Multidirectional geometry of piezosonic cutting blade: Technical note

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ABSTRACT

Introduction: The principle of piezosurgery is electrification by pressure. When electrical voltage is applied to certain materials, such as quartz and Rochelle salts, it causes the materials to expand and contract, producing ultrasonic vibrations. This device uses ultrasonic vibrations of 60-210µm/s at 24-36kHz to selectively remove bone, with minimal damage to soft tissue such as blood vessels and nerves. It also provides excellent visibility due to its cavitation effect. Piezosurgery uses low-frequency ultrasonic vibration for osteotomies, minimizing the risk of damage to soft tissues (nerves, vessels and mucosa). Micrometric vibration ensures precise cutting action and allows operational control, increasing safety in anatomical areas that are difficult to access. **Objective:** The objective of this article is to present an ultrasonic tip geometry capable of providing a smaller contact area, less effort, reduced heat generation, faster cutting and shorter surgical time.

Keywords: Piezosurgery. Ultrasonic device. Osteotomy.

Introduction

Piezosurgery was first used in oral and maxillofacial surgeries by Vercellotti et al.[1], who aimed to simplify the maxillary sinus surgery by avoiding perforation of the Schneider membrane. Recently, ultrasonic bone cutting has been used in procedures such as orthognathic surgeries,[2-10] extraction of impacted third molars,[11] corticotomy-assisted orthodontics,[12] preparation of implant sites,[13-15] treatment of temporomandibular disorders,[15] cyst enucleation[16,17] and reconstructive head and neck surgeries[18]. Piezosurgery uses low-frequency ultrasonic vibration for osteotomy, minimizing the risk of injury to soft tissues (nerves, blood vessels, and mucosa).[1,5,6] Micrometric vibration ensures precise cutting action and allows surgical control, increasing safety in anatomical areas that are difficult to access.[1]

The principle of piezosurgery is electrification by pressure. When an electrical voltage is applied to some materials, such as quartz and Rochelle salts, these materials expand and contract, generating ultrasonic vibrations. This device uses ultrasonic vibrations of 60-210 μm/s at 24-36 kHz to selectively remove bone, with minimal damage to soft tissues, such as blood vessels and nerves. It also offers excellent visibility, due to its cavitation effect.[5,10,19,20]

The use of ultrasonic tips has brought great benefits to osteotomy procedures in oral and maxillofacial surgeries, when compared to conventional saws. One of the main advantages is lower heat generation, reducing the possibility of bone necrosis and increasing the surgical safety and predictability. However, ultrasonic tips with straight tooth geometry still present limitations.

Therefore, this paper presents a tip geometry design that provides a smaller contact area, less effort, less heat generation, faster cutting, reduced surgical time, better postoperative care, elimination of bone debris and less wear on the motor and handpiece, to optimize osteotomies in procedures in the areas of Oral and Maxillofacial Surgery, Orthopedics, Neurosurgery and Otolaryngology.

Geometry

BYPRO Medical do Brasil has proposed a new cutting geometry for ultrasonic tips, called CROSSonic™. This consists of an angled and multidirectional tooth geometry, alternating the angulation to the right and left in the active part of the tip. This geometry has a circular shape at the end, combined with a flat geometry, a straight and flat segment, a curved cylindrical shaft, a truncated segment, a cylindrical segment with flattening, and a cylindrical segment with internal thread, as illustrated in Figures 1A and 1B. This differs from the conventional piezoelectric tip, which has straight teeth, as shown in Figures 1C and 1D.

The creation of a new tip includes the geometry of angular and multidirectional teeth present in a piece that presents a design composed of a circular surface at its end (Fig 2), combined with a flat geometry (Fig 3). The differentiated teeth in a piece with this combination (straight and flat surface) is the main objective of this development.

