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Piezoelectric ultrasonic bone surgery system in the extraction surgery of supernumerary teeth

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ABSTRACT

Introduction: The anterior maxillary region is a common site for supernumerary teeth. The aim of this study was to compare the use of piezoelectric ultrasonic bone surgery for the extraction of supernumerary teeth and the use of traditional method using bone chisels.
Methods: 60 patients with supernumerary anterior maxillary teeth were considered in this study. They were randomly divided into two groups: 1) the control group, in which the supernumerary teeth were extracted using the traditional bone chisels method; 2) the experimental group, in which the supernumerary teeth were extracted using a piezoelectric ultrasonic bone surgery system. The operative time, amount of bleeding and post-operative pain were quantified and compared; in addition, the post-operative swelling was evaluated.
Results: We observed a significant decrease ($P < 0.01$) in the amount of bleeding and post-operative pain in the experimental group respect to the control group; but the operative time was significantly increased ($P < 0.01$) with the use of piezoelectric system. In addition, post-operative swelling resolved more quickly in the experimental group.
Conclusion: Although the operative time for the extraction of the maxillary anterior supernumerary teeth was longer using the piezoelectric ultrasonic bone surgery system, the amount of bleeding and the post-operative complications were less, so this system could be considered an appropriate surgical method for the extraction of supernumerary teeth.

1. Introduction

Hyperdontia or supernumerary teeth are defined as teeth formed in excess of the normal dental formula of 20 deciduous and 32 permanent teeth.
The aetiology of supernumerary teeth is not completely understood. Several theories have been suggested, such as the phylogenetic theory, the dichotomy theory, hyperactive dental lamina or a combination of both genetic and environmental factors have been considered (Shah et al., 2008; Parolia et al., 2011). They are associated with many syndromes, such as Cleidocranial dysplasia, Gardner's syndrome, the Ehler–Danlos syndrome, the Apert syndrome, Down syndrome and developmental disorders, such as clef and lip palate and Chondroectodermal dysostosis (Akgun et al., 2013; Kumar and Gopal, 2013; Tuna et al., 2013).

Supernumerary teeth may occur either in the maxilla, mandible or in both the jaws with a predilection for the premaxilla (Amarlal and Muthu, 2013) and they are more frequently found in permanent dentition with a male predilection (Kumar and Gopal, 2013). They can be single or multiple, unilateral or bilateral, malformed morphologically or normal in size and shape, and erupted or impacted. Consequently they may be classified based on chronology (pre-deciduous, and post-permanent or complementary), form (conical type, tuberculate type, supplemental type, odontome), position in the dental arch (mesiodens, paramolar, distomolar, parapremolar) and orientation (vertical, inverted and transverse) (Parolia et al., 2011; Akgun et al., 2013). Conically shaped supernumerary teeth situated between the maxillary central incisors are

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the most common type in the permanent dentition; the second common supernumerary tooth is the maxillary fourth molar, whereas the most common supernumerary teeth in primary dentition is the maxillary lateral incisors (Nallanchakrava, 2011).

Most of the supernumerary teeth are asymptomatic. However, they often affect the replacement of deciduous teeth, leading to delay or failure of eruption of permanent teeth, malocclusion, displacement, crowding, root anomaly, root resorption, loss of vitality of adjacent teeth, subacute pericoronitis, gingival inflammation, periodontal abscesses, dental caries, failure of orthodontic treatment and pathological problems, such as dentigerous cyst formation, ameloblastomas, odontomas and fistulae (Akgun et al., 2013; Parolia et al., 2011). When these complications are present, surgical removal followed by orthodontic treatment is indicated. The traditional way to extract supernumerary teeth is with an osteotome or bone drill for bone fenestration (Qiu, 2008). The shortcomings of the traditional way are the trauma for bone and soft tissues and damage to the adjacent teeth and other anatomical structures. The piezoelectric ultrasonic bone surgery system ensures high accuracy and safety in surgical procedures, and it has been widely used in the shaping of bone and bone-cutting surgery. Recently, it has been applied in the field of oral surgery, in particular, for oral and maxillofacial surgery (Rullo et al., 2013; Pappalardo and Guarneri, in press). In this paper, a piezoelectric ultrasonic bone surgery system was compared to the use of bone chisels for the extraction of anterior maxillary supernumerary teeth in a randomized clinical study.

