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Dentistry

A SYSTEMATIC REVIEW ON ULTRASONIC IRRIGATION OF ROOT CANAL SYSTEM

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KEYWORDS :

INTRODUCTION-

Ultrasound is sound energy with a frequency above the range of human hearing, which is 20 kHz. The range of frequencies employed in the original ultrasonic units was between 25-40 kHz.[1]During the past few decades endodontic treatment has benefited from the development of new techniques andequipment, which have improved outcome and predictability. Important attribute such as the ultrasonics (US) have found important applications in a number of dental procedures and it have been prominently used in endodontics. There are two basic methods of producing ultrasound.[3,4]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, as a result of which vibrations are produced. 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.[1]Use of ultrasonic instruments have revolutionized the art of endodontic treatment. These instruments have multiple uses and have become an integral part of endodontic armamentarium. However the use of ultrasonic instruments requires specialized knowledge and development of certain skills that required training before use.Hence it becomes a need for all endodontists to know the mechanisms that operate behind these advanced tools. This dissertation is an attempt to highlight the basic concepts of ultrasonics and its various applications in endodontic practice.History of ultrasonics in dentistry-Ultrasonic devices were used in industry to remove unwanted materials and debris for many years. Use of an ultrasonic instrumentation was first introduced to dentistry for cavity preparations using an abrasive slurry.[2]However, a different application was introduced in 1955, when Zinner in 1955 reported the use of an ultrasonic instrument to remove deposits from the tooth surface. This was later improved by Johnson and Wilson in to the ultrasonic scaler which later became an established tool in the removal of dental calculus and plaque.[2]The concept of ultrasoncis in endodontics therapy was suggested by Richman in 1957, who reported the use of utrasonics in canal preparation and apical resection by connecting a barbed broch to ultrasonic delivery system.[2]Other applications in endodontics were not reported for more than 20 years but vibrations at ultrasonic levels (20-30 KHz) were used in medicine and dentistry for cleaning instruments during this period.Then, it was in 1976, Martin and Cunningham and their group in the Washington, D.C./Bithesda Naval Hospital Area stated to report studies on many aspects of ultrasonic treatment. Martin created a commercial system harnessing the properties of ultrasonic energy for the preparation and cleaning of the root canal in 1976 and termed the technique endodontics.Physics behind ultrasonics[3,8]There are 2 basic methods of producing ultrasound.Magnetostriction.,Piezo electric.

MAGNETOSTRICTION:

If a piece of iron is placed in a magnetic field, it will reduce in overall size by a slight amount this effect is known as magnetostriction. If the magnetic field is made to alternate, the piece of iron will vibrate at a corresponding rate.**Piezoelectric**:A crystal is used which changes dimensions when an electrical charge is applied. This crystal deformation is converted to mechanical oscillation with no production of heat.[1]Methods of action Martin and Cunningham – have coined the term Endosonics – Refers to endodontic treatment by Supersonic, Sonic or Subsonic systems. They also stated that "use of this equipment creates or synergistic system whereby canal preparation and cleaning, irrigation and disinfection and canal packing and filling are all accomplished with the same group of devices.[5,6]cavitation :Ultrasonic cleaning was described initially, as Implosion or Cavitation.**Cavitation :** Occurs when the ultrasonic file vibrates in a liquid to produce alternating compressions and rarefactions of pressure..A negative pressure develops within the exposed cells of the intracanal materials (pulp tissue, bacteria, debris, metabolites substrates etc).This causes an implosion or inward explosion, that breaks these cell apart inwardly and leads to their destruction. Because an irrigation or aspiration system is employed in an endodontic equipment for ultrasonic, the broken cell parts are washed out and then removed from the canal system.[5,6]Acoustic microstreaming **:**Ahmad and her group from Guy's Hospital published papers that offered another mechanism for ultrasonic cleaning i.e. acoustic streaming.[10]They stated that (a) Power setting used to energige the endodontic unit was too low to produce cavitation. (b) Width of the canal space was to small to allow for this condition. So they suggested this principle of acoustic streaming.Process by which the vibrating fil generates a stream of liquid to produce Eddies and Flows of oscillation. The dimension of these eddies and flows around the file are consistent and reproducible.[11]Acoustic streaming is produced around an object oscillating in the liquid. Characterized by production of large shear forces that are capable of dislodging or dissociating lumps of material.[10,11]

Start-X:[2]The Start-X tips from Dentsply have the following characteristics –**Micro Milled active part:**Micro Milled active part of Start- X tips minimizes the risk of potential diamond grit loss in the patient's mouth.,**Water Port:-**Associated water port, cools down the insert and avoids overheating of the treated tooth. This is particularly important when removing metal posts which usually require high energy.The intermittent use of irrigation enables the clinician to alternate between dry precision work and debris evacuation.**Excellent resistance to fracture:**The Start-X tips from Dentsply have Excellent fracture resistance.

