PIEZOSURGERY®: AN ULTRASOUND DEVICE FOR ORAL SURGERY AND ORAL IMPLANTOLOGY

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ABSTRACT

Piezosurgery® uses modulated ultrasonic vibration to allow controlled cutting of bony structures. Delicate bony structures can be cut easily and with great precision, without destruction of soft tissue. We have found this device useful when exact cutting of thin bones is essential. However, it is of only limited use in cutting thick bones and in regions with limited access.

RESUMO

Piezosurgery® usa vibração ultrasónica modulada para permitir o corte controlado de estruturas ósseas. Estruturas ósseas delicadas podem ser facilmente cortadas com grande precisão, sem destruição dos tecidos moles. Consideramos este instrumento útil quando é essencial executar cortes exactos em ossos finos. No entanto o seu uso é limitado no corte de ossos espessos e em regiões de acesso limitado.

KEY-WORDS

Piezosurgery, ultrasound, oral surgery, oral implantology.

PALAVRAS-CHAVE

Piezosurgery, ultrassom, cirurgia oral, implantologia oral.

INTRODUCTION

The first reported use of ultrasound in dentistry was in 1952 when an industrial ultrasonic grinder was used to prepare cavities in extracted human teeth. The potential of an ultrasonic drill for use on patients was realised and such a suitable instrument was subsequently developed and introduced clinically[2,5,7].

Histological examination of cut bone surfaces have shown that healing is uneventful following the use of an ultrasonic drill[3].

A substantial part of the oral surgery practice deals with maxillofacial bone healing. In the past decades, low-intensity ultrasound treatment has been shown to reduce the healing time of fresh fractures of the extremities up to 38%, and to heal delayed and non-unions up to 90% and 83%, respectively. Based on the assumption that the process of bone healing in the bones of the extremities and maxillofacial skeleton is essentially the same, the potential of ultrasound to stimulate maxillofacial bone healing was investigated. Although limited evidence is available to support the susceptibility of maxillofacial bone of the ultrasound signal, ultrasound may be of value in the treatment of delayed unions, in callus maturation after distraction, and in the treatment of osteoradionecrosis[8].

This technique was created and developed in response to the need to reach major levels of precision and safety in bone surgery, as compared to that available by the usual manual and motorizes instruments. The micrometric vibration ensures precise cutting action and at the same time maintains a blood-free site because of the physical phenomenon of cavitation. The micrometric vibration makes the instrument manageable and permits major interoperative control with a consequent increase in safety especially in anatomically difficult areas. The absence of macrovibrations makes the instrument more manageable and allows greater interoperative control with a significant increase in the cutting safety in the more difficult anatomical cutting zones. Given its innovative nature, Piezosurgery® distinguishes itself as being different from the conventional techniques utilised in bone surgery, allowing exact cutting of bone structures without destruction of soft tissue. Consequently, it requires different surgical skill. To master the right surgical skill it is essential to demonstrate an adequate learning curve [9].

TECHNIQUE

Piezosurgery® (Mectron, Carasco, Italy) is a recently developed system for cutting bone with microvibrations. These are created by the piezoelectric effect: certain ceramics and crystals deform when an electric current is passed across them, resulting in oscillations of ultrasonic frequency [1].

The equipment consists of a piezoelectric handpiece and a foot switch that are connected to a main unit, which supplies power and has holders for the handpiece and irrigation fluids. It contains a peristaltic pump for cooling with a jet of solution that discharges from the insert with an adjustable flow of 0-60ml/min and removes detritus from the cutting area. The settings of power and frequency modulation of the device can be selected on a control panel with a digital display and a keypad according to the planned task. The unit uses a frequency of 25-29kHz. In "boosted" mode, a digital modulation of this oscillation produces an alternation of high frequency vibrations with pauses at a frequency of up to 30Hz. This alternation prevents the insert from impacting the bone and avoids overheating while maintaining optimum cutting capacity. For the handpiece several autoclavable tooltips, called "inserts", are available. Some are coated with titanium or diamonds in various grades. The microvibrations that are created in the piezoelectric handpiece cause the inserts to move between 60 and 210μm, providing the handpiece with power exceeding 5W [1].

The instrument was originally designed for augmentation in implant operations, including sinus lift and ridge expansion. For the cutting of bone in maxillofacial surgeries, the most efficient setting is boosted mode with maximum irrigation. The handpiece is guided over the bone firmly, but without excessive force. The sound of the cutting can be used as acoustic feedback for the force to be used. During surgeries, it is important to pay attention to irrigation to avoid heating of the bone. After prolonged cutting the handpiece will warm and a short pause may be advisable to let the handpiece cool down [1].

