Piezosurgery-A Review

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Abstract

Piezosurgery is a relatively new technique of bone surgery that is recently gaining popularity in implantology, periodontics and oral surgery. Useful in a variety of oral surgery procedures, piezosurgery has therapeutic features that include a micrometric cut (precise and secure action to limit tissue damage), a selective cut (affecting mineralized tissues, but not surrounding soft tissues) and a clear surgical site. Because of its highly selective and accurate nature, with its cutting effect exclusively targeting hard tissue, its use may be extended to more complex oral surgery cases, as well as to other interdisciplinary problems.

Keywords: *Piezosurgery, ultrasonic device, osteotomy, alveolar splitting, sinus lifting.*

Introduction

Dental surgical techniques have been developed rapidly over the last two decades. Traditionally, osseous surgery has been performed by either manual or motor-driven instruments. Manual instruments offer good control when used to remove small amounts of bone in areas with relatively less dense mineralization. Motor-driven instruments are often used when bone is very dense. Motor-driven instruments transform electric or pneumatic energy into mechanical cutting action using the sharpened edge of burs or saw blades. These instruments generate a significant amount of heat in the cutting zone that must be minimized by water irrigation. Overheating of adjacent tissue may alter or delay the healing response. Reduced rotational speed decreases not only frictional heat but also cutting efficiency. A new surgical technique based on the novel application of the principle of piezoelectric ultrasonic vibration is introduced with wide range of applications in dentistry and periodontics.

It was Pierre Curie who discovered in 1881 piezoelectricity – the phenomenon that gave the basis of piezosurgery, developed in the mid 20th century. Piezoelectricity is found in some crystals that, when subjected to mechanical charges, acquire electric polarization[1]. An ultrasonic transducer is a device used to convert some other type of energy into an ultrasonic vibration. By far the most popular and versatile type of ultrasonic transducer is the piezoelectric crystal, which converts an oscillating electric field applied to the crystal into a mechanical vibration. Piezoelectric crystals include quartz, rochelle salt, and certain types of ceramic. Particular shapes can be chosen for particular applications. Piezoelectric and magnetostrictive transducers also are employed as ultrasonic receivers, picking up an ultrasonic vibration and converting it into an electrical oscillation[2, 3].

Piezoelectric bone surgery techniques have been developed for clinical applications in dentistry and are becoming state of the art for a variety of procedures[4]. Piezosurgery was invented by Vercellotti and developed by Mectron Medical Technology. The device consists of a piezoelectric ultrasound transducer powered by an ultrasonic generator, capable of driving a range of specially designed cutting inserts (Fig.3)[5].

Piezosurgery is a new and modern bone surgery technique for Periodontology and Implantology. Piezosurgery has therapeutic features with several advantages over conventional surgical methods. The technology enables a micrometric cut that is uniquely precise and secure and limits tissue damage, especially to surrounding soft tissues. A selective cut is possible owing to different ultrasonic frequencies and only affects hard (mineralized) tissues, sparing fine anatomical structures. The intra-operative field remains almost free

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of blood. With piezo-electrical surgery techniques, bone harvesting (chips and blocks), crestal bone splitting and sinus floor elevation can be easily and safely performed.

The applications of piezosurgery in dentistry include bone cutting for use in oral surgery; removing supra and subgingival calculus deposits and stains from teeth; scaling and root planing; and retrograde preparation of root canals. Not only does it perform sinus lifts with great precision, but it can also handle ridge augmentation, bone graft harvesting, bone block harvesting, tooth extraction, crown lengthening, root scaling, dentoalveolar surgery (ankylosed tooth extraction, implant surgery and implant site preparation, ridge expansion, bone grafting and root debridement to name a few) plus sinus lifts (lateral and crestal approach).6

Fig. 1 : The Equipment

Fig 2 : Piezosurgery handpiece with a saw-shaped insert while working with the water spray show a contemporary picture of novel piezosurgery principles

Piezoelectric devices typically consist of a handheld device (handpiece)(Fig.1), a base unit and a foot pedal. There are different-shaped inserts that correspond to different applications that can be screwed into the handpiece (Fig.3). The handpiece is controlled by a foot pedal with settings that can be adjusted on the base unit. The first model of piezoelectric devices was developed by Vercellotti et al [7] and is generally called as 'Piezosurgery' in reference to the first model.

