Review paper
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THE POSSIBILITY OF USING ULTRASOUND IN ENDODONTICS: A REVIEW

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Abstract

Over the past few decades, endodontic treatment has benefited from the development of new techniques and using newer instruments. The use of ultrasonics in endodontics gives better predictability and outcome of endodontic root treatment. The purpose of this study is to review the literature regarding the use of ultrasound in certain phases of endodontic treatment of root canals, and critically evaluate the benefits and possible unwanted consequences on the outcome of endodontic treatment.

In preparing this paper, research from relevant databases was done (MEDLINE, PubMed, ScienceDirect), using the following keywords: ultrasonics in endodontics, ultrasonic irrigation, ultrasonic files, ultrasonic cavity preparation, root canal and obturation by ultrasonic condensation, ultrasonic retreatment, ultrasonic root-end preparation in apical surgery. The results of the review revealed that the ultrasound: has been proven to provide better visualization, and better access, and considerably shortens the duration of endodontic treatment. During ultrasound work we will have better irrigation compared to traditional irrigation with a syringe, ultrasound removes more organic tissue, planktonic bacteria, and dentin particles in the root canal. The ultrasonic method of placing the sealer in the root canal is more thorough than placing the sealer with manual instruments, and ultrasonically condensed gutta-percha is more homogeneous and has fewer cavities than gutta-percha condensed by classical lateral condensation. The audit of root canal filling is facilitated by ultrasound, and also instrumentation is more successful in removing broken instruments and intracanal extensions.

The ultrasound device has the potential to become routinely incorporated into almost every step of endodontic treatment and retreatment. The evolution of dentistry is strongly correlated to the development of science and technology.

***Key words**: Ultrasonic irrigation, Ultrasonic files, Ultrasonic cavity preparation, Ultrasonic retreatment.*

1. Introduction

Endodontics is a branch of dentistry that deals with the etiology, prevention, and treatment of diseases of the pulp and apical periodontium. The fundamental task of endodontic treatment is to remove infected pulp tissue, microorganisms, and detritus, cleaning, treatment, and disinfection of the root canal, followed by precise hermetic filling of the canal to the apex. Ultrasonic instruments have enabled the clinician to overcome the problems associated with conventional methods of endodontic root canal treatment [1, 2, and 3].

During the last few decades, endodontic treatment has been facilitated by the development of new techniques such as ultrasound, which significantly facilitates endodontic treatment, and provides better predictability and the outcome of treatment. The use of ultrasound in endodontics has improved the quality of treatment [4].

Since its introduction, ultrasound has been an important adjunct in the treatment of difficult cases, becoming more and more useful in the case of access to hard-to-reach canal openings, it is used for cleaning and shaping the root canal, removal of intracanal materials and obstructions, and in endodontic surgery.

The most important aspect of successful endodontic therapy is proper root canal debridement. Even after chemomechanical treatment, the remains of pulp,

necrotic tissue, bacteria, and their products remain in the inaccessible parts of the canal [5].

A smear layer is created on the canal walls during chemomechanical preparation. The smear layer serves as a breeding substrate for bacteria, it is made up of organic and inorganic debris as well as bacteria left behind in the channel. Also, the smear layer represents a physical barrier on the walls of the root canal, prevents the penetration of the sealer into the dentinal tubules, hinders their adhesion, and leads to microleakage between the canal wall and the filling. In this way, the quality of the obturation decreases, and therefore it is necessary to remove the smear layer [10, 11].

Bacteria are mostly retained in inaccessible places such as accessory and lateral canals, isthmuses, ramifications, deltas, and dentin canals. The conventional method does not achieve complete removal of the smear layer in the apical parts of the root, in inaccessible places, or in curved and other aberrant forms of the canal [6].

Therefore, in the last two decades, more efficient and newer methods of active washing and canal treatment have been researched, which could have a greater effectiveness in the decontamination of root canals than the classic method of irrigation and treatment, so that the irrigants reach inaccessible places in the canal and thereby increase the success of endodontic treatment [36].

For the preparation of this paper, a literature search was used through the electronic databases: MEDLINE, PubMed, and Science Direct. The purpose of this research was to review the literature, to show in detail the use of ultrasound in certain phases of endodontic treatment of root canals, and to critically evaluate the benefits and possible unwanted consequences on the outcome of endodontic treatment.