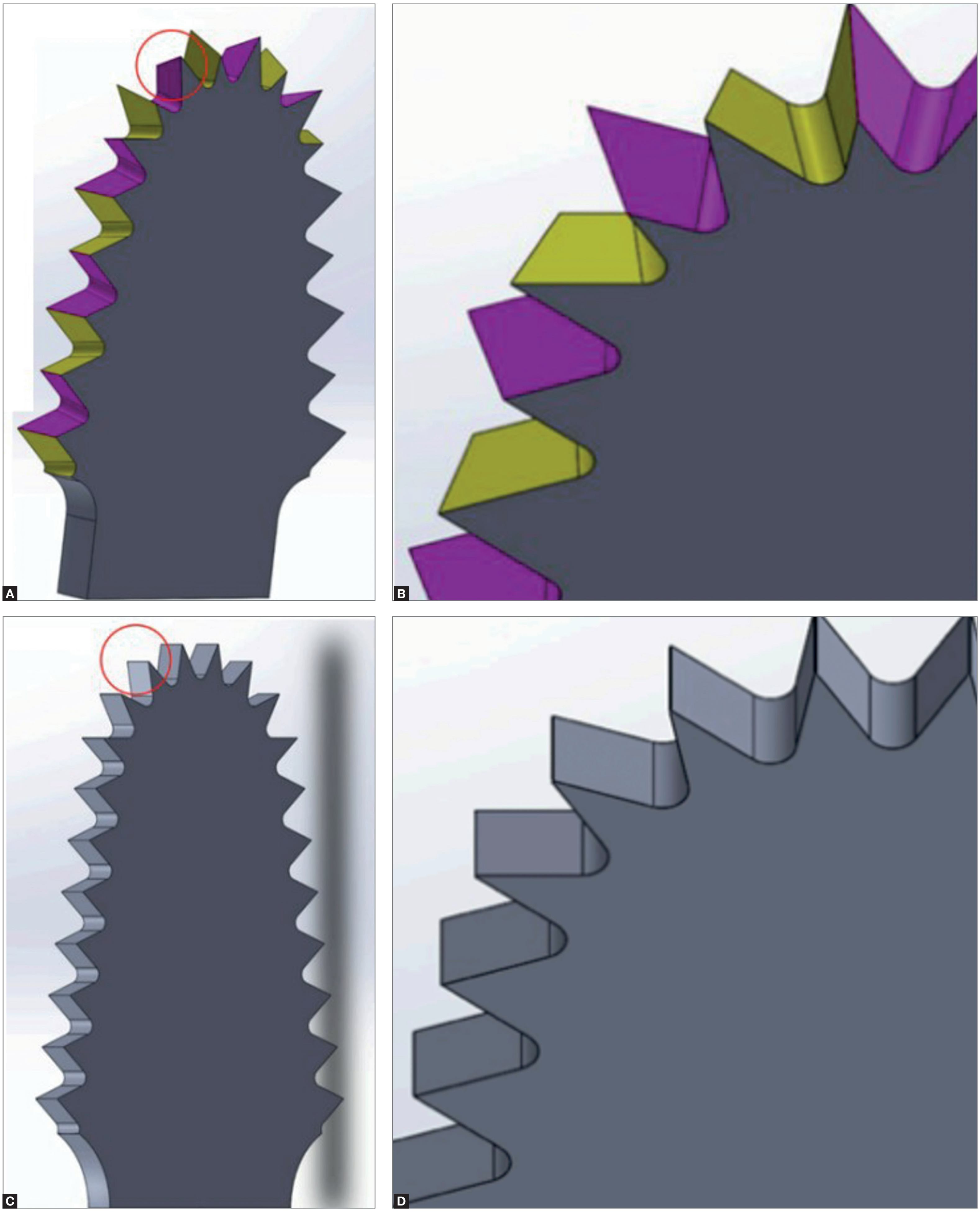

Figure 1. A) Blade with angled and multidirectional teeth (CROSSonic®, BYPRO Medical do Brasil). **B)** Angled and multidirectional teeth at greater magnification (CROSSonic®, BYPRO Medical do Brasil). **C)** Conventional straight tip. **D)** Greater magnification of tip with conventional teeth.

