**ULTRASONICS IN ENDODONTICS**

**Author Details:**

Dr. Prajakta C. Ambulkar

Assistant Professor

Department of Conservative Dentistry and Endodontics

VSPM’s Dental College & Research Centre, Nagpur

**Content**

1. Introduction
2. Physics Behind Ultrasonics
3. Ultrasonic Devices
4. Application of Ultrasonic Tips

-Pulp Chamber:

* Access refinement
* Finding calcified canals
* Removal of attached pulp stones

-Coronal and Middle Third of Root Canal:

* Removal of intra-canal obstructions,
* Increased action of irrigating solutions,
* Placement of MTA

-Apical Third of Root Canal:

* Surgical Endodontics
1. Conclusion
2. References

**INTRODUCTION:**

Preservation of natural teeth is of paramount importance to rehabilitate the dentition to its natural form and function. During the past few decades endodontic treatment has been benefited from the development of novel methods and equipment, among them the use of ultrasonic sources has procure such importance that leads us to consider it as one of most intriguing advances in contemporary endodontics

Ultrasonics are one of the most used non-invasive technological facilities in contemporary dentistry, which is defined as waves with frequencies of at least 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 use of ultrasonic devices in conjugation with surgical operating microscope’s magnification and illumination.

The first time an ultrasonic device had been used in dentistry to prepare cavities with an 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.

**PHYSICS BEHIND ULTRASONICS**

In dentistry, there are two principal types of ultrasonic energy 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 certain materials expand and contract when exposed in an alternating magnetic field. The operating range of magnetostrictive units is from 18kHz to 45kHz. The **Piezoelectric Generator** (ie, P5 Newtron, Acteon Merignac Cedex, France), on the other hand, uses the piezoelectric effect to transform alternating current electrical energy directly into mechanical energy. The operating range of piezoelectric units is from 15 kHz to 50 kHz. Piezoelectric generators are more efficient (95%) than magnetostrictive units 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.

Oscillations, heat, cavitational activity, acoustic microstreaming, and radiation are some of the **physical effects** of ultrasonic production. In general, endodontic treatments benefit from the significant physical effects such oscillations, cavitation, and acoustic microstreaming; yet, in some clinical situations, the development of heat and the emission of electromagnetic radiation 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 vibrating object. When a vibrating file is immersed in a fluid, the file is observed to generate a streaming fluid comprising two components: the Primary field consisting of rapidly moving eddies in which the fluid element oscillates about a mean position, and a superimposed secondary filed consisting a patterns of relatively slow, time independent flow.

Due to friction, when ultrasonic instruments come into contact with tooth structure or dental materials, heat is produced. It is advised to routinely cool the post with water or air since, in dry conditions, ultrasonic vibration of a metal post can significantly increase heat transfer to nearby dental tissues in as little as 20 seconds. The temperature of the irrigant in a root canal may rise by up to 10oC as a result of ultrasonic activation. It has been discovered that heating sodium hypochlorite considerably improves tissue dissolving.

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.

**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,
* Foot pedal
* Handpiece with ultrasonic tips

**Endodontic Ultrasonic Tips:**

There is a wide range of ultrasonic tips available for use in endodontics, periodontics, surgery, and general practice. The tips are made from a variety of metal alloys, including stainless steel and titanium alloys, and can be coated with an abrasive, such as diamond or zirconium nitride, to improve cutting efficiency. Many of the tips include a built-in water port, allowing debris to be washed away and cooling to occur if needed. Because of the diversity of tips available, there is a suitable tip design for almost every phase of endodontic therapy, from access to obturation, and each should be utilised in the suggested power setting range.

**APPLICATION OF ULTRASONIC TIPS:**

I. Pulp Chamber**:**

1. Access Cavity Refinement, Finding Calcified Canals and Removal of Attached Pulp Stones

Recently, a combination of ultrasonic access refinement tips and magnification has revolutionised the fundamental idea of access cavity preparation.An ultrasonic tip such as the BUC-1, CPR-2D, or BL-1 can be utilised for the gross removal of dentin in an access preparation because they have a length adequate for most access preparations, a strong tip that is less prone to fracture, and abrasive grit along half of their length.

Bigger tips with a restricted diamond-coated extension should be utilized during the initial phase of searching hidden canals, eliminating calcification, interferences, materials, 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:-

1. Vision - There is unobstructed view due to smaller handpiece head and cutting action may be seen directly under the microscope.

 2. Superior control - Because ultrasonic tips are smaller in size than the tiniest burs, dentin may be brushed off in smaller increments and with more control. The procedure exposes any missing or hidden canals or recesses containing necrotic pulp tissue without gutting the tooth structure. Brush off the dentine in small increments until the road map on the pulp chamber floor is entirely exposed. The term "uncovering the floor of the pulp chamber" is more suitable for pulp chambers that have receded due to calcification.

