

Endodontology

1. Principles Pertinent to the Evaluation Criteria

Endodontology deals with the form, function, and health of the dental pulp and periradicular tissues as well as with their injuries and diseases and the diagnosis, prevention, and treatment of these. The treatment comprises health maintenance of the pulp and the preservation of the normal periradicular tissues in case of diseases or injuries of the pulp. If a pulpal disease has expanded into the periradicular tissues, the treatment aims at the restitution of health of the damaged tissues. This is mostly achieved by means of a root treatment which in some cases is combined with endodontic surgery.

The root canal treatment involves the use of chemical and mechanical methods which have to meet biological requirements. The objective of the treatment is to eliminate the pulpal and periradicular disease, to stimulate healing, and to restore the periradicular structures. Cleaning, contouring, disinfection, and obturation of all canals is carried out under aseptic conditions and as far as possible with the aid of rubber dam. For the subsequent obturation of the canals biologically acceptable materials are used in order to attain a hermetic seal of the root canal system.

In a root treatment there is always a risk that in occasional cases root canal instruments can fracture. The reasons for this are mostly beyond the control of the dentist. If this happens and the fragment cannot be removed any more, the canal is tightly sealed using a biocompatible material and the patient is informed. If pathologies appear or persist, surgical measures have to be taken.

Endodontic revisions are measures for the removal of previously applied filling materials as well as for the adjustment of canal obstructions, steps, and perforations in order to enable cleaning, disinfection, and obturation of the root canal. If the pathologies cannot be removed using conventional endodontic measures, the correction must be brought about by means of endodontic surgery. Thereby the diseased tissues and possibly overfilled foreign material are removed via an intervention. The cause or causes of the pathologies are eliminated from the root canal system in a retrograde way and the root is sealed using a biocompatible material.

In case of tooth fractures, the dentin and/or pulp wound is to be covered as soon as possible with biocompatible materials in order to prevent bacterial contamination of the pulp.

In case of luxation injuries, the tooth is repositioned as soon as possible and stabilized using a splint, whereby the physiologic mobility of the tooth has to be ensured. After periodontal healing has occurred the splint is removed. Solely root fractures are fixated for extended periods using a rigid splint. Vitality tests are performed at regular intervals. If clear signs of missing vitality ensue, a root treatment is to be commenced. In the case of a total luxation of teeth with completed root growth, a root canal treatment has to be started about ten days after the accident.

The quality of endodontic treatments is ensured by proper knowledge of the biological basic principles of the specialty and their implementation in every therapeutic measure. Endodontic treatments are based on scientific insights which are attested by published papers.

2. Evaluation Criteria for the Quality Levels A+ to C

	ISOLATION AND ACCESS	PREPARATION/ROOT CANAL TREATMENT
A+	<ul style="list-style-type: none"> ▪ Absolutely tight isolation of the operating area (rubber dam) ▪ Substance sparing access to all canals with unrestricted view 	<ul style="list-style-type: none"> ▪ Efficient cleaning and preparation of all canals ▪ Complete removal of the pulp tissues ▪ Alteration of the course of the canal/minimal apical transportation ▪ Precise adherence to the defined working length ▪ Efficient, frequent rinsing with an antimicrobial solution of low toxicity ▪ Preparation/pulp extirpation under endometric control
A	<ul style="list-style-type: none"> ▪ Complete caries excavation ▪ Suboptimal isolation of the operating area ▪ Suboptimal access to all canals ▪ Partly restricted view 	<ul style="list-style-type: none"> ▪ Loss of working length only 1 mm at the maximum ▪ Apical preparation up to instrument ISO #25 ▪ Rinsing with antimicrobial solution of medium toxicity ▪ Preparation/pulp extirpation without endometric control as an emergency measure
B	<ul style="list-style-type: none"> ▪ Partial isolation of the operating field ▪ Obturation macroscopically leaky 	<ul style="list-style-type: none"> ▪ Loss of working length greater than 1 mm or overinstrumentation ▪ Step formation ▪ Excessive removal of dentin in the coronal half ▪ Rare rinsing with antimicrobial solution of major toxicity
C	<ul style="list-style-type: none"> ▪ No protection of the pharynx ▪ Accidental perforation of the pulp cavity floor ▪ Caries not removed 	<ul style="list-style-type: none"> ▪ Complete preparation/pulp extirpation without endometric control ▪ Considerable weakening of the tooth due to over-preparation ▪ Perforation (zip, strip) ▪ Instrument fracture without information of the patient and documentation ▪ No rinsing ▪ Preparation using laser

