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ULTRASONIC IN ENDODONTICS: REVIEW

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Abstract: During the past few decades, the development of new techniques and equipment has improved the outcome and predictability of restorative and endodontic treatment. Ultrasonics have contributed a lot in this development. Since its introduction, Ultrasonics has become increasingly more useful in applications such as gaining access to canal openings, cleaning and shaping, obturation of root canals, removal of intra canal materials and obstructions, and endodontic surgery. Currently, although ultrasonics (US) is used in dentistry for therapeutic and diagnostic applications as well as for cleaning of instruments before sterilization, its main use is for scaling and root planning of teeth and in root canal therapy, both for orthograde and retrograde therapy. This review article brushes up the role of ultrasonics in endodontotlogy.

Keywords: Ultrasonics , Mineral trioxide aggregate ,Passive ultrasonic irrigation

Introduction

The Ultrasonic instrumentation was first introduced to dentistry for cavity preparations using abrasive slurry. It never became popular because it had to compete with the much more effective and convenient high-speed hand piece.1 Now the concept of minimally invasive dentistry and the desire for small dimension preparations have stimulated new approaches in cavity design and tooth-cutting concepts, including ultrasound for cavity preparation. These devices have gained widespread acceptance in surgical procedures for tissue dissection, fragmentation and ablation applications.2 Ultrasonic medical and surgical devices operate in the range of20–60 kHz for biological tissue cutting, ablation or fragmentation, and removal.3

In 1957, Richman first introduced the concept of using Ultrasonics in Endodontics. The term Endosonics was first coined by Martin H. and Cunningham W. and was defined as the ultrasonic and harmonious system of root canal instrumentation and disinfection. The range of frequencies employed in original ultrasonic units was between 25 and 40 kHz. Subsequently, the low-frequency ultrasonic handpieces operating from 1 to 8 kHz were developed, which in turn out lower shear stresses, which produce less alteration to the tooth surface.4

The most useful application of ultrasonics to endodontics includes access refinement, finding calcified canals, removal of attached pulp stones, removal of intra canal obstructions (separated

instruments, root canal posts, silver points, and fractured metallic posts),increasing action of irrigating solutions, ultrasonic condensation of gutta-percha, placement of mineral trioxide aggregate (MTA) and surgical endodontics, root-end cavity preparation and refinement and placement of root-end obturation material and root canal preparation. The ultrasonic devices are more powerful than sonic ones and have better chemical and mechanical efficiency of root canal irrigation procedures and widely used method now a days.5

Basic principle of ultrasonics

The first is magnetostriction, which converts electromagnetic and magnetomechanical energies. A solenoid is a type of electromagnet used for conversion between electric and magnetic energies, and a magnetostrictive material is used as the transducer driver to convert between magnetic and mechanical energies. For actuation, passing the current through the solenoid converts electrical energy into magnetic energy. A magnetostrictive device produce more of an elliptical motion.6

The second method is piezoelectric principle, based on a crystal that changes dimension when an electrical charge is applied. Crystal deformation produces mechanical oscillation without heat production. Piezoelectric devices operate at 40 kHz and the strokes occurs in a linear, back-and-forth, piston-like motion, which is ideal for endodontic applications.5,6

Ultrasonic tips

The ultrasonic tips are classified according to the features as:

- According to tip:
  Active tip
  Non active tip
- According to surface:
  Smooth
  Milled
- According to coating:
  Diamond coated

Non diamond coated

- According to material used

Stainless steel

Nickel titanium

The active tip is an effective tool when used for removal of fibre post and obstacles present in pulp chamber and a low risk of creating iatrogenic injury. The smooth tip is useful in pulp stone and intracanal obstructions (such as post) removal. The tips with milled surface have a higher lateral cutting ability and longer lasting even compared to the diamond coated tips .Surface coatings on ultrasonic tips are intended to increase efficiency and durability; diamond-coated tips have been shown to require less time than stainless-steel tips to cut similar preparation.7

SINE TIPS: featured a patented and innovative double composite diamond coating, specially designed working ends, and a water delivery system. Synergistically, these combined features increases precision, efficiency, durability and safety.

SL TIPS: Surface Lesion have been designed for prevention and conservation of sound tooth structure. Occlusal sealants/composites, cervical restorations, repairs to crown margins, retentive preparations for bonded composites and other restorative dentistry can now be done with greater precision, visibility and accessibility.