3. Cavitation - Cavitation is simply defined as bubble activity in a liquid capable of generating enough shock waves to destroy remains of necrotic pulp tissue and any calcific deposits. As a result, the access cavities prepared using ultrasonic instruments seem thoroughly washed out and clean.

**II. 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, hard impenetrable pastes in their root canals.

If endodontic treatment has failed, these obstructions need to be removed to perform non-surgical re-treatment.

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

1. Removal of separated instruments:

Ruddle proposed a technique for the removal of broken instruments using modified Gates Glidden drills (size 3 or 4) to prepare a circumferential “staging platform” at the coronal aspect of the obstruction. Later the ultrasonic tip is placed between the exposed end of the file and inner surface of the curvature of the root canal wall, to aid loosening the file.

1. Removal of root canal posts:

US has provided clinicians with a useful adjunct to facilitate 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.

c. Removal of Gutta Percha:

In order to remove Gutta Percha and paste an ultrasonic tip is chosen that can passively fit into the straight part of a root canal and is activated. As the tip goes deeper into the canal, the heat from friction will soften the guttapercha and cause it to be displaced coronally.

2. 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.

3. Placement of MTA

MTA placement that included ultrasonic vibration and an endodontic condenser improved the material's flow, settling, and compaction.

The recommended method of putting MTA is selecting a condenser tip, picking up and positioning the MTA with the ultrasonic tip, activating the tip, and then gradually pushing the MTA material down using a 1- to 2-mm vertical packing motion. The cement may be moved and sculpted to fit the canal walls due to the direct ultrasonic energy's vibration and wavelike action.

 Ruddle suggested the indirect ultrasonic activation of MTA in which the working end of an ultrasonic device is placed on the shaft of the file whose vibratory energy stimulates MTA to migrate and adapt to the configurations of the canal laterally as well as controlling its movement.

**III. Apical-Third Canal of root canal**

1. Surgical Endodontics

The most recent surgical endodontic procedure is a retrograde preparation utilizing specifically designed ultrasonic retropreparation tips and a root-end resection with a minimal bevel. 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 have many advantages, such as they allow us to follow the longitudinal axis of the tooth with more conservative preparations, less need for beveling the root tip (reducing the number of dentinal tubules exposed on the root surface and minimising api­cal leakage), and the ability to prepare the canal farther in a coronal direction from the apex with parallel walls for better retention.

During retrograde root end preparation ultrasonic tips are placed in the long axis of the canal and then activated through the ultrasonic unit. It vibrates in the range of 30-40 KHz, and a root-end cavity is prepared with parallel walls 2.5 to 3 mm in depth. 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. This aids in removal of root canal obstruction material, followed by smooth retro tip to smooth and clean cavity walls.

**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 will play a pivotal role in shaping the future 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 non-surgical retreatment. Dent Clin North Am 1997;41:429 –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: 36: 1558–1562.
16. Trenter SC, Walmsley AD. Ultrasonic dental scaler: associated hazards. J Clin Periodontol 2003: 30: 95–101.
17. Yamada H, Ishihama K, Yasuda K, Hasumi-Nakayama Y, Shimoji S, Furusawa K. Aerial dispersal of bloodcontaminated aerosols during dental procedures. Quintessence Int 2011: 42: 399–405.
18. Harrel SK, Barnes JB. Reduction of aerosols produced by ultrasonic sealers. J Periodontol 1996: 67: 28–32.
19. Glassman G. The expanded role of ultrasonics in endodontic treatment. Oral Health 2010: 38–52.
20. Garg S, Goel M, Garg V, Gupta S. Recent Advancement in Root Canal Treatment: A Review. J Dent herald. 2016; 1(3): 12-18.
21. 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;34(2):93-9.
22. Griffiths BM, Stock CJR. The efficiency of irrigants in removing root canal debris when used with an ultrasonic preparation technique. Int Endod J. 1986; 19(3):277- 84.
23. 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: 36: 1757–1765.
24. Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: a review of the literature. J Endod. 2007; 33(2):81-95.
25. 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. Brazilian dental journal. 2014;25(6):489-93.
26. Clifford J, Ruddle. Non-surgical endodontic treatment. Advanced endodontics. J Calif Dent Assoc. 2004; 1-14.
27. Clark D. The operating microscope and ultrasonics: a perfect marriage. Dent Today 2004;23:74 – 81.
28. Buchanan LS. Innovations in endodontics instruments and techniques: How they simplify treatment. Dent Today 2002; 21:52– 61.
29. Basturk, F.B., Nekoofar, M.H., Gunday, M. *et al.* X-ray diffraction analysis of MTA mixed and placed with various techniques. *Clin Oral Invest* **22,**1675–1680 (2018).
30. Ruddle CJ. Nonsurgical endodontic retreatment. J Calif Dent Assoc 2004;32: 474 – 84.
31. 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.
32. 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;10(6):ZC06-10