Heal Talk

Piezosurgery in Implant Dentistry : A Review of Literature

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Abstract :

The use of piezoelectric devices is increasing in oral and maxillofacial surgery. The advantages of this technique are precise and selective cuttings, no thermal damage and preservation of soft-tissues. Piezoelectric surgery can be used in various procedures like implant-site preparation, sinus-floor elevation, bone grafting, lateralization of the inferior alveolar nerve and edentulous ridge splitting. This clinical overview provides a short summary of the current literature and brief outlines of the advantages and disadvantages of piezoelectric surgery in implant dentistry. Delicate or compromised hard- and soft-tissues can be handled with less risk for the patient. Piezoelectric surgery helps to perform minimally invasive osteotomies and other procedures.

Keywords: Implantology, Piezosurgery, Piezoelectric device, Maxillary sinus elevation, Bone grafting, Edentulous ridge Splitting, Osteotomy.

Historical Background

The term "piezo" was originated from the Greek word pieze in, which means "to press tight or squeeze"[1]. In 1880, the Curie brothers- Jacques and Pierre discovered the piezoelectricity. They found that putting pressure on various ceramics, crystals or bone created electricity. Later Gabriel Lippmann found the converse effect of piezoelectricity. He then demonstrated that when an electric field was applied to a crystal, the material get deformed[2]. The application of ultrasonic vibrating technology was demonstrated by different work groups for cutting mineralized tissues[3-5]. McFall et al group was one of them. They compared the healing by rotating instruments with an oscillating scalpel blade. The healing was slower in the oscillating scalpel blade group, with no severe complications[4]. A note was published by Torrella et al in 1998[6], Vercellotti had published the first clinical study about "piezoelectric bone surgery" in human[7]. It was the first time when an edentulous ridge was split which was very narrow. The Piezosurgery® was introduced in 2001. It is a tool that combines the ultrasound and the piezoelectric effect[8].

The bone-cutting with piezoelectric device is by microvibrations at a specific ultrasonic frequency which is modulated by sonic waves[9]. The mechanical shock waves produced sonic and ultrasonic frequency (25–30 kHz) which vibrates in a linear manner. The cutting tip of piezo works with a reduced vibration amplitude (horizontal 20–200µm and vertical 20–60µm)[9]. The main advantages of this device are precise and selective cutting, avoidance of thermal damage and safety of the patient[9,10]. The selective cutting is done with limited amplitude. Only mineralized tissue will be cut at this amplitude, because the soft tissue requires greater frequencies of more than 50 kHz[11]. Due to the mechanical micromovements (at a frequency of approximately 25-30kHz), cavitation effect is generated in irrigation solution which accounts for reduced bleeding, better surgical visibility and increased safety[9].

Biological Aspects of Piezoelectric Device

The reduced blood loss by piezoelectric surgery improves healing conditions[9]. The constant irrigation in piezo surgery helps to reduce thermal damage and reduces the risk of bone necrosis. The excess heat produced during implant-site preparation affects the osseointegration process thus hampers the final outcome of implant placement. Different tips are used in cutting of bone which generates different temperatures, the smooth tips creats the lowest temperature[12]. The piezoelectric bone cutting does not influence bone remodelling[13].

Esteves et al focused on the dynamics of bone healing. He compared the differences of osteotomies performed with piezosurgery and a conventional drill for "histomor phometrical, molecular and immuno histochemical analysis"[13]. He showed that the bone healing showed no differences between the two groups histologically and histom or phometrically. Only the newly formed bone found slightly higher after the use of the piezosurgery device after 30 days[13].

Stoetzer et al published an example which showed that the use of piezoelectric technology does less soft-tissue damage for subperiosteal preparation[14].

Different Applications of Piezoelectric Surgery in Implantology

Implant Site Preparation

Implants have appreciable outcomes in edentulous patients[15,16]. In healthy bony conditions piezosurgery can be used forthe preparation of the implant site[17]. Thermal and mechanical damage to the bone will be reduced by the use of a special tip. Preti et al in 2007 used piezosurgery and a conventional drill to assess the neo-osteogenesis and inflammatory reaction after implant-site preparation[18]. They discovered that more newly formed bone and an increased amount of osteoblasts were visible on the piezoelectric implant site[18]. Da Silva Neto et al done a prospective study with 30 patients who had bilateral edentulous areas in the maxillary premolar region. They received dental implants using conventional drilling and piezoelectric tips[19]. He found that the stability of implants which were placed using the piezoelectric method was greater than the of implants placed by the conventional technique[19].

