

Analysis of the Effectiveness of Different Endodontic Irrigation Techniques in Smear Layer Removal: Literature Review

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Abstract— One of the main objectives of endodontic treatment is the decontamination of root canal systems. The removal of the smear layer is important, as it acts as a barrier, interfering in the diffusion of antimicrobial agents and in the adequacy between the filling materials and the canal walls. In this way, different irrigation techniques and devices have emerged to increase chemical disinfection and improve cleaning after mechanical instrumentation. The main objective of the present study was to analyze the effectiveness of different endodontic irrigation techniques in removing smear layer. As an inclusion criterion, articles from the PubMed and Google Scholar database were used. In PubMed, 397 articles were found, 10 were selected and in Google Scholar, 857 articles were found, 11 of which were selected for the research. . Thus, a final sample of 21 articles inserted in the work was obtained. It is concluded that all endodontic irrigation techniques removed more smear layer compared to conventional irrigation, but none was able to remove it entirely. Further laboratory and clinical studies are needed to prove the effectiveness of removing this layer with the standardization of clinical protocol.

Keywords— Irrigation Technique, Endodontics, Smear Layer.

I. INTRODUCTION

One of the main objectives of endodontic treatment is the decontamination of root canal systems (SCR), to reestablish the function of the tooth instead of opting for its extraction. Disinfection is done through the use of manual and mechanical instruments with the association of irrigating solutions (URBAN et al., 2017).

Along the chemical - mechanical preparation of the root canal system, an amorphous and irregular layer is formed on the root canal wall (CR), known as the smear layer. The smear layer is composed of organic and inorganic substances originating from dentin, odontoblastic processes, necrotic dentrites and microorganisms, together with their metabolic products (AHUJA et al., 2014; YILMAZ et al., 2017). This smear layer can retain bacteria inside the dentinal tubules, act as a barrier against disinfectant agents and interfere with the adhesion of the filling materials. Therefore, it must be removed due to its potential for contamination and to enhance the effect of irrigants and medicines (PRADO et al., 2016).

Irrigation becomes an essential complement to the success of the treatment, as it has several important functions, which may vary according to the solutions used: it reduces the friction between the instrument and the dentin, improves the efficiency of cutting files, dissolves the tissues in addition, it has a washing effect and an antimicrobial/antibiofilm effect (HAAPASALO et al., 2014).

Among the various options, sodium hypochlorite (NaOCL) is the most used at the present time and the closest to being an ideal solution, in association with ethylenediaminetetraacetic acid (EDTA) (HARGREAVES; COHEN, 2011).

The conventional irrigation method, using a syringe and needle, has not proved to be sufficiently sufficient to clean the inaccessible areas of the SCR. In this way, different irrigation techniques and devices have emerged to increase chemical disinfection and improve cleaning after mechanical instrumentation, such as manual dynamic activation (MDA), passive ultrasonic irrigation (PUI), sonic activation system with the EndoActivator device ,

apical irrigation by negative pressure (ANP) with the EndoVac device, among others (AHUJA et al., 2014; SCHMIDT et al., 2015; YILMAZ et al., 2017; URBAN et al., 2017).

Therefore, the present study intends, through the literature review, to analyze the effectiveness of different irrigation techniques in removing the smear layer

II. MATERIALS AND METHODS

In order to produce a literature review, the research was carried out in databases such as Pubmed (Medical Publications) and Google Scholar. The articles were attached in different folders by the name of the database.

In PubMed the keywords (irrigation techniques, endodontics and smear layer) were used, where 397 articles were found being selected 10. In Google Scholar the keywords were used (irrigation technique, irrigation solution and smear layer), where 857 articles were found and 11 were selected.

As an inclusion criterion, a scientific article and books were included that contained the keywords delimited from the year 2005 until the year 2020.

III. RESULTS AND DISCUSSION

To extract data from the main references included in the review based on the level of evidence (systematic review), we used a research instrument containing the identification of the article, the objectives, the methodological characteristics, results and the conclusions of the authors. The summary is shown in table 1.

During the endodontic treatment through instrumentation, a smear layer is formed, which consists of organic and inorganic substances, including fragments of odontoblastic processes, microorganisms, their by-products and necrotic materials (SABER; HASHEM, 2011; YILMAZ et al., 2017).

According to the authors of the research, it is important to remove the smear layer, as this layer can form a barrier and promote the invasion of bacteria in the dentinal tubules. Therefore, its removal will promote greater contact and action of irrigating substances, allow greater penetration and action of intrachannel medications and also promote a better seal between dentin and filling material (ODA et al., 2016; PRADO et al., 2016; URBAN et al., 2017; YILMAZ et al., 2017; SCHIAVOTELO et al., 2017).

