How to Cite:
Gupta, A., Pareek, A., & Kapila, H. (2021). Ultrasonics in endodontics: A review. *International Journal of Health Sciences*, *5*(S1), 264–277. https://doi.org/10.53730/ijhs.v5nS1.5602

Ultrasonics in endodontics: A review

Artika Gupta
Senior Lecturer, Department of Conservative Dentistry & Endodontics, Desh Bhagat Dental College & Hospital, Mandi Gobindgarh

Ankur Pareek
PG student (1st year), Department of Conservative Dentistry & Endodontics, Desh Bhagat Dental College & Hospital, Mandi Gobindgarh
Email: raghav.ankur.pareek@gmail.com

Himani Kapila
Lecturer, Department of Conservative Dentistry & Endodontics, Desh Bhagat Dental College & Hospital, Mandi Gobindgarh

***Abstract*---**The piezoelectric ultrasonic device has the potential to become routinely incorporated into almost every component of endodontic treatment, re-treatment, and apical microsurgery. It is already indispensable as a precise tool with which the most challenging clinical situations, such as finding hidden root canals and removing root canal obstructions, can be done with relative ease, predictability, and conservancy. It can be seen by the few innovative studies which take advantage of the energizing ability of ultrasound that a thorough understanding of how ultrasonic tips and files behave with irrigants and tooth structure can produce methods and conditions to truly enhance the beneficial effect of such energy in the confined root canal space.

***Keywords*---**ultrasonics, endodontics, root canal.

Introduction

Ultrasonics in endodontics has enhanced the quality of treatment and represents an important adjunct in the treatment of difficult cases. 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 intracanal materials and obstructions and endodontic surgery. [1] The term “ENDOSONIC” was coined by Martin and Cunningham and was defined as the ultrasonic synergistic system of instrumentation and canal disinfection.[2,3,,4] It uses waves with frequencies of at least 25 kHz and is one of the most used non-

Corresponding author: *Pareek, A.; Email: raghav.ankur.pareek@gmail.com*
Manuscript submitted: 18 April 2021, Manuscript revised: 9 June 2021, Accepted for publication: 5 July 2021

invasive technology facilities in modern dentistry, particularly in endodontics [5] The ultrasonic techniques are used in prophylactic procedures, scaling and root planing in periodontology, tissue regeneration, piezo and oral surgery techniques. [1,2,6]

Types of ultrasonic units

There are two fundamental transducer designs used to power ultrasonic applications today:

- Magnetostrictive
- Piezoelectric.

The first is magnetostriction, which converts electromagnetic energy into mechanical energy. A stack of magnetostrictive metal strips in a handpiece is subjected to a standing and alternating magnetic field, because of which vibrations are produced.[7] The second method is based on the piezoelectric principle, in which a crystal is used that changes dimension when an electrical charge is applied. Deformation of this crystal is converted into mechanical oscillation without producing heat.[7] In the last decade piezoelectric units have become the most common ultrasonic devices in dentistry. They have some advantages compared with earlier magnetostrictive units because they offer more cycles per second, 40 versus 24 kHz. The tips of these units work in a linear, back and- forth, "piston-like" motion, which is ideal for endodontics.[9]

Lea et al. demonstrated that the position of nodes and antinodes of an unconstrained and unloaded endosonic file activated by a 30-kHz piezon generator was along the file length. As a result, the file vibration displacement amplitude does not increase linearly with increasing generator power. This applies in particular when "troughing" for hidden canals or when removing posts and separated instruments. In addition, this motion is ideal in surgical endodontics when creating a preparation for a retrograde filling. A magnetostrictive unit, on the other hand, creates more of a figure eight (elliptical) motion, which is not ideal for either surgical or nonsurgical endodontic use.[9]

In endodontic surgery, for example, this characteristic does not allow a precise cut of a cavity. The magnetostrictive units also have the disadvantage that the stack generates heat, thus requiring adequate cooling. Once again, this overheating is not desirable in surgical endodontics.[10] The magnetostrictive tips are composed of a stack of metal strips or rod of ferromagnetic material capable of being magnetized resulting in an elliptical or figure eight motion of the working end. This type of motion allows the use of all sides (360°) of the working tip.[11]