In sinus-lift operations it is easy to cut a bony window into the maxilla without lacerating the mucosa of the maxillary sinus. The cut is thin, witch reduced the loss of bony tissue. The mucosa could be peeled off the bone with a cone compressor, causing no damage. However, the access to the posterior regions of a LeFort osteotomy of the maxilla is extremely difficult [1].

In osteotomies and biopsies of bone it is possible to place cuts at the desired location of the bony surface. In particular, it is possible to cut the bone between teeth precisely at the desired angle. However, when deep cuts into the bone are necessary, the system is less efficient. While the cutting speed decreased temperatures rose, so pauses are necessary to let the system cool down. In these cases, the combination of Piezosurgery® for the initial incision and a chisel for the final osteotomy of the bone can be useful [1].

In cases where it is necessary to obtain autologous material to fill bony defects, such as in sinus lift, a specially designed insert could be used to collect material from the bone surface. When gently moved over the surface, small deposits of

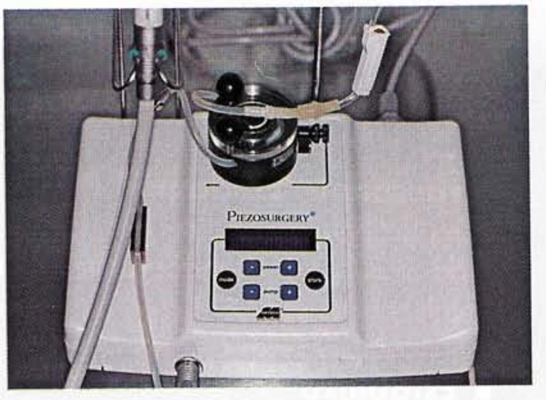

Fig. 1 The Piezosurgery device, consisting of a platform with a piezoelectric handpiece

Fig. 2 A selection of available inserts – Mini box 1

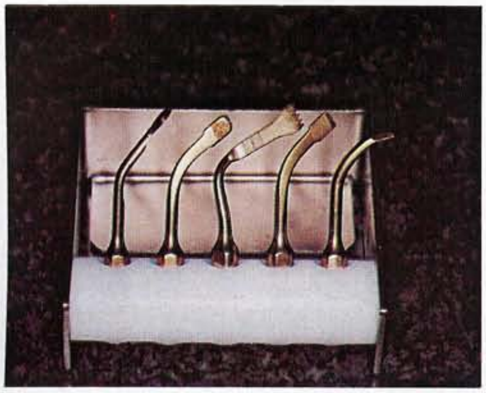

Fig. 3. A selection of available inserts – Mini box 2

bone particles accumulated on the surface and could easily be collected with a small curette [1].

CLINICAL APPLICATIONS

Ultrasonic and Sonic Scalers

Ultrasonic scalers were first introduced into the field of periodontics in the 1950's and are accepted as an alternative to the use of hand instruments in the removal of plaque, calculus and stains from teeth [4].

Ultrasound in Endodontics

The use of ultrasound in the field of endodontics was first suggested in 1957, with the adaptation of an ultrasonic scaler that could be used for apicectomies and root canal therapy. However, it was not until 1976 that the first ultrasonic device, specifically designed for instrumentation of the root canal, was introduced [4].

Ultrasonic Retrograde Cavity Preparation

The first application of ultrasound in apical surgery was described by Richman, who used an ultrasonic chisel to cut bone and resect tooth tissue. The use of ultrasonic instruments for the preparation of root end cavities during endodontic surgery is becoming more widespread [4].

Ultrasound in Maxillary Sinus Lift

All of the surgical techniques to elevate the maxillary sinus present the possibility of perforating the schneiderian membrane. This complication can occur during the osteotomy, which is performed using rotating instruments, or during the elevation of the membrane using manual elevators [10].

To reduce this eventuality, large-diameter diamond burs are generally used in a way that better allows control of the cut. Notwithstanding this precaution, perforations occur in 20% to 30% of surgical cases. The occurrence of perforations is relative to the experience of the operator, but even after complication still exists in one in four to five cases [10].

The use of Piezosurgery® in this procedure will avoid the schneiderian membrane perforation.

Ultrasound in Alveolar Crest Expansion

When compared to conventional rotating burs the use of Piezosurgery® in alveolar crest expansion allows a more precise and delicate cutting of the bone with less bone loss, therefore achieving better results.

Ultrasound in Bone Grafts

The precise and selective cut that recognizes tissue hardness and works only on mineralized structures, therefore causing no soft tissue damage (mucous membrane, nerves and vascular structures) makes the Piezosurgery® an ideal device to use in this kind of procedure.

CLINICAL CASE

This clinical case shows a female patient with 31 years-old, that presents to our clinic for oral rehabilitation with dental implants. After radiological evaluation with Orthopantomogram and CT Scan a surgical plan was made, including alveolar crest expansion in the maxilla (lateral and central parts) and an autologous bone graft from the mental area to the pre-maxilla using Piezosurgery®. After a period of 4 months 10 dental implants were placed.

