ULTRASONICS IN ENDODONTICS

Abstract

The use and purpose of ultrasonic vibrations in the field of dentistry has been evolved for just over 70 years. Ultrasonics along with operating microscope has improved the endodontic treatment quality and represents important tool in the treatment of difficult cases. During endodontic procedures Ultrasonic has been used for access refinement, finding calcified canals, removal of attached pulp stones, removal of intra-canal obstructions, irrigant activation, placement of MTA and surgical endodontics. This chapter will highlight all the possible avenues of ultrasonics in endodontics.

Authors

Dr. Prajakta C. Ambulkar
Assistant Professor
Department of Conservative Dentistry and Endodontics
VSPM's Dental College & Research Centre
Nagpur, India.

I. INTRODUCTION

Preservation of natural teeth is of paramount importance to rehabilitate the dentition to its natural form and function. From the last few decades endodontic procedures has been benefited from the development of novel methods and equipments. Among them the utilisation of ultrasonic sources has procure such significance that leads us to consider it as one of most intriguing advances in contemporary endodontics.

In contemporary dentistry Ultrasonics are the most frequently used non-invasive instrument. **Ultrasonic** is defined as waves with minimum frequencies of 25 kHz. It is a Latin word in which ultra meaning "beyond" and sonic meaning “sound”. Thus, the usage of sound waves beyond of human audible range is a component of ultrasonic field. **Microultrasonics** refers to the ultrasonic devices use in conjugation with surgical operating microscope’s magnification and illumination.

The first time an ultrasonic device had been used in dentistry to prepare cavities using abrasive slurry. In 1957, Richman was the first to suggest using ultrasound in endodontics. However, this use did not become extensively employed in root canal preparation prior to filling and obturation until Martin et al. demonstrated the ability of ultrasonically activated K-type files to cut dentin. The word "**Endosonics**," which Martin and Cunningham invented, was characterized as an ultrasonic and synergistic method of root canal instrumentation and disinfection. The first ultrasonic tips were presented by Gary Carr in the 1990s, and after that, attention turned to the application and potential consequences of ultrasonic root-end preparations during apicoectomy. After the invention of the piezoelectric device and the development of multiple ultrasonic tip designs, practitioners could remove dentin or other dental materials with extreme control and precision using tips that were typically the same size as a root canal or smaller. Parallel to this, the market witnessed the introduction of tips designed to focus and transfer vibrational energy without removing tooth structure.

II. PHYSICS BEHIND ULTRASONICS

In dentistry, there are two principal variants of ultrasonic generators that function in various modes - Magnetostrictive Generator (converts electrotmagnetic energy into mechanical energy) and Piezoelectric Generator (crystal deformation causes mechanical oscillations). The **Magnetostrictive Generator (**ie, Cavitron, Dentsply, York, PA) works on the magnetostriction principle, which states that expansion and contraction of certain materials happen when exposed in an alternating magnetic field. The operating range of magnetostrictive units is from 18kHz to 45kHz. The **Piezoelectric Generator** (i.e., P5 Newtron, Acteon Merignac Cedex, France), on the other hand, uses the piezoelectric effect to directly transform alternating current into mechanical energy. The operating range of piezoelectric units is from 15 kHz to 50 kHz. Magnetostrictive generators are less efficient than piezoelectric generators (95%) because magnetostrictive units require two energy transformations. The tips of piezoelectric units move linearly, which is suitable for endodontics, whereas the tips of magnetostrictive units move elliptically.

Cavitational activity, acoustic microstreaming, heat, oscillations, and radiations are some of the **physical effects** of ultrasonic production. In general, endodontic treatments benefit from the significant effects such as cavitation, acoustic microstreaming and

oscillations; yet, in some clinical situations, the development of heat and the electomagnetic radiation emission need caution.

Cavitation refers to the oscillatory motions of gasfilled bubbles in an acoustic field, bubbles that are powered by energy from the ultrasonic field. The microscopic bubbles are formed and then collapse and explode, resulting in localized areas of pressure and heat production.

Acoustic microstreaming is defined as the generation of time independent, steady unidirectional circulation of fluid in the vicinity of a small oscillating object. When an oscillating file is immersed in a fluid, the file generates streaming fluid which includes two components: the primary field of rapidly moving eddies consisting of the fluid element oscillating about a mean position. A superimposed secondary field consists of patterns of relatively slow, time independent flow.

Due to friction, when ultrasonic instruments touch tooth structure or dental materials, heat is produced. Hence advise is given for routinely cooling the post with water or air since, in dry conditions, ultrasonic vibration of a metal post can significantly increase the transfer of heat to nearby dental tissues in as little as 20 seconds. The irrigant temperature may rise by up to $10^{o}C$ as a result of ultrasonic activation. Heated sodium hypochlorite considerably improves tissue dissolving has been noticed earlier.