Fig: Start-X ultrasonic tips

One Tip-One Clinical Indication:Start-X#1 : Access cavity wall refinement.,Start-X#2 : MB2 canal scouter.,Start-X#3 : Canal opening scouter,Start-X#4 : Metal post removal,Start-X #5 : Reveals the original pulp chamber floor anatomy.

A review on Ultrasonic irrigation of root canal sysytem

Removal of the remains of vital and necrotic pulp tissue, microorganisms and microbial toxins from the root canal system is essential for successful endodontic treatment.[40]Irrigating solutions act mainly as lubricant and cleaning agent during biomechanical treatment, removing micro-organisms, products associated to tissue degeneration and organic and inorganic remains, guaranteeing elimination of contaminated dentin and permeability of the canal throughout its length. Effective action is achieved by ensuring that irrigants come into direct contact with all canal walls, particularly in the more apical portion.[41]At present, no single irrigant combines all the ideal characteristics, even when they are used with a lower pH, increased temperature or added surfactants to increase their wetting efficacy. No single irrigant has demonstrated an ability to dissolve organic pulp material and demineralise the calcified organic portion of canal walls.In practice, current endodontic treatment uses two irrigants, sodium hypochlorite (NaOCl), alone or in combination with ethy lenediaminetetraacetic acid (EDTA) or chlorhexidine.[41] Throughout the history of endodontics, ongoing efforts have been made to develop more effective systems to send and agitate irrigant solutions in the canal system. These systems can be divided into two broad categories of manual and mechanical agitation techniques. Machine-assisted procedures include using rotary brushes, simultaneous irrigation with rotary instrumentation of the canal, pressure alternation devices and sonic and ultrasonic systems. All of them appear to improve canal cleaning in comparison to conventional syringe and needle irrigation.The literature describes two types of ultrasonic irrigation. The first is the simultaneous combination of ultrasonic irrigation and instrumentation. The second type functions without simultaneous instrumentation and is known as passive ultrasonic irrigation (PUI).[42] The first one has been almost discarded in the clinical practice, because of the difficulty of controlling the cut of dentin and subsequently the final shape of the prepared canal, being present the possibility of making aberrant conformations. When ultrasonic-activated files are used, canal deviations, apical zips and radicular perfo-rations can be present, especially in curved canals. Is therefore not considered as an alternative to conventional manual instrumentation.The literature claims that it is more advantageous to apply ultrasound for passive irrigation. The term PUI was first used by Weller et al. in 1980 to describe irrigation without simultaneous instrumentation.[42] This non-cutting technology reduces the potential for creating aberrant shapes in the root canal system. During PUI, energy is transmitted from a file or smooth oscillating wire to the irrigant by means of ultrasonic waves that induce two physical phenomena: stream and cavitation of the irrigant solution. The acoustic stream can be defined as a rapid movement of the fluid in a circular or vortex shape around the vibrating file. Cavitation is defined as the creation of steam bubbles or the expansion, contraction and/or distortion of pre-existing bubbles in a liquid.During the last decade, numerous successful devices have appeared for agitating irrigant solutions, that provide various irrigant transfer mechanisms, elimination of soft tissue and also, depending on the treatment philosophy, elimination of the smear layer. In comparison to sonic irrigation, ultrasonic irrigation has proved to be more powerful and able to eliminate more debris, and so it is claimed that passive ultrasonic irrigation is significantly more efficient than sonic activation.

