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Factors affecting Removal Efficiency of Intracanal Medicaments - A Literature Review

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Abstract: ***Microorganisms are one of the primary etiological factors in the occurrence and development of diseases of the dental pulp and periapical space. Therefore, the main aim of endodontic treatment is their complete eradicate from the root canal. This is done mainly through chemo-mechanical preparation of the root canal walls. Complete disinfection of complex intracanal anatomy cannot be achieved with the most modern root canal preparation techniques, which is why the use of intracanal medicaments is considered a significant additional step in the destruction of the remaining bacteria in the root canals. On the other hand, removal of the intracanal medicaments before obturation of the root canal is mandatory, as other amounts may compromise the outcome of endodontic treatment. The review also examines the existing factors influencing the removal effectiveness of intracanal medicaments.***

Keywords: intracanal medicaments, irrigants, calcium hydroxide

1. Introduction

Root canal treatment can be the result of a variety of reasons, but whatever they are, the long-term goal of any endodontic therapy remains the same: to preserve the tooth or its root, and to rule it out as a source of infection [1]. To achieve the above goal of treatment in endodontics, two points are essential: the maximum reduction of the number of microorganisms in the root canal system and the prevention of microbial multiplication in the endodontics. Clinically, this means that optimal antiseptic conditions must be created to provide conditions for homogeneous and three-dimensional obturation of the root canal system, hermetic coronary restoration of the tooth, in order to prevent re-infection [1].

Microorganisms are the main etiological factors in the occurrence and development of diseases of the dental pulp and periapical space, as well as for the occurrence of apical periodontitis as a result of unsuccessful primary endodontic treatment. Research shows that microorganisms can be found in 35– 100% of endodontic failure cases with persistent periradicular inflammatory lesion after treatment [2]. So the main goal is to completely remove microorganisms from the root canal.

This is done by chemical-mechanical preparation of the channel. Complete disinfection of complex intracanal anatomy cannot be achieved with the most modern root canal preparation techniques. It has been found that 35-53% of the root surface remains untreated [3].

Intracanal medications are considered an essential step in killing bacteria in the root canals. In modern endodontics, shaping and cleaning may be more important than intracanal drugs, but it cannot eliminate all the root bacteria that are in the dentinal tubules. Intracanal medication is usually recommended when treatment cannot be completed in one visit, and there is a chance that surviving intracanal bacteria will often multiply between visits, often reaching the same level as at the beginning of endodontic treatment if the canal is not disinfected between visits [4].

Intracanal medications improve the prognosis of endodontic treatment, reduce pain and inflammation, protect roots from resorption due to inflammation, and play a significant role in preventing reinfection of the complex root canal system. Therefore, the use of intracanal medications to treat the infection is necessary.

It is known that intracanal medications traditionally go hand in hand in treatment of infected root canals. They are usually considered an integral part of treatment and important for the success of endodontic therapy. This requires the use of an effective intracanal medication that will help disinfect the root canal system. Such a drug should be effective throughout the administration period and penetrate the dentinal canal, eliminating bacteria that may be present with little or no irritation to the periradicular tissue.

The question of the role of intracanal medicaments is becoming more relevant and complex in the treatment of cases of pulp necrosis and apical periodontitis. There is evidence in the literature that most root canals contain viable microorganisms even after completion of chemo-mechanical preparation [1, 4].

Indications of intracanal medicaments

- To dry persistently wet or the so-called weeping canals
- To eliminate persistent microorganisms in the endodontic space
- To neutralize tissue debris
- In symptomatic cases, act as a barrier against micropermeability [5].

Requirements for intracanal medication

- To be an effective antimicrobial agent
- It should be non-irritating to the periradicular tissues
- It should remain stable in solution
- It should have a have a long-lasting antimicrobial effect
- To be active in the presence of blood, serum and protein derivatives of tissues
- It should have a low surface tension, it must be able to penetrate to depth
- Do not interfere with the repair of periradicular tissues

- It should not stain tooth structures
- It should not induce a cell-mediated immune response
- It should be easily inserted into the root canal.
- To prevent coronary microleakage and not to diffuse during temporary recovery.

Types of intracanal medicaments

The chemical nature of the drugs used is different; they can be from different chemical groups (chemicals or drugs) and can be combined in an attempt to cause different effects with one application [6].

According to Grossman, the intracanal medicament can be classified as containing *essential oils, phenolic compounds, salts of heavy metals, halogens, quaternary ammonium compounds, fatty acids, sulphonamides and antibiotics* [7].

Over time, different approaches have been sought in the treatment of pulpal and periodontal diseases using a variety of medications. Antibiotics, sulfonamides and hydrocortisone preparations were used. They successfully replace highly active and toxic antiseptics, such as phenol, tricresol-formalin, chlorophenolcamphor and others. The latter release steams, have a strong bactericidal, fungicidal and virocidal action. All phenolic derivatives coagulate cellular contents and cause tissue necrosis. For these reasons, these antiseptics are unsuitable for use in modern endodontic treatment. Due to advances in medicine and research, new approaches have been introduced such as photoactivated disinfection, ultrasound, endox, ozone, lasers and electrochemically activated water for root canal disinfection [4]. In modern endodontics, the most commonly used intracanal medicaments are calcium hydroxide alone and in combination with iodoform, chlorhexidine, antibiotic pastes.

