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TOPICAL REVIEW

Concept of predictable disinfection in endodontics

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Abstract: Factors influencing the appropriate time to obturate a tooth are the patient's signs and symptoms, pulp and periradicular status, degree of difficulty, and patient management. The current consensus is that one-step treatment procedures are acceptable in cases where the patient exhibits a vital pulp. The removal of normal or inflamed pulp tissue and performance of the procedure under aseptic conditions should result in a successful outcome because of the absence of bacterial contamination. Obturation at the initial visit also precludes the contamination as a result of leakage during the period between the patient's visits. When patients present with acute symptoms caused by pulp necrosis and acute periradicular abscess, the obturation is generally delayed until the patient is asymptomatic. The interappointment antimicrobial dressing is indicated before the definitive obturation *(Ref. 15)*. Full Text in free PDF *www.bmj.sk.*
Key words: antimicrobial dressing, endodontic infection treatment, apical periodontitis.

The primary purpose and aim of treatment of tooth root canal system is to prevent the creation of apical pathosis. We need to be aware of this purpose when facing exstirpation of a vital pulp in case of pulpitis. In this case, we have to pay special attention to cleanliness of the operation field and abide the aseptic work principles. Every breach of these principles including those of securing the dryness of field, clearing up carious dentin from access cavity, x/ray analysis, defining the working length of root instruments and accordingly provided antisepsis leads to danger and potential risk. It also increases the risk of conversion of pulpitis into apical periodontitis. The ethics of reasonable endodontic therapy are focused on prevention, minimization and elimination of infection, which are not easy tasks within the conditions of a dentin canal system. Nowadays we know that with chemo-mechanic instruments in the root canal we are able to minimize effectively the amount of microbes, although we cannot prove their total elimination clinically (2). We assume that following the correct technical procedure of extirpating an inflamed but still partially vital pulp containing a purulent inflammation minimizes the possibility of infection of the root canal system as a whole. Nevertheless, the treatment of teeth with a necrotic pulp and clinical signs of a periapical infection is more complicated. In this case, depending on the length of endodontic communication with the mouth environment, persistence of symptoms, their intensity, and age of root dentin we can count with massive bacterial habitation of macrocanal walls and tubular dentin. Usually, the clinical or x-ray symptoms of reaction of the apical periodontium are present. Although in these cases, the aseptic procedure is the basic and major condition, the whole following process is an antiseptic manipulation in form of exhaustive mechanic elimination of carious dentin in cavity and infected material from the root canal with simultaneous chemical elimination of microorganisms and debris. These two frequent situations can be described by terms that are more efficient. We distinguish the canal system, in which microorganisms have not found suitable conditions from that already infected. These canal systems are referred to as infected and non-infected root canal systems, respectively. The symptoms of apical lesions do not manifest unless microorganisms colonize the canal system. After they have done so, it is mostly associated with evolving into apical periodontitis. The elimination of microbiological colonization in any parts of the human body is a crucial principle of treating every infection. The root canal system is no exception (10). Many clinical studies have proven a high percentage of success in cases when the anti-infection intervention is made prior to the root filling. Surviving microorganisms are the cause of failure and thus the elimination of infected content is the essence of intervention mechanisms. Most of microorganisms colonizing the endodontic system can be originally found in the macrocanals of root dentin. Thus, the chemo-mechanical cleaning can be considered as the fundament of treating the infection and disinfecting the root canal wall. A complete elimination of microorganisms is limited by features of used materials, antiseptic irrigation fluids and anatomic conditions of teeth roots. An important supply of microorganisms is the tubular dentin system, where the intricacy of the elimination of microorganisms results from its histological structure. The infection infiltrates the dentin tubulus depending on the age of dentin and length of endodontic communication with the mouth environment. In addition, this mouth flora is considered the crux medicorum of the endodontic therapy. When it comes to the effect of disinfec-

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tion materials, this part of the dentin is the most interesting one. At the same time, we need to realize that the amount of dentin tubules declines in apical direction. In the most interesting area of the root, the tubulization is represented by ramifications of the main root canal, the so-called apical delta (6).