	INSERTION/DISINFECTION OF THE ROOT CANALS	OBTURATION
A+	<ul style="list-style-type: none"> ▪ Antibacterial substances of minor toxicity with long-term effect (entire duration of insertion) ▪ Change of insertion under endometric control 	<ul style="list-style-type: none"> ▪ Root canal filling under endometric control ▪ Tight obturation of all canals and canal bulges down to the defined working length
A	<ul style="list-style-type: none"> ▪ Antibacterial substances of minor toxicity with short-term effect ▪ Change of insertion without endometric control as an emergency measure ▪ Temporary tight coronal seal 	<ul style="list-style-type: none"> ▪ Tight apical obturation of all canals and canal bulges with a loss of working length of no more than 1mm ▪ Temporary tight coronal seal ▪ Use of biocompatible, radiopaque, inert, dimensionally stable, and revisable materials enabling an intracanal retentive anchorage ▪ Postoperative X-ray
B	<ul style="list-style-type: none"> ▪ Antibacterial substances of high toxicity with short-term effect ▪ Change of insertion without endometric control ▪ Temporary leaky coronal seal 	<ul style="list-style-type: none"> ▪ Root canal filling without endometric control ▪ Use of resorbable materials ▪ Use of toxic materials without overfilling ▪ Proper instrumentation with partial obturation and overfilling ▪ Overinstrumentation with underfilling ▪ Overinstrumentation with overfilling ▪ Underinstrumentation with underfilling
C	<ul style="list-style-type: none"> ▪ Arsenic medications ▪ Toxic medications forming deposits ▪ Disinfection using laser only 	<ul style="list-style-type: none"> ▪ In permanent teeth: obturation using only cement ▪ Leaky root canal filling or overfilling using toxic and/or non-revisable materials ▪ Iatrogenic root fracture ▪ Leaky temporary coronal seal ▪ No postoperative X-ray

	PAIN CONTROL AND AFTERCARE	SURGICAL ENDODONTICS
A+	<ul style="list-style-type: none"> ■ Adequate pain control prior to and during treatment ■ Information of the patient about possible postoperative discomfort ■ Prescription of efficient analgesics in case of foreseeable pain ■ Case-specific regular follow-up check including all radiographic and clinical examination methods ■ Bacteria-proof permanent coronal obturation in order to avoid coronal leakage ■ No major prosthodontic treatment without documented complete healing 	<ul style="list-style-type: none"> ■ Optimal protection of involved anatomical neighboring structures (vessels, nerves, sinuses) ■ Complete visualization, cleaning, and obturation of all involved apical and radicular orifices using adequate methods for optical magnification ■ Damage-related retrograde preparation and instrumentation with as complete as possible elimination of the infection and necrotic tissue rests from the root canals ■ Use of tight, biocompatible, radiopaque, inert, non-resorbable retrograde materials
A	<ul style="list-style-type: none"> ■ Irregular follow-up checks including all radiographic and clinical examination methods ■ Major prosthodontic treatment without documented positive course of healing ■ Sufficient permanent coronal obturation without tentative planning of a further permanent treatment 	<ul style="list-style-type: none"> ■ Adequate access to the periradicular pathology
B	<ul style="list-style-type: none"> ■ Follow-up checks only upon the occurrence of discomfort ■ Partial pain control prior to and during treatment ■ No information of the patient about possible postoperative discomfort ■ No prescription of adequate analgesics in case of foreseeable pain ■ Insufficient clarification of the patient about further necessary therapeutic measures for the preservation of the tooth (attention: patient compliance!) ■ Insufficient permanent coronal obturation 	<ul style="list-style-type: none"> ■ Resection without utilization of auxiliaries for visualization ■ Excessive resection of the root ■ Inadequate retrograde cavity preparation: under- or overpreparation ■ No retrograde cleaning of the root canal system ■ Incomplete depiction of the root canal orifices ■ Inadequate access with avoidable reversible damage to anatomical neighboring structures
C	<ul style="list-style-type: none"> ■ No pain control prior to or during treatment ■ No follow-up check ■ No clarification of the patient about further necessary measures for the preservation of the tooth 	<ul style="list-style-type: none"> ■ Resection without ensuring a tight apical obturation ■ Inadequate access to the root apex with avoidable, irreversible damage to anatomical neighboring structures ■ Implementation of a surgical therapy, although a conventional intervention would be reasonable and possible ■ Use of resorbable, non-biocompatible, non-radiopaque materials ■ Accidental iatrogenic damage of neighboring structures ■ No aftercare