Piezoelectric tips alternate electrical currents applied to reactive crystals horizontally, resulting in a linear motion. As a result, only the lateral (two) sides of the working tip are activated. Little heat is generated when using these tips, minimizing the amount of water necessary. [11] The very first ultrasonic devices were developed early in the 20th century when the piezoelectric effect was discovered by Jacques and Pierre Curie. These devices consisted of naturally occurring piezoelectric minerals such as quartz crystals attached by various means to surfaces to be vibrated. These early devices were inherently fragile due to the fragile nature of the piezoelectric materials used in their construction and rudimentary adhesive bonding technology. In the 1930's, as there was an effort to utilize ultrasonic energy more extensively, the piezoelectric technology then available fell short of the need for reliable, robust ultrasonic devices. It was at this time that magnetostrictive technology eclipsed piezoelectric technology as the "motor" for ultrasonic devices including early ultrasonic cleaning systems. Magnetostrictive devices of that era were unquestionably more reliable than their piezoelectric counterparts.[12]

All of that began to change, however, with the development of new piezoelectric ceramics for use in SONAR (Sound Navigation and Ranging) applications during World War II. New, stronger, man-made ceramics replaced naturally occurring "crystals" as the source of vibration. In addition, ways were found to pre-stress the new piezoelectric materials (much like in the architectural use of pre-stressed concrete) to prevent failure due to their limited tensile strength. The remaining "weak link", the attachment of composite piezoelectric drivers to suitable vessels for ultrasonic cleaning use, was overcome with the development of advanced adhesive bonding methods necessitated by the aircraft industry during the 1950's. This technology continues to advance to this day.[13,14]

The word piezo comes from the Greek "piezein" which means to push, press, or squeeze. The principle for this ultrasonic technology dates back to 1880 when Jacques and Pierre Curie discovered an unusual characteristic of certain crystalline minerals; when subjected to a mechanical force, the crystals became electrically polarized. The opposite also proved to be true; if one of these voltage-generating crystals was exposed to an electric field it lengthened or shortened according to the polarity of the field, and in proportion to the strength of the field. When this principle is applied to ultrasonics, electrical current produces a wave in the crystals (i.e., series of ceramic disc or quartz plates inside the handpiece of the ultrasonic), which are transferred to the ultrasonic tip. This creates a linear tip motion which is ideal for many endodontic procedures.[15,16]

The handpiece in this process does not generate excessive heat, so any water required is simply to cool the tooth and tip. Accordingly, if water is required at all, (depending on the procedure), a very light aerosol is all that is required, enhancing vision and patient comfort.[16]

Fig-Series of Ceramic Disc or Quartz Plates Inside the Handpiece of The Ultrasonic

The most important feature of any ultrasonic unit is how its "drives" the tip and adapts to a variety of tip designs and intended functions, as well as the often-unpredictable clinical conditions. "The mechanism of ultrasonics is very different than other instruments", such as a high-speed handpiece. As Dr. David Clark (Tacoma, WA) has noted, it is somewhat "counter-intuitive", that increasing hand pressure or power settings does not necessarily increase cutting or vibrating efficiency. In many cases, it decreases efficiency.[17]

There are two variables of ultrasonic tip vibration; the frequency (number of vibrations per second) and power or intensity (usually operator controlled). The power function does not increase the frequency, it simply increases the back and forth range or amplitude of the tip.[16] So, although there was a period when magnetostrictive transducers ruled the world of ultrasonic cleaning, the pendulum has now swung back toward piezoelectricity as the preferred ultrasonic source. There is abundant support for this switch in preference for piezoelectricity.[12] The following brief description of both magnetostrictive and piezoelectric technology as it is utilized in ultrasonic transducers is provided to assist the reader in an understanding of the discussions that follow.[12]

The principles of ultrasonic cleaning

Ultrasonic Cavitation

Cavitation refers to the oscillatory motions of gas filled bubbles in an acoustic field, bubbles that are powered by energy from the ultrasonic field[18]. The microscopic bubbles are formed and then collapse and explode, resulting in localized areas of pressure and heat production[19]. This transient type of cavitational activity has been shown to occur around the tips of ultrasonic scalers[20].