and therefore are less influenced by activated irrigation, while ultrasound irrigation is more effective in wide canals. Therefore, it seems important to apply the ultrasound instrument after completing preparation of the root canal. Also, free oscillation of the instrument will cause more ultrasonic effects in the irrigant solution than an oscilla-tion forced against canal walls. The use of a smooth wire during ultrasonic irrigation in vitro seems to be as effective as a K file in eliminating debris.[11]Two flushing methods can be used during PUI, continuous or intermittent flush of the irrigant. The continuous flush technique provides an uninterrupted supply of fresh irrigation solution in the root canal. According to some authors this technique can provide more effective results and reduce the time required for ultrasonic irrigation.This is due to the fact that chloride (responsible for dissolving the organic tissues and NaOCl's antibacterial property) is unstable and quickly consumed during the first part of tissue dilution, probably within two minutes.[41] In the intermittent flush technique the irrigant is injected in the root canal with a syringe, the irrigant solution is then activated with an oscillating ultrasonic instrument and the canal is filled several times after each activation cycle. The amount of irrigant flushed through the apical region of the canal can be controlled by the depth of penetration of the syringe and the volume of irrigant. This degree of control is not possible with continuous flush. Both flush methods have proved to be equally effective in removing dentin debris from the root canal in an ex vivo model when irrigation time was set at three minutes.Mechanism of passive ultrasonic irrigation-Frequency and intensity-An ultrasonic device converts electrical energy into ultrasonic waves of a certain frequency by magnetostriction or by piezoelectricity. On one hand, magnetostriction is generated by the deformation of a ferromagnetic material subjected to a magnetic field; on the other hand piezoelectricity is the generation of stress in dielectric crystals subjected to an applied voltage. The properties of the ultrasonic material determine the frequency of the oscillating instrument, which in dental practice, is fixed at 30 kHz. The intensity or energy flux, expressed in units of Watt cm^2, of the oscillating instrument can be adjusted by the power setting. Frequency and intensity do play a role in the transmission of energy from the ultrasonically oscillating file to the irrigant but a full understanding of the mechanism is still lacking. A higher frequency should in principle result in a higher streaming velocity of the irrigant, as will be addressed later. This in turn results in a more powerful acoustic streaming. Increasing the intensity does not result in a linear increase of the displacement amplitude of the oscillating file.[7,8,10]**Acoustic streaming-** Acoustic streaming is the rapid movement of fluid in a circular or vortex-like motion around a vibrating file. The acoustic streaming that occurs in the root canal during ultrasonic irrigation has been described as acoustic micro-streaming. This is defined as the streaming which occurs near small obstacles placed within a sound field, near small sound sources, vibrating membranes or wires, which arise from the frictional forces between a boundary and medium carrying vibrations of circular frequency. Several researchers have confirmed that acoustic micro-streaming occurs during PUI. The streaming pattern corresponds to the characteristic pattern of nodes and antinodes along the length of the oscillating file. The displacement amplitude is at its maximum at the tip of the file, probably causing a directional flow to the coronal part of the root canal.[10]When the file touches the root canal wall at an antinode a greater reduction in displacement amplitude will occur compared with when it touches at a node. When the file is unable to vibrate freely in the root canal, acoustic micro-streaming will become less intense, however, it will not stop completely. The resultant acoustic micro-streaming depends inversely on the surface area of the file touching the root canal wall. In curved canals, pre-shaping the file will result in more powerful acoustic micro-streaming. A pre-shaped file shows the same pattern of nodes and antinodes as a straight file both in air and in the confined geometry of a root canal. The intensity of the acoustic micro-streaming is directly related to the streaming velocity.[7,10]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. Acoustic cavitation can be defined as the creation of new bubbles or the expansion, contraction and/or distortion of pre-existing bubbles (so-called nuclei) in a liquid, the process being coupled to acoustic energy. Cavitation is beneficially used in industrial ultrasound cleaning, megasonic chip cleaning, lithotripsy and even by small shrimp to stun prey. Transient cavitation only occurs when the file can vibrate freely in the canal or when the file touches lightly (unintentionally) the canal wall. Increased (intentional) contact with the canal wall, as in ultrasonic irrigation, excludes transient cavitation. The surface property of the file is important for the enhancement of cavitation. In their study a smooth file with sharp edges and a square cross-section produced significantly more transient cavitation than a normal K-file. The sharp edges could have induced so- called edge cavitation. The transient cavitation was visible at the apical end and along the length of the file. When the file came in contact with the canal wall, stable cavitation was affected less than transient cavitation and was mainly seen at the midpoint of the file. A pre-shaped file brought into a curved canal is more likely to produce transient cavitation rather than a straight file. Other researchers claim that cavitation provides only minor benefit in ultrasonic irrigation, or that it does not occur at all.The effects and use of passive ultrasonic irrigation Passive ultrasonic irrigation versus syringe irrigation-After shaping the root canal, cleaning can be completed with PUI or a final flush of syringe irrigation. From the studies where PUI and syringe irrigation were compared, it can be concluded that PUI is more effective in removing remnants of pulp tissue and dentine debris and planktonic bacteria. In the study of Mayer et al. (2002) no significant difference was found between PUI and syringe irrigation in dentine debris removal from the root canal.[43] Before activating ultrasonically the NaOCl, EDTA was left in the root canal. Removal of EDTA before the injection of 2 mL NaOCl in the root canal was not mentioned. EDTA inactivates the NaOCl and it is possible that this had an influence on the outcome. PUI with NaOCl as irrigant During PUI, NaOCl removes significantly more smear layer or bacteria from artificial smear layer, pulp tissue or dentine debris from the root canal than water. The significant increase in dissolving capacity of organic material by NaOCl, when NaOCl is agitated by ultrasound or when the temperature rises because of ultrasound can be an explanation for the enhanced performance of NaOCl. When a greater concentration of NaOCl is used the efficacy appears to increase.

CONCLUSION-

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 surgical and non-surgical applications in endodontics. The non-surgical applications of the ultrasonics are like gaining access to canal openings, cleaning and shaping, obturation of root canals, removal of intracanal materials and root canal obstructions. Ultrasonics has various surgical applications in endodontics such as osteotomy, apicectomy, retrograde preparation and retroseal. Detail knowledge about the ultrasonics in endodontics and its use in clinical practice will enhance the quality of treatment.

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