Factors affecting removal efficiency of medicaments

Variations in root canal morphology

The complex anatomical morphology of the root canal system poses challenges for both cleaning and shaping, as well as the removal of intracanal medicaments. Removal of $Ca(OH)_2$ residues from irregularly shaped canals is difficult [8, 9, 10]. In straight root canals, additional activation with the master apical file (MAF) in combination with irrigation has been found to lead to improved removal of Ca $(OH)_2$ compared to using only an irrigator [11]. Various devices or techniques have been used to remove medications, such as pressure change devices [12], rotary brush irrigation [13], NiTi rotary instrument, ultrasonic [14] and sound devices [15], and Er: YAG laser [16].

Rotary NiTi instruments and various irrigation devices facilitate the removal of the most commonly used $Ca(OH)_2$ from curved root canals without affecting the anatomy of the root canal [17]. In fact, the anatomical feature of the root canal omitted by the irrigation protocol can be considered as one of the reasons for endodontic failure [18, 19].

Medicament formulation (physical state, concentration, excipients used)

The physical state of the medicament may affect its removal. Calt et al. found that removing the Temp Canal is very difficult due to its rigidity. According to Lambrianidis et al., the content or concentration of $Ca(OH)_2$ does not affect its removal efficiency from the root canal walls. A number of studies have shown that the vehicle used to mix $Ca(OH)_2$ paste is important for its complete removal: The methylcellulose vehicle resists root canal removal when 17% EDTA is used. This is probably due to the interactions between methylcellulose and EDTA [20]. Nandini et al. found that particles in the form of $Ca(OH)_2$ in distilled water were easily removed, but Metapex (oily vehicle: silicone oil) resists dissolution in water and was therefore retained in the channel. Both EDTA and citric acid effectively remove $Ca(OH)_2$ powder in distilled water. Also, citric acid removes the medicament better than EDTA when removing Metapex, as EDTA chelates calcium ions in water, but citric acid can penetrate silicone oil better than EDTA [21]. $Ca(OH)_2$, combined with an oily vehicle, is difficult to remove and leaves residues on the walls of the canal [22].

Type of irrigation solution used

Irrigation solutions have different ability to remove intracanal medicaments. For example, NaOCl [23] is ineffective in removing $Ca(OH)_2$ because it lacks chelating ability; it simply removes superficial debris [24, 25]. Chelators such as EDTA [26], maleic acid [27] and peracetic acid [28] neutralize $Ca(OH)_2$ residues, but these residues must then be removed with NaOCl, or a neutral agent such as saline [29, 30].

Factors related to chelating agents

Various factors associated with chelating agents can affect the removal of intracanal medicaments:

Application time

There is no clear recommendation on the duration of administration of chelating agents. Usually each canal is rinsed for at least 1 minute. Prolonged use of strong chelators such as EDTA can weaken the dentin of the root, as the hardness and modulus of elasticity of dentin are functions of its mineral content [31]. The chelating activity of EDTA is observed at 1-4 min, decreasing after 5 min. But Teixeira et al. reported that EDTA had similar chelation efficacy at 1, 3, and 5 min [30].

For citric acid there is a tendency to saturate the demineralizing ability. da Silva et al. reported good results in terms of smear layer removal when applied to root canals for 30s. Citric acid has a time-dependent effect, because with increasing decalcification over time (3-10 min) the physicochemical properties of the original acid are not preserved in the salt (substrate / dentin + acid = salt). No chelation was observed after 15 min [32].

Etidronic acid (1-hydroxyethylidene-1,1-bisphosphonate / HEBP) is a relatively slow chelator. De-deus et al. found that complete elimination was achieved only after 300s [33].

pH and concentration of solution

EDTA is more effective at neutral pH than alkaline pH. EDTA has a self-limiting action; this is explained on its ability to for complexes: EDTA has special affinity for chelation in the ratio of 1:1, and its action stops after the depletion of EDTA molecules. Protonation, manifested at

reduced pH, has a decrease in the demineralizing power of EDTA over time [34].

According to Sousa et al., pH of citric acid is more important than the concentration for its chelating ability. It is not an effective chelator at neutral pH. Sterrett et al. reports that this phenomenon may be due to a balance between a decrease in pH and an increase in the viscosity of the solution caused by an increase in the concentration of the ingredients. At high concentrations, citrate monopolizes so much of the solvent that the amount of solvent available for Ca^{2+} diffusion is drastically reduced.

Volume of solution
It is recommended to use 5-10 ml of the chelating irrigant for each canal [35].

Reaction by-products
Citric acid decalcifies the dentin, resulting in the precipitation of calcium citrate crystals, which appear as debris under a scanning electron microscope (SEM.). NaOCl oxidizes EDTA, which leads to the formation of intermediate by-products (glyoxylic acid, ethylenediaminetrioacetic acid). The significance of these reaction products remains unknown, but could potentially affect SEM analysis in determining the degree of medicament removal [36].

Apical third of the root canal
The efficiency of the chelator decreases significantly from the coronary part of the canal to the apical. This is due to the fact that, towards the apex, the density of the tubules and therefore the permeability of the dentin decreases. Also, apical dentin is often sclerosed, and there are more branches of the apical delta [29].

2. Conclusions

The existing variety of intracanal medicaments, as well as their wide application, make their removal a major and important task for the clinician. The complex anatomy and different types of medications make it difficult to eliminate them. There is still no good and affordable technique for removing intracanal medicaments from the root canal space. Therefore, research continues to be relevant and constantly looking for new methods and means to improve the removal of intracanal drugs and achieve optimally clean surfaces of the dentinal wall of the root canal before its obturation.

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