



PIEZOSURGERY IN IMPLANTOLOGY.

Dental Science

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ABSTRACT

Piezosurgery (piezoelectric bone surgery) is a promising, precise, bone-cutting system that is based on ultrasonic micro-vibrations and spares soft tissue. The cuts produced by piezosurgery are micrometric and selective and most of the damage is limited to the adjacent tissues with minimum trauma. Concerning current and future minimally invasive and innovative surgical concepts, piezoelectric surgery offers a wide range of new possibilities to perform customized osteotomies for bone reconstruction and placement of dental implants with more predictability, less post-operative pain, and increased patient compliance.

KEYWORDS

Piezosurgery, Dental Implants, Osteotomy, Osseointegration, Ridge Augmentation.

INTRODUCTION

Over the last few decades, there has been rapid development in various dental surgical techniques, evolving a world of painless dentistry. Traditionally, hand instruments and various rotary instruments were used for osseous surgery. This led to heat production, which necessitates external copious irrigation while performing the surgeries. In addition to heat, a considerable amount of pressure was also exerted in osseous surgeries, with a limitation in the case of fractured or brittle bones.^[1] To overcome these limitations, a new paradigm shift in osseous surgeries, termed piezosurgery, has occurred over time. Piezoelectric bone surgery was introduced in dentistry by the oral surgeon tomaso vercellotti in 1988.^[2] Piezosurgery (piezoelectric bone surgery) is a promising, precise, bone-cutting system that is based on ultrasonic micro-vibrations and spares soft tissue. The cuts produced by piezosurgery are micrometric and selective and most of the damage is limited to the adjacent tissues with minimum trauma.^[3] The distinguishable features of the piezoelectric device are ultrasonic micro-vibrations with an average frequency of 25–29 khz, an oscillation (amplitude) of 60–210 μm , and power up to 50 w, which allows selective cutting only in mineralized structures without damaging soft tissue.^[4] Piezoelectric osteotomy devices are based on the modulation of ultrasonic vibration of an active tip called insert and are characterized by three essential points:

- 1) precise and clean cutting,
- 2) selective bone-cutting
- 3) surgical field relatively free of blood^[2]

This review article aims to focus on the clinical applications of piezosurgery in implantology and demarcate their advantages and disadvantages over conventional surgical systems and their biological aspects.

Biological aspects of piezosurgery in bone tissues

The bone tissue is sensitive to thermal injury and the temperature threshold survival of this tissue during osteotomy is established at 470 C for 1 min which is documented by zadehet al.^[5] The osteotomy procedure involving the repeated use of burs, drills, and saws reduces the cutting power and results in excessive trauma, followed by an increase in frictional heat. Chiriac et al.^[6] in their study proved that bone chips harvested by piezoelectric surgery, and with a conventional rotating drill, contained vital cells that have the capacity to differentiate into osteoblasts in vitro. Von see et al.^[7] showed that the cell count contained more osteoblast-like cells in the harvested samples when a piezoelectric device was used.

They concluded that:

- (1) The surgical sites which were treated with carbide and diamond drills resulted in bone loss in 14 days, contrary to piezosurgery, where there was an increase in bone tissue.
- (2) There was an increase in the bone level with the regeneration of cementum and periodontal ligament after 28 days in the 3 systems used.
- (3) The piezosurgery system increased bone mass, whereas carbide

and diamond drills resulted in a loss of bone tissue at 56 days post-surgery.

This study highlighted the greatest capacity of bone regeneration and efficacy with the use of piezosurgery.

Applications of piezosurgery in implantology

The piezoelectric device has wide use in implantology which serves abundant applications such as implant surgery, ridge augmentation, sinus floor elevation, bone graft harvesting, lateralization of inferior alveolar nerve, and ridge expansion.

Preparation of the implant site

In healthy bony conditions, piezosurgery can be advocated for the preparation of the implant site.^[8] Special drills are available which allow for the drilling of a precise implant hole, which in turn will reduce the thermal and mechanical damage to the bone. In a prospective study conducted by da silva Neto et al.^[9] with 30 implant sites that received dental implants using either conventional drilling or piezoelectric tips, the resonance-frequency value was significantly high in the piezosurgery group compared to the conventional drilling. This indicates that the implant stability quotient was significantly greater for implants placed with piezosurgery compared to the conventional technique. In 2007, Preti et al.^[10] conducted a study to assess the neoosteogenesis and inflammatory reaction after implant site preparation in two groups, comparing piezosurgery and conventional drills. They discovered that during the early phase (7–14 days), the piezoelectric implant site showed an increased amount of osteoblasts and more newly formed bone when compared to conventional drilling. In their study, bmp-4, tgf- β 2, tnfa, il-1 β , and il-1 α were investigated in detail. During this early period, the piezoelectric group showed an increase in bmp-4, tgf- β 2, and il-10, while il-1 β and tnfa were not.^[10] In conclusion, the piezoelectric device stimulated periimplant osteogenesis and a reduction of pro inflammatory cytokines.