MECHANISM OF ACTION OF PIEZOELECTRIC DEVICES:

Following are the innovative qualities of a piezosurgery device: [6]

- Micrometric cutting action for maximum surgical precision and intra-operative sensitivity
- Selective cutting action for minimal damage to soft tissue, maximum safety for the surgeon and the patient.
- Cavitation effect for maximum intra-operative visibility and a blood-free surgical site. (Fig.2)

The following effects are considered as the distinguishing features of piezoelectric surgery: cavitation, heat, formation of bubbles, ultra massage, electrical and acceleration[5]. The cav-itation effect of piezoelectric surgery is crucial in bone surgery. Cavitation is the formation and the immediate implosion of cavities within a liquid (i.e. small liquid-free zones, 'bubbles'). These bubbles are formed as a consequence of the forces that are acting upon a liquid. It typically occurs when a liquid is subjected to a rapid change in pressure, leading to the formation of cavities within the liquid where the pressure is relatively low. In piezoelectric surgery, the cavitation phenomenon describes the process of vapourization, bubble generation and subsequent implosion (growth and collapse of bubbles) into many minute fractions of its original size (microscopic gas bubbles) that will occur in a flowing liquid as a result of the decrease and increase in pressure that is caused by the ultrasonic vibrations. In ultrasonic osteotomy, the cavitation phenomenon helps to maintain good visibility in the operative field by dispersing a coolant fluid as an aerosol that causes the blood to essentially be washed away. Furthermore, the cavitation effect will bring about haemostasis, which results in a bloodless surgery.

Fig 3 : Different sizes and types of piezosurgery inserts can be utilized for intra-oral procedures.

Majewski 8 conducted a study to describe the reconstruction of the alveolar ridge in the esthetic zone with the help of autogenous bone blocks harvested from the chin that were shaped to fit and stabilize at the recipient site. A total of 23 procedures were performed in patients between the ages of 24 and 47 with a clinical observation period of 5 to 7 years. The procedures were performed using piezosurgery, which made it possible to introduce surgical modifications and had a significant impact on the accuracy of the procedure. The procedure was divided into the following stages: preparation of the recipient site, bone block harvesting, stabilization of the bone block at the recipient site, contour modification of the bone block after its stabilization and primary wound closure. Implants were placed 4 months later, after the shape of the regenerated region and the possibility of placing the implant in the proper position were assessed. An observation period of 2 to 7 years showed positive stable results for treatment in terms of function and esthetics.

Schmidt et al [9] conducted a study by presenting various clinical applications of sonic surgical handpiece (SSH) in implant dentistry. The handpiece and the tips were evaluated in various procedures. These included: 1) ridge augmentation; 2) maxillary sinus augmentation; 3) atraumatic tooth extraction; and 4) autogenous bone harvesting. The SSH device was able to make very precise incisions through bone and atraumatically separate teeth from their periodontal ligaments. All of these cases healed uneventfully and successfully. The SSH was able to produce precise atraumatic bony incisions. With the variety of procedures the device can perform, it proved to be of value to any clinician performing surgical implant dentistry.

Kelly and Flanagan [10] conducted a study in 2 patients. This study described an approach to edentulous ridge expansion with the use of piezosurgery and immediate placement of implants. This technique used a piezoelectric device to cut the crestal and proximal facial cortices. Space was then created with motorized osteotomes to widen the split ridge. This technique allows for expansion of narrow, anatomically limiting, atrophic ridges, creating space for immediate implant placement. In this study, the 2 patients had adequate bone height for implant placement but narrow edentulous ridges. In patient 1 at site #11, the ridge crest was 3.12 mm thick and was expanded to accept a 4.3 mm X 13 mm implant. The resulting ridge width was 8.88 mm, which was verified using cone beam computerized tomography (CBCT). In patient 2 at site #8 and site #9, the narrow ridge was expanded using the same technique to accept 2 adjacent 3.5 mm X 14 mm implants. At the end of the study it was seen that the implants were restored to a functional and esthetic outcome.

Gulnahar et al [11] conducted a study to examine the expression of heat shock protein 70 (Hsp70) as a potential biomarker of immediate postoperative stress in patients undergoing two different surgical procedures of different severity. Expression of Hsp70 both at mRNA and at protein level in the conventional group was two-fold higher than that of the piezosurgery group. This suggests that tooth movement by the piezosurgery method causes relatively lower stress in the alveolar bone. Piezosurgery provides relatively low stress to the patients and this may help cell repair after the surgical procedure. Patients undergoing more aggressive surgery using conventional methods showed a significant increase in Hsp70 in the immediate postoperative period.

Piezosurgery allows bone to be cut in a selective and atraumatic manner. Bone, being rigid, is cut easily by the high frequency micro-vibrations of the instrument tips (60 to 200 mm/sec), whereas oral soft tissues (mucosa, neurovascular bundles) are soft and pliable at these same frequencies, which means that they are not harmed even if they come into direct contact with the piezosurgery instruments.

Limitations

There are few limitations. Operating time for osteotomies is slightly longer than with traditional saws, and increasing the working pressure impedes the vibration of devices that transform the vibrational energy into heat, so tissues can be damaged[12,13]. The technique can be difficult to learn.

Conclusion

Thus it can be truly said that during some surgical procedures the piezoelectric device provides a great facility and even to some extent becomes indispensable. The ultrasound unit allows for precise removal of bone with minimal risk of injury to underlying soft tissues. It allows a more successful and more complication-free surgeries.

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