CHAPTER 1

Root Canal Treatment and the Role of Filling Materials

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《**Abstract**》

Endodontics includes diagnosis and treatment as well as management of pulpal and periapical diseases. Treatment aims to reduce inflammation of the periapical tissues, to dissolve remaining organic material, and to counteract coronal microleakage in the root canal through the use of medication and mechanical instruments. Finally, irrigated root canals should be obturated with filling material and sealer to prevent reinfection.

Introduction

Endodontics is a broad field, dealing with the diagnosis and treatment of pain with a pulpal or periapical origin, vital pulp therapy, nonsurgical root canal treatment, retreatment of unsuccessful treatment, internal bleaching, and endodontic surgery [1, 2, 3]. Endodontics also involves the morphology, physiology, and pathology of the dental pulp and periapical tissues [4]. Endodontic treatment relieves the pain of pulpitis or periodontitis to restore oral function and preserve the natural dentition. Endodontic procedures should be safe, and the condition of the removal of diseased tissue, the elimination of microorganisms, and the recontamination after treatment should be conserved [5].

Successful endodontic therapy depends on the opening of the pulp chamber, cleaning using instruments, irrigation or application of medicine, and obturation of the root canal system. It is necessary to make a straight-line access into some canal orifices to make irrigation and medication effective. The irrigated root canal is then filled by paste material or is obturated by solid materials such as gutta-percha points using a sealer [6]. In the last few decades, varied irrigants, medications and sealers have been produced. They contain different components; however, various products are clinically available with adequate physical, chemical, and biologic properties [7]. One such product, calcium hydroxide, is used as both a medication and a sealer [8, 9]. The sealer contacting the periodontal tissues through the apical foramen may generate different reactions in the tissues. Therefore, it is important to select suitable material for endodontic treatment, while good maintenance leads to long-term success.

In this chapter, we introduce the general procedure of endodontic treatment, and the specific character of the medications, filling materials, and sealers.

Root canal preparation

Endodontic access openings are based on the anatomy and morphology of each individual tooth group. The root depth of the pulp chamber can be estimated from the preoperative radiograph. Pre-measuring prevents perforation of the pulp floor during access cavity preparation. Simultaneously, the entire area of caries is removed and a cavity of an estimated depth is made using a tungsten carbide or diamond bur in a turbine. Then the roof of the pulp chamber is removed with a round bur and the cavity is refined using a non end-cutting bur to lift the lid of the pulp chamber [10]. The major objectives are to remove the infected dentin and to locate all canals within while conserving tooth structure. Next, a straight-line access into some canal orifices is made to perform the cleaning of the root canal.

The length of the root canal can be estimated using an apex locator and a confirmatory working-length radiograph. Consulting the measured length, the infected debris in the root canal system is removed with hand and engine–driven instruments, k-files and reamers, Hedstroem files, Getes-Glidden drills, and nickel-titanium rotary instruments [11]. Though mechanical removal relies on the ability of the operator, infected pulp and dentin should be completely removed from the surfaces of the root canal. Moreover, the instrumentation also makes space for medications and the final root canal filling. The combination of mechanical and chemical means helps kill microbes and remove their byproducts.

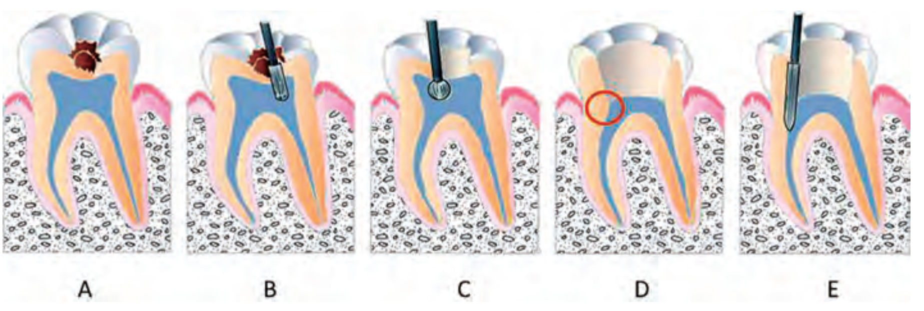

Figure 1 Basic steps of access preparation. A: Reoperative caries exposure. B: Penetration to the pulp chamber. C: Lifting off the roof with a round bur. D: Cavity with carious material and roof removed. E: Straight-line access to the first curve.