In endodontic treatment, instrumentation and irrigation can be considered the most important parts for

the successful treatment of the root canal (HAAPASALO et al., 2014). Irrigation has several functions that vary according to the type of irrigation solution, the most important of which are to dissolve tissues and have an antimicrobial effect. Thus, irrigation is essential to remove the smear layer (AHUJA et al., 2014).

The use of irrigating solutions during biomechanical preparation is important for cleaning and eliminating microorganisms present within the root canal system. There are several types of irrigating solutions, the most used being sodium hypochlorite (NaOCl), chlorhexidine (CHX) and ethylenediaminetetraacetic acid (EDTA) (CÂMARA; ALBUQUERQUE; AGUIAR, 2010).

Sodium hypochlorite has been used for many years as an irrigant due to its action characteristics, such as dissolving organic tissue and having antimicrobial action (GATELLI; BORTOLINE, 2014). In their study, Gatelli and Bortoline (2014) through a literature review concluded that chlorhexidine has been indicated as an alternative to sodium hypochlorite, because unlike sodium hypochlorite it does not dissolve organic tissue, but it has a good antimicrobial activity against Gram-positive and Gram-negative bacteria and its main advantages are biocompatibility and substantivity. EDTA promotes the removal of only the inorganic part of dentin and smear layer and has no significant bactericidal or bacteriostatic activity (CÂMARA; ALBUQUERQUE; AGUIAR, 2010; HAAPASALO et al., 2014). In the study by Bonan, Batista and Hussne (2011) it was confirmed that, like chlorhexidine, sodium hypochlorite is also incapable of remove the smear layer completely, requiring the use of ethylenediaminetetraacetic acid (EDTA) after biomechanical preparation.

However, different irrigation management techniques and devices have been suggested to increase the flow and distribution of irrigation solutions in the root canal system, thereby increasing chemical disinfection and improving cleaning after instrumentation (SABER; HASHEM, 2011; AHUJA et al., 2014).

A few years ago, research sought to compare and evaluate the efficiency of different irrigation activation techniques in removing smear layer (AHUJA et al., 2014; EKIM; ERDEMIR, 2015; RÖDIG et al., 2010; SABER; HASHEM, 2011; SCHIAVOTELO et al., 2017; SCHMIDT et al., 2015; URBAN et al., 2017; YILMAZ et al., 2017), obtaining significantly positive results in relation to new techniques and irrigation management devices.

To assess the removal of the smear layer, the research included in our literature review (AHUJA et al.,

2014; EKIM; ERDEMIR, 2015; RÖDIG et al., 2010; SABER; HASHEM, 2011; SCHIAVOTELO et al., 2017; SCHMIDT et al., 2015; URBAN et al., 2017; UZUNOGLO et al., 2015; YILMAZ et al., 2017) used the Scanning Electron Microscope (SEM). This Scanning Electron Microscope (SEM) is used to identify this layer on the CR walls after endodontic preparation, allowing to obtain detailed images with greater magnification of the dentinal tubules (EKIM; ERDEMIR, 2015).

Conventional irrigation with a syringe and needle remains a widely accepted technique (YILMAZ et al., 2017). However, for some research authors, its effectiveness in removing the smear layer is still questionable (AHUJA et al., 2014; EKIM; ERDEMIR, 2015; PRADO et al., 2016; SABER; HASHEM, 2011).

Saber and Hashem (2011), compare in their research the removal of the smear layer using apical negative pressure (ANP) with the EndoVac device, manual dynamic agitation (MDA) and passive ultrasonic irrigation (PUI) using 2.5% NaOCl and 17% EDTA as irrigating solutions, and according to the data obtained, EndoVac and MDA removed the smear layer better than PUI. A possible explanation for what happened was that both techniques reach full working length of the instrumented channels and, therefore, allow for adequate replacement of the irrigator, which is not possible or recommended with conventional needle irrigation devices or ultrasonic agitation. Ahuja et al. (2014) obtained similar results in their study, in which the EndoVac was more effective in removing smear layer followed by MDA and PUI, also using 2.5% NaOCl and 17% EDTA as irrigators.

The study by Schiavotelo et al., (2017) compared non-activated irrigation, passive ultrasonic irrigation (PUI) and EndoActivator to remove the smear layer using 17% EDTA followed by 2.5% NaOCl as irrigating solutions, found it was found that the EA was more effective in removing the smear layer in the cervical and middle third

of the instrumented root canals compared to the PUI and the non-activated irrigation, however, there was no statistically significant difference in the removal of the smear layer between the techniques of irrigation tested in the apical region. Controversially, Urban et al., (2017) in their study sought to evaluate manual irrigation (MI), EndoActivator (EA), EDDY sonic activation and passive ultrasonic irrigation (PUI) using only 3% NaOCl and obtained the result that all techniques were superior in removing the smear layer compared to manual irrigation, but did not completely remove the smear layer. They also observed that PUI and EDDY performed equally and that both achieved significantly better scores compared to manual irrigation.