3. Explanatory Notes on the Evaluation Criteria

Diagnosis

In every case a diagnosis that is as accurate as possible should be made. The auxiliaries for the diagnosis are:

History

- General medical history
- Dental history: accidents in the oral area, previous infections, orthodontic treatment, questioning regarding the causes of the current problems; questions regarding the nature, duration, location, and frequency of discomfort as well as regarding triggering and alleviating influences

Collection of Clinical Findings

- Search for fistulas, swellings, fractures of teeth or restorations as well as assessment of the type and quality of existing restorations; evaluation of the periodontal condition and the tooth color; evaluation of the occlusion, articulation, tooth mobility, and tenderness on percussion
- Sensibility tests (heat, cold, electrical tests)

Collection of Radiographic Findings

- Apical radiolucency (osteolysis)
- Fractures
- Periodontal space/lesions
- Caries
- Antecedent root treatment
- Anatomy and morphology
- Restorations

Differential Diagnosis

The differential diagnosis enables the decision to either keep the tooth vital (more or less normal sensibility, hope for reversibility of the pulpitis, temporary therapy, capping) or perform a root treatment (irreversible pulpitis, necrosis).

This is essential for an adequate therapy.

Indications

Indication for Endodontic Treatments

An endodontic treatment can be carried out in all patients in whom also other dental treatments are possible. Specific indications are: a) irreversibly damaged or necrotic pulp with or without clinical and/or radiographic alterations in the periradicular region; b) root amputation or hemisectioning. Moreover, an elective devitalization of the pulp can prove necessary for the following reasons: i) prosthetic indication, in particular to achieve an otherwise unavailable retention; ii) in case of a questionable pulp condition prior to a restorative reconstruction; and iii) in case of a probable pulp exposition while preparing a (malpositioned) tooth.

Contraindication for the Root Treatment

In a) teeth which cannot be restored or do not serve a functional or esthetic purpose; b) teeth with insufficient periodontal attachment; c) teeth with a bad prognosis; moreover, no root treatment is performed if another dental treatment is not possible either (uncooperative patient or medical contraindication).

Indication for the Revision of a Root Treatment

A revision is required in teeth with an inadequate root canal filling, a) if they exhibit periapical pathologies with or without symptoms; b) if the coronal restoration has to be replaced; c) before bleaching. In addition, a revision is indicated in teeth with a root canal filling which appears radiographically adequate, but exhibits an apical radiolucency that has not yet healed after five years.

Indication for Surgical Endodontics

a) Blocked canal with a radiographic finding and/or symptoms; b) overfilling associated with a clinical or radiographic finding and/or symptoms persisting for extended periods (at least one week); c) failure of a root treatment, if a revision is not possible or is out of the question; d) perforations and pathology exhibiting a radiographic finding or symptoms in cases where a (conventional) orthograde treatment is not possible.

Contraindication for Surgical Endodontics

a) Local anatomical factors, e.g. an inaccessible apex; b) insufficient periodontal attachment; c) uncooperative patient; d) surgical intervention contraindicated for general medical reasons

Preservation of Vitality and Therapy of the Pulp

Prevention of Pulp Damage

Cavity size should be minimized. During preparation, the rotating instruments should be cooled efficiently using water or air. Exposed dentinal tubules are sealed using materials which protect the pulp and allow the repair and healing of the dentinal wound.

Indirect Pulp Capping

In this procedure, the dentin lying very close to the pulp is covered with a protective layer (e.g. bonding).

The indirect pulp capping is carried out if the pulp is not exposed macroscopically. Upon the preparation, the infected dentin is completely removed, solely a thin layer of slightly softened and not infected dentin can be left so as not to expose the pulp. Infectious dentin is soft and can be marked with a solution staining caries or using another method. Subsequently, the cavity is thoroughly rinsed, dried, and covered with materials that protect the pulp and allow the repair and healing of the dentinal wound.

Direct Pulp Capping

In this procedure, a pulp wound is covered with a protective layer and sealed.