2. Possibility of using ultrasound in endodontics

2.1 Use of ultrasound in specifying access, finding access channels, and removing pulp calcifications

The clinical approach to root canal calcifications is certainly not the easiest. First, they must be recognized. The radiographic aid, in this sense, can be a double-edged sword. Therefore, objective evidence will be diriment: it is essential to visualize the chromatic detachment between the hard tissues, possibly through substances that can enhance these differences. Put in simplistic terms, since dentin does not always have the same color, a calcification will certainly present a coloration that is not that proper to the hard tissues of the tooth. The therapeutic strategy is ideally to remove the calcification, thereby clearing the space previously occupied by pulpal tissue, and then finalize endodontic therapy [13, 25].

As much as calcifications constitute the intracanal counterpart of chamber calcifications, their removal is different because it virtually always involves gradual erosion of the tissue. The use of irrigating solutions, such as sodium hypochlorite or EDTA, is essential. Tissue removal, depending on the case, can be conducted by hand, rotary, ultrasonic, or combined technique. It will not be necessary, once the obliterated canal tracts are cleared, to remove all calcific tissue before finalizing therapy [12].

The access is the first phase of endodontic treatment. It permits entry to the pulp chamber through the removal of its roof as well as dentin, facilitating access to the canal orifices. A well-designed and well-executed access is paramount to achieving proper cleaning, shaping, and obturation of the root canal system [25].

The cleansing effect of ultrasound depends on cavitation and molecular mechanical vibration phenomena. Ultrasonic cavitation is a physical compression and expansion, known for many years in hydraulics because ultrasound emitted by transducers compresses and then expands fluids. Molecules of a fluid subjected to the action of ultrasound change size, and positive and negative pressure bubbles are created that become unstable, collapse, and cause an "implosion" similar to a decompression vacuum [14, 15].

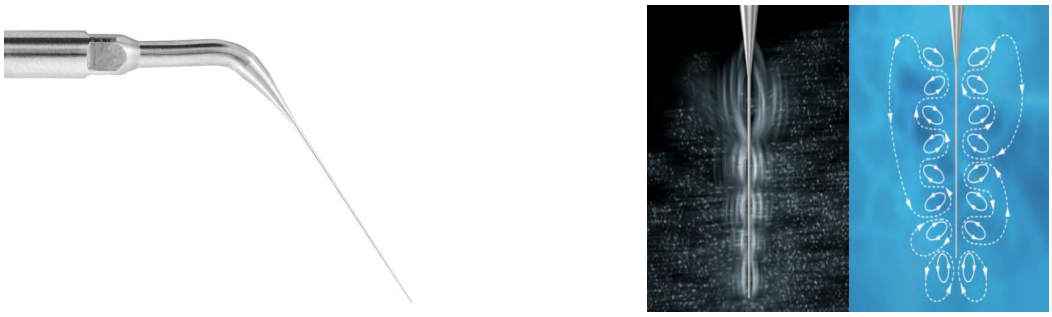
2.2 Ultrasound-enhanced action of irrigation solutions PUI (Passive Ultrasonic Irrigation):

Activation and enhancement of irrigants (clorexidina, sodium hypochlorite, hydrogen peroxide, chelators, etc.) that do not involve contact of the ultrasonic file with the canal walls: from this characteristic comes the definition of passive (Figure 1) [3].

For this method, special inserts of different shapes have been designed, but with the common characteristic of being without a cutting angle, to reduce the possibility of any alteration of the canal shape in case of accidental contact of the insert with the canal walls. It is a two-step technique as the irrigant is introduced with a syringe and then activated with the use of ultrasonic inserts. In this technique, the ultrasonic insert, by vibrating, produces acoustic streaming that generates sufficient shear stress to dislodge debris in the instrumented canals: this would result in improved cleaning of the canal walls [16, 17].

2.3 Ultrasonic removal of smear layer

Ethyldiaminetetraacetic acid or EDTA is a chelator used for the removal of the smear layer within canals.



a) b)

Figure 1. a) Ultrasonic attachment for passive irrigation "E1 - Irrisonic"; b) The effect created by the extension "E1 - Irrisonic" in the irrigation liquid

Combined use of EDTA and sodium hypochlorite on instrumented canal walls is known to effectively remove the smear layer and pulpal debris. Ultrasonic activation (US) increases the effectiveness of the irrigating solution in removing organic and inorganic debris from the canal wall because the vibration produces a continuous current close to the file as it keeps the irrigant in continuous motion. Ultrasonic devices operate at higher frequencies (25 - 40kHz) than sonic devices (2 - 3 kHz). One minute of ultrasonic hypochlorite irrigation significantly reduces the number of bacterial colonies and is seven times more effective than instrumentation alone [34, 35]. The oscillation of an endosonic file produces a very large displacement of irrigant at the level of the tip, and it was seen that the imposition of the contact of the file with the walls inhibited the production of the transient cavitation: therefore, the tip must move freely in the canal for this a good canal widening must be performed [8]. Regarding the apical third of curved roots, the oscillating tip is more susceptible to constriction; this explains the occasional inefficiency of ultrasonic devices. Devices working at lower frequencies, especially in the apical third of curved canals, produce less shear stress, which causes less modification of the tooth surface [18].

