Piezoelectric ultrasonic units have been used to power periodontal scalers and endodontic instruments for many years. In these applications, the rigid nature of calculus and radicular dentine is essential for the effective operation of the instrument as a selective cutting tool. In parallel, shock waves in the fluid environment assists in reducing levels of bacteria, providing a disinfecting action.

Piezosurgery (piezo-electric surgery) is a hard tissue surgical application which can be undertaken using multi-purpose high-end ultrasonic units, employing different settings on the base ultrasonic unit. A critical feature of a piezosurgery unit is the ability to vary the oscillation frequency and the cutting energy. A typical piezoelectric handpiece uses a functional frequency between 25 and 29 kHz, with the possibility of digital modulation up to 30 kHz as a “boost”. Piezosurgery devices are fitted with a cooling irrigation system with 0 to 60 mL/min of variable sterile solution flow. Specific inserts act in a linear vibration pattern, moving over a spatial range between 60 and 210 µm, at an ultrasonic power of up to 16 Watts. Piezosurgery units are some 3 times more powerful than conventional ultrasonic units (5 Watts), which allows them to cut highly mineralized cortical bone. The reduced range and the linearity of the vibrations allow for precise control of cutting.

Examples of contemporary multipurpose base units are the Satalec Newtron (Figure 1) and the Mectron Piezosurgery, which offer a range of applications according to the handpiece and tips used. Multipurpose units can also be used for bone cutting (Figure 2), endosonics, periodontal applications, and implant debridement (Figure 3), offering considerable versatility within the operatory. Instrument tips with abrasive particles can be used for caries removal, and finishing crown and bridge preparations.
Piezosurgery was developed by Italian oral surgeon Tomaso Vercellotti in 1988 to overcome the limits of traditional instruments in oral bone surgery by modifying and improving conventional ultrasonic technology. It uses a modulated ultrasonic frequency to permit highly precise and safe cutting of hard tissue.1 It was first reported for pre-prosthetic surgery, alveolar crest expansion, and sinus grafting.2 Piezosurgery can be used for hard tissue crown lengthening, where a flap is raised to gain full control of the dimensions of the biological width, however the most common uses of piezosurgery are in implant dentistry (Table 1).

It is in these applications that the unique properties of piezosurgery come to the fore. 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. This is perhaps best seen by the example of peeling the shell from a raw egg (a rigid tissue), whilst not damaging the outer shell membrane (the thin membrane located just inside the shell), using first a diamond coated tip to penetrate the shell, and then an inverted cone tip to displace the outer shell membrane (Figures 4, 5 and 7). Blood vessels run through this membrane, and these are not damaged when the rigid overlying shell is removed by brittle fracture. The eggshell procedure has an important parallel to the preparation of a window in the lateral wall of the sinus. The sinus membrane is not perforated even if the piezosurgery tip comes into contact with it. Using a blunt inverted cone tip, the sinus lining can be raised further without risk to the sinus membrane, exactly like the action of peeling the shell from the raw egg and then dislodging the outer shell membrane.

The learning curve for using piezosurgery for this type of application is not impossibly steep. It is important to acquire both adequate dexterity and a gentle touch. To address problems with the speed of cutting during surgery, instead of increasing pressure on the handpiece (as in traditional techniques with burs and saws), 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, and the energy is transformed into heat.6 Thus, the most effective way to use a piezosurgery handpiece is with a higher speed and a lower pressure.

Piezosurgery is accompanied by minimal intra-operative bleeding. Because the method does not traumatize bone thermally, post-surgical wound healing is rapid. In contrast, traditional cutting or drilling osteotomes are relatively crude tools, with rotating instruments capable of producing excessively high temperatures during osseous drilling, resulting in marginal osteonecrosis and impaired bony regeneration.6 Thermal stress with conventional bone cutting methods is a major problem clinically, and for that reason, it is strongly recommended to use careful surgical technique and to limit frictional heating with saline solution irrigation.

This is particularly important when harvesting bone blocks for ridge augmentation. Traditionally, these are harvested using oscillating microsurgical saws, or a surgical handpiece with bone-cutting fissure burs. Using straight and angled piezosurgery tips, block grafts can be harvested with clear visibility of the surgical site, but with minimal risk of damage to adjacent oral soft tissues, and with less loss of bone since the bone cut is smaller in dimension. Using piezosurgery tips, the harvested bone can then be modified and shaped to fit accurately to the recipient site, before being stabilized with a fixa-
the cutting | EDGE

Collection of particulate bone with a piezosurgical unit and a bone trap is an effective means for obtaining a quantity of autogenous bone sufficient for correction of localised defects during oral surgery.\(^5\)

Histomorphometric evaluation of collected bone chips has shown average dimensions of bone chips from a Mectron Piezo-surgery\(^6\) unit were 1451.649 µm x 460.26 µm, with the largest bone chip measuring 6034 µm x 1125.7 µm, and the smallest 73.12 µm x 29.9 µm. Of interest, even though the diameter of the pores in the bone trap was 300 µm, bone chips of smaller dimensions (approximately 70 µm) were trapped in the filter mesh. In fact, the pore dimensions of the mesh do not in themselves ensure that the bone particles collected are homogeneous in size. This reported size distribution is important since a dimension smaller than 200 µm may lead to overly rapid resorption of fragments, which does not guarantee sufficient osteoconductive capacity for the new bone formation process in the receiving site. On the contrary, bone fragments greater than 1000 µm in dimension require longer healing times.

It appears likely that the presence of bone chips with varied dimensions combines the advantages of the bone being subjected to early remodelling (small-sized chips), and the mechanical support provided by the larger particles, which undergo slower remodelling and serve as a scaffold for new bone formation in the grafting site.\(^4^5\)

A recent (2007) study provided strong evidence of the advantageous of piezosurgery for bone cutting, in this case in major maxillofacial procedures rather than in in-office dental implant procedures. In this French study, an ultrasonic device (Mectron) was used to perform 144 Le Fort I osteotomies, 140 palatal expansions after Le Fort I osteotomies, 134 bilateral sagittal osteotomies, 5 segmental osteotomies, 3 osteotomies of the inferior edge of the mandible for facial asymmetry; 2 cases of cortical calvarial bone grafting, 20 cases of removing the superior orbital roof, and 10 cases of removing the external wall of the orbit or the anterior and posterior wall of the frontal sinuses. In these craniofacial surgical procedures, piezosurgery allowed very precise cutting, avoided bone cutting using an osteotome; spared soft tissues (brain, dura-mater, palatal mucosa, and the inferior alveolar nerve). Importantly, the time taken to cut bone increased but not the overall operating time, because there was no requirement for soft tissue protection.\(^4^\) This has been confirmed in other studies.\(^2^3^8\)

With their variable frequency and variable power, multipurpose piezosurgery units are a platform for a range of applications in minimally invasive caries therapy, prosthodontics (Figure 6), periodontology, and endodontics (Figure 8), making such a unit a highly effective tool in clinical practice.

References

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