Elevation of Sinus Floor

Seoane et al showed that the use of the piezoelectric device reduces the chances of membrane perforation among surgeons who have limited experience[20]. Specific tips can be used to decrease the risk of accidental perforations.

Vercellotti et al published a surgical protocol using piezoelectric surgery which showed a clear reduction of 5% in membrane perforation[21]. In comparison of this, the prevalence of perforation with rotary instrumentation varies between 5% and 56%[22,23]. Sohn et al showed that while using piezoelectric device, the replacement of the bony lateral window into the former defect is possible[24].

Piezoelectric surgery has gained a wide approval for sinus lift evaluation but many people having the opinion that it does not show clear benefits[25].

Bone Grafting

Dental implants are only possible if sufficient amount of residual bone is available. Mouraret et al compared the piezoelectric device with that of conventional bur in an in vivo mouse model. Osteotomies performed with the piezoelectric device showed greater osteocyte viability and reduced cell death The piezoelectric device showed slightly more new bone deposition and bone remodeling[26]. Piezosurgery requires less hand pressure than traditional rotary instruments[27]. Accurate shape of the graft can be removed from the donor site[28]. This also enables surgeons to get grafts from the regions which are more difficult to reach eg- the zygomatico maxillary region and the lateral wall of the maxillary sinus[29,30].

The use of a piezoelectric device is not difficult. It is a safe method which prevents soft-tissue and nerve damage. Altipa rmak et al evaluated donor-site morbidity with piezoelectric and/or conventional surgical techniques following bone harvesting. They investigated the ramus and symphysis as donor sites. They found that temporary paresthesia in the mucosa was higher in the symphysis group than in the ramus group. They showed that temporary skin and mucosa paresthesia was lower in the piezoelectric group when compared to the conventional group. No permanent paresthesia of the skin of any region occurred in either donor-site group[31].

Edentulous Ridge Splitting by Piezosurgery

Amato et al revealed that the maxilla allows fast osteotomy with atraumatic ridge expansion[32]. Due to the inferior alveolar nerve, the ridge splitting of the mandible creates complications. There is risk of fracturing the bone segments in the cortical mandible. Edentulous ridge splitting is possible with conventional instruments[33,34] but bone separation using the piezoelectric device is possible in difficult bony situations, due to the well-defined cutting abilities of piezoelectric device without macro vibrations. Case reports and studies demonstrated the successful use of the piezosurgical device, to lateralize the inferior alveolar nerve[35-38].

Lateralization of the Inferior Alveolar Nerve

Gowgiel conducted a cadaveric study in which he found that the distance from the lateral border of the neuro vascular bundle to the external surface of the buccal plate was usually half a centimeter in the molar and premolar regions[39]. In regions, particularly with a limited view, it is essential to perform the osteotomies with a tool which reduces the risk of nerve

damage. This is possible with the piezoelectric device because of the shape of the tip, cavitation effect, and the surgical control[40]. This helps in the removal of deeply impacted wisdom teeth which are located close to the inferior alveolar nerve and for the lateralization of the inferior alveolar nerve[41]. Free and clear access to the nerve is can be achieved by performing cuts with the piezoelectric device[9]. The negative side effects are very much higher if a rotating instrument comes into contact with the nerve[42]. Another advantage of the piezoelectric device is that it produces less noise so the patients experience less stress and fear[9]. The only disadvantage is that the piezoelectric device takes longer operating time.

Clinical Applications

The piezoelectric device is widely used in all fields of dentistry eg- orthodontic traction of mandibular third molars[43], orthodontic closure of edentulous spaces[44], surgical cortical micro-incisions[45], can be combined with endoscopic assistance for corticotomies[46], to remove root segments displaced in maxillary sinus[47], for the removal of third molars[48-52], for removal of osteoma associated with third molar[53], for lower third molar germectomy[54], in orthognathic surgery[55-59]. The device can be used for unilateral condylar hyperplasia when a high condy-lectomy is performed[60] and for harvesting of microvascular free bone flaps[61].

Conclusion

Piezoelectric device is an excellent tool for handling delicate or compromised hard and soft tissues with less risk to the patient. Damage to adjacent soft-tissue structures is minimum with a gentle surgical approach. The piezoelectric device is used to cut large or extensive bone volumes without necrosis of bone. It helps in precise cutting of the tissues. Piezoelectric surgery provides a wide range of possibilities which includes bone reconstruction by performing customized osteotomies and implant placement.

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