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Piezosurgery in Prosthodontics: A Review

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Abstract

Aim: This study was aimed to review the role of Piezosurgery in dentistry and to assess how relevant it is in Prosthodontics.

Methodology: A systematic literature search was performed electronically and also hand-searched with the terms Piezosurgery, Piezosurgery in dentistry, Piezosurgery in Prosthodontics. The search was restricted to full-text articles published in the English language. The search was carried out through Medline via Pubmed, Wiley online library, Ebscohost, Science Direct as well as the Google Scholar for articles published from 1990 to 2017. A total of 200 articles were found. Finally, a total of 42 articles were found relevant to the topic. Articles selected were critically appraised to evaluate their quality.

Results: Different articles described various uses of piezosurgery in dentistry, especially in Prosthodontics. The literature search revealed 84 articles in PMC and 95 in Google search. Additional 21 articles were identified by hand search.

Conclusion: Piezosurgery appears to be an advanced and conservative tool when compared with the existing methods for the treatment of bone and soft tissues.

Keywords: Piezosurgery, Ultrasonic device, Implantology, Osteotomy

Introduction

As the name implies, the ultrasonic or ultrasonic frequenc y is a frequency above the audible range, generally above 20 kHz.The Ultrasound frequency used in dental applicati ons varies from 24 kHz to 36 kHz the frequency range cap able of penetrating mineralized tissue.[1] Jacques and Pierre Curie invented a piezoelectric effect in 1880.[2] The word "piezo" derives from the Greek word piezein, which means "to press tight, squeeze."[3]

Piezoelectric bone surgery, also known simply as piezosurgery, is a new technique developed in 1988 by Italian oral surgeon Tommaso Vercellotti using an innovative ultrasonic surgical device known as Mectron piezo surgery.[4] Piezoelectric bone surgery is a relatively new alternative to traditional bone cutting tools to resolve oral hard tissue surgery limitations.[5] In the field of medical sciences, piezoelectricity was originally used to break bone adjacent to critical structural units such as the dura mater or the ethmoids or maxillary sinuses throughout sinus lifting procedures.[6] Piezosurgical clinical applications in dentistry range from dentoalveolar and maxillary sinus procedures to implant and temporomandibular joint surgery.[5]

Material and Methodology:

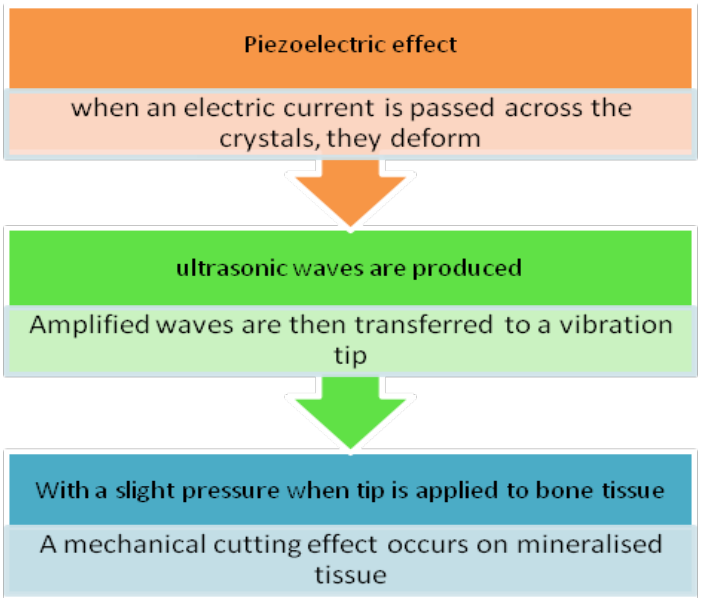
PubMed/Medline were the electronic resources used to review the biomedical literature, using the following keywords: piezosurgery, piezoelectric surgery, ultrasonic vibration, and osteotomy, either disconnected or linked. In total, we found 200 relevant articles. The literature search revealed 84 articles in PMC and 95 in Google search. Additional 21 articles were identified by hand search.

As a criterion for selection of these studies, we included only the articles published in English; and, because piezosurgery is used in other areas of dentistry and medicine (eg, periodontal, endodontic, orthopedic, and neural surgery), we focused on the use of ultrasound in bone surgery, especially in implantology and maxillofacial surgery,

plus some classical articles of surgical techniques in implantology. After reading the abstracts, we selected 42 articles that fit these criteria, with publication dates ranging from 1990 (the beginning of ultrasonic surgery in bone tissue) to 2017. Among

them, we have 10 review articles, 8 case reports, 12 clinical trials, 2 in vitro studies, 2 in vivo studies, 2 mechanical studies, 5 editorial, and 1 classical articles of implantology. (Flowchart -1)

Flowchart 1: Mechanism of piezosurgery



Flowchart 2: Diagrammatic representation of piezoelectric effect [2]