Irrigation

The instrumentation against an infected root canal alone cannot clean all the internal surfaces of the root canal, because the dentin surface is covered with a smear layer of attached bacteria after cleaning and shaping using reamers and files [12]. A number of bacteria remain on the root canal walls, within dentin tubules, and in lateral canals. Therefore, irrigation is needed to kill the remaining micro-organisms. Recently, sodium hypochlorite (NaOCl) has been used as an antimicrobial irrigant, and chelating agents such as ethylenediamine tetra-acetic acid (EDTA) are also used to aid in the removal of the smear layer [13]. NaOCl and EDTA are recommended for irrigation to facilitate the penetration of the sealer into radicular dentin. Moreover, these solutions are used for removing the smear layer produced by dissolving some root canal sealers during nonsurgical endodontic retreatment [14].

NaOCl has been used as an alkaline irrigant in endodontics for many years. The effervescence created by mixing NaOCl with hydrogen peroxide has been used to remove debris from the root canal, but this is not an effective method. The solution causes the mechanical flushing of debris from the canal and it has the ability to dissolve vital tissue [15] as well as necrotic tissue by breaking down proteins into amino acids. Moreover, this has antimicrobial effects [16] and a lubricating action [17]. Concentrations ranging from 0.5% to 5.25% have been recommended, and the action of the irrigant is related to the amount of free chlorine. Warming the solution can also increase solution effectiveness [18]. The advantage is strong toxicity; therefore, extrusion into the periapical tissues and effusion into the mouth must be avoided. A safe-ended needle or rubber dam will prevent leakage of the solution.

EDTA is a chelating agent that will dissolve dentin chips within the root canal system, although it is not antibacterial. EDTA of high concentration results not only in removal of the smear layer, but also in demineralization of dentin immediately below the smear layer, reducing its hardness. A 3% EDTA solution allows smear layer removal without excessive demineralization. The influences of 3% EDTA solution are evaluated in terms of the permeability of root canal disinfectants into the dentin, wetting by endodontic sealer, and adhesive strength of the endodontic sealer [19]. Chelators remove the inorganic components and leave the organic tissue elements intact. Therefore, NaOCl as an active rinse is necessary for removal of the remaining organic components [20]. Irrigation with EDTA for 1 minute followed by a final rinse with NaOCl is recommended.

Ultrasonics is sometimes used for cleansing and removal of materials from the canal wall [21]. Ultrasound produces small, steady vibrations and causes a vortex in the cleaning solution, which helps improve permeability [22]. Therefore, agitation of the irrigant with an ultrasonically-activated file has the benefit of increasing the effectiveness of the solution [23].

Intracanal medication

Infected root canals are not completely cleaned using an antibacterial irrigant or by removing debris using instruments during root canal treatment. Residual bacteria remaining in the root canal are able to multiply rapidly between appointments. Antibacterial medications, such as calcium hydroxide, corticosteroid, phenol or aldehyde, are used during the period to kill the few remaining bacteria and prevent re-infection of the root canal. These agents must have a wide antibacterial spectrum, and should be greater that the cytotoxic effect. However, agents which have antibacterial activity may damage the periapical tissues if extruded from the root canal system.

1) Calcium hydroxide

Calcium hydroxide is used as an intracanal medication for infected teeth. The medication can be easily inserted into the prepared root canal using a needle to deliver calcium hydroxide paste or a file with the medication. It is also easy to remove from the root canal system. It has antimicrobial activity owing to high pH, and it may aid in dissolving necrotic tissue remnants, bacteria, and their byproducts [24]. Therefore, it has been recommended for use in teeth with necrotic pulp tissue and bacterial contamination. Irrigation with NaOCl alone reduces the bacteria level by 61.9%, but the use of calcium hydroxide in canals results in a 92.5% reduction [25]. In addition to killing bacteria, the medication has the extraordinary ability to hydrolyze the lipid moiety of bacterial lipopolysaccharides, thereby inactivating the biologic activity of the lipopolysaccharide and reducing its effects [26]. This is a very desirable effect because dead cell wall material remains after the bacteria are killed and can continue to stimulate an inflammatory response in the periapical tissue. It is important to place the material deeply and densely using a lentulo spiral for maximum effectiveness. When calcium hydroxide is placed in the root canal for at least 7 days, it has been shown to effectively kill most of the pathogens found within the confines of the root canal system. It probably has little benefit with vital pulp, and it demonstrates no pain-reduction effects [27].

Recently, calcium hydroxide and iodoform mixture (Vitapex) produced in Japan has also been used as a medication for treatment of infected root canals, and as a permanent filling material.

2) Corticosteroids

Corticosteroids are anti-inflammatory agents that are advocated for decreasing postoperative pain or flare-up after endodontic treatment by suppressing inflammation. They are known to reduce acute inflammatory response. Their use as intracanal medications may decrease lower-level postoperative pain [28]; however, they may be ineffective, particularly with greater pain levels. These materials are available for use in cases of irreversible pulpitis and in cases of acute apical periodontitis [29]. Normally, they are applied by attachment on the top of a cotton plug.