The formation of cavities and the implosion phenomenon

Formation of microscopic bubbles of gas is the start of cavitation (i.e. the formation of gaseous cavities in the liquid). During the second phase of ultrasonic compression, the enormous pressure exerted on the newly expanded bubble compresses the same, hugely increasing the temperature of the gas contained in it until the bubble collapses on itself, imploding with a consequent vast release of impact energy . The impact energy caused by implosion of the gas bubble hits the surface of the object to be cleaned, interacting both physically and chemically[21,22].

In physical terms a "**micro brushing**" effect is achieved at very high frequency (around 50,000 times per second for a machine operating at 50 kHz) with, in chemical terms, the cleansing effect of the chemical substance present in the detergent of the ultrasonic bath. [22]

Sweep system: technology and benefits

Other important parameters for achieving good levels of cavitation in a liquid are:

a) The frequency of the ultrasound's generator,

b) The power used,
c) The use of the Sweep System generator,
d) The type of transducer used. [22]

Ultrasonic Tips[23]:

A variety of ultrasonic tip designs are available, varying in complexities from simple curves to multi angled bends. These tips can be long and slender or short and sturdy; they also can be end cutting or side cutting and made of different materials such as stainless steel or titanium alloys. Stainless steel tips may be coated with zirconium nitride or diamond grit to increase efficiency and durability.

There are two types of ultra-sonic tips in the market,

1. Nonsurgical tips
2. Surgical tips.

Non-Surgical Tips[23]:

1) Long and Slender
   Short and Sturdy
2) End cutting
   Side cutting
3) Stainless steel coated with
   Zirconium nitride
   Diamond grit
   Titanium alloys
4) Function in dry environment
   Function in wet environment (Cooling / washing/ both system) [23]

Two types of non-surgical tips are available commercially:

a) CPR Tips[23]
b) BUC Tips[23]

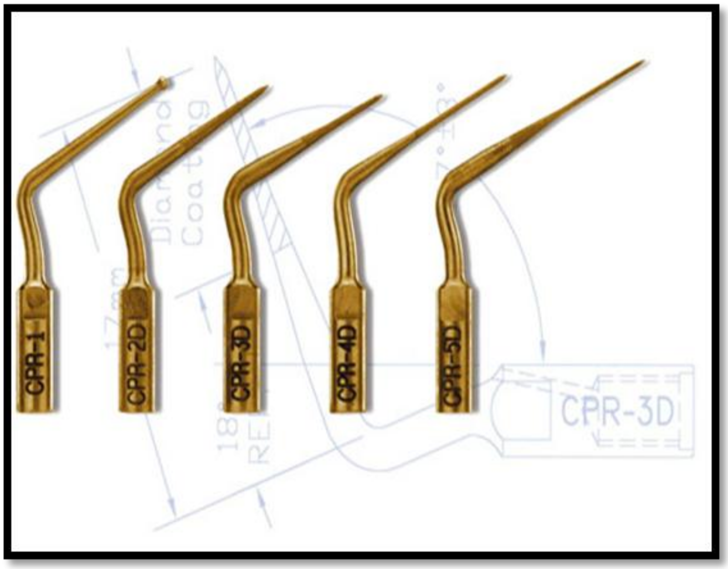


Fig- Retreatment Tips – CPR 1-5, TIT SERIES

Fig- ACCESS REFINEMENT TIPS – BUC TIPS

Surgical Tips[23]:

- CT Tips
- UT Tips[23]
- SJ Tips
- KIS Tips[23]