While using an ultrasonic device in conjunction with water, an aerosol is generated that may include bacteria or even blood contamination. The amount of aerosol formed can be significantly reduced by using an extraoral high-volume evacuation.

III. ULTRASONIC DEVICES:

In 1979, the Satelec Company developed the first piezoelectric ultrasonic dental device; such device typically comprises of:

- Main body - houses the ultrasound generator,
- Handpiece with ultrasonic tips
- Foot pedal

Endodontic Ultrasonic Tips: There is a wide range of ultrasonic tips available for use in endodontics, periodontics, surgery, and general practice. These tips are made from a variety of metal alloys, including titanium and stainless steel alloys. These tips can be coated with zirconium nitride or diamond abrasive, to improve cutting efficiency. Many tips include an in-built water port, allowing debris to be washed away and cooling to occur if needed. Because of the diverse tips available in the market, a suitable design of tips for almost all phases of endodontic therapy. Each tip should be utilized in the suggested power setting range.

IV. APPLICATION OF ULTRASONIC TIPS

Pulp Chamber: Refinement of access cavity, searching calcified canals and attached pulp stones removal. A combination of magnification and ultrasonic access refinement tips has

revolutionized the fundamental idea of access cavity preparation. BUC-1, CPR-2D, or BL-1 ultrasonic tips can be utilised for the overt excision of dentin during access preparation because they have incorporated adequate length for most access preparations, abrasive grit along half of their length and a strong tip that is less prone to fracture.

Bigger tips with a restricted diamond-coated extension should be utilized during the initial phase of searching hidden canals, eliminating calcification, interferences and secondary dentin as they give the greatest cutting efficiency as well as enhance control when working in the pulp chamber. The subsequent step of locating canal orifices needs to be done with longer, thinner tips that render it easier to work in deeper places while maintaining vision. It should be noted that the floor of the pulp chamber is darker and greyer in appearance, but secondary dentin is often yellowish or opaque when searching for hidden canals. When removing the calcification covering the canal opening, US is effective. For this task, a troughing tip works well.

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

- **Vision:** There is unobstructed view due to smaller handpiece head and cutting action may be seen directly below the microscope.
- **Superior Control:** As ultrasonic tips are smaller than the tiniest bur available, they offer more control. As a result dentin can be removed precisely while working with ultrasonic tips.
- **Cavitation:** The shock waves of cavitation destroy remains of pulp tissue and calcific deposits. As a result, the access cavities appear cleaner when prepared with ultrasonic instrument.

V. CORONAL & MIDDLE THIRD OF ROOT CANAL

1. **Removal of Intra-Canal Obstructions:** Clinicians are challenged by endodontically treated teeth that have obstruction such as separated instruments, silver points or posts, and hard impenetrable pastes in their root canals.

   If failure of endodontic treatment occurs, non-surgical re-treatment should be performed to remove these obstructions.

   The intracanal obstructions the US tips can remove are as follows:

2. **Removal of broken or separated instruments:** For instrument removal Ruddle proposed a technique of preparing a circumferential “staging platform” at the coronal aspect of the broken file using altered Gates Glidden of sizes 3 or 4. Later, to aid loosening the file, an ultrasonic tip should be placed between the bare end of the broken file & inner curvature of root canal.

3. **Removal of Root Canal Posts:** Clinicians are provided with US as a useful adjunct, facilitating post removal with minimal loss of tooth structure and root damage.
   In retreating cast post and cores, the core portion is reduced and sculpted until it becomes an extension of the post itself. The core build up around the post should be removed before applying the vibratory tip. This is done using bulk removal tips, BUC 1 and CPR

2D. They are sharp and sturdy tips that are operated at moderate and maximum intensity of the ultrasonic unit. [20] Later, the troughing tips, CPR 3D, 4D, 5D are used to create a sufficiently deep trough around posts. The ultrasound energy transfers to the post and breaks down the surrounding cement until the post loosens and is easily removed as it spin out of the preparation.

The most efficient method for removing fiber posts appears to be ultrasonic vibration, which disrupts the composite structure around it. In order to clean the remaining fibers and dentin, the removal procedure is carried out in a dry field utilizing a continuous stream of air with direct visibility of the ultrasonic tip and the coronal area of the post. The whole composite material that was applied during the luting process must be entirely removed. Grey streaks left behind by the ultrasonic tip are a definite sign that resin composite or resin composite cement is still present. Because composite resin is viscoelastic and absorbs energy, it is necessary to consume fiber posts to reduce vibrations.