3) Phenols and aldehydes

These materials have been used extensively in endodontic therapy despite their high toxicity, and their mutagenic and carcinogenic potential. If they are normally applied on a cotton pellet in the pulp space for disinfection, they release antimicrobial vapors. Historically, it was thought that these agents were effective. However, the majority of the medications exhibit nonspecific action and can destroy host tissues, as well as microbes [30]. Moreover, the effectiveness of vapor-forming solutions decreases rapidly after insertion, and contact with tissue fluids renders them inactive. Clinical studies assessing the ability of these agents to prevent or control interappointment pain indicate that they are not effective [31]. The use of these materials is no longer justified in clinical study.

Root canal filling materials

1 Obturation

After the pulp space is appropriately cleaned, it must be obturated with a material to completely prevent communication between the oral cavity and the periapical tissue. It is very important to seal the root canal system at both its coronal and apical ends. Coronal obturation prevents reinfection of the pulp space from the oral environment. Apical obturation blocks the exit to the periapical tissues for surviving organisms in the root canal. The material to obturate is selected according to physical and biologic properties. The materials used for root canal fillings can be divided into paste and solid material with a cementing medium.

2 Iodoform paste

Iodine is a potent antibacterial agent in spite of low toxicity; however, some patients are allergic to the compounds. Iodoform pastes can also be used as a medication in refractory cases. KRI paste and Vitapex are both iodoform pastes. The former is mixture of iodoform, camphor, parachlorophenol and menthol; the latter is pre-mixed calcium hydroxide and iodoform. KRI, which has excellent clinical and radiographic results, has been used as a pulp canal medicament in abscessed primary teeth because it is a sorbable material. Recently, Vitapex was introduced. This is packed in a very convenient and sterile syringe, and the paste is injected into the canal with a disposable plastic needle. It is particularly easy to use in primary incisors but less practical for the narrow canals of primary molars [32]. The material shows good biocompatibility with biographic results and radiopacity. Vitapex is also a nearly ideal root canal filling material for primary teeth owing to its being a resorbable material [33]. When it is extruded into apical areas, it can either diffuse away or be resorbed in part by macrophages [34] in as short a time as one or two weeks. In order to present the examination results of tissue reactions and the resorption of subcutaneously embedded Vitapex in rats and mice, we examined the fate of this embedded root canal filling material paste, made of calcium hydroxide and iodoform with a silicone oil [35- 47]. We introduce the results of our animal examinations in Chapter 2, 3, 4, 5. Bone regeneration has been clinically and histologically documented after use of this paste [48]. This may be particularly useful in difficult retreatment and refractory cases.

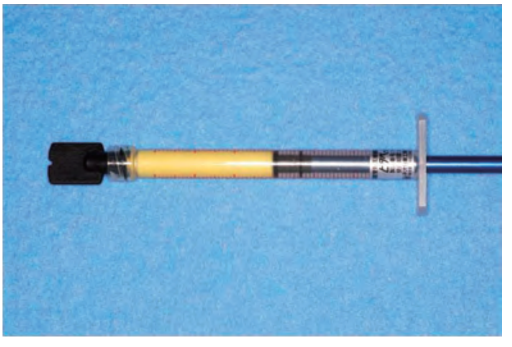

Figure 2 Iodoform paste (Vitapex)

3 Solid material

Gutta-percha, the dried juice of the Taban tree, was introduced as an obturating material more than 160 years ago, and it is most commonly used to fill root canals as gutta-percha cones, master points and accessory points. The cones consist of approximately 20% gutta-percha, 65% zinc oxide, 10% radiopacifiers, and 5% plasticizers [49]. The material has plasticity and adapts with compaction to irregularities in prepared canals. It is relatively easy to manage and manipulate despite some complex obturation techniques. The master point is placed in the root canal and condensed with hand and finger metal spreaders. An accessory point of similar size to the spreader is chosen and placed into the vacated space. The spreader is again replaced between the points and the walls of the curved canal, and the procedure is repeated until the canal is filled. There are three phases, alpha, beta, and amorphous [50], and these phase transformations are very important. Heating the gutta percha during obturation results in shrinkage on cooling as the phase changes occur [51]. It can be made to flow if it is modified by either heat or solvents such as chloroform, which permits adaptation to the irregularities of the canal walls. In addition, it can easily be removed from the canal, either partially to allow post placement, or totally for retreatment. The other advantage is that it tends to be self-sterilizing and not support bacterial growth. One disadvantage is a lack of adhesion; therefore, it needs a sealer for the space between the gutta-percha cones and between the gutta-percha and the canal wall.

