IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

PIEZOSURGERY : A BENEFIT TO DENTISTRY

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Abstract :

Dentistry has made many advances over the last few decades and has seen many changing concepts. One of these recent innovations is piezoelectric surgery. Piezoelectric bone surgery, also known as piezosurgery, is a new technique introduced by his Professor Vercellotti in 1988, which modifies and improves conventional ultrasonic techniques to replace conventional scalpel blades in oral bone surgery. Overcome the limits of surgery. It is a promising, gentle and soft-tissue sparing osteotomy technique based on low-frequency ultrasonic micro-vibration. The absence of macro-vibration makes the instrument more manageable, greatly improves cutting safety in more difficult anatomical cut zones, and provides greater intraoperative control. This overview distinguishes piezosurgery from conventional oral surgery, discusses its mechanism of action, instruments, biological effects, advantages and limitations, and its diverse applications in the fields of oral surgery and dentistry itself.

Keywords :

Bone cutting, osseous surgery, cavitation, micro vibrations.

IndexTerms - Component,formatting,style,styling,insert.

Introduction :-

During the past decades, there have been rapid developments in various dental surgical techniques that have brought about a world of pain-free dentistry. Traditionally, bone surgery was performed using hand instruments with different burs and various rotary instruments that required a large amount of external irrigation due to the heat generated by these instruments. rice field. In addition to heat, bone surgery also used considerable pressure, with fractures and/or brittle bone limitations.[1] To overcome the above limitations, a new surgical technique based on ultrasonic microvibration for precise and selective bone cutting has

been introduced, with the added benefit of sparing the surrounding soft tissue.[2] This new alternative method introduced in dentistry for bone-related surgical procedures was called piezosurgery.
Piezoelectric surgery is a relatively new technique, introduced by Professor Vercellotti in 1988, that modifies and improves conventional ultrasound techniques to offer the advantages and overcome the limitations of conventional instruments in oral bone surgery. doing. The basic principle of piezoelectricity that Jacques and Pierre Curie discovered for cutting bone in his late 19th century was based on ultrasonic micro-vibrations.[3]

Piezoelectric devices mainly consist of a handpiece and footswitch which are connected to mains power. It has a holder for the handpiece and contains a rinse solution that produces an adjustable jet from 0 to 60 ml/min via a peristaltic pump. Removes dirt from the cut surface and ensures precise cuts. It also maintains a bloodless surgical field through cavitation of the irrigation fluid and provides better visibility, especially in complex anatomical regions. The piezosurgical insert should be moved back and forth in rapid succession with as little pressure as possible.[4]

The device has a control panel with a digital display for setting power and frequency modulation. The device also has multiple autoclavable tool tips, known as inserts, coated with various grades of titanium and/or diamond that are driven by the microvibrations generated by the piezoelectric handpiece.[5] This device is widely used in dentistry for a variety of applications including root planning. Removal of supragingival and subgingival deposits and stains, crown lengthening procedures, traumatic tooth extractions, prominence augmentation procedures, sinus floor elevation procedures, bone graft harvesting, inferior alveolar nerve lateralization, implants Such as surgery and ridge enlargement procedures.[6,7]

Principle :

Piezoelectric surgery works on the principle of the piezoelectric effect, which is based on the phenomenon of cavitation effect and micro-vibration. A crystal of piezoelectric material deforms when placed in an electric field. Periodic changes in electric field polarity generate ultrasonic vibrations, which are amplified through the vibrating tip and transmitted to various solid, liquid, or gaseous materials. A tip of bony tissue under light pressure produces a mechanical cutting effect called cavitation. It typically produces an operating frequency of 20 kHz, like an ultrasonic scaler. Adding a 50 kHz pulse every 10 ns to this fundamental frequency increases the output power of the receiving device and can cut bone without damaging soft tissue.[8,9]

Mechanism of action :

Electric current is passed by generator through piezo ceramic rings to produce piezoelectric ultrasonic frequencies . In dental applications, ultrasonic frequencies typically range from 24 to 36 kHz and can cut calcified tissue. Thus, motion resulting from the deformation of the piezoceramic ring induces vibrations in the transducer that produces the ultrasonic power. These waves are transmitted to the tip of the handpiece, also known as the insert, causing longitudinal motion and cutting bone tissue by microscopic bone comminution.[10] Transducers are a very important part of the instrument system as they contain piezoelectric elements that convert electrical signals into mechanical vibrations and mechanical vibrations into electrical signals.