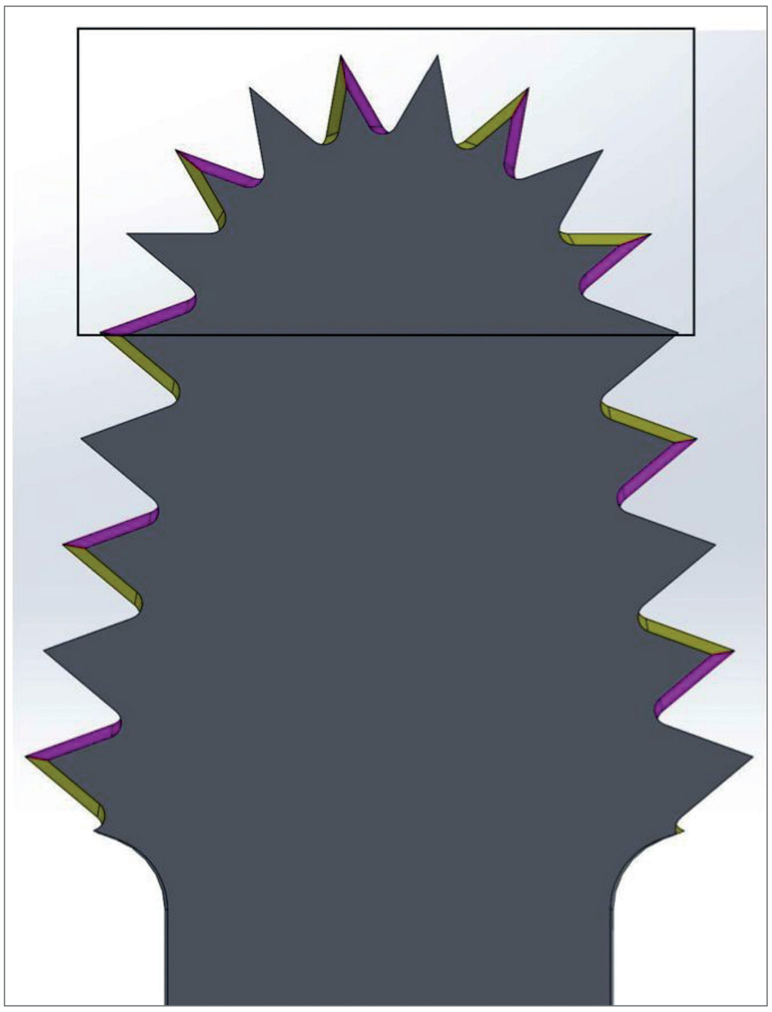

Figure 2. Flat surface of the piezo tip.

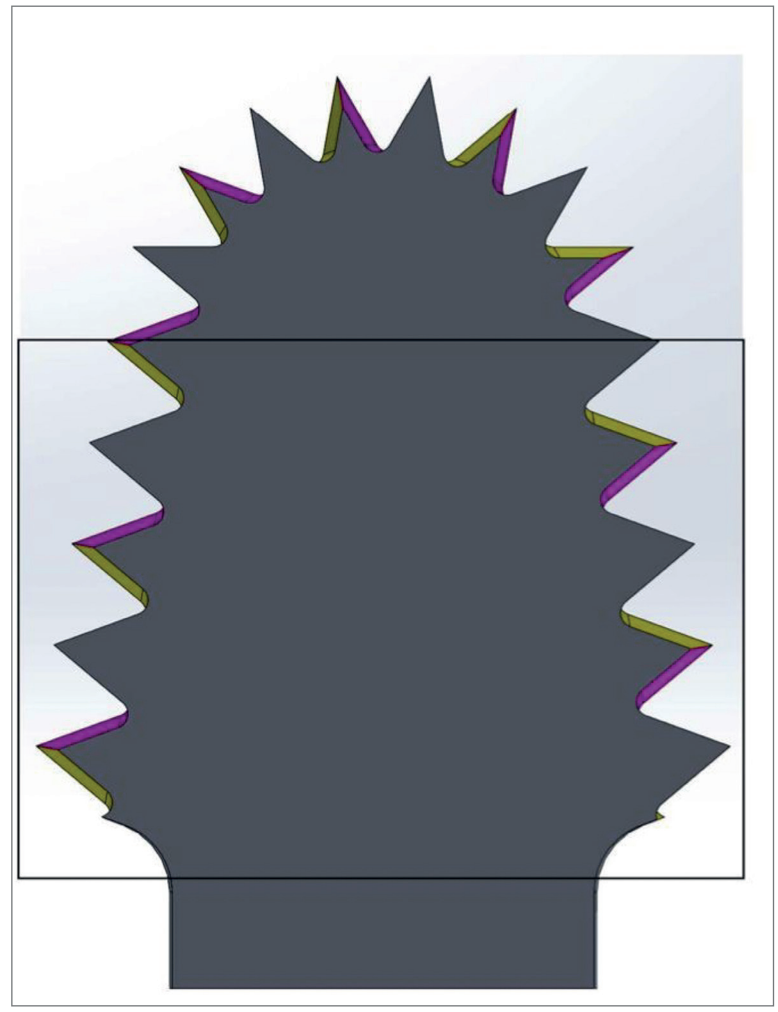

Figure 3. Circular surface of the piezo tip.

With the increasing demand for efficiency in osteotomy procedures, the choice of the type of ultrasonic tip is crucial to optimize productivity and reduce costs. The objective of this technical note was to analyze the technical superiority of the ultrasonic tip with angled and multidirectional teeth, compared to the ultrasonic tip with conventional parallel teeth, based on a pilot test.