Sinus floor elevation

The sinus-floor elevation is often the most suitable solution to prepare a sufficient donor site for implant insertion, in edentulous patients with insufficient bone volume and reduced height of the alveolar crest. Aldajani et al.^[11] found that the risk for the incidence of sinusitis or infection is doubled with the perforation of the schneiderian membrane. Therefore, it is of great importance that perforation of the schneiderian membrane should be avoided. Seoane et al.^[12] showed that the use of the piezoelectric device reduces the frequency of membrane perforation among surgeons with limited experience. Vercellotti et al.^[13] published a surgical protocol using piezoelectric surgery showing a clear reduction (5%) of membrane perforation. In comparison, the prevalence with rotary instrumentation varies between 5% and 56%,^[14] advantage of using piezosurgery is the thin cut that is produced by it.

Bone graft harvesting

Majewski et al.^[15] in their study have shown that with the use of piezosurgery, it was possible to harvest an accurate shape of the bone block for a ridge defect, in turn allowing for stabilization of the block into the recipient size more precisely. Piezosurgery also allowed to delicately shape and contour the cortical part of the graft serving as an element supporting the shape of the reconstructed alveolar process. Bone graft particles with a size of 500 µm are ideal for bone regeneration, maintaining the osteogenic, osteoinductive, and osteoconductive ability. Piezosurgery is the most suitable device to collect bone particles of ideal size with low heat generation, which in turn minimizes the possibility of thermal necrosis.^[16]

Edentulous alveolar ridge splitting

The edentulous ridge-splitting technique can be applied in case of insufficient width of the alveolar ridge. Even if the inferior alveolar nerve is accidentally touched, the procedure is very safe when using the piezoelectric device as bland tips are available. As no graft is needed in case of edentulous ridge expansion, the donor site morbidity can be avoided which is an added advantage.^[17] Amato et al.^[18] revealed that the maxilla allows an effective and fast osteotomy with atraumatic ridge expansion. A study by Majewski et al.^[15] in the evaluation of ultrasonic bone surgery or piezosurgery, in cases of split-crest procedures with immediate implant placement, displayed an overall success rate of 97.2%, with no risk of thermonecrosis, minimum risk of soft tissue alteration, and satisfactory bone cutting efficiency. The ridge splitting of the mandible can raise complications due to the inferior alveolar nerve, particularly if a significant amount of bone is lost. Another risk factor is the fracturing of the bone segments in the cortical mandible. Edentulous ridge splitting is possible with conventional instruments, but the piezoelectric device showed a different dimension. Bone separation using the piezoelectric device is even possible in difficult bony situations, due to the exact and well-defined cutting abilities.^[19]

Lateralization of the inferior alveolar nerve

The localization of the inferior alveolar nerve can vary distinctively in the edentulous mandible. Gowgiel et al.^[20] in their cadaveric study found out that, "the distance between the lateral border of the neurovascular bundle and the external surface of the outer buccal cortical plate was usually half a centimeter in the molar and premolar regions". It is of utmost importance to perform osteotomies with a device that reduces the risk of nerve damage, especially in cases with limited access and view. The characteristic shape of the piezoelectric tip, surgical control, and the cavitation effect of the device supports the operator in interventions involving the inferior alveolar nerve.^[21] This accounts for the removal of deeply impacted wisdom teeth, which are often located close to the inferior alveolar nerve, as well as for the lateralization of the inferior alveolar nerve. This procedure is an alternative to the augmentation technique if implants are planned in an edentulous jaw.^[22] For this, free and clear access to the nerve is desirable. 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.

CONCLUSION

In conclusion, the clinical rationale that uplifts the growth of piezoelectric implantology depends on lowering the surgical risk involved and achieving a more effective clinical healing response. The main objective is to improve the immediate loading technique through the use of micro-vibrations that, combined with the cavitation effect and sonic overmodulation, activate the process of tissue ultra-ossseointegration.^[10] concerning current and future minimally invasive and innovative surgical concepts, piezoelectric surgery offers a wide range of new possibilities to perform customized osteotomies for bone reconstruction and placement of dental implants.

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