Modes of piezoelectric device

Mainly 3 modes are used :

1) Low mode - is used for apical root canal treatment, orthodontic surgeries
2) High mode - is used for cleaning and smoothing the radicular surfaces
3) Boosted mode - is used for bone surgeries and for performing osteotomy and osteoplasty procedures

Clinical Applications :-

1.) Sinus lift :-

The Piezoelectric Internal Sinus Elevation (PISE) technique[11] uses an ultrasonic piezoelectric device with a special carbide tip instead of a surgical hammer to apply flushed saline internally or externally to the sinus membrane. is a surgical sinus augmentation technique that uses hydraulic pressure. Detachment from the sinus floor. This carbide tip indicates bone depth during osteotomy and minimizes the risk of membrane perforation.
After perforation of the sinus cortex, the bone graft or substitute is injected with platelet-rich plasma or Fibrin glue can be implanted into prepared alveoli using an amalgam carrier or a small spoon shaped curette. Reduced incidence of benign paroxysmal positional vertigo (BPPV) and Membrane perforation makes this technique a more attractive alternative to direct or indirect .The sinus lift procedure[11] in Wallace et al. Only 7 of his 100 cases of Schneider's disease have been reported

Membrane perforation in the study of sinus lift surgery using piezosurgery. Vercelotti et al. Membrane perforation was observed in only 5% of patients.[12,13] Extra Bone grafts can be placed to raise the sinus floor to the required height. A 0.5-1cm3 bone graft is usually recommended to lift the sinus floor up to 5mm for single dental implant placement. Sinus elevation is suitable if there is at least 3mm of residual bone under the maxillary sinus floor. Shorter operating time and patient discomfort make it more beneficial.

2) Surgical removal of impacted third molars :-

Traditionally, rotary handpieces and burs have been used to remove bone above impacted third molars and other impacted teeth. Piezo surgery has been proposed as an alternative to rotating instruments. The tool used to remove the bone of the impacted third molar is a rotary handpiece. Recently, piezosurgical techniques have gained popularity. Various studies have suggested piezo surgery as a better alternative to rotating headpieces.

The insert uses micro vibrations of a scalpel maintained at frequencies of 24–29 KHz to enable precise, safe, and efficient bone resection.[14] Piezoelectric instruments act selectively on hard tissue, reducing the likelihood of damaging surrounding tissues, including iatrogenic trauma, mucous membranes and neurovascular structures. Although a very time-consuming technique compared to rotary instruments, selective cutting of calcified structures, reduced temperature at the surgical site, and improved visibility of the surgical site with a constant irrigation system accelerates bone healing. and is ideal for osteotomies at the sites which are closer to critical structures. There is reduced postoperative swelling and trismus.[15]

3) Bone harvesting :-

Bone can be harvested in the form of bone chips or blocks that serve as guides for bone regeneration via osteoconduction and as placeholders for growth factors that promote bone healing.[3,16,17] Traditional methods of bone harvesting include bone scrapers, forceps, tubular chisels, trophies, or block harvesting. Recently, piezosurgery bone harvesting has become of paramount importance due to its many advantages over traditional methods.

Piezoelectric devices with tips for Osteoplasty #1 through Osteoplasty #3 are used in a gentle rubbing motion along the bone surface to reach a sufficient amount of bone, which is very difficult with conventional bone grinders. you can get a piece of bone fragments obtained with a conventional bone crusher have a small particle size and are easily resorbed without serving as placeholders or guides for bone regeneration, whereas piezoelectric surgery has a low complication rate and particle size reduction. A significant amount of bone with a size of 500 µm is obtained with minimum absorption.[9] The bone rim structure obtained by piezoelectric surgery is less affected compared to conventional methods. Berengo et al. reported that piezosurgery retained significant amounts of viable osteocytes and osteoblasts.[18] Although a time-consuming technique, piezo surgery remains one of the easiest and safest methods of bone harvesting.

4) Distraction osteogenesis :-

Bone formation with mandibular distraction is considered a surgical option for neonatal Pierre-Robin syndrome. It provides a safe and effective option to reduce airway obstruction and dysphagia due to micrognathia and avoid the need for tracheostomy.[19] Piezoelectric osteotomy allows for well-defined, microscopically selective osteotomy during the distraction procedure, thereby sparing osteocytes and periosteal tissue, thus the technique is expected to promote new bone formation through early release of morphogenic proteins. promotes it.

