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USE OF PIEZO SURGERY DURING SINUS LIFT

УПОТРЕБА НА ПИЕЗОХИРУРГИЈА ПРИ СИНУС ЛИФТ ИНТЕРВЕНЦИЈА

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Abstract

Introduction: MInsufficient bone volume is a common clinical finding during rehabilitation procedures involving the posterior maxilla, and is a complicating factor in the placement of dental implants in this region. In case of greater resorption of the alveolar bone in the maxilla, an open method of raising the maxillary sinus, and creating conditions for placing implants in the posterior regions is used. **The aim** of this paper is to summarize the current knowledge about piezoelectricity/piezosurgery and its comparative analysis in terms of potency, efficacy, and safety in using during lateral sinus lift procedures. **Material and method:** To achieve the purpose, authors reviewed existing papers in the PubMed medical database, Web of Science, and Google Scholar database with access to full text documents, searching for the studies written in the last 10 years (50 analyzed articles). **Results:** The great variety of the analyzed articles emphasize the safety and advantages of using piezoelectric devices, with specific biologic effects on the bone, sustaining bone structure, and cell viability (vital bone) during osteotomies and bone harvesting. Piezosurgery is less invasive, mechanical and thermal injury of the vital structures is avoided, the intra and postoperative complications are decreased, the visibility of the operative field is ideal, and due to less vibrations and noise, the psychological stress and fear of the patient is reduced. **Conclusions:** Piezosurgery is a method of choice in the field of implantology and sinus augmentation procedures for precise, safe, and effective osteotomies sparing the adjacent vital structures. **Key words:** piezoelectricity, piezosurgery, lateral sinus lift, postoperative complications, sinus membrane.

Апстракт

Вовед: СНедоволниот волумен на резидуален алвеоларен гребен е вообичаен клинички наод за време на процедурите за рехабилитација кои ја вклучуваат задната максила и е комплицирачки фактор во поставувањето дентални импланти во оваа област. Во случај на поголема ресорпција на алвеоларната коска во максилата се користи отворен метод на подигање на максиларниот синус и создавање услови за поставување импланти во задните регии.
Целта на овој труд е да ги сумира тековните знаења за пиезоелектрицитетот/пиезохирургијата и компаративно да ги анализира во однос на моќта, ефикасноста и безбедноста при латерален синус лифт процедурите. **Материјал и метод:** За да се постигне поставената цел, авторите ги прегледаа постоечките трудови во медицинската база на податоци PubMed, Web of Science и Google Scholar базата со податоци со пристап до целосни документи, пребарувајќи ги студиите напишани во последните 10 години (50 анализирани статии). **Резултати:** Големата разновидност на анализираните статии ја нагласува безбедноста и предностите од користењето пиезоелектрични уреди, со специфични биолошки ефекти врз коските, одржување на структурата на коските и одржливоста на клетките (витална коска) за време на остеотомиите и при земањето автографтови. Пиезохирургијата е помалку инвазивна, се избегнуваат механички и термички повреди на виталните структури, се намалуваат интра и постоперативните компликации, видливоста на оперативното поле е идеална, а пониските вибрации и бучава го намалуваат психолошкиот стрес и стравот кај пациентот. **Заклучоци:** Пиезохирургијата е метод на избор во областа на имплантологијата и синус лифт процедурите за прецизни, безбедни и ефективни остеотомии со неповредување на соседните витални структури. **Клучни зборови:** пиезоелектрицитет, пиезохирургија, латерален синус лифт, постоперативни компликации, синусна мембрана.

Introduction

Dental implants are an effective method for rehabilitation of simple as well as complex cases of tooth loss. When patients lose their teeth in the posterior regions of the maxilla, there is bone resorption centripetally, as a result of physiological remodeling due to tooth loss, and also bone resorption in the direction from the sinus to the alveolar ridge. These two processes lead to a limited possibility of placing implants in the posterior maxilla, therefore, for this purpose, additional surgical procedures are needed to increase the dimensions of the alveolar ridge both vertically and horizontally. Insufficient bone volume is a fairly common clinical finding during rehabilitation procedures involving the posterior maxilla and is a complicating factor in the placement of dental implants in this region[1].

In order to increase the bone height of the maxillary ridge and to allow the placement of dental implants, the floor of the maxillary sinus is raised, and grafts are placed under the Schneiderian membrane[2].

The classic sinus lift procedure was first described in the seventies of the last century by Tatum, and consists of raising the maxillary sinus through the alveolar ridge dur-

ing bone preparation during the actual placement of the implants. This technique was modified by Summers in 1994, using concave osteotomes that fracture the maxillary floor allowing elevation of the maxillary sinus membrane.

This method, which is called the closed method, is less invasive, shorter and allows for greater bone density which contributes to better primary stability of the implant, and is most often used when the thickness of the alveolar ridge, i.e. bone, is 3 to 5 mm.