The direct pulp capping is carried out if the pulp has been exposed through non-infected dentin, if no spontaneous pain has occurred, and moreover, if the tooth can be treated with a bacteria-proof restoration.

The pulp can also be directly capped after exposure due to an injury. In this case the tooth should be isolated to avoid contamination of the open pulp with saliva and the bacteria present therein. The cavity should be rinsed using a non-irritating and sterile solution and subsequently dried quickly and carefully. The pulp wound and the surrounding dentin are covered using materials which protect the pulp against further irritation, seal it and thus promote repair and healing.

A monitoring time of at least one year should be observed. During this period, the condition of the pulp is traced radiographically and clinically. Vitality tests must indicate normal values. A prosthodontic restoration (crown) should only be incorporated, when healing is complete. However, a permanent filling makes sense.

Pulpotomy

In the pulpotomy, part of the exposed pulp is removed to keep the remaining pulpal tissues vital and functioning. This measure is only performed in teeth whose root growth is not completed yet to allow root growth to continue. A pulpotomy can also be indicated as an emergency measure until a conventional root treatment is commenced.

The tooth must be isolated to avoid bacterial contamination. The injured and inflamed coronal pulp is removed. The level of the amputation is selected in such a way that bleeding from the pulp can be arrested by compression with a cotton pellet soaked with physiologic saline. The wound is cleaned, the bleeding staunched, and the site of the amputation together with the surrounding dentin covered with a material that protects the wound against further irritation. The remaining pulp is extirpated after completion of root growth. Subsequently the canal is permanently filled.

Pulpectomy

In a pulpectomy, the pulp is completely removed and subsequently a root treatment is performed.

This is indicated if the pulp is irreversibly damaged or if part of the root canal system is needed for the retention of a restoration.

Under no circumstances may the devitalization of the pulp be made using materials containing arsenic or aldehydes or using physical means.

Root Canal Treatment

Prior to treatment, an X-ray is made, which preferably should be taken using the parallel technique. On this radiograph the tooth (if possible life-size) should be depicted with its roots as well as 2–3 mm of the periapical region.

Preparation of the Tooth

At first caries and defective restorations are removed. In order to protect the tooth against fractures, the occlusion should be reduced. Subsequently it should be possible to restore the tooth, to carry out a periodontal rehabilitation, and to surround it circularly, whereby the margins possibly have to be exposed first by means of a periodontal-surgical intervention.

Isolation of the Tooth

During an endodontic treatment, the tooth must always be isolated by means of rubber dam to avoid contamination with saliva and bacteria, to prevent an inadvertent penetration of instruments in the airways or the esophagus, and to rule out that rinsing solutions can get into the oral cavity.

Preparation of the Access Cavity

The access to the root canals should be as direct as possible in order to be able to insert the root canal instruments without unnecessary deformation into the canal.

Determination of the Working Length

The working length is positioned as closely as possible to the cementum-dentin junction (foramen physiologicum). The cementum-dentin junction is between 0.5 mm and 2 mm away from the radiographic apex.

The working length can be determined with the aid of an X-ray or an electronic measurement.

Radiographic Determination of the Working Length

The length of the root canal instrument inserted into the canal is 0.5–2 mm shorter than the root length estimated in the radiograph. If an adjustment of the working length of less than 3 mm is necessary, the preparation of the root canal can be continued by directly transferring the difference to the subsequently used instruments. If the difference is greater than 3 mm, a second X-ray is made and the length of the instrument inserted into the canal is adjusted. Sometimes it is also necessary to make measuring pictures from various exposure angles (superposition of roots).

Electronic Determination of the Working Length

In most cases the indicated values of the electronic measuring devices are rather accurate estimates of the working length. Nevertheless, it is recommended to verify the working length using an X-ray. Even if the working length is exclusively determined by electronic means, an initial radiographic examination is absolutely necessary.

Preparation/Instrumentation of the Root Canal System

With the instrumentation of the root canal, the entire pulp tissues as well as necrotic debris are removed and existing microorganisms eliminated. The root canals are shaped in such a way that the canal system can be rinsed and sealed under optimal conditions.

In the root canal preparation, the original course of the canal as well as the natural morphologic canal architecture should be maintained. The apical constriction is preserved, and the preparation ends at the narrowest position of the apex. Upon the final enlargement, the entire length of the root canal from the crown to the apex is brought into a conical shape.