4. **Gutta Percha Removal:** A passively fitting ultrasonic tip is chosen and activated to remove gutta percha and paste from the straight part of the canal. As tip travels down into the canal, the heat from friction will soften the guttapercha and cause it to be displaced coronally.

5. **Increased Action of Irrigating Solutions:** Ultrasonic is a useful adjunct in cleaning difficult anatomical features. Irrigation in conjunction with US vibration, which generates a continuous movement of the irrigant, is directly associated with the effective cleaning of root canal space.

   Two types of ultrasonic irrigation have been described in the literature:

   - Passive Ultrasonic Irrigation (PUI) / Ultrasonically Activated Irrigation (UAI), operates without simultaneous instrumentation. It has been described as ultrasonic activation of an irrigant after instrumentation has been completed. It consists of the use of a size 15 or 20 endodontic- type file or wire attached to an ultrasonic handpiece from which ultrasonic energy is supplied to the irrigant.
   - Continuous ultrasonic irrigation (CUI) is the simultaneous use of irrigation and ultrasonic instruments. Through a water port built into the ultrasonic tip, continuous ultrasonic irrigation is accomplished by simultaneously and continuously supplying irrigant during ultrasonic activation.

6. **Placement of MTA:** An ultrasonic vibration along with endodontic condenser helps in improving the flow, compaction, and settling of MTA.

   After placement of MTA into the canal, an ultrasonic tips is activated followed by down packing the MTA using 1to 2 mm strokes . MTA may be sculpted to fit the root canal walls due to the direct ultrasonic energy's vibration and wavelike action.

   The indirect ultrasonic activation of MTA suggested by Ruddle consists of placing the working end of an ultrasonic tips on the shaft of the file that is in contact with MTA.

The ultrasonic vibrations transferred to the file helps MTA to migrate and adapt to the root canal walls as well as control its movement across the canal length.

VI. APICAL-THIRD CANAL OF ROOT CANAL

Surgical Endodontics: The most recent surgical endodontic procedure is a retrograde preparation utilizing ultrasonic tips specifically designed it. Also minimal bevels (3 to 10^{o}) are given while root end resection. These changes have led to greater healing rates and more consistent healing than when conventional treatments utilizing bur were applied. When compared to traditional bur technique, ultrasonic retro preparation technique offer many advantages, such as:

- Allow more conservative preparation,
- Long axis of tooth is followed during retro-preparations,
- Minimal root-end bevel required
- Increased depth of retro-preparation with parallel walls aids in better retention.

During retrograde root end preparation ultrasonic tips are placed parallel to the canal and then activated through the ultrasonic unit. It vibrates in the range of 30-40 KHz, which results in retro-preparation with parallel walls, having depth of 2.5 to 3 mm. Continuous irrigation cools the surface and maximizes cutting and debridement. The cavity should be started with diamond coated retro tip, using its better cutting ability to provide the main cavity. Diamond coated retro tip aids in removal of root canal obstruction material, followed by smooth retro tip to smooth and clean cavity walls.

VII. CONCLUSION

In conclusion, the application of ultrasonic in endodontics has significantly advanced the field, offering numerous benefits. From efficiently cleaning the root canal system and clearing the obstruction during various phases of root canal treatment, ultrasonic instruments have proven their worth by improving the treatment outcomes. As we delve deeper into the world of endodontics, apparently ultrasonic technology seems to adapt a pivotal role in shaping the fate of this vital speciality in dentistry.

REFRENCES

[1] Ansar A, Shetty HS. Uses of ultrasonics in endodontics, a review. Int J Adv Res. 2018 ; 6(12): 1448-1459.
[2] Iqbal MK. Nonsurgical ultrasonic endodontic instruments. Dent Clin North Am 2004: 48: 19–34.
[3] Richman RJ .The use of ultrasonics in root canal therapy and root resection. Med Dent J. 1957; 12:12-18.
[4] Martin H. Ultrasonic disinfection of the root canal. Oral Surg Oral Med Oral pathol. 1976; 42:92-99.
[5] Martin H, Cunningham* W. Endosonics–the ultrasonic synergistic system of endodontics. Dental Traumatology. 1985;1(6):201-6.
[6] Carr G. Advanced techniques and visual enhancement for endodontic surgery. Endod Rep 1992: 7: 6–9.
[7] Samyuktha S, Pradeep S. Ultrasonics in modern endodontic practice – a review. Int J Cur Adv Res. 2017; 6(4):1-6.
[8] Yousefimanesh H, Robati M, Kadkhodazadeh M, Molla R. A comparison of magnetostrictive and piezoelectric ultrasonic scaling devices: an in vitro study. J Periodontal Implant Sci. 2012;42 (6):243-7..
[9] Laird W, Walmsley AD. Ultrasound in dentistry. Part 1—biophysical interactions. J Dent 1991: 19: 14–17.
[10] Ruddle CJ. Nonsurgical retreatment. In: Cohen S, Burns RC, eds. Pathways of the pulp, 8th ed. St Louis: Mosby; 2002:875–930.