If 4–5 mm of vertical augmentation to the eminence is required, or if the overlying soft tissue does not support bone augmentation, distraction osteoplasty is a useful alternative and piezocer. Jelly is an effective tool for distraction osteotomies.[20]

When performing region-specific distraction osteogenesis, it is important to complete carefully as the osteotomy is performed close to the tooth and periodontal structures and soft tissues that provide vascularization. The advantage is that its micrometric and linear oscillations allow the osteotomy to be as precise as possible, with minimal damage to hard and soft tissues.[21]

Piezosurgery provides an ideal osteotomy preparation without damaging the flap, providing sufficient vascularization for successful new bone formation. In addition, direct visualization of the entire osteotomy is possible. The only small limitation is the slightly longer time required for the operation.

5) Alveolar nerve decompression :-

Use of Piezosurgery allows minimal thermal or mechanical damage of neurovascular structures thereby promoting accuracy and precision of osteotomy for alveolar nerve decompression .[22]

In a cadaver study conducted by Gowgiel, "the distance from the lateral edge of the neurovascular bundle in the molar and premolar region to the lateral surface of the buccal plate was typically 0.5 cm".[23]

Preservation of the inferior alveolar nerve is critical to the patient's quality of life. The position of the N. alveolaris mandible is very different in edentulous jaws. The orientation of horizontal layers appears to be fairly stable. This is true for both the

removal of deeply moved wisdom teeth, which are often near the inferior alveolar nerve, and the lateralization of the inferior alveolar nerve. This procedure is an alternative to augmentation techniques when implants are planned in edentulous jaws.[24]
Neurosensory damage to the innervated area of the inferior alveolar may be an adverse effect of bilateral sagittal split osteotomy. To assess the tenderness of the lower lip and mandible after bilateral sagittal split mandibular osteotomy in her 20 patients undergoing piezoelectric surgery, a Lyon oral surgeon determined that the inferior alveolar nerve was affected in all cases. indicated that it was not Gap osteotomy.[25] These results confirmed those of Metzger,The use of piezoelectric devices was compared to conventional burrs in soft and hard tissues for correction or translocation of the inferior alveolar nerve in sheep.[26] Bovi reported on the recruitment of the inferior alveolar nerve by simultaneous insertion of implants.[27] Both studies reported less damage to soft tissue, especially neurovascular tissue, when using piezoelectric devices than traditional methods.

6) Cyst removal :-

Another area of application for piezo surgery is extraction of jaw cysts. The use of piezosurgery to treat jaw cysts and tumors is a recent development with very few applications described in the literature.[28,29] The obvious advantage of piezosurgery over conventional techniques is the gentle removal of the thin bony laminate covering the cyst and the ability to meticulously manipulate the cyst without tearing the epithelial wall. This may lead to lower postoperative recurrence and complication rates.
With the use of Piezosurgery devices odontogenic and non odontogenic cyst of the jaws can be removed very efficiently without damaging adjacent vital structures thereby promoting the bone healing after cystic removal.[3,6]

7.) Periodontic and endodontic surgery :-

Piezosurgery using ultrasonic vibration is widely used for removal of supragingival and subgingival plaque, removal of root canal fillings and fractured instruments from root canals. Ultrasonic scalers typically operate at a functional frequency of 20 kHz. Ultrasonic piezoelectric retrotips reduce the need for root dissection, reducing the number of exposed dentinal tubules and the risk of apical leakage. It also improves cleaning of the cavity walls after root canal preparation and reduces the amount of smear layer.[30]

8) Dental implantology :-

In today's world, piezo-surgery is most prevalent in the field of implants. Sufficient height and width of alveolar bone are the most important requirements before placing dental implants. This can be achieved by various techniques such as sinus lift, ridge segmentation and bone harvesting, and can be done more precisely and precisely by piezoelectric devices. Piezoelectric surgery offers a more customized and minimally invasive osteotomy, making implant site preparation and lateralization of the inferior alveolar nerve more feasible.[31] Da Silva Neto and others In a prospective study, using resonance frequency analysis to assess the stability index of implants at sites prepared by conventional drills or piezoelectric tips, implants placed piezoelectrically over conventionally-placed implants improved implant stability. Their study showed a significant increase in quotient values in the piezo surgery group.[32]
The osseointegration process and the final result of implant rehabilitation are adversely affected by overheating during implant bed preparation. Different tips produce different temperatures, smooth tips produce the lowest. There are also other factors that affect temperature rise. B. The method by which the cut is made and the characteristics of the bone itself.[33] Heinemann et al. Various sonic and ultrasonic devices were compared to rotary drills in pig jaws. In this study, piezoelectric surgery showed that there is highest rise in temperature, but osteocytes and trabeculae appeared to be intact, as with other devices.[34]

