ABSTRACT

Dentistry, an art in science and tranquilizer in medicine, has seen a lot of changing concepts over a decade. To overcome the limitations of traditional tools, researchers have come up with advanced therapeutic devices and one such novel innovation is piezosurgery. Piezosurgery is a true revolution in bone surgery as it fulfils both biological and technical criteria. It is a sophisticated ultrasonic device introduced by Dr. Tomaso Vercellotti. It has a variety of applications ranging from minor surgical procedures to complex Implantology, plastic and reconstructive surgeries. Piezosurgery uses a low frequency modulated ultrasonic insert which produces micro vibrations in the range of 60-200 micro meter/sec and leads to safe and precise bony incision without damaging underlying vital structures like nerves, mucosa and vessels. It overcomes technical difficulties such as visibility by producing bloodless field during surgery and removes debris simultaneously through internal irrigation mechanism.

INTRODUCTION

In dentistry a lot of dramatic advancement has occurred over the years\textsuperscript{1-4}. Latest diagnostic imaging techniques like ultrasonography, cone beam computed tomography and procedures like microsurgery, implants, lasers and nanotechnology
have made dentistry, as one of the front runners in medical fraternity. The success of any treatment modality in dentistry depends upon the tools by which the treatment is being carried out, tools as in hard tissue cutting tools, such as micromotor handpiece, air rotor handpiece which remove enamel, dentin, cementum as well as bone. The amount and quality of hard tissue removal determines the post-operative outcome of any dental surgical procedure, be it Implantology or Periodontology. Treatment efficiency is one of the goals of every practitioner and in this regard ultrasound has been used for many years in periodontics to remove tartar, debride root surfaces, and to degranulate periodontal defects. Osseous surgery can be performed by either manual, motor-driven instruments, or ultrasonic devices. Manual instruments offer good control when used to remove small amounts of bone in areas with relatively less dense mineralization. However, manual instruments are difficult to control in order to achieve precise cutting in cortical bone, which is better performed by motor-driven instruments or ultrasonic devices. 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 and decrease tactile sensitivity. This is particularly troublesome when cutting across an area of dense cortical bone into either trabecular bone or soft tissue, as when drilling an osteotomy above the mandibular canal or preparing a lateral window for sinus grafting. To overcome the limitations of traditional tools, researchers have come up with advanced therapeutic devices which use the principle of ultrasonic micro vibrations to make precise and selective cut on the bone in harmony with the surrounding tissues. In the last decade a novel family of ultrasonic powered devices has been developed that is revolutionizing maxillofacial bone surgery. The instruments used for ultrasonic cutting of bone create micro vibrations that are caused by the piezoelectric effect first described by the French physicists Jean and Marie Curie, in 1880. Ultrasound is an oscillating sound pressure wave with a frequency greater than the upper limit of the human hearing range, which is 20 kHz (kilohertz). The range of frequencies employed in the original ultrasonic units was between 25 and 40 kHz (kilohertz). Two rudimental ways of ultrasound production are used in dentistry; magnetostriction and piezoelectric manipulation. Magnetostriction converts electromagnetic energy into mechanical energy by virtue of vibrations in magnetostrictive metal strips produced via an alternating magnetic field. Magnetostriction has tips that move in a figure eight (elliptical) motion, which is less desirable for surgical use. Piezoelectric surgery, also simply known as piezosurgery, is an osseous surgical technique first described by Vercellotti (2004) utilizing an innovative ultrasonic surgical apparatus, known as the Mectron piezosurgery device. Piezosurgery was developed in response to the need to reach major levels of precision and intra-operative safety in bone surgery, as compared to that available by the traditional manual and motorized bone cutting instruments. The piezosurgery device is basically an ultrasound machine with modulated frequency and a controlled tip vibration range. The ultrasonic frequency is modulated from 10, 30, and 60 cycles/s (Hz) to 29 kHz. The low frequency permits highly precise and safe hard tissue cutting.
EQUIPMENT DESIGN

The piezosurgery unit is composed of the main body, activated with a pedal, a handle, and number of inserts with different shapes depending on the surgical need.

Main Body

The main body has a display, an electronic touchpad, a peristaltic pump, one stand for the handle and another to hold the bag containing irrigation fluid. The interactive touchpad has four keys that enable to select the feature mode, the specific program and the flow of the flowing cooling liquid. Every command is shown on the display.

There are two primary operating modes:

a. Bone Mode
b. Root Mode

Root Mode

The vibrations generated by selecting root mode are characterized by average ultrasonic power without frequency over modulation.

