patient,

parent or helper, because prognosis deteriorates rapidly the longer the tooth is out of its socket. The tooth is gently inserted back into its socket and the patient should hold it in place whilst being taken to the dental clinic. If the tooth is dirty, it should be rinsed with saline or tap water; it should not be scrubbed, neither should antiseptics be used. The tooth should only be handled by the crown. If immediate replantation is not possible the tooth should be placed in a physiological solution (e.g. commercial tooth transport medium, glass of cold milk or physiological saline). If none is available the tooth may be held in the buccal sulcus of the mouth. The tooth must not be allowed to dry out. When the patient arrives, the tooth should be inspected, rinsed and replanted immediately. A slightly flexible splint should be placed for 1 week. The splint should allow optimal oral hygiene and function of the tooth. Good oral hygiene supported with a disinfecting mouthwash should be stressed. If the replanted tooth has an open apex, the pulp may revascularize provided that <1 h has elapsed between injury and replantation. No endodontic treatment may then be required, but the tooth should be kept under observation. If the pulp becomes necrotic the procedure for root-end closure should be performed (see 'Crown fracture'). If the replanted tooth has a fully formed root, the pulp should be removed and root canal procedures started within 1–2 weeks after replantation.

### Diagnosis of pulp vitality in traumatized teeth

Teeth subjected to trauma may not respond normally to pulp sensitivity testing for some months and should be reviewed periodically up to 12 months or longer in case of doubt, to determine sensitivity and vitality. Radiographs should be taken at every recall appointment to check for signs of apical periodontitis and progressive external resorption. If disease is confirmed by several tests, appropriate endodontic treatment should be performed without delay.

Suggested follow-up periods after injury are 1 week (avulsion), 3 weeks, 2 months, 6 months, 12 months and then annually. Where pulp vitality has been established by 1 year, further follow-up is not indicated in the absence of other signs of disease. In the case of luxation injuries follow-up should be for 5 years to detect late root resorption.

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The Guidelines have been agreed following wide consultation within the structures of the ESE including the country representatives and member societies.

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