Endo success cap ultrasonic kit: Supplied with the CAP1, CAP2, CAP3 microblade tips, a metallic support, and a universal autoclavable wrench. The success of root canal treatment involves shaping an irreproachable access cavity. The new "Endo Success™ Canal Access Prep" kit is

desired for locating and opening hidden or calcified canals and shaping and finishing the access cavity.

Endo success apical surgery ultrasonic kit: This ultrasonic tip kit is used during non-surgical endodontic retreatments. It contains AS3D, AS6D, AS9D, ASLD, ASRD tips, an autoclavable metal support.

START.X: Achieve superior control and precision with ultrasonic inserts peculiarly designed for access cavity refinement and canal orifice location.

CK TIPS: Indicated for the removal of broken instruments, irrigation and troughing. For an ultrasonic and synergistic system of root canal, Ultrasonic vibration through a file ensures an efficient cleaning of the root canal system through acoustic micro streaming.8

Applications of US in Endodontics

1. Access refinement. Finding calcified canals, and Removal of connected pulp stones.
2. Removal of intracanal obstructions (separated instruments, root canal posts, silver points, and fractured metallic posts).
3. Increased action of irrigating solutions.
4. Ultrasonic condensation of gutta-percha.
5. Placement of mineral trioxide aggregate (MTA).
6. Surgical endodontics: Root-end cavity preparation and refinement and placement of root end obturation material.
7. Root canal preparation 9

Access refinement, finding calcified canals, and removal of connected pulp stones.

Locating the canals during the root canal treatment is a considerable challenges, particularly in cases in which the orifice has become occluded by secondary dentin or calcified dentin secondary to the placement of restorative materials or pulpotomies. The lack of straight-line access is the potential cause of instrument separation, perforation, and the inability to negotiate files to the radiographic terminus.

Advantages of using Ultrasonics over burs to refine the access cavity to locate the underlying anatomy:

1. Vision- Progressive cutting action can be observed directly and continuously under the microscope.
2. Superior control- Dentine can be brushed off in smaller increments and with greater control. The process allows for

the exposure of any missed canals containing necrotic pulp tissue without gutting down the tooth structure.

3. Cavitation- is the term used to describe the formation of bubbles in the liquid flow that are capable of generating enough shock waves to cause disruption of remnants of necrotic pulp tissue and any calcific deposits in the root canal system.

The use of ultrasonic tips with abrasive coatings helps in penetration, coarse enlargement, refinement and extension of the cavity take away dentine gradually.10 Ultrasonic devices are particularly advantageous for the removal of remarkably large pulp stone in single mass.11 Ultrasonic works well when break the calcification that covers the canal orifice. For these applications, the larger tips with a diamond coated extension should be used during the initial phase of removing calcification, interferences, materials, and secondary dentin, as they offer maximum cutting efficiency and control while operating the root canal. The subsequent phase of finding calcified canals such as MB2 in the maxillary molars or sclerotic canals in traumatic teeth should be carried out with thinner and longer tips that facilitate working in deepest areas with clear vision, avoiding iatrogenic injury such as coronal-middle perforations.12

Ultrasonic in post removal

Application of ultrasonic in removal of post cemented with resin cements, possibly because of the increase in heat. The capacity of adhesion of a resin cement, and consequently mechanical retention, gradually reduces with the number of thermal cycles.13

Ultrasonic in GP condensation

Spreaders that have been activated ultrasonically used to thermoplasticize gutta-percha in a warm lateral condensation technique. The linear vibration of the spreader produces heat after the application of ultrasonics, thus thermoplasticizing the gutta-percha, achieved a more homogeneous mass with a decrease in number and size of voids and a complete three-dimensional obturation of the root canal system is obtained. The protocol for obturation by activation of ultrasonics are as follows : (a) ultrasonic softening of the master cone followed by cold lateral condensation ; (b) activation of ultrasonic after completion of cold lateral condensation (c) activation of ultrasonic after placement of each second accessory cone; or (d) ultrasonic activation after placement of each accessory cone.8,14

Ultrasonic in separated instruments

Separated instrument is removed with the ultrasonic tips or endosonic files in the root canal system. The removal of an obstacle from a root canal must be performed with minimum damage to the tooth structures and the surrounding tissues. Straight-line access is essential and allows for maximum visibility of the metallic fragment. For that reason, the use of magnification (dental operating microscope or loupes) is essential, as it provides direct visualization with excellent illumination, allowing instrumentation at high magnifications.5

Ultrasonic in cleaning of instrument

Ultrasonic energy enhancing the cleaning efficiency than any other alternatives, including spray washing, brushing, turbulation, air agitation, and electro-cleaning in many applications. Ultrasonic cavitation and implosion effectively displaces the saturated solvent layer to allow fresh solvent to come into contact with the surface and remaining contaminant is to be removed. In addition, this is beneficial when irregular surfaces or internal passageways are to be cleaned.15

Ultrasonic in root canal irrigation

Ultrasonic Irrigation Techniques

• Continuous flush technique

It provides an uninterrupted supply of fresh irrigating solution into the root canal. This technique provides more effective results and reduces the time required for ultrasonic irrigation.