When studying a topic, we are often faced with contradictory results. One of the best ways to try to clarify and rely on better quality studies related to the subject. It refers to a type of investigation focused on well-defined issues that aims to identify, select, evaluate and synthesize the relevant evidence that is available (GALVÃO, PEREIRA., 2014). To elucidate the main references included in this literature review, we selected randomized clinical trials using an instrument containing the identification of the article, the objectives, the methodological characteristics, results and the main conclusions of the authors.

According to data obtained from randomized clinical trials on the efficiency of different irrigation activation techniques in removing smear layer (AHUJA et al., 2014; EKIM; ERDEMIR, 2015; SABER; HASHEM, 2011; SCHIAVOTELO et al., 2017; URBAN et al., 2017; UZUNOGLO et al., 2015) allow us to consider that in addition to endodontic irrigation being significantly important, the activation of irrigating solutions is also important, improving its action in removing the smear layer.

Table.1: Summary of the main articles found

Author / periodic / Year	Study Objectives	Research Method	Results and Conclusions
Ahuja et al., Journal Of Dentistry 2014	-Compare the removal of the smear layer after the final irrigation with techniques of negative apical pressure (ANP), manual dynamic agitation (MDA), passive ultrasonic irrigation (PUI) and needle irrigation in curved root canals.	Randomized Clinical Trial	<p>* ANP (EndoVac) showed the greatest efficiency in removing the smear layer. Followed by MDA and PUI, which were not statistically significant. Removing the smear layer was less effective with the NI technique.</p> <p>* EndoVac resulted in better removal of the smear layer in curved root canals when compared to manual dynamic agitation, passive ultrasonic irrigation and needle irrigation.</p>
Ekim, S N A; Erdemir, A Microscopy Research And Technique 2015	- Evaluate the efficiency of different irrigation activation techniques in removing smear layer	Randomized Clinical Trial	<p>* Activation with PUI, ANP, Nd: YAG, Er: YAG and PIPS (Photon-induced photoacoustic streaming) has been shown to be effective in removing the smear layer and ANP is the most efficient technique for removing the smear layer in the apical part of the root canal system</p>
Saber, S E; Hashem, A A R Journal Of Endodontics 2011	-Compare smear layer removal after final irrigation activation with negative apical pressure (ANP), manual dynamic agitation (MDA) and passive ultrasonic irrigation (PUI).	Randomized Clinical Trial	<p>* PI and PUI had the highest smear scores, with no significant differences between them. This was followed by the MDA and, finally, the ANP, which showed the lowest statistically significant mean score.</p> <p>* They concluded that the final activation of the irrigant with ANP and MDA resulted in a better removal of the smear layer than with PUI or PI.</p>
Schiavotelo et al., The Open Dentistry Journal 2017	- Compare the effectiveness of one non-activated irrigation technique and two activated in removing the smear layer after alternative instrumentation of single file in curved root canals.	Randomized Clinical Trial	<p>* No statistically significant difference was found in the effectiveness of irrigation techniques for removing the smear layer for the apical third.</p> <p>* The effectiveness of the EndoActivator system in removing the smear layer in the cervical and middle third of the instrumented root canals with alternating movement was significantly greater than PUI or non-activated irrigation. Both the EA and the PUI had a similar performance in the apical third.</p>

Urban et al., Clinical Oral Investigations 2017	-Evaluate the effectiveness of different final methods of activating irrigation in removing debris and smear layer in the apical, middle and coronal portion of the straight root canals.	Randomized Clinical Trial	* Removing the smear layer with PUI, EA and EDDY was not significantly different, but only EDDY and PUI were superior to IM. * All activation methods created channel walls almost free of debris and were superior in comparison to manual irrigation.
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IV. CONCLUSION

Most of the authors researched in this literature review consider that all techniques had superior results in removing the smear layer compared to conventional irrigation with a syringe and needle. However, none of the techniques was able to completely remove the smear layer from the inside of the root canal. Thus, the following conclusions could be reached:

1. All endodontic irrigation techniques had superior results in smear layer removal compared to conventional syringe and needle irrigation.
2. None of the techniques were able to completely remove the smear layer from the inside of the root canal.
3. It is necessary to standardize the clinical protocol using the same irrigating solutions in the same sequence.
4. Further laboratory and clinical studies are needed to prove the effectiveness of removing the smear layer.

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