During the preparation, it should be rinsed frequently and abundantly. The ultimate length of the preparation should coincide with the endpoint predefined with the determination of the working length.

Rinsing

The canal rinse should have a disinfecting effect, should dissolve organic debris, and, at the same time, should not irritate the periradicular tissues. In addition, the rinsing solution ensures that debris which has accumulated in the canal during the preparation is flushed out.

The rinsing solution should be instilled in abundant amounts and as deeply as possible into the canal, albeit without getting beyond the apical foramen.

After every change of the root canal instrument, it preferably should be rinsed again.

Disinfection between Sessions (Canal Insertion)

If following appropriate cleaning and rinsing in a session a permanent obturation of the canals cannot be performed any more (treatment of non-vital teeth), an agent for temporary disinfection is inserted so that residual germs cannot multiply.

A temporary coronal obturation of the tooth is essential to prevent a bacterial contamination of the canal system between two sessions.

A temporary insertion in the root canal has a disinfecting effect, does not irritate the periradicular tissues, and has no systemic effect. Moreover, it should be easy to completely remove and must not damage either the tooth or the filling material.

In general, inorganic materials, which do not bind to proteins and have no immunogenic effect, are preferred.

Disinfectants on an organic basis or agents containing phenols or aldehydes are not recommended.

Obturation of the Root Canal System

The root canal filling should only be made when the canals are completely dry and the tooth is again asymptomatic. The objective of the root canal filling is to prevent a discharge of microorganisms and fluids through the canal. Therefore it should fill the entire canal system and thereby not only obturate the orifice into the periapex, but also seal the dentinal tubules and accessory canals. Furthermore, percolation and microinfiltration (“microleakage”) of substances in both coronal and apical directions should be prevented.

Root canal filling materials are biocompatible, dimensionally stable, little soluble, and radiopaque. They should seal well and not permit bacterial growth; they are not affected by body fluids and, if necessary, are easy to remove from the root canal.

The prepared lumen is completely sealed from the pulp cavity over the entire length down to the apical constriction.

The root canal filling consists of a (semi-)solid material which is combined with the so-called “sealer”. The latter fills the intervening spaces between the (semi-)solid material and the canal walls. A filling with cements containing organic components such as aldehydes is not recommended.

The quality of the obturation is checked using a final X-ray. It should clearly depict the root tip and at least 2 mm of the periapical region. The canal to be obturated, except the space possibly allowed for a root post, should be completely filled. The preparation as well as the obturation of the canal toward the apex should be made in a conical manner and take into account the original course of the canal. No gap between the root canal filling and the canal wall and no void apically of the filling should persist.

Endodontic Surgery

Drainage

Incision and drainage

The objective of incision and drainage is the discharge of the exudate which has accumulated in the tissues, provided that this does not happen spontaneously through the root canal. In the case of a fluctuating swelling, the incision is made prior to the emergency root treatment. In addition, drainage is carried out in the respective area for a maximum of 24 hours, either along a coronal way or by means of a drain. After the root treatment, the tooth is again closed and sealed, unless the secretion cannot be halted.

Periradicular Surgery

Periradicular curettage

The objective of the periradicular curettage is the removal of diseased tissues and foreign material from the periradicular bone of a root-treated tooth. The procedure as a sole measure is indicated only if the entire root canal system had been adequately treated and the foreign material is identified as the only etiology of the lesion.

Explorative surgery

The objective of an explorative intervention is the search for the etiology of an endodontic problem if this could not be identified using another method. The respective radicular structure is exposed, thus allowing to assess whether e.g. a visible fracture exists.

Biopsy

The objective of the biopsy is the removal of a bone and/or soft tissue sample for a histopathological examination. It is carried out every time there are doubts about the etiology of periapical pathology.

Apicoectomy

The objective of the apicoectomy is the removal of the apical portion of the root if it could not be filled and its content could maintain an inflammation of the periapical region.

It facilitates the preparation of an apical cavity and the placement of a retrograde filling. The apicoectomy as the sole measure is indicated only if the root canal treatment could be performed adequately.

Apicoectomy with retrograde treatment

The objective of the retrograde treatment following an apicoectomy is the cleaning and retrograde filling of an untreated or insufficiently treated root canal portion and of all apical orifices from the root canal system. Thereby, the percolation of toxic products from the oral environment into the periradicular region is to be prevented.

