ORIGINAL RESEARCH PAPER

Maxillofacial Surgery

ADVANCEMENTS IN ORAL AND MAXILLOFACIAL SURGERY-EXPLORING THE APPLICATIONS OF PIEZOSURGERY

KEY WORDS: Piezosurgery, applications in oral and maxillofacial surgery, dental implantology, orthognathic surgery, sinus lift procedures, harvesting bone grafts, enucleation of bone jaw cysts and resection of tumours.

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ABSTRACT

Piezosurgery has emerged as a groundbreaking technique in oral and maxillofacial surgery, offering a minimally invasive approach to bone cutting with unparalleled precision and safety. In oral and maxillofacial surgery, piezosurgery finds widespread of applications in various procedures, including dental implantology, orthognathic surgery, sinus lift procedures, harvesting bone grafts, enucleation of bone jaw cysts and resection of tumours. It utilizes ultrasonic vibrations generated by piezoelectric crystals to precisely cut mineralized tissues like bone while preserving adjacent soft tissues. This selective cutting ability distinguishes piezosurgery from traditional rotary instruments, minimizing trauma to surrounding structures and reducing the risk of postoperative complications. In conclusion, piezosurgery represents a significant advancement in oral and maxillofacial surgery, offering a minimally invasive, tissue-preserving approach to bone cutting. By harnessing the precision, safety, and patient benefits afforded by piezosurgery, oral and maxillofacial surgeons can elevate the standard of care, achieve superior surgical outcomes, and enhance patient satisfaction in diverse clinical aspects.

INTRODUCTION

Piezosurgery, a relatively novel technique invented by Professor Vercelloti in 1988, offers advantages and overcomes the limitations of traditional instrumentation in oral bone surgery by modifying and improving conventional ultrasound technology[1]. The basic principle of piezoelectricity discovered by Jacque and Pierre curie in late 19th century for bone cutting is based on ultrasonic micro vibrations[2].These micro vibrations are created by the piezoelectric effect where in certain ceramics and crystals deform on passing electric current through them, resulting in oscillations of ultrasonic frequency. Piezosurgery has a wide role in oral and maxillofacial surgical procedures. Piezosurgery can be very easily and successfully used in cases which require meticulous handling of delicate structures like soft tissues, piece of a tooth; impacted teeth which is close to anatomical structures and it has been effectively used in atraumatic tooth extraction, enucleation of cyst and tumour, sinus lift procedure, alveolar ridge expansion, ridge augmentation, bone harvesting, dentoalveolar surgery, atraumatic dissection of sinus mucosa, alveolar distraction osteogenesis, jaw resection, TMJ ankylosis/resection[3,4,5,6].

The device consists of a cutting edge piezoelectric ultrasonic transducer mechanized by an ultrasonic generator competent of driving a range of resonant cutting inserts, a hand piece and a foot switch connected to the main unit which supplies power and has holders for the hand piece and irrigation fluids. It contains a peristaltic pump for cooling with a jet of solution that discharge from the inserts and also helps in removing rubble from the cutting area. The device has a control panel with a digital display to set the power and frequency modulation. They also have several autoclavable tool tips called Inserts, which are titanium or diamond coated in various grades and move by micro vibrations created in piezoelectric hand pieces[7]. The frequency of vibrations and power of cutting, as well as the amount of irrigation, can be adjusted. The frequency is usually set between 25 and 30 kHz. This frequency causes microvibrations of 60– 210 mm amplitude, providing the hand piece with power exceeding 5W.

Clinical applications of peizosurgery in oral and maxillofacial surgery

Tooth extraction:

One of the advantages of the ultrasonic unit is the ability to prepare the bony window in the external cortex. That provides an easy access to the impacted tooth or root with limited loss of bone[8]. Moreover, it enables one to replace the removed bony piece in its previous position to improve the healing process and reduce the regeneration period. It also used for the removal of a piece of a broken wisdom tooth that has a close relationship with an important anatomical structure[9,10].

Dental implantology:

In implantology, piezosurgery can be used in implant socket preparation, recontouring of alveolar crest, mental nerve repositioning, mobilization of inferior alveolar nerve and simultaneous implant placement and immediate implant placement after extraction[11]. The role of Piezosurgery is symbolic, delicately helps in critical procedures like alveolar ridge expansion which involves separation of palatal and vestibular bone flaps and subsequent implant placement[12]. As a new technique, implant site preparation can be performed with a specifically designed set of piezosurgery inserts. Piezosurgical site preparation allows for the selective enlargement of only one socket wall. This is called 'differential ultrasonic socket preparation' by Vercellotti[13]. Piezosurgical site preparation provides a similar primary stability and short-term survival rate of an implant when compared with conventional site-preparation techniques. Stelzle et al[14] 30 emphasized that the applied load on the handpiece may increase the preparation speed but may also increase the negative thermal effect on the bone. Therefore, it is recommended that a maximum load of 400 g is used during implant site preparation. Piezosurgery is a predictable method that can be used to perform split-crest procedures without the risk of bone thermo-necrosis, and it also carries a reduced risk to damage of the adjacent soft tissues. Bone cutting efficiency is satisfactory with current devices because of the enhanced vibration power, especially in soft type IV[15].