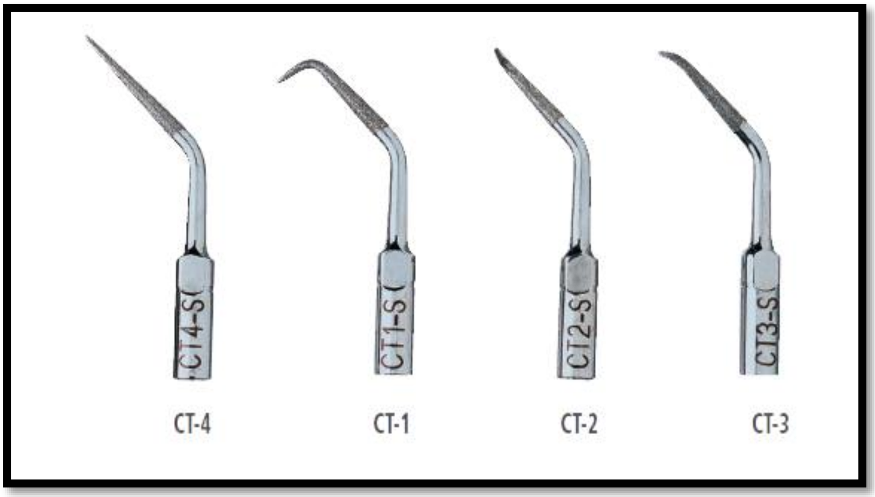


Fig- CT TIPS

Fig- UT TIPS

Fig- SJ TIPS

Fig- KIS TIPS

Clinical applications in endodontics

1) Non-Surgical Applications[24]

- Access refinement, finding calcified canals and removal of attached pulp stones.
- Removal of intracanal obstructions. (E.g. separated instruments, root canal posts, silver points and fractured metallic posts)
- Increased action of irrigating solutions. [24]
- Ultrasonic condensation of gutta percha.
- Placement of Mineral Trioxide Aggregate (MTA).
- Root canal preparation. [24]

2) Surgical Applications[24]

- Root end cavity preparation & refinement
- Placement of root end obturation material[24]

Although ultrasonics is used in dentistry for therapeutic and diagnostic applications as well as for cleaning of instruments before sterilization, currently its main use is for scaling and root planning of teeth and in root canal therapy. [24]

Passive Ultrasonic Irrigation

Passive ultrasonic irrigation was first described by Weller et al. (1980). The term "passive" does not adequately describe the process, as it is in fact active; however, when it was first introduced the term "passive„ related to " the noncutting„ action of the ultrasonically activated file. [25]

Acoustic Streaming

Acoustic streaming is the rapid movement of fluid in a circular or vortex-like motion around a vibrating file (Walmsley 1987). The acoustic streaming that occurs in the root canal during ultrasonic irrigation has been described as acoustic microstreaming. [25]

Cavitation and cavitational microstreaming

Cavitation in the fluid mechanical context can be described as the impulsive formation of cavities in a liquid through tensile forces induced by high-speed flows or flow gradients. These bubbles expand and then rapidly collapse producing a focus of energy leading to intense sound and damage, e.g. pitting of ship propellers and pumps. [25]

Recent Advances

Sine Ultrasonic Instruments

The SINE tips feature a patented and innovative double composite diamond coating, specially designed working ends, and a water delivery system. Synergistically, these combined features promote precision, efficiency, durability and safety[26]