As a new technique, implant bed preparation can be performed using a set of specially designed piezo surgical inserts. Piezoelectric surgical site preparation allows expansion to target only one shaft wall. This is called “differential ultrasonic shaft preparation” by Vercellotti.[35]

9) Reconstructive surgery :-

The Piezosurgery devices are useful in reconstructive procedures. Using Piezosurgery devices it minimises the bony part of flaps and neurovascular structures which improves the flap viability.
The principle of piezoelectric surgery is US transduction, achieved by contraction and expansion of piezoelectric ceramics. The vibrations thus obtained are amplified and transmitted to the use of the drill. The drill, when applied quickly with slight pressure on the bone tissue, causes the phenomenon of cavitation with a mechanical cutting effect only on calcified tissue when flushed with a physiological solution. In contrast to conventional cutting instruments, piezosurgery offers cutting possibilities with the following properties: Micrometric: the insert vibrates at a modulated US frequency in the range 60-200 µm So the bone is always kept clean during cutting and avoids being too high. Temperature; selective as the vibrational frequency is optimal for calcified tissue (in fact, different frequencies are needed to cut soft tissue). Due to the reduced range of micrometric vibrations, it is possible to perform operations with very high precision, thus making it safer. In fact, cutting is as easy to

control as drawing an outline. As a result, osteotomies can also be performed in close proximity to sensitive structures, such as common vascular nerve structures, without damaging them. Soft tissue contact does not usually result in immediate amputation, as is the case with hands and mechanical instruments. It is important to interrupt cutting immediately after contact is made to avoid unnecessary heating of the soft tissue. Mechanical energy not used to cut mineralized structures is felt to be practically inert in soft tissue as far as the mechanical profile is concerned, but heat is dissipated.[36]

10) . Osteonecrosis :-

Piezosurgery devices show a better results in removal of necrotic bone. In a cohort study, it was observed that piezo surgery could prevent further necrosis after bone removal . Billimoria et al. Investigating the role of L-PRF (autologous blood product rich in cytokines and growth factors) in combination with piezoelectric debridement as a minimally invasive treatment technique for osteonecrosis by promoting hard and soft tissue wound healing .[37] Surgical approaches using flapless piezoelectric surgery show positive response in the treatment of stage 1 and stage 2 osteonecrosis of the jaw.[38]

Piezoelectric vibration can be used to cut or reshape bone tissue very easily and precisely. The level of accuracy is similar to lasers, but without the lack of depth control or excessive heat.[39] This makes the technique particularly beneficial when the bone to be cut is adjacent to sensitive and critical soft tissue such as nerves. This method also produces significantly less heat than traditional osteotomy, and more with increased irrigation. This also helps prevent damage to surrounding tissue and prevents bone necrosis.
Piezoelectric surgery also has a positive effect on hygiene and visibility of the surgical site, as bleeding is minimized. Cutting with an ultrasonic device should not affect adjacent blood vessels while preventing the bone tissue itself from bleeding.[40]

Another advantage is that piezoelectric devices generate less noise than traditional motors. This reduces anxiety and stress on the part of the patient when he is conscious during surgery.

11).Osteotomies in TMJ area :-

Piezoelectric scalpels were introduced in 2006 for osteotomies in the temporomandibular joint region.[41] This allows for safe and precise osteotomies on the medial aspect of the condyle and medial condyle, reducing the risk of injury to the internal maxillary artery and meningeal vessels. This is one of the greatest advantages of condylectomy in cases of condylar hyperplasia and temporomandibular ankylosis.[42]