Sinus lift procedure:

Elevating the maxillary sinus membrane is the most successful therapeutic method in the case of the atrophic alveolar ridge in the posterior part of the maxilla. The traditional sinus lift membrane technique implies a great risk of perforating the Schneider membrane, which is the most common complication. It can occur either while separating

the sinus membrane or while preparing the window and performing the ostectomy to reach the sinus membrane using the surgical round bit of the piece of low speed[16]. The piezoelectric bony osteotomy cuts the mineralised tissue without damaging the membrane, and allows easy separation.

Harvesting various bone grafts:
Bone graft harvesting includes several procedures for obtaining chips or blocks of bone tissue. The piezo device makes it easier to harvest grafts of optimum dimensions. The piezoelectric device with osteoplasty No. 1 to osteoplasty No. 3 tips can be used with gentle scratching movements along the surface of the bone to obtain sufficient bone chip volume which is very difficult with conventional bone mills. The bone chips obtained via conventional bone mills have lower particle size which get easily resorbed without fulfilling its role as a space maker or guide for bone regeneration whereas piezosurgery provides significant amount of bone with particle size of 500 mm at lower complication rate and minimal resorption rate[17]. The structure of piezosurgically obtained bone margins are less impaired compared to conventional methods. Berengo et al. reported that piezosurgery retains a significant amount of viable osteocytes and osteoblasts [18]. Even though it is a time consuming technique, piezosurgery still remain as one of the most easier and safer method for bone harvesting. The usage of may piezosurgery provide obvious advantages that include the good adaptation of grafts.

Orthognathic surgery:
The increasing trend for minimally invasive surgery with more precision encouraged the development of piezoelectric surgery in orthognathic procedures, such as the BSSO, surgically assisted rapid maxillary expansion, and LeFort I osteotomy. Reduced intraoperative bleeding with piezo-osteotomy compared to the osteotomy with the bur. Blood-free surgical field enabled better visualization. Better clinical outcomes in terms of neurosensory disturbances – most patients attained complete recovery on the piezo side within a shorter duration than the bur side. During piezo-osteotomy, the cut design was precise, and neat cut edges were observed compared to the ragged and uneven edges with bur osteotomy. Bone loss during piezo-osteotomy cuts was less compared to the bur osteotomy, which enabled proper interdigitation of the segments with piezo-osteotomy cuts[19].

Enucleation of jaw cysts:
The use of piezosurgery for the treatment of jaw cysts and tumors is a new development and only a small number of applications have been reported in the literature[20]. One clear advantage of piezosurgery over conventional techniques is that it allows for careful removal of the thin bone laminate that covers the cyst and the meticulous handling of the cyst without tearing the epithelial wall. This may result in a reduction in the rate of postoperative recurrence and complications. Meticulous enucleation of jaw cysts can be performed by utilizing various shapes of piezosurgery inserts. Diamond-coated inserts can be used to remove the bone lamina over the cyst, whereas dull, bell-shaped insert can be used for the dissection of cyst epithelium from the bone.

Aesthetic facial surgery:
This technique is particularly useful for lateral osteotomies in rhinoplasty procedures with less likelihood of lacerating the nasal tissues and damaging associated vessels when compared use of chisel may cause damage to soft nasal tissue and underlying vessels.

These postoperative complications can be minimized by the precise and safer piezosurgical osteotomy, which was reported by Robiony et al[21]and Lagunas[22]. New piezoelectric insertswere specifically designed for rhinoplasty which preserves the soft tissues and thereby improves the stability of the position of the bone fragments after the osteotomy[22].

Temporomandibular joint surgery:
The piezo device is particularly useful for temporo mandibular joint ankylosis cases when performing condylectomies. Condylectomy is a delicate procedure as the surgical access is narrow, the condylar process is elongated lateromedially, and the maxillary artery is located medial to the joint. When facing TMJ ankylosis, the normal anatomy is often distorted with severe bone remodeling and fusion. The LED illumination, continuous irrigation, precise cutting, and preservation of vascular structures, such as the maxillary artery located medially, makes this procedure more effective and safer with a piezo device.

Inferior alveolar nerve lateralization technique:
These are an alternative to augmentation techniques if implants are planned in edentulous jaws. This decreases the risk of damage to the nerve at the osteotomy lines. Schaeren and colleagues[25] showed that direct exposure of a nerve to piezosurgery does not dissect the nerve, but only induces some structural or functional damage. In most cases, the nerve is able to regenerate with the perineurium intact, in contrast with conventional drills or oscillating saws.

CONCLUSIONS
Piezosurgery is a relatively new surgical technique that can be used to complement traditional surgical procedures and in some cases can replace traditional procedures. This instruments allows for increased operator sensitivity and control allowing the clinician to have a better grip and hence an increased precision while cutting. The cutting action is less invasive, producing less collateral tissue damage which results in better healing. Piezosurgery applications in oral and maxillofacial surgery with indications of dental extractions, dental implants, bone grafts removal, orthognathic surgeries, preparation of one window for maxillary sinus lifting, and inferior alveolar nerve lateralization. Piezosurgery is a safe technique to perform osteotomies, replacing conventional rotary systems and oscillating saws and it also effective in regions with anatomical difficulties due to intraoperative visibility and selective cutting, preserving delicate anatomical structures and blood vessels that nourish the bone.

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