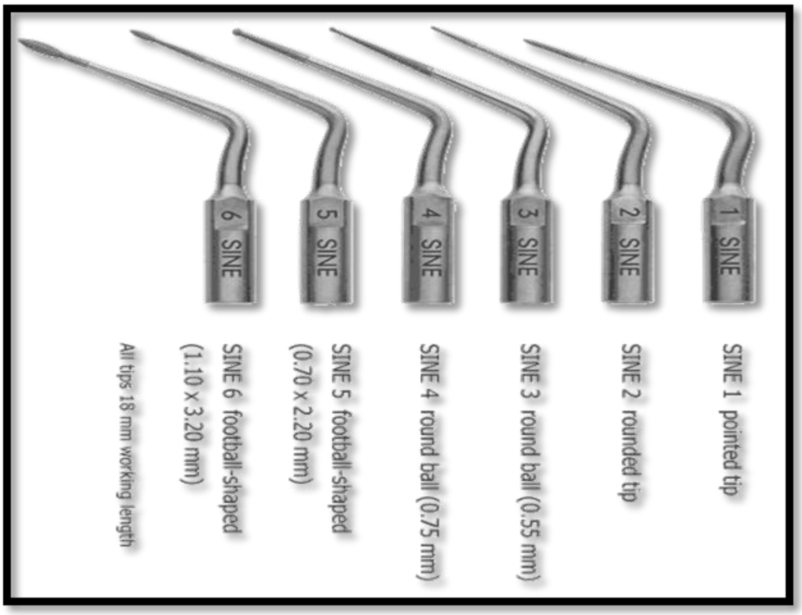


Fig**-** Proultra Sine Access Refinement Tip

SL (Surface Lesion) Ultrasonic Tips

Spartan's new Surface Lesion SL Tips have been designed to accomplish restorative preventative procedures while conserving 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.[27]

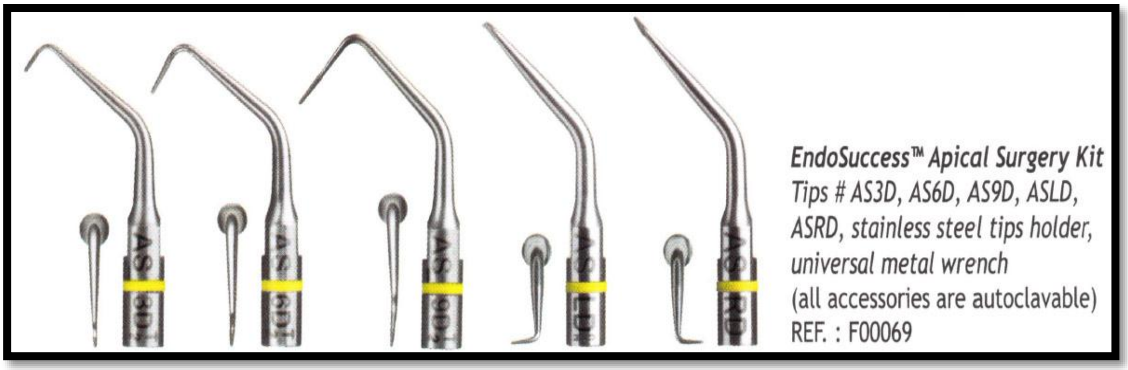
Fig- Spartan's Surface Lesion SL Tips

Endo Success Retreatment Ultrasonic Kit

The Endo Success Retreatment kit addresses the problems most commonly met during endodontic retreatment procedures. The use of the patented Titanium-Niobium alloy is a major innovation giving optimal ultrasound use in the most delicate of circumstances[28]

Endo success apical surgery ultrasonic kit

This ultrasonic tips kit is the perfect solutions for the problems most encountered during apical surgery. Delivered with AS3D, AS6D, AS9D, ASLD, ASRD tips, on an autoclavable metal support.[29]



Pro Ultra Piezoflow Ultrasonic Irrigation Needle

ProUltra PiezoFlow Ultrasonic Irrigation Needles are for use in non-surgical root canal irrigation by application of ultrasonic vibration. The PiezoFlow irrigation needles are used in conjunction with a piezoelectric ultrasonic energy-generating unit to provide the energy for tip oscillation.[30]

Fig-ProUltra PiezoFlow Ultrasonic Irrigation Needle

Conclusion

The piezoelectric ultrasonic device has the potential to become routinely incorporated into almost every component of endodontic treatment, re-treatment, and apical microsurgery. It is already indispensable as a precise tool with which the most challenging clinical situations, such as finding hidden root canals and removing root canal obstructions, can be done with relative ease, predictability, and conservancy. It can be seen by the few innovative studies which take advantage of the energizing ability of ultrasound that a thorough understanding of how ultrasonic tips and files behave with irrigants and tooth structure can produce methods and conditions to truly enhance the beneficial effect of such energy in the confined root canal space.