[11] Walmsley AD, Lea SC, Felver B, King DC, Price GJ. Mapping cavitation activity around dental ultrasonic tips. Clin Oral Investig 2013: 17: 1227–1234.
[12] Lea SC, Landini G, Walmsley AD. Thermal imaging of ultrasonic scaler tips during tooth instrumentation. J Clin Periodontol 2004: 31: 370–375.
[13] Davis S, Gluskin AH, Livingood PM, Chambers DW. Analysis of temperature rise and the use of coolants in the dissipation of ultrasonic heat buildup during post removal. J Endod 2010: 36: 1892–1896.
[14] Ruddle CJ. Micro-endodontic nonsurgical retreatment. Dent Clin North Am. 1997 Jul;41(3):429-54.
[15] Stojicic S, Zivkovic S, Qian W, Zhang H, Haapasalo M. Tissue dissolution by sodium hypochlorite: effect of concentration, temperature, agitation, and surfactant. J Endod. 2010 Sep;36(9):1558-62.
[16] Trenter SC, Walmsley AD. Ultrasonic dental scaler: associated hazards. J Clin Periodontol. 2003 Feb;30(2):95-101.
[17] Yamada H, Ishihama K, Yasuda K, Hasumi-Nakayama Y, Shimoji S, Furusawa K. Aerial dispersal of blood-contaminated aerosols during dental procedures. Quintessence Int. 2011 May;42(5):399-405.
[18] Harrel SK, Barnes JB, Rivera-Hidalgo F. Reduction of aerosols produced by ultrasonic scalers. J Periodontol. 1996 Jan;67(1):28-32. doi: 10.1902/jop.1996.67.1.28.
[19] Glassman G, Kratchman S. The Expanded Role of Ultrasonics in Endodontic Treatment. Oral Health. 2010;100(11):38.
[20] Gomes AP, Kubo CH, Santos RA, Santos DR, Padilha RQ. The influence of ultrasound on the retention of cast posts cemented with different agents. Int Endod J. 2001 Mar;34(2):93-9.
[21] Griffiths BM, Stock CJ. The efficiency of irrigants in removing root canal debris when used with ultrasonic preparation technique. Int Endod J. 1986 Nov;19(6):277-84.
[22] Setzer FC, Shah SB, Kohli MR, Karabucak B, Kim S. Outcome of endodontic surgery: a meta-analysis of the literature--part 1: Comparison of traditional root-end surgery and endodontic microsurgery. J Endod. 2010 Nov;36(11):1757-65.
[23] Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: a review of the literature. J Endod. 2007 Feb;33(2):81-95.
[24] Sáinz-Pardo M, Estevez R, Pablo ÓV, Rossi-Fedele G, Cisneros R. Root canal penetration of a sodium hypochlorite mixture using sonic or ultrasonic activation. Braz Dent J. 2014 Nov-Dec;25(6):489-93.
[25] Clifford J, Ruddle. Non-surgical endodontic treatment. Advanced endodontics. J Calif Dent Assoc. 2004; 1-14.
[26] Clark D. The operating microscope and ultrasonics; a perfect marriage. Dent Today. 2004 Jun;23(6):74-6, 78-81.
[27] Buchanan LS. Innovations in endodontic instruments and techniques: how they simplify treatment. Dent Today. 2002 Dec;21(12):52-4, 56-61.
[28] Basturk FB, Nekoofar MH, Gunday M, Dummer PMH. X-ray diffraction analysis of MTA mixed and placed with various techniques. Clin Oral Investig. 2018 May;22(4):1675-1680.
[29] Ruddle CJ. Nonsurgical endodontic retreatment. J Calif Dent Assoc. 2004 Jun;32(6):474-84.
[30] Salim S, Feroze Raheem D, Kumar GA, Ch T, Mustafa M, Vajpayee A. Ultrasonic in endodontics. Saudi J Oral Dent Res. 2019;4(6):421-7.
[31] Kasam S, Mariswamy AB. Efficacy of Different Methods for Removing Root Canal Filling Material in Retreatment - An In-vitro Study. J Clin Diagn Res. 2016 Jun;10(6):ZC06-10.