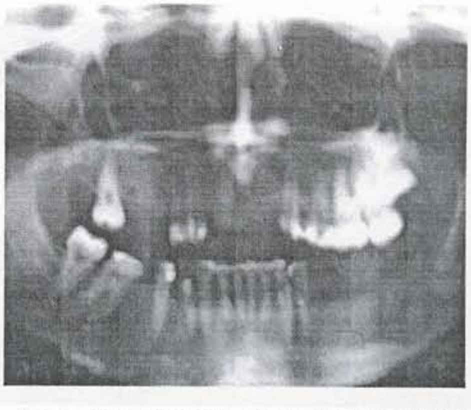

Fig. 4 Panoramic view of patient's initial presentation

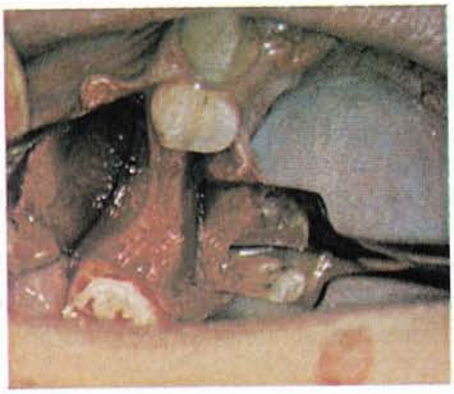

Fig. 5 Clinical view of lateral maxilla

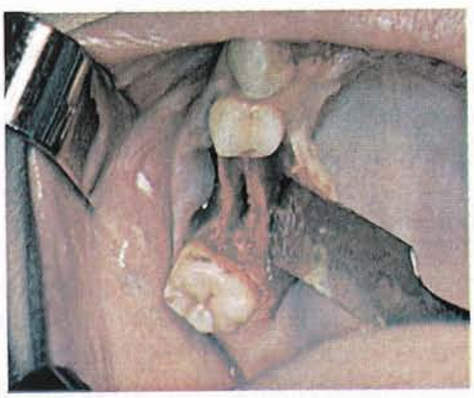

Fig. 6 Lateral maxilla after alveolar crest expansion

Fig. 7 Clinical view of pre-maxila

Fig. 8 Pre-maxilla after alveolar crest expansion

Fig. 9 Piezoelectric bone harvesting technique in the mental area

Fig. 10 Donor site after the completion of the bone harvesting

Fig. 11 Autologous bone graft from the mental area

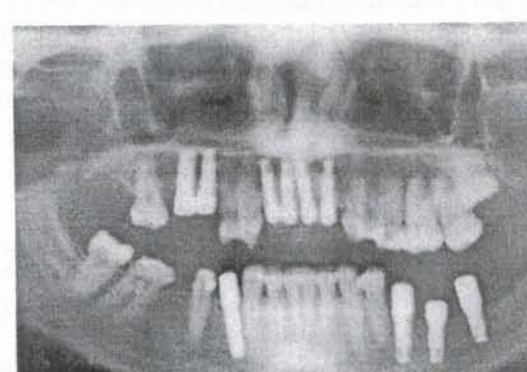

Fig. 12 Panoramic view of patient's final presentation with 10 implants placed

DISCUSSION

The manufacturer claims that bone can be cut precisely without damage to soft tissue and with little bleeding[1].

This device works only on mineralized tissues, sparing soft tissues and their blood supply[7].

Piezoelectricity is 3 times more powerful than normal ultrasound and therefore can cut highly mineralised bone. The main advantage of Piezosurgery® is its selective cut that recognizes tissue hardness and works only on mineralized structures, therefore causing no soft tissue damage (mucous membrane, nerves, etc). This is due to cessation of the surgical action when the scalpel comes in contact with nonmineralized tissues[7].

The use of Piezosurgery® requires a short learning curve, but it is important to gain adequate dexterity because it is definitely different from that used for conventional tools. To overcome problems during surgery, instead of increasing pressure on the handpiece, as in traditional techniques, it is necessary to find the correct pressure to achieve the desired result. With piezoelectric surgery, increasing the working pressure above a certain limit impedes the vibrations of the insert, the energy is transformed into heat, and tissue damage therefore can occur[7].

CONCLUSION

Ultrasound has been used for decades to cut tissue, and commercially available systems for ultrasonic cutting of soft tissue are used in various medical disciplines and environments. Ultrasonic cutting of bone is feasible and alveolar bone that had been cut ultrasonically healed uneventfully[1].

Piezoelectric surgery is an innovative technique in oral surgery and oral implantology, its significant advantages allows the performance of surgical techniques that greatly reduces complications and operating time and therefore the morbidity of the patient.

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