References

1. Gianluco Plotilo, Corneles H. Pameiger, Nicola Maria Grande And Francesco Somma. Ultrasonics in Endodontics: A Review of The Literature. J Endod; Feb2007; Vol.33: No.2
2. Gianfranco De Paolis, Valentina Vincenti, Matteo Prencipe, Valerio Milana, Gianluca Plotino. Ultrasonics in endodontic surgery: a review of the literature; Annali di Stomatologia 2010; I (2): 6-10
3. Sandra Mozo, Carmen Llena, Leopoldo Forner Review of ultrasonic irrigation in endodontics: increasing action of irrigating solution. Med Oral Patol Oral Cir Bucal. 2012 May 1;17 (3): e512-6.
4. Martin H, Cunningham W. Endosonic endodontics: the ultrasonic synergistic system. Int Dent J. 1984; 34:198-203.
5. Niculescu Adrian Gabriel, Totorean Alin-Florin, Vînătu Vlad-Florin and Mnerie Dumitru. APPLICATIONS OF ULTRASONICS IN ENDODONTICS, nonconventional technologies review, Romania, September 2012
6. Luc van der Sluis, Ultrasound in endodontics, ENDO 2007;1(1):29- 36.
7. Stock CJR. Current status of the use of ultrasound in endodontics. Int Dent J 1991; 41:175– 82

8. Gianluco Plotilo, Corneles H. Pameiger, Nicola Maria Grande And Francesco Somma. Ultrasonics in Endodontics: A Review of The Literature. J Endod; Feb2007; Vol.33: No.2
9. Lea SC, Walmsley AD, Lumley PJ, Landini G. A new insight into the oscillation characteristics of endosonic files used in dentistry. Phys Med Biol 2004; 49:2095–102
10. Stock CJR. Current status of the use of ultrasound in endodontics. Int Dent J. 1991; 41:175-182.
11. Access, Special Supplemental Issue May-June 1999 Ultrasonics
12. Blackstone-NEY Ultrasonics, Inc. Magnetostrictive Versus Piezoelectric Transducers for Power Ultrasonic Applications
13. Hendee, W. R., and Holmes, J. H. History of Ultrasound Imaging, in Fullerton, G. D., and Zagzebski, J. A. (eds.), Medical Physics of CT and Ultrasound. New York: American Institute of Physics, 1980
14. Hendee, W. R. Cross sectional medical imaging: A history. Radiographics 1989; 9:1155–1180.
15. Graff KF. Ultrasonics: Historical aspects. Presented at the IEEE Symposium on Sonics and Ultrasonics, Phoenix, October 26–28, 1977.
16. Gary Glassman, DDS, FRCD(C), Sam Kratchman, DMD The Expanded Role of Ultrasonics in Endodontic Treatment oral health November 2010 38-52
17. Clark, DJ The Operating Microscope and Ultrasonics, A Perfect Marriage Dentistry Today June 2004.
18. Walmsley AD. Ultrasound and root canal treatment: the need for scientific evaluation. Int Endod J 1987: 20: 105–111.
19. Walmsley AD, Lea SC, Felver B, King DC, Price GJ. Mapping cavitation activity around dental ultrasonic tips. Clin Oral Investig 2013: 17:1227–1234.
20. Lea SC, Walmsley AD. Mechano-physical and biophysical properties of power-driven scalers: driving the future of powered instrument design and evaluation. Periodontol 2000 2009: 51: 63–78.
21. Walmsley AD, Laird WRE, Williams AR. Displacement amplitude as a measure of the acoustic output of ultrasonic scalers. Dent Mater 1986: 2: 97–100.
22. Ahmad M, Pitt Ford TR, Crum LA, Walton AJ. Ultrasonic debridement of root canals: acoustic cavitation and its relevance. J Endod 1988: 14: 486–493.
23. Ultrasonic Tips book Sybron Endo
24. Mian K. Iqbal, BDS, DMD, MS Nonsurgical ultrasonic endodontic instruments. Dent Clin N Am 48 (2004) 19–34
25. Gianfranco De Paolis, Valentina Vincenti, Matteo Prencipe, Valerio Milana, Gianluca Plotino. Ultrasonics in endodontic surgery: a review of the literature; Annali di Stomatologia 2010; I (2): 6-10