Seal of a perforation

The objective of the seal of a perforation is the cleaning and tight seal of a perforation using a suitable filling material.

Root amputation

The objective of the root amputation is the removal of one of the roots of a multi-rooted tooth without making changes to the respective crown structure. The following can be indications for this therapy: periodontal disease, root fracture, non-restorable parts of the root, failure of a root canal treatment, or an apicoectomy with retrograde filling. Prior to the amputation the remaining roots should preferably be subjected to a root treatment.

Assessment of the Endodontic Therapy

Follow-up checks are absolutely necessary to diagnose possible later alterations which can convert an initial success into a failure (e.g. caries, loss of tightness of the restoration etc.).

Assessment of the Pulp Capping and Pulpotomy

Pulp cappings and pulpotomies should be checked at regular intervals. The first follow-up should take place not later than six months after the treatment. For a treatment success, the following criteria must be met: normal reaction to sensibility tests, absence of pain and other symptoms, radiographic signs of a dentinal bridge formation or of progressing root growth, and absence of clinical and radiographic signs of an internal resorption or a periradicular alteration.

Assessment of the Root Treatment

Root treatments should be checked at the latest after one year and subsequently at regular intervals depending on the situation.

Treatment success

For a treatment success the following criteria must be met: absence of pain, inflammatory signs, and other symptoms. No fistula exists, the tooth is functional, and there are radiographic signs that the root is surrounded by a normal periodontal space.

Uncertain prognosis

If the follow-up radiograph only reveals a reduction of the lesion, albeit the symptoms have disappeared, this is referred to as an uncertain prognosis. The lesion must be checked further at regular intervals till the complete healing.

If four years after a major apical periodontitis a broadened periodontal space has persisted, scar formation is assumed. In this case, the tooth has equally to be monitored over the long term.

Failure

One refers to a failure if clinical symptoms appear and/or the radiograph reveals the following:

- a) Appearance of a new lesion
- b) Enlargement of the lesion
- c) Signs of a resorption

In the case of a failure, a revision, endodontic surgery, or the extraction of the tooth are taken into consideration.

Assessment of the Endodontic Surgery

The result should be checked at the latest one year after the intervention. Depending on the healing process, further controls should follow thereafter. The following criteria for a success must be met: absence of pain, inflammatory signs, and other symptoms. The tooth is functional, and there are radiographic signs of healing of the periradicular structures associated with a normal periodontal space.

In individual cases, it is possible that a persisting radiolucency reflects the formation of scar tissues without an inflammation at the apex being present.

Dental Trauma

If dirt has got into the wound or at tooth fragments, tetanus prophylaxis is to be arranged depending on the vaccination status of the patient. In addition to the usual medical history, the type of injury as well as the time, place, and course of the accident have to be documented.

Infraction of the Crown

Incomplete enamel fracture lacking loss of tooth substance; except for a vitality test no special measures are necessary.

Crown Fracture

Enamel or dentin fracture without pulp exposure

Enamel/dentin fractures have to be treated as soon as possible. Sensibility tests should be made at regular intervals.

Enamel-dentin fracture with pulp exposure

Open apex, vital pulp

If the patient can be treated within the first 24 hours, the pulp wound is directly capped, while the dentin wound is protected using a bacteria-proof material (see p. 5 "Direct Pulp Capping") and the lost tooth substance can be restored.

If the patient only can be treated after 24 hours or if there is an extensive pulp wound, the coronal pulp is amputated (pulp amputation) at the level of the non-inflamed pulp (where bleeding can be controlled more easily). Vitality tests should be made at regular intervals (three weeks; three, six, and twelve months; subsequently once a year for five years). Initiation of the root treatment only upon clear signs of absent vitality: negative vitality test associated with symptoms and/or formation of a fistula and/or an apical lesion (attention: not to be confounded with normal root development!).

Open apex, necrotic pulp

Measures for the initiation of the apical closure (apexification) are commenced. At first, these comprise opening of the tooth, determination of the root canal length, and root canal cleaning with thorough rinsing. Subsequently, the canal is dried and filled with a material that on the one hand enables apical healing and repair of the apex and on the other hand prevents contamination and bacterial infection. Furthermore, the material must be easy to remove. The access cavity has to be sealed tightly. Formation of an apical barrier can take 16-18 months. Thereby, it is sometimes necessary to change the root canal insertion several times. The progression of barrier formation has to be checked at regular intervals. If the apex is completed, the root canal is permanently filled.