In case of greater resorption of the alveolar bone in the maxilla, an open method of raising the maxillary sinus, and creating conditions for placing implants in the posterior regions is used. With this method, the placement of the implants can be performed in the first phase or can be delayed after about 6 (six) months of raising the maxillary sinus by placing a bone graft in order to obtain sufficient height and thickness of the alveolar ridge. The technique is performed by opening a lateral bone window through which the bottom of the maxillary sinus is raised and a bone graft is placed, paying attention not to cause a perforation of the Schneiderian membrane (lateral window technique)[3], which is indicated in cases where the height on the residual ridge is less than 5mm. During the lateral approach, osteotomy is usually performed with rotating implant instruments and drills[2], during which the occurrence of postoperative complications such as pain, edema, limited opening of the mouth, hematoma is possible and common[4].

In order to minimize these clinical manifestations and optimize the surgical procedure, a piezosurgical approach can be used as an alternative in the sinus lift technique with a lateral approach.

Piezosurgery is based on an ultrasonic effect that is obtained as a result of the deformation (contraction and expansion) of certain materials (crystals and ceramics) under the influence of current, which results in oscillating movements[5,6]. In this way, selective cutting (removal) is ensured only in bone tissue, which is especially important in cases where soft tissue anatomical structures (nerves, blood vessels, sinus membrane, dura matter) are located near the operative field[5,7].

Piezoelectricity and piezoelectric bone surgery is contemporary, relevant, and original method of new oral surgery approach, and pre-implantation procedures in minimizing surgical trauma and postoperative discomfort. Piezoelectricity is the electric charge that accumulates in certain solid materials (such as crystals, certain ceramics, and biological matter such as bone, DNA, and various proteins) in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure and latent heat. Piezoelectric bone surgery is a process that utilizes piezoelectric vibrations in the application of cutting bone tissue by adjusting the ultrasonic frequency of the device, making possible to cut hard tissue (cavitation phenomenon) while leaving soft tissue untouched by the process. The ultrasonic frequency is modulated from 10, 30, and 60 cycles/s (Hz) to 29 kHz. The low frequency enables cutting of mineralized structures, not soft tissue. The power can be adjusted from 2.8 to 16 W, with preset power settings for various types of bone density. The tip vibrates within a range of 60–200 μm which allows clean cutting with precise incisions.

Research across many fields of medicine now points towards the clinical advantages of minimum invasive piezosurgery. Piezosurgery has a wide application in implantology including sinus lift, provision of autologous bone grafts, bone crest splitting, removal of implants, etc.[8]. Bone removal that is performed using a piezotome is precise and safe without using high pressure while preventing excessive heat generation that would result in bone damage or osteonecrosis[9].

The aim of this paper is to summarize the current knowledge about piezoelectricity/piezosurgery and its comparative analysis in terms of potency, efficacy, and safety in using during lateral sinus lift procedures. Summarizing this information can be a step forward in choosing the most adequate sinus lift treatment in oral surgery practice.

Material and method

To accomplish our goal, we reviewed existing papers in the PubMed medical database as our main source as well as Web of Science, and Google Scholar search that covers wider variety of publications offering easier access to full-text documents, searching for the studies written in the last 10 years (50 analyzed articles). We used specific search query for every part of our research. For analyzing the potency and efficacy of piezosurgery in sinus lift procedures, compared with other classical techniques, we used this search query: “piezosurgery, comparative or compare with conventional surgery with burs”, with the only filter applied: “in the last 10 years”. For analyzing the safety of using piezosurgery in implantology practice we searched: “piezosuregry and safety”.

Results and Discussion

A piezosurgery unit consists of piezoelectric headpiece, control unit for vibrations frequency, cutting power and the amount of irrigation, holders for the headpiece, irrigation fluids, and foot switch which activates the headpiece tips. Various types of headpiece tips are available. Piezosurgery requires light headpiece pressure and continuous saline irrigation to avoid overheating of the bone, and to increase the visibility of the surgical

site. The frequency is usually set between 25 and 30 kHz, producing microvibrations of 60–210 mm amplitude, with power exceeding 5 W. The applied pressure and the speed of the tip in contact with bone influence the cutting power.

The piezoelectric devices have specific biologic effects on the bone, they sustain bone structure and cell viability (vital bone) during osteotomies and bone harvesting. In conventional oral surgery, high pressure from the applied burs and high temperatures, even for short time, may cause bone necrosis. In histomorphological studies, Preti at al.[10] reported that neo-osteogenesis was consistently more active in bony samples from implant sites prepared by piezosuregy with early predominance of anti-inflammatory cytokines BMP-4 and TGF-β2 proteins[11]. In some studies, authors report lower expression of pro-inflammatory cytokines after osteotomy with piezoelectric devices[11,12]. Various studies gave the evidence of improved wound healing and bone formation compared to conventional approaches. The soft tissue sparing capability with improved patient comfort and decreased blood loss gave high level of positioning piezosurgery in the modern world of surgery[13].