• Intermittent flush technique

The irrigating solution is injected in the root canal with a syringe and then activated with an oscillating ultrasonic instrument and the canal is filled several times after each activation cycle. The amount of irrigating solution flushed through the apical region of the canal can be controlled by the depth of penetration of the syringe and the volume of irrigant. 16

Activation of irrigants

Acoustic streaming and cavitation of the irrigant solution

The acoustic streaming is the steady flow of the fluid in a circular or vortex shape around the vibrating file.

Cavitation is defined as small gas bubbles being grown, oscillated, and collapsed in a fluid while being affected by ultrasound waves.

Mechanism of action of ultrasonic irrigation

ultrasonic irrigation causes acoustic streaming effect by mechanical energy when a file is placed into the root canal, thus dislodging the debris from canal through the warming effect, it potentiates the activity NaOCl which has tissue- dissolving and antibacterial properties. Cleaning of the root canal space by ultrasonic synergistic system is more superiorwhen compared to conventional hand filing irrigating technique.17

Advantages

1. PUI is more effective in cleaning canals than traditional syringe irrigation, in terms of removing more organic tissue, planktonic bacteria, and dentine debris.
2. The influence of taper and diameter of the root canal are important parameters in determining the efficacies of dentine debris removal.
3. During PUI, irrigation is more effective with sodium hypochlorite than with water.18

Ultrasonic in removal of smear layer

Ultrasonic delivery system reduces bacterial loads by increasing the NaOCl efficacy within the root canal system. Whilst concentrations of 2–4% sodium hypochlorite in combination with ultrasonic energy were able to remove smear layer, lower concentrations of the solutions were unsatisfactory. Cameron compared the effect of ultrasonic irrigation in smear layer removal at different time period and found that a 3- and 5-min irrigation with NaOCl produced smear-free canal walls, whereas 1-min irrigation was ineffective .19

Placement of MTA with ultrasonic tips

Application of ultrasonic vibration to an endodontic condenser aims to improve the flow, settling, and compaction of MTA. Ultrasonic activation has been directly applied to MTA appears denser radiographically, with fewer voids. Application of MTA consists of selecting a condenser tip, then picking up and placing the MTA with the ultrasonic tip, followed by activating the tip and slowly moving the MTA material down using a 1 to 2 mm vertical packing motion.20

Ultrasonics in apical surgery (apicoectomy)

Apicoectomy is a minor surgical procedure in which tip the the root tipis removed along with the pathological periapical tissues. Accessory root canal and additional apical foramina are also removed. The root end cavity is prepared and filled with the biocompatible material.

Preparation of root end is an important step in establishing an apical seal. The prepared cavity is dimensionally adequate for the placement of root-end filling material without damage to the root-end structures.21

According to Carr, an ideal root- end preparation should have following :

(i) Cleaning and shaping of the apical 3 mm of the root.

(ii) Parallel and coincident with the anatomic outline of the pulp space.

(iii) Has adequate retention form.

(iv) Take away all isthmuses tissue while not weakening the remaining dentinal walls.

Comparison of Ultrasonic Microsurgical Root-End Preparations Verses Traditional burs

The major advantages of ultrasonics technique over traditional bur technique include deeper and more conservative cavities that follow the outline of the root canal space, better preparation of anatomical difficulties such as isthmuses and smaller size of bony crypts and minimal bevel of the root-end are needed, this technique has a significantly better treatment outcome compared to bur technique.22

Summary -Ultrasonics offers many applications and advantages in conservative dentistry and endodontics with a more conservative approach for selectively removing tooth structure, particularly in difficult situations in which a specific angulation or tip design permits access to restricted work

areas, offers opportunities that are not possible with conventional treatment.The design of the ultrasonic instruments provides better visualization compared to high or low speed air turbine instruments, and this advantage increases the success rate in access refinement, locating calcified canals and removing calcifications. The piezoelectric ultrasonic device has the potential to become routinely incorporated into almost every component of endodontic treatment, re-treatment, and apical microsurgery.

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