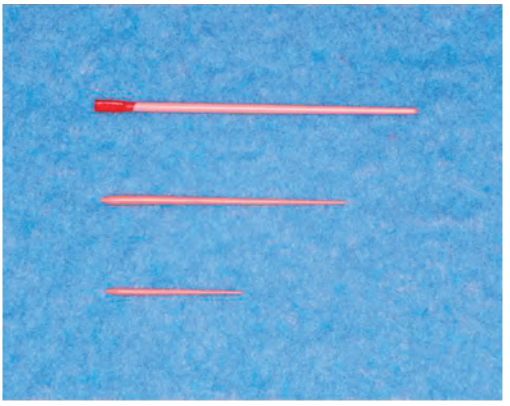

Figure 3 Master point and accessory points

Figure 4 Radiograph demonstrating adequate length, density and taper of first molar filling with gutta-percha and sealer involving calcium hydroxide

4 Sealers

Sealers play an import role in the root canal filling. First, they must have the ability to adhere to both the filling material and the root canal wall. The ideal sealer should be antibacterial, non-irritant, and insoluble in tissue fluid. Moreover, the sealer should have some degree of radiopacity to be clearly visible on adequately exposed radiographs. A sealer is a mixture that hardens through a chemical reaction, normally including the release of toxic material. It should be easy to mix and to remove, if required. Unfortunately, there are no materials that satisfy all the above properties. Most sealers are absorbable when exposed to tissue fluids, making them the weak link in providing a seal. Therefore, these materials are used in low volumes. Four major types of sealers, zinc oxide and eugenol-based, glass ionomer, resin, and calcium hydroxide, are available.

1) Zinc oxide and eugenol-based sealers

Many zinc oxide and eugenol (ZnOE)-based sealers have a long history of successful usage, because they exhibit long-lasting antibacterial activity [52]. However, the material has a slow setting time and is relatively weak owing to porosity, shrinkage, and solubility [53]. The sealer includes silver particles to improve the radiopacity; this may potentially contribute to dentin staining following root canal treatment, and care should be taken when treating anterior teeth. Sealer extruded through the apex will produce an inflammatory reaction in the periapical tissues because it is cytotoxic. There are many different kinds of ZnOE-based sealer, each of which has improved upon the negative aspects of the original formulation.

2) Glass ionomer sealers

Glass ionomer endodontic sealers have been introduced recently. The sealers have the ability to adhere to dentin, which provides an adequate apical and coronal seal, enabling adhesion between the gutta-percha and the canal wall [54, 55]. Moreover, as this material is biocompatible and hard, it is a suitable material for use as an endodontic sealer. However, the hardness and insolubility make for difficulty in removing the sealer from the root canal when carrying out root canal retreatment [56]. However, there is little tissue irritation and low toxicity in vitro [57].

3) Resin

Resin sealers have a long history of use. These sealers provide adhesion and antimicrobial action. Moreover, desirable properties include very good sealability, ease of mixing, and a long working time. However, the material can initially produce a severe inflammatory reaction if present in tissue because of toxicity, due to the release of formaldehyde. This situation normally subsides over a few weeks. Other disadvantages include staining, relative insolubility in solvents, and some solubility in oral fluids. A recently improved sealer has better biocompatibility in addition to similar physical properties. It releases less formaldehyde and has a decrease in dentin staining by elimination of silver from the formula [58].

4) Calcium hydroxide

Calcium hydroxide is used as a sealer for obturating between the canal wall and solid material such as gutta-percha. Sealers have been introduced in which calcium hydroxide is incorporated in a ZnOE or plastic base. Recently, there have been variations, including non-eugenol, calcium hydroxide polymeric root canal sealer such as Sealapex or a powder mixed with liquid (local anesthetic solusion, saline, water or glycerin) to form a thick paste. Calcium hydroxide shows antimicrobial properties, osteogenic-cementogenic potential, and adequate short-term sealability [59]. However, long-term exposure to tissue fluid may possibly lead to dissolution of the material as calcium hydroxide is leached out. Some hydroxyl ions could be detected in the dentin close to the root filling with the sealer because this releases more ions but disintegrates in the process [60]. These sealers easily disintegrate in the tissue [61]; therefore, they also have poor cohesive strength.

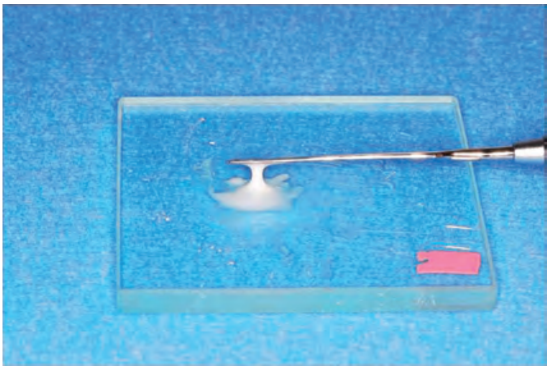

Figure 5 Calcium hydroxide sealer mixed as a powder and with glycerin as a liquid

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