The ultrasonic tip herein demonstrated has a cutting geometry with angled and multidirectional teeth. This configuration reduces the contact area between the ultrasonic tip and bone, reducing the cutting effort and, consequently, the heat generated during osteotomies in oral and maxillofacial, neurosurgical, head and neck and orthopedic procedures, details that are crucial to avoid bone necrosis. The multidirectional geometry makes the osteotomy more favorable and requires less mechanical force and time due to the reduction in friction, which increases the surgeon's precision and dexterity. The advantages of the CROSSonic™ ultrasonic tip design over conventional tips include:

1. Smaller contact area: provides a reduced contact area with bone during osteotomy, resulting in less friction and pressure during the procedure.
2. Reduced effort: the force distribution in the procedure is multidirectional, resulting in less effort. This can reduce the surgeon's fatigue and provide a more comfortable experience during surgery, besides reducing the risk of blade fracture.
3. Lower heat generation: the smaller contact area and more efficient cutting of the multidirectional teeth result in less heat generation during osteotomy.
4. Faster cutting: the multidirectional shape of teeth allows faster and more efficient cuts compared to traditional teeth.
5. Reduced surgical time: due to the greater speed and efficiency of cutting.
6. Elimination of bone debris: the angular and multidirectional tooth geometry favors the elimination of bone debris resulting from osteotomy, promoting a smoother cut and preserving bone tissue.
7. Less wear on the motor and handpiece: all these benefits contribute to reduce the wear on the motor and handpiece of the surgical unit, increasing the lifetime of the equipment and reducing the need for maintenance.

The piezoelectric blade has been used in oral and maxillofacial surgeries for over 20 years, and several types and shapes provided by different manufacturers are available on the market. To date, the literature describes different blade formats, but there is no knowledge of changes in the direction of teeth.

A frequent criticism by many authors in relation to the piezoelectric blade is the technical difficulty of learning, which presents a slow learning curve[1,3,21,22]. One study revealed that, after a period of two years, surgical times were reduced by approximately 20% with the regular use of ultrasonic surgery[3]. The multidirectional geometry also facilitates osteotomy from a technical standpoint and, due to the reduction of friction, requires less mechanical force and time, increasing the surgeon's precision and dexterity. Consequently, this can reduce the surgeon’s fatigue, provide a faster learning curve and decrease the chance of blade fracture, although piezosurgery is considered slower compared to other osteotomy methods, especially when learning the technique[23].

A study comparing procedure time for craniotomies showed a mean time of one hour and ten minutes using a piezoelectric saw, compared to a mean time of 43 minutes using a craniotome[3]. A clinical study for hallux valgus correction showed an osteotomy time of three minutes using an oscillating saw and ten minutes using a piezoelectric blade[23]. The piezoelectric saw blade is already irrigated with saline solution to control the temperature. However, cases of overheating and bone necrosis may occur due to the procedure duration.[21] It is believed that the multidirectional shape of teeth would allow for faster and more efficient cutting compared to traditional teeth, which would result in less heat generation during osteotomy. The speed of osteotomy and costs are the main limitations of piezoelectric surgery. All features and advantages of angled and multidirectional geometry can reduce problems in the motor and handpiece, resulting in longer equipment life and less need for maintenance, indirectly reducing costs.

Studies in the literature often compare oscillating saws, in different osteotomy methods, with piezoelectric saws[3,10,23,24]. One study compared three piezoelectric tips from different manufacturers, but with the same characteristics and tooth shape, reporting better performance in one of the tips and minimum temperature difference between them.[25]

Another study compared different piezoelectric tips, maintaining the straight shape of teeth, to perform osteotomies and osteoplasties in pig mandibles heated to 36°C. The methodology used temperature sensors positioned 3 mm deep and 1 mm away from the work site, while osteotomies were performed with Piezosurgery 3 saw (Mectron) and cooled with Ringer solution. The variation in intraosseous temperature was significant between the different tips, with maximum peaks above 47°C for short periods, not exceeding 29 seconds.[26]

Preliminary tests comparing the new multi-angled blade geometry with straight-tooth blades indicate a clear advantage for the ultrasonic tip with angled and multidirectional tooth design, in several performance metrics, when compared to the traditional piezoelectric blade. Superior cutting efficiency may result in greater productivity and shorter surgical times, thus enabling the cutting of stronger/longer bones. New larger blade formats and their use in other specialties, such as Orthopedics, may be a next step towards the geometric evolution of piezo tips.

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