Two different programs:

a. ENDO Program: a limited level of power provided by applying reduced electrical tension to the transducer, which generates insert oscillation by a few microns. These mechanical micro vibrations are optimal for washing out the apical part of the root canal in endodontic surgery.

b. PERIO Program: an intermediate level of power between the endo program and the bone program. The ultrasonic wave is transmitted through the transducer in continuous sinusoidal manner characterized by a frequency equal to the resonance frequency of the insert used.

Bone Mode

The vibrations generated by selecting bone mode are characterized as follows: extremely high ultrasonic power compared to root mode. Its performance is monitored by several sophisticated software and hardware controls. Frequency over modulation gives the ultrasonic mechanical vibrations its unique nature for cutting different kinds of bone.

The selection recommended is:

- Quality 1: for cutting the cortical bone or high density spongy bone.
- Quality 3: for cutting low density spongy bone.

Special Program: was designed with a standard power level slightly lower than the bone programs and is characterized by the same frequency over modulation. The special program is dedicated to a limited series of surgical inserts that are particularly thin and delicate. The latter are recommended only for surgeons who have experience using piezosurgery and would like an extremely thin and effective cut.

Handle

The cutting action is based on the generation of ultrasonic waves by piezoelectric ceramic disks inside. These ceramic plates are subjected to an electrical field produced by an external generator and vary their volume to generate ultrasonic vibrations. These are channeled into the amplifier, which transmits them to the sharp end of the
handle. The insert is tightened with a special key for that purpose. In this manner, the highest degree of efficiency is obtained for the cut and duration of the inserts.

Inserts

The design and features of all inserts used in Piezoelectric Bone Surgery have been conceived and developed by the Mectron Medical Technology. The prototype of each specific insert was developed to satisfy the specific clinical needs of each surgical technique. The inserts have been defined and organized according to a dual classification system, taking into consideration morphological-functional and clinical factors. This system helps understand the cutting characteristics and clinical instructions for each insert.

MECHANISM OF ACTION

'Piezo' the term is derived from 'piezein' meaning pressure in Greek language. Piezosurgery works on the principle of 'Pressure Electrification', meaning when electric tension is applied across certain materials, the material in question expands and contracts, thus producing ultrasonic vibrations. Materials used here are piezoelectrical crystals which generally include quartz, Rochelle salt and certain types of ceramic. When these crystals are subjected to an electrical charge, they expand and contract alternately to produce ultrasonic waves. Since these ultrasonic waves are mechanical in nature, they can induce disorganization and fragmentation of different bodies. The ultrasonic waves can allow segmentation of interfaces from solid to solid by means of distinct vibration, and solid-liquid by means of cavitation. In dentistry these two phenomena are used.

The term cavitation describes the process of vaporization, bubble formation and subsequent implosion into many fractions of its original size that occurs due to decrease in pressure as a result of ultrasonic vibration. When pressure increases, the voids implode and can generate an intense shockwave. The cavitation effect necessitates low vapor pressure of the oscillating tip. This effect maintains bone temperature, washes away debris, regulates homeostasis and clears the field by the bursting of water bubbles under high pressure. This causes erosion and cleaning of the osseous crest. Hence forth increases visibility and ease of operation.

In addition cavitation also illustrates an antibacterial property which helps in obtaining high predictability and low morbidity in bone surgery. The antibacterial property is attributed to the fragmentation of bacterial cell wall.

APPLICATIONS IN DENTISTRY

1. Tooth extraction
2. Maxillary sinus elevation
3. Bone grafting
4. TMJ ankylosis
5. Alveolar nerve transposition
6. Crown lengthening
7. Ridge expansion
8. Implantology
9. Orthodontic microsurgery
GENERAL APPLICATIONS

1. Otological surgery
2. Neurosurgery
3. Orthopedic and hand surgery

ADVANTAGES

1. Precise cutting and safety
2. Great control of the surgical device
3. Bleeding-free surgery site
4. Faster bone regeneration and healing process
5. No risk of emphysema

DISADVANTAGES

1. Initial investment
2. Increased operation time that is required for bone preparation.

CONCLUSION

Piezosurgery is a relatively new surgical technique for Periodontology and Implantology that can be used to complement traditional oral surgical procedures, and in some cases, replace traditional procedures. This invention of Dr. Tomaso Vercelloti though has few limitations of its own has helped surgeons overcome the limits of precision and safety of traditional bone cutting instruments. It has helped surgeons make the results of bone surgery more predictable, has improved healing, minimized the trauma and provided greater safety for patients.

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