Dental Applications:[7,8,9]

1. Oral surgery
a. Root extraction
b. Apicectomy
c. Cystectomy
d. Osteogenic distraction
e. Sinus lift
f. Enucleation of jaw cyst
g. Removal of odontogenic tumors
h. Jaw resection
i. Treatment of TMJ ankylosis
2. Periodontology
a. Osteotomy and osteoplasty techniques
b. Reconstructive operations
c. Bone harvesting for regenerative surgery
d. Root debridement
e. Root planning
f. Crown lengthening
3. Orthodontics
a. Palatal impacted teeth removal
b. Orthodontic corticotomy
c. Orthognathic surgery
4. Endodontics
a. Root-end resection
b. Nucleation of radicular cyst
c. Root end cavity preparation
d. Bone tissue management
5. Implantology
a. Preparation of implant site
b. Sinus floor elevation
c. Bone grafting
d. Edentulous ridge splitting
e. Lateralization of the inferior alveolar nerve
f. Relocation of malpositioned implants

Clinical application in Prosthodontics

In prosthodontics, piezosurgery is used mainly in implantology. The piezoelectric device can be used for different clinical applications in implantology Various applications in implantology include –

A. **Preparation of implant site[10,11,12]:** By using a special tip, which allows a specific implant hole to be drilled, thermal and mechanical damage to the bone is reduced. Preti et al discovered in 2007 that during the early phase (7–14 days) more newly formed bone with an increased amount of osteoblasts was visible at the piezoelectric implant site.(Figure1)

B. **Sinus floor elevation[14-19]:** For edentulous patients with inadequate bone volume and therefore decreased alveolar crest height, an elevation of the sinus floor is often the most suitable solution for planning an implant injection donor site. The surgical procedure involves removing a bony opening from the maxillary membrane of the anterior sinus. Preferably to conventional methods is a precise cutting device which does not perforate the Schneiderian membrane. Vercellotti et al reported an operating procedure using piezoelectric surgery showing a significant reduction of membrane perforation (5%). (Figure2)

C. **Bone grafting[20,21]:** Dental implants are only possible when there is sufficient residual volume of bone. The most popular options are autogenous bone grafts from the chin or ramus when only a limited amount of bone is required. Other donor locations, like the iliac crest, have to be considered for greater bone amounts. Bone grafts showed greater short-term viability of cells with the piezoelectric unit and showed slightly more new bone deposition and remodeling. The shape of the graft can be separated Accurately from the donor site, and morbidity of the donor site can be kept as low as possible. (Figure3)

D. **Edentulous ridge splitting[22,23,24]:** In insufficient width of the alveolar ridge, the edentulous ridge-splitting technique can be applied. For this procedure, the lingual plate is separated from the buccal plate of the edentulous ridge. Because bland tips are available, the procedure is very safe when using the piezoelectric device, even if the inferior alveolar nerve is accidentally touched. In the available space, the implant will be inserted. Due to the exact and well – defined cutting abilities it is now possible to separate bone even in difficult bony situations.

E. **Lateralization of inferior alveolar nerve[25-27]:** The localization of the inferior alveolar nerve can vary distinctively in the edentulous mandible. Particularly in regions with a limited view, it is essential to perform the osteotomies with a tool that reduces the risk of nerve damage. This is possible with the piezoelectric device, because the shape of the tip, surgical control, and the cavitation effect support the surgeon in interventions close to the inferior alveolar nerve. This procedure is an alternative to the augmentation technique if implants are planned in an edentulous jaw. This can be achieved by performing cuts with the piezoelectric device, so that the cortical lateral bone lid is replaceable over the neurovascular bundle. This procedure protects the nerve structure after nerve retraction and transposition. (Figure4)

F. **Relocation of malpositioned implants[28]:** Implant relocation is a relatively new surgical technique used to move integrated implants along with their surrounding bone into a more desired position. The disadvantage of surgically removing the implant is that bony defects may be created, which compromise the ideal placement of another implant. The advantage of using piezosurgery for this procedure is that maximum intra-operative control can be maintained to ensure a precise cut and minimal bone ablation. Also, the healing response is likely to be more favorable in comparison to cuts using burs or saws.

Advantages[2,28]

1. Safe
2. Selective for the mineralized tissues
3. It vibrates in a range of 60-200 μm and thus maintains the bone constantly clean, thus avoiding excessive temperatures;
4. Surgical control with piezosurgery is maximum as the strength required by the surgeon to affect a cut is far less compared to that with a drill or with oscillating saws.
5. It is possible to have direct visibility over the whole osteotomies since there is minimal intra-operative bleeding.
6. The slightly increased time for operation using the Piezosurgery instrument, compared with that of the conventional drill, is negligible.
7. Piezoelectric bone surgery induces an earlier increase in bone morphogenetic proteins, better healing, controls the inflammatory process better, and also fastens the remodeling of bone.
8. It provides faster bone regeneration and healing process
9. Great control of the surgical device

10. Selective cutting and minimal operative invasion
11. Reduced traumatic stress
12. Decreased postintervention pain, and
13. No risk of emphysema.