The piezoelectric device provides precise cutting of bone tissues without damaging the noble structures (vessels, nerves, and mucous membranes), less heating during osteotomies, and a more favorable postoperative period[14].

In order to increase the bone height of the maxillary ridge in clinical cases with insufficient bone quantity, and to allow the placement of dental implants, the floor of the maxillary sinus is raised (sinus lift procedure), and grafts are placed below the Schneiderian membrane increasing the bone height of the maxillary ridge (sinus augmentation procedures). One of the most used surgical techniques for this procedure is the lateral window technique.

In this technique, incisions should be made to allow adequate exposure of the surgical site in the region of posterior maxilla. After the lateral wall of the maxilla has been exposed, four linear ostectomies are performed to outline the window. The superior horizontal cut should be made at the level of the planned augmentation height, which should allow placement of implants at least 11 mm long. The lateral window approach involves the removal of outlined cortical bone from the lateral aspect of the maxilla without perforation of the sinus membrane using conventional round bur. Another method for exposing the sinus membrane is the use of a piezosurgery device.

Some postoperative complications are common after using lateral window technique in classical manner, such as pain, ecchymosis, limited mouth opening, and edema[15]. These complications are possibly due to high temperatures produced during osteotomy, which may induce marginal osteonecrosis and consequently compromise the bone repair processes[16].

As an alternative, using the piezoelectric device in the lateral window technique was proposed to optimize the surgical procedure and to minimize postoperative complications[17]. Piezosurgery has the advantages of greater precision, effective selective cutting of the bone tissue, protection of the soft tissue, less bleeding in the surgical field, and faster bone tissue regeneration[18].

When the sinus lift surgery with lateral approach is performed with piezoelectric devices, patients experience less pain, less edema and greater mouth opening within 48 hours after the procedure[19]. Piezoelectric devices cause less inflammation after surgery, especially after 48 hours, when the inflammatory process reaches its peak. Less pain intensity and greater level of mouth opening seems to be associated with lower intensity of the inflammatory process after using piezosurgery approach in sinus lift procedures[19].

The performance of piezoelectric devices during sinus elevation was evaluated from various authors to determine the percentage of sinus membrane perforation, and the time required to perform the antrostomy and elevation of the membrane. Studies demonstrated that a piezoelectric device could be an attractive alternative for successful sinus augmentation with low rate of sinus membrane perforations[20].

The most common intraoperative complication during sinus lift surgical approach is perforation of the Schneiderian membrane, with reported perforation rates of 14% to 56% in the literature[21]. In most instances, perforation occurs either while using rotary instruments to make the window or when using hand instruments to gain initial access to begin the elevation of the membrane from the sinus walls. The membrane perforation rate in series of 100 consecutive cases using the piezoelectric technique has been reduced from the average reported rate of 30% with rotary instrumentation to 7%. Furthermore, all perforations with the piezoelectric technique occurred during the hand instrumentation phase and not with the piezoelectric inserts[21].

In the review article of Corinne et al., 377 articles were analyzed. Selected non-randomized and non-controlled prospective and retrospective studies were incorporated. Conventional rotary instruments were associated with a perforation rate of 24%, the piezoelectric devices with 8%, with statistically significant difference between both modalities ($p < 0.05$). The authors concluded that membrane perforations in maxillary sinus floor augmentations may be significantly reduced by using piezoelectrical devices[22].

Schneiderian membrane perforation is the most common complication (noted in the 25 percent of performed

sinus lifts). Some studies reported 56 percent of perforation accidents[23].

Reducing the risk of perforation can be achieved by ultra-careful evaluation of preoperative CT for the assessment of: the thickness of the sinus bone wall, the location of septa, and the membrane thickness; the incidence of perforation is higher when the thickness is less than 1.5 mm[24].

From the analyzed studies, the advantages of piezosurgery in lateral sinus lift procedures can be summarized: improved soft tissue protection, mechanical and thermal injury of the vital structures nerves, blood vessels, Schneiderian membrane are avoided; ideal visibility of the operative field by voiding the blood of the cutting area by cavitation and microvibration effects; reduced blood loss; piezosurgery can be performed with small amount of pressure, piezosurgery reduces the incidence of necrosis of osteotomized fragments and produces less vibrations and noise thereby reducing the psychological stress and fear of the patient (patient comfort).

Conclusions

Piezosurgery is a method of choice in the field of implantology and sinus augmentation procedures for precise, safe, and effective osteotomies sparing the adjacent vital structures. It facilitates the bone healing by increasing the bone morphogenic proteins and reduces the inflammatory process with less postoperative patient discomfort.

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