2.4 Ultrasound-assisted obturation

Nonsurgical retreatment is a clinical procedure suggested when there is a failure of the endodontic treatment of a tooth. It consists of removing the present obturation material, followed by the shaping, cleaning, and filling of the root canal system. Among the instruments that can be employed in this procedure, the US tips are extremely relevant, since they allow the clinician to work easily and safely even in areas that are difficult to reach, without compromising the visibility of the operative field. Used together with magnifying devices and adequate illumination, ultrasound (US) tips are effective in removing intracanal obstructions, posts, and broken instruments, allowing them to achieve good results even in complex cases (where the original tooth anatomy was altered) and reducing the operative timing, above all in posterior teeth [7].

Moreover, US tips are useful for activating irrigating solutions, increasing their effectiveness in cleaning root canal systems. Peculiarity extremely useful in nonsurgical retreatments is the possibility to bend the US tips and files, making the instrument work, without losing efficiency, in situations in which using rotary instruments would not be possible. Regardless of the technology on which they are based, ultrasonic instruments work optimally when they are designed and manufactured for a specific generator [33].

2.5 Application of ultrasound in the revision of root canal filling

Non-surgical endodontic treatment is routinely practiced in modern dentistry. The revolution of material science and techniques in root canal treatment has resulted in the retention of millions of teeth that would have otherwise been lost. Even as recent advances in surgical, prosthetic, and restorative care have made tooth replacement less onerous than in the past, it is universally accepted that a natural tooth with a good prognosis is a superior choice to loss and replacement [32].

Retreatment is a procedure to remove root canal filling material from the tooth, followed by cleaning, shaping, and obturation of the canals. Complete removal of gutta-percha from root canal walls, reestablishing working length, promoting disinfection, and re-obturating the root canal are the main goals of non-surgical retreatment to reestablish healthy periapical tissues and obtain predictable success [29].

Ultrasonic systems can be magnetostrictive or piezoelectric, the latter most used in endodontics, as they make the tip vibrate linearly. The design of an ultrasonic tip promotes visibility over the common

rotating handpiece, and therefore its use is perfectly matched to that of the operating microscope and its illumination system [31].

Ultrasonic instrumentation, in part because of the variety of inserts available on the market, is suitable for use in a variety of clinical settings indicated for retreatment and even in different phases of the same procedure. Access to the chamber space, for example, is often complicated because of anatomy subverted by the previous procedure or because of the presence of obstructions (root canal filling material, calcifications, or others). Switching from a larger diamond tip to a thin insert will expose previously treated or unintentionally missed canal orifices [32].

2.6 Application of ultrasound in the removal of broken instruments and intracanal extensions

Clinicians frequently encounter endodontically treated teeth that contain metal obstructions such as fractured instruments, silver cones, or pins within their roots. If endodontic treatment has failed, to facilitate successful nonsurgical retreatment, the need arises to remove intracanal obstructions that may be caused by any type of previously used material that may be difficult to remove, whether metallic or not. Many removal techniques exist, including the use of a variety of appropriate drills, specific forceps, direct or indirect contact ultrasonic instruments, peripheral preparation techniques in the presence of solvents, chelators, or irrigants, microtube systems using mechanical and adhesive, various instruments and extractors [8, 9].

Ultrasonic energy has proven effective in facilitating the removal of silver cones, fractured instruments, and cemented posts, In addition, it has often been used for the removal of broken instruments because ultrasonic tips or endodontic files can be used deep into the root canal system. The use of ultrasonic devices is not limited by the location of the fragment in the root canal or the tooth involved. The prognosis of these cases depends mainly on the preoperative condition of the periapical tissues [37, 38]. For these reasons, an attempt to remove fractured instruments should be undertaken in every case [27].