Principles of correct application of antimicrobial dressing in endodontics

The aim of this review is to define the function of medicamentous dressing prior to the final closure of dentin canal, as well as to assess how many times the up-to-date antimicrobial materials are to be used prior to the definitive obturation of the endodontium. Based on the primary diagnosis, the procedure of temporary filling should include disinfection of tubulized dentin, elimination of remnant pulp and debris and pain relief. Endodontists prefer the methods of treatment that shorten the preparation phase for filling the root in the sense of number of visits necessary to accomplish a calm clinical stage. Practically this means that during the same visit the root is treated after the exstirpation of vital pulp. When this cannot be processed within one visit, we need to close the cavity to prevent the recolonization by microorganisms persisting in the cavity or the crown. In cases of evident acute reaction of periapical periodontium we definitely close the cavity with root filling when acute symptoms vanish after antisepsis application. The temporary filling is expected to be efficient and biocompatible as well as easily used and eliminated. Controversial discussions are led even today about the most suitable type of filling. Based on the distinguishment of infected and non-infected endodontium, we prefer one-time treatment of root cavity in cases with irreversible pulpitis. We do not need additional application of the temporary filling. The advantage lies in decreasing the risk of new infection between the patient's visits. Some risk involves the post operation reaction. It is to be noted that the treatment must obey the asepsis rules and the canal root must be prepared for filling including the preoperative x-ray, definition of the working length of root instruments, and postoperative x-ray. Our experience from decades and publications shows that there is no significant difference between single and gradual interventions when treating pulpitis with temporary filling. The chance of a more intense antimicrobial effect with the help of root canal instruments speaks for a gradual process with two or three phases. In real life, the risk of new infection or re-infection is high. This risk is accompanied by a problem of correct application and elimination of the temporary filling (4).

Antimicrobial dressings used in endodontic infection treatment

The list of disinfectants being used is quite vast, and almost each of them has been used with this indication. In the past years, a high number of phenol materials have been eliminated from the indication for temporary filling (15). They have a very aggressive effect on the bodies of microorganisms but they also damage the cell tissues. Modern methods of endodontics rely on the use of Calcium hydroxide ($Ca(OH)_2$), sodium hypochlorite (NaOCl), ethylenediaminetetraacetic acid (EDTA) and chlorhexidine (CHX). Calcium hydroxide has become very popular due to its wide-spectrum effect and other features, namely pH of 12.5, releasing of OH^- ions, effect on the bacterial cell membrane, denaturation of proteins and enzymes and inactivation of LPS bacteria by destroying their DNA (11). These are features used also in endodontics. It has been used as a temporary filling since 1920. To reach an optimal effect on bacteria, the preferred length of stay in endodontium is up to ten days. If left longer, it leads to transformation into calcium carbonate, which is not efficient and can raise the risk of dental fracture (1). Most endodontic pathogens are not able to survive in strongly alcalic environment. They die within short time after direct contact with calcium hydroxide. Hydroxyl ions react with numerous organic substances. Reactions are not specific but intense. The reason why free radicals recede only slightly from the place of application further into the dentin is that they bind very fast and react with the organic substratum of the canal walls. The contact of calcium hydroxide with bacteria is complicated and not always optimal. A high concentration of hydroxyl ions is necessary for the antibacterial result to be optimal. In the environment of root canal, its antibacterial effect is reduced or even completely useless due to the effect of buffering systems. Bacteria impacted in dentin tubulus, especially after a longer communication with mouth flora and with younger patients, could be the cause of underachievement of endodontic therapy when accompanied by insufficient chemo-mechanical elimination and absence in the obturation of root canal (10, 12). It is thus very important to carry out a therapy, which is able to fight the intertubular infection. Calcium hydroxide maintains its inner concentration of pH 12.2 but it drops rapidly in the point of contact with wall dentin to 8-11 and with peripheral dentin only to 7.4-9.6. Many measurements prove this statement. Because many bacteria and especially the fungi are resistant to alcalic environment at pH of 6-9, the result cannot be guaranteed (3). Hence, we need to reconcile ourselves with the proof of our inability to eliminate bacteria in deeper parts of tubular dentin because some components of dentin neutralize the calcium hydroxide. Besides, the bacterial biofilm alone is a barrier to diffusion of hydroxyl ions to tubular dentin. Apart from inactivation of calcium hydroxide by dentin and other components of this tissue, we need to be aware of the resistance of some microorganisms e.g. candida albicans, Enterococcus. faecalis, fungi, etc. (9). This fact has to be considered when applying intracanal medication. All said leads to a conclusion, that though calcium hydroxide reduces the amount of bacteria in the root canal, still it is not able to eliminate the bacteria consistently. Neither the result of cultivation is the proof whether bacteria persist in periodontium. Perhaps it only tells us that only a small amount remained in these cases. An extended mechanical preparation of the canal route with simultaneous irrigation with hypochlorite, chlorhexidine or EDTA solution has to be performed prior to the application of calcium hydroxide as a temporary filling. Their impact on dentin and bacteria of infected endodontium requires a deeper insight (8). Calcium hydroxide is applied into the root canal via an injection or smeared over the canal wall. Its x-ray opacity is similar to dentin.