Completed apex, vital pulp

Capping of the pulp within the first 24 hours if the wound is not very extensive; in all other cases the initiation of a root canal treatment is indicated.

Completed apex, necrotic pulp

The root treatment is carried out.

Crown–Root Fracture

Fracture with involvement of enamel, dentin, and cementum and a possible pulp exposure; the treatment of the dentin and pulp wound is performed according to the same principles as in the case of crown fractures.

Root Fracture

Fracture with involvement of dentin, cementum, and the pulp tissues; the objective of the treatment is to maintain the vitality of the pulp and to reduce the fragments. The coronal fragment is fixated semi-rigidly to the uninjured teeth for about three weeks (in case of increased mobility even longer). An efficient oral and dental hygiene has to be practiced, which must not be hampered by the splint.

If the coronal pulp necrotizes, only this part is treated endodontically. If the fragments are not optimally reduced, an apexification in the coronal fragment can be aimed for.

If the apical fragment exhibits pathological alterations which cannot be treated, it is removed surgically.

Luxation Injuries

Subluxation

Injuries of the periodontium without dislocation of the tooth out of the bony alveolus and without bone injury; the tooth must be spared for 10–14 days, however, a splint is not required. Vitality is checked at regular intervals. If the vitality test is negative, the initiation of an endodontic therapy has to be postponed until clear clinical signs (e.g. apical lesion, pain, loosening of teeth, discoloration) emerge. For this purpose, X-rays are made at every follow-up check. As a rule, follow-ups take place after three and six weeks as well as after six and twelve months.

Extrusive or lateral luxation

Extrusive luxation: partial dislocation of the tooth out of the alveolus without bone injury; the tooth is repositioned immediately. After a check of the correct tooth position, a slightly flexible splint is made which fixates the tooth for 7–20 days. Splinting has to allow for the physiologic mobility of the tooth and to enable good oral and dental hygiene. Vitality is tested at regular intervals. Subsequently it is proceeded as described under “Subluxation”.

Lateral luxation: dislocation of the tooth in a direction other than its main axis with or without a fracture of the bony alveolus; the tooth should be repositioned immediately and treated as described beforehand.

Intrusive luxation

Axial dislocation of the tooth in the direction of the bony compartment with possible fracture of the alveolar bone

Open apex

In case of a less marked intrusion, a spontaneous eruption can be awaited without further treatment. Vitality is checked as described under “Subluxation”.

In serious cases, an immediate orthodontic or surgical extrusion must be carried out. Upon signs of a necrosis an endodontic treatment has to be commenced.

Closed apex

Better by surgical than orthodontic means the tooth is brought into the correct position. The pulp is extirpated within 7–14 days in order to prevent an infection. Root treatment is initiated.

Exarticulation

Complete dislocation of the tooth out of the alveolus; the tooth should be replanted as soon as possible by the patient, their parents, a first aider, or the dentist. The prognosis aggravates very rapidly the longer the tooth stays outside the alveolus. The tooth is rinsed (if it is dirty) and carefully reinserted into the alveolus.

If a tooth cannot be replanted immediately at the place of accident, it is stored as follows: preferably in a special storage solution (“tooth preservation kit”), if this is not available, in milk, if this is not available, in physiologic saline or in water, or wrapped in cling film, or directly in the mouth. The tooth must not desiccate and be mechanically cleaned or disinfected at any time.

Following thorough rinsing with physiologic saline or nutrient solution the tooth immediately is replanted carefully. A splint is made which permits a physiologic mobility. The splint is incorporated for 7–10 days unless there are further injuries which require longer splinting (e.g. fracture of the alveolar process). This should enable good oral hygiene. In addition, a disinfecting rinsing solution is prescribed.

If the tooth at the time of the exarticulation exhibited an open apex, a revascularization can ensue, as long as no more than two hours have elapsed since the exarticulation. Vitality is checked as described under “Subluxation”.

If root growth is already complete, the pulp has to be extirpated within 7–14 days after the accident.

4. References

SWISS SOCIETY FOR ENDODONTOLOGY: DATABASE OF SYSTEMATIC REVIEWS FOR ENDODONTOLOGY, www.endodontology.ch

www.e-s-e.eu

5. Authors of the Guidelines Endodontology

The guidelines of the SSE are in agreement with the guidelines of the European Society of Endodontology (ESE).

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