Disadvantages[2,28]

1. The main disadvantage is that it is slow. It takes up to 4 times longer time than with a rotary bur.
2. Breakage of tip is frequent which makes it necessary to maintain a stock of tips.
3. Cost is high.

Discussion

Piezosurgery is a fairly modern periodontology and implantology surgical technique which can be used to supplement conventional oral surgical procedures and, in some cases, replace traditional procedures. In a study by Vercellotti T et al.,[12] a modulated-frequency piezoelectric knife was investigated as a means of performing ostectomy and osteoplasty.[12] The postoperative bone change rate was used to equate the effectiveness of this instrument with a standard carbide bur bur and a standard diamond burst, and the findings showed that PS produced a more desirable osseous reaction than conventional carbide and diamond burs when surgical ostectomy and osteoplastic procedures were performed. Because the PS insert vibrated at a modulated ultrasonic frequency within a width of 60–200 mm, a temperature increase was avoided, which eliminated bone damage.[29]

Wallace SS et al.[30] conducted a study in which one hundred maxillary sinus surgeries were performed using the piezoelectric device. Only seven cases of perforation of the sinus mucosa were observed. None of these perforations occurred because of the inserts of the piezoelectric unit and all of them were caused by the subsequent elevation of the Schneiderian membrane with hand tools.[30]

Ueki K et al[31] showed that the bone cut with piezoelectric ultrasound was effective in patients requiring maxillary orthognathic surgery, as it helps in the rapid palatal expansion, providing less surgical trauma and precise control during the osteotomy.

Berengo M et al[32] collected autogenous bone particles and analyzed them by histomorphometry, measuring the surface of the bone fragments and the percentage of necrotic and vital bone. According to some studies, piezoelectricity can be used in implantology to collect bone grafts in osteotomy for alveolar bone crest expansion and in the sinus floor elevation and lateralization of the inferior alveolar nervewith greater security than conventional techniques.

Conclusion

Piezoelectric surgery is an ideal technique for working with fragile or damaged hard-and soft-tissue problems with less harm to the patient. Ultrasonic bone surgery device with its various ranges of tips has a variety of applications in Dentistry like in the fields of Periodontics and Implantology and Oral and Maxillofacial surgery. The instrument 's precise design allows geometries to be sliced perfectly, cleanly and effortlessly during surgery. If used judiciously, this could be of great help in performing precise bone surgeries.

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Legends Figure

Figure 1: After definition of the initial implant length, widening of the implant hole, using different tips in an ascending order (**A**–**C**). Finally, control of the angulation and implant placement (**D**).[13]

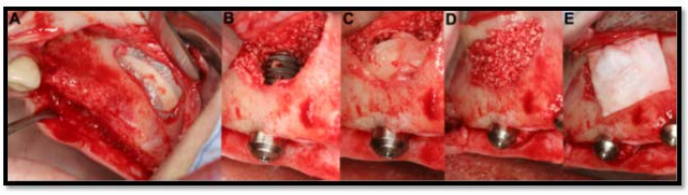

Figure 2: Removal of the vestibular alveolar wall (**A**), elevation of the Schneiderian membrane and dental implant placement (**B**). The sinus cavity was filled with bone substitutes and bone chips. Use of the buccal bone for additional stabilization and protection (**C** and **D**). The complete area was finally covered with a collagen membrane (**E**).[13]

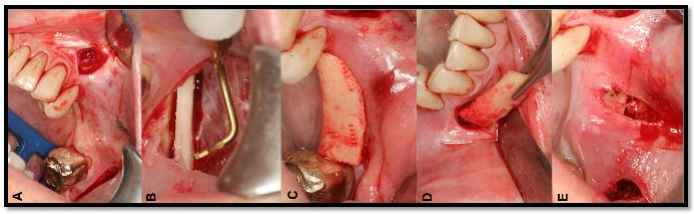

Figure 3: Two vertical incisions (**A**) were performed (mesial and distal ends of the intended region for augmentation), followed by elevation of a mucoperiosteal flap. A bone graft from the contralateral side was harvested (**B**). The block was adapted to the defect (**C**), and inserted under the flap accessed from the mesial incision (**D**). The block was secured with two titanium screws onto the alveolar crest (**E**).[13]

Figure 4: Complete removal of the vestibular bone in that area and gentle loosening of the nerve (from the remaining nerve canal walls) (**A**). The nerve was carefully kept away from the osteotomy site (**B**). After implant insertions, the nerve was returned to its original place (**C**).[13]