Practice has taught us that it is not easy to clean up the applied suspension completely from the canal walls. We can minimize the layer of wall material with intense irrigation. The combination of physiological solution and EDTA increases the effect of irrigation (10, 11). Antiseptic elimination of bacteria in endodontium requires time, a particular concentration of disinfection, eventually their combination and suitable anatomic and histological structures. Clinical examination and x-ray observation in a longer period remain the most reliable proof of successful treatment. The use of intracanal medication has been advocated to improve the root canal disinfection (10, 11). Temporary root canal dressings are intended to act against bacteria that have not been eliminated after conventional endodontic biomechanical preparation. $Ca(OH)_2$ and chlorhexidine (CHX) have confirmed antibacterial properties and can be used either alone (10, 11) or combined (8) in order to reach successful endodontic treatment outcomes. $Ca(OH)_2$-containing materials have been used in endodontic therapy also to stimulate hard tissue formation and to mediate the neutralization of lipopolysaccharides (11, 14). However, it cannot be considered a universal intracanal medication because it is not effective against some resistant microorganisms (3). Therefore, the association of $Ca(OH)_2$ and CHX aims to enhance the antimicrobial efficacy, particularly against Enterococcus faecalis (12). The intracanal dressings must be removed from the root canals prior to final obturation in order to obtain the best interface possible between the canal walls and the filling material. However, it has been demonstrated that $Ca(OH)_2$ pastes are not easily removed from the root canal system (8).

Conclusions

The ultimate goals of endodontic treatment are the complete removal of bacteria, their byproducts and pulpal remnants from infected root canals as well as the complete sealing of the disinfected root canals. Intracanal medicaments have been thought to be an essential step in killing the bacteria in root canals; however, in modern endodontics, the shaping and cleaning may be assuming greater importance than intracanal medicaments as a means of disinfecting root canals. Until recently, formocresol and its relatives were frequently used as intracanal medicaments but it was pointed out that such bactericidal chemicals dressed in the canal are distributed to the whole body from the root apex, and in this way, they might induce various harmful effects including allergies. Furthermore, as these medicaments are potent carcinogenic agents, there is no indication for these chemicals in modern endodontic treatment. Today, biocompatibility and stability are essential properties for intracanal medicaments. A more modern meaning of intracanal dressing is the blockade against coronal leakage from the gap between filling materials and cavity wall. Calcium hydroxide has been approved as suitable for the use as an intracanal medicament as it is stable for long periods, harmless to the body and bactericidal in a limited area. It also induces hard tissue formation and is effective for stopping the inflammatory exudates. Single endodontic visit, where intracanal medicaments are not used is now generally not contraindicated and various reports have shown that the clinical outcomes between single and multiple endodontic visits are similar. There is no reason to counsel against single endodontic visit, however, if the pattern of multiple endodontic visit is chosen, calcium hydroxide is recommended to be used as an intracanal medicament.

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