Biological effects :-

Biological Effects on Piezoelectric Device Osteotomy: Actions on cortical and cancellous bone and the surface roughness produced by various osteotomy techniques have strong biological effects on bone tissue and its ultimate healing.[43] Piezoelectric osteotomies allow for more precise cuts in the clinical setting due to the relatively small amplitude of the cutting tool compared to oscillating saws. Blood-free surgical sites offer improved intraoperative visibility.Local overheating, cavitation effects, and coolant flow from the use of piezoelectric tools may serve as possible explanations for the absence of blood at the osteotomy site.[44] In one study, postoperative wound healing rates in a canine model after osteotomies and osteoplasties were used to compare the efficacy of piezoelectric instruments with commonly used carbide and/or diamond burs. It was a marker. Surgical sites treated with carbide and/or diamond burs lost bone compared to baseline measurements by 14 postoperative days, whereas surgical sites treated with piezoelectric instruments showed increased bone levels. showed. At 28 postoperative days, surgical sites treated with all three instruments showed increased bone levels and regeneration of cementum and periodontal tissue. However, at the end of postoperative day 56, surgical sites treated with carbide and/or diamond burs showed bone loss and bone gain compared to sites treated with piezoelectric instruments. Piezoelectric bone surgery therefore appears to have enabled bone repair and remodeling that is preferable to carbide and/or diamond burs when performing surgical procedures. Therefore, piezoelectric bone surgery may be effective for use in a variety of bone surgeries.[45]

Indications :-

1. Cranial osteoplasties.
2. ENT surgeries, neurosurgeries, pediatric surgeries & orthopedic procedures
3. Rhinoplasty procedures
4. Otologic surgeries
5. Orthodontics applications, including corticotomy,
6. exposure of impacted canines etc.;
7. Oral surgery such as temporomandibular joint ankylosis, nerve mobilization and/or dislocation, lateralization of the inferior alveolar nerve, atraumatic tooth extraction, cystectomy.

8. Root planning, removal of supragingival and subgingival plaque and stain from teeth, cleaning of periodontal pockets, crown lengthening procedures, soft tissue debridement, excisional surgery, and obtaining autografts from donor sites periodontal procedures, including various reconstructive surgeries for Implant procedure for graft bone harvesting, osteotomy procedure, implant placement after osteoplasty, blade implant removal, prominence enlargement procedure, maxillary sinus elevation, implant placement and bone for implant placement such as drilling.

Contraindications :-

1) In patients having certain diseases like heart disorders
2) Patients having uncontrolled diabetes
3) Patients receiving radiotherapies
4) Piezoelectric surgery is avoided in patients with pacemakers or other implantable electronic devices
5) This technique should not be carried on patients having metal or ceramic prosthesis
Which can lead to decementation of prosthesis.[46]

Advantages :- [3,47,48,49]

1) Improved soft tissue protection.
During osteotomy procedures risk of mechanical and thermal injury to Structures like nerves , blood vessels, Schneiderian membrane and dura matter is reduced.
2) Minimal vibration and noise reduces patient's mental stress and anxiety during surgical procedures.
3) Protect the vitality of your teeth.
4) Reduced blood loss. Improved patient comfort.
5) It can be done with little pressure.
6) Eliminates the need for chisel availability.
7) Reduces the incidence of coagulative necrosis in osteotomized fragments.
8) Make micrometric bone cuts with greater precision.

Disadvantages :- [47,48]

1) It is very expensive
2) The procedure is very technique sensitive
3) To perform piezoelectric surgery the surgeon should be well trained to use the devices as it may damage the soft tissues.
4) Difficult to learn .
5) High level surgical control is required.

Limitations :- [50]

1) The operator should be skilled in performing tasks with such type of instruments as these procedures require different learning curve
2) When the working pressure rises above a certain limit , it transforms the energy into heat.Therefore the most effective way to use piezoelectric devices is to use them at lower pressure and higher speed
3) Operative time is increased as compared to conventional cutting instruments
4) Deeper osteotomy procedures can be challenging using piezoelectric devices.
5) Piezoelectric devices should be used carefully during the surgical procedures as it may cause damage to the soft tissues due to rising heat.

Conclusion:-

The use of piezosurgical devices in dental procedures has particular advantages such as lack of macro-vibration, ease of use, control, safe and precise cutting compared to traditional hard and soft tissue (motor driven) methods. It has many advantages in anatomical areas. Due to the presence of important physical and mechanical properties such as protection of the neurovascular bundle and better visualization of the surgical field, the use of the device and its intervention in routine dental practice should be considered. It facilitates the bone healing by inducing early increase in bone morphogenetic proteins and reduce the inflammatory process.Even though it is the time consuming technique with a large learning curve, it's clinical advantages overrules its drawbacks.

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