2.7 Application of ultrasound in modern endodontic surgery

Surgical endodontics represents the procedure of choice to be performed for the treatment of lesions of endodontic origin (granulomas or cysts) that do not respond to conventional endodontic therapy or cannot be treated with conventional endodontic therapy through the crown of the tooth. The aim of surgical endodontics is, therefore, to achieve cleansing, shaping, and three-dimensional obturation of the apical portion of the root canal when this cannot be treated through the access cavity made in the tooth crown, but can only be reached through a surgical flap. The procedure is performed entirely with the help of the operating microscope and has a very high long-term success rate [19, 20].

The only real indication for surgical endodontics is the presence of an obstacle that prevents probing and thus preparation and then filling of the canals with a traditional approach. This obstacle may be the presence of a pin (although today there are instruments with which even large metal pins can be safely removed), calcifications, old canal-filling materials that cannot be removed, etc. In other cases, during previous unsuccessful endodontic therapy, the original endodontic anatomy has been so altered as to make any attempt at recovery by the traditional approach futile.

In all these cases, it is preferred to lift a surgical flap and treat the root apex with a retrograde approach, that is, placing a seal by the retrograde route since orthodontic access was for some reason impeded. The preservation of a tooth element that can be treated by such a method is a definite advantage for the patient from a biological point of view. In addition, in a single session the patient solves the dental problem without having to undergo time-consuming and expensive treatment, such as performing prosthetic work, the classic bridge, to replace an extracted tooth element, or implantation [21].

The procedure consists of administering a local anesthetic, after which the gingiva is incised to expose the bone and find the tooth to be treated. At this point, the most apical portion of the root is removed (usually about 3 mm), the apical 3 millimeters of the canal is prepared with special ultrasound tips, and the filling material is placed: the retrograde seal. Today we have biocompatible materials that provide higher healing rates than what was obtained years ago. If the lesion was sustained by bacteria present in a lateral canal, obviously retrograde preparation and obturation of the lateral canal is performed [22, 24].

All endodontic treatments, whether performed by traditional approach through the dental crown or surgically, should be rechecked regularly at six-month intervals for at least two years. If the surgery has been successful, after about 6 - 12 months of radiographic inspection the area of radiolucency should have completely disappeared.

The tooth that has undergone apicoectomy surgery, if properly reconstructed conservatively or prosthetically,

may have a distant prognosis similar to that of the other teeth in the arch [30].

A root canal surgery, also known as apicoectomy is an endodontic surgical procedure whereby a tooth's root tip is removed and a root canal cavity is prepared and filled with a biocompatible material. State-of-the-art procedures make use of microsurgical techniques, such as a dental operating microscope, micro instruments, ultrasonic preparation tips, and calcium-silicate-based filling materials.

A conventional endodontic treatment is indicated if the dental pulp (nerve) of a tooth becomes non-vital (dies) or is likely to be put at risk due to the type or size of restoration needed to repair the tooth. During endodontic treatment, it is removed the dead remnants of the dental pulp and replaced with an inert filling material which is visible on an X-ray. In this procedure, the endodontist opens the gum tissue near the tooth to see the underlying bone and to remove any inflamed or infected tissue. The very end of the root is also removed. A small filling may be placed in the root to seal the end of the root canal, and a few stitches or sutures are placed in the gingiva to help the tissue heal properly. Over months, the bone heals around the end of the root [28].

3. Conclusions

- The ultrasound device has the potential to become routinely incorporated into almost every step of endodontic treatment and retreatment. Several conclusions were drawn from the preparation of this review paper.
- Ultrasound has been proven to provide better visualization, and access and considerably shortens the duration of endodontic treatment, enabling a more conservative approach in removing tooth structure.
- Ultrasonic instruments show superiority compared to classic drills when it comes to creating an access cavity and showing the anatomical position of the entrance to the root canals.
- Better irrigation is achieved, compared to traditional irrigation with a syringe, ultrasound removes more organic tissue, planktonic bacteria, and dentin particles in the root canal [23].
- The ultrasonic method of placing the sealer in the root canal is more thorough than placing the sealer with manual instruments. Ultrasonically condensed gutta-percha is more homogeneous and has fewer cavities than gutta-percha condensed by classical lateral condensation [25].
- The audit of root canal filling is facilitated by ultrasound. Ultrasonic instruments generate heat that warms and softens the gutta-percha. Ultrasound instrumentation is more successful in removing broken instruments and intracanal extensions. Ultrasonic vibrations tend to loosen the instrument in the canal making it easier to remove, also ultrasonic vibrations break the bond between the stake and the walls of the canal, making it easier to remove [26, 27].
- The use of ultrasound in endodontics increases the overall quality of treatment and ensures long-term success.

4. References

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