2. Materials and method

2.1. Patient selection and study design

This study followed a protocol in compliance with the World Medical Association Declaration of Helsinki on medical research protocols and ethic. The study was conducted in the Ninth People's Hospital of Shenzhen by the Oral and Maxillofacial Surgery department between August 2009 to August 2012. 35 males and 25 females (mean age 29 ± 6.58 years, range 12–50 years) were selected and 116 maxillary anterior supernumerary teeth were considered. Criteria (inclusion and exclusion) for patient selection were: (a) the presence of impacted maxillary anterior supernumerary teeth, including teeth that may affect replacement of deciduous teeth; (b) forceps extractions not requiring osteotomy were excluded; (c) no systemic diseases; (d) age range from 12 to 50 years old; (e) non-smoker; (f) not pregnant; (g) no allergy to penicillin or other drugs used in the standardized post-operative therapy. Informed consent was obtained for all patients. The patients were randomly divided into two groups: the control group ($N = 30$, 15 males and 15 females), in which 58 supernumerary teeth were extracted using traditional bone chisels methods and the experimental group ($N = 30$, 20 males and 10 females), in which 58 supernumerary teeth were extracted using a piezoelectric ultrasonic bone surgery system. None of the patients had contraindications to tooth extraction. A balancing test was carried out on the patient's age and gender and showed that there was no statistical difference between the two groups ($P < 0.05$).

2.2. Surgical instruments

In the experimental group, we used a piezoelectric ultrasonic bone surgery system, Surgybone (Silfradent, Italy): power source 230 V-50/60 Hz, nominal power consumption 170 VA, maximum vibration 200 micron, ultrasound frequency 25–35 Hz and Hydraulic circuit capacity 0–50 ml/min; the working head number SB0600 was used for bone cutting and for extracting the supernumerary teeth; SBP0911 was used for fenestration because of its high cutting efficiency; SBP0710 and SBP0720 were used for cutting bone in deep surgical areas because of its curved working head (Fig. 1A and Fig. 1B). A multifunctional aspirator, which is patented by the Authors in China (No. 201020232094.2) was used to aspirate saliva, blood and cooling water for improving the clarity of the surgical field (Jiang et al., 2011a). In the control group, we used bone chisels made by Shanghai Kangqiao Dental Instruments Factory, with 3 kinds of working heads, including 048-1243, 048-1443 and 048-1543 (Fig. 1C).

2.3. Surgical procedures

The supernumerary tooth was examined with Cone-beam CT (Planmeca Promax 3D, Finland). The tooth size, its direction (three-dimensional position), as well as its distance from the adjacent teeth and other close critical anatomical structures, were recorded (Fig. 2). The lip and palatal bone thickness around the supernumerary tooth was measured and the surgical approach was decided on. All patients were treated under general anaesthesia because the supernumerary teeth were so deep. The choice of the surgical procedure depended on the position of the supernumerary tooth. If the diseased tooth was on the buccal, a curved or trapezoidal para-marginal incision of the labial side was chosen, whereas if the diseased tooth was in on the palatal side, a curved para-marginal incision of palatal side was chosen. After the incision, the muco-periosteal flap was turned over and saliva, blood and cooling water were aspirated by a modified aspirator, to keep the visibility of the surgical field.

In the experimental group, the piezoelectric system was used for bone fenestration and to remove the free bone block completely (Fig. 3A and Fig. 3B). The supernumerary tooth was exposed, the bone mass around the supernumerary tooth was removed and the tooth was elevated with a dental elevator and removed (Fig. 3C and D). The margin of bone window was trimmed. For small bone window, it was filled with blood clot after washing with normal saline; for large bone window, the free bone

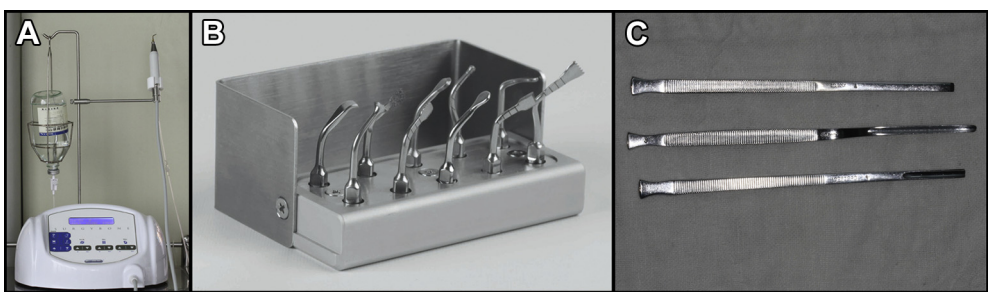

Fig. 1. A) Piezoelectric ultrasonic bone surgery system Surgybone and B) Working head for Surgybone; C) bone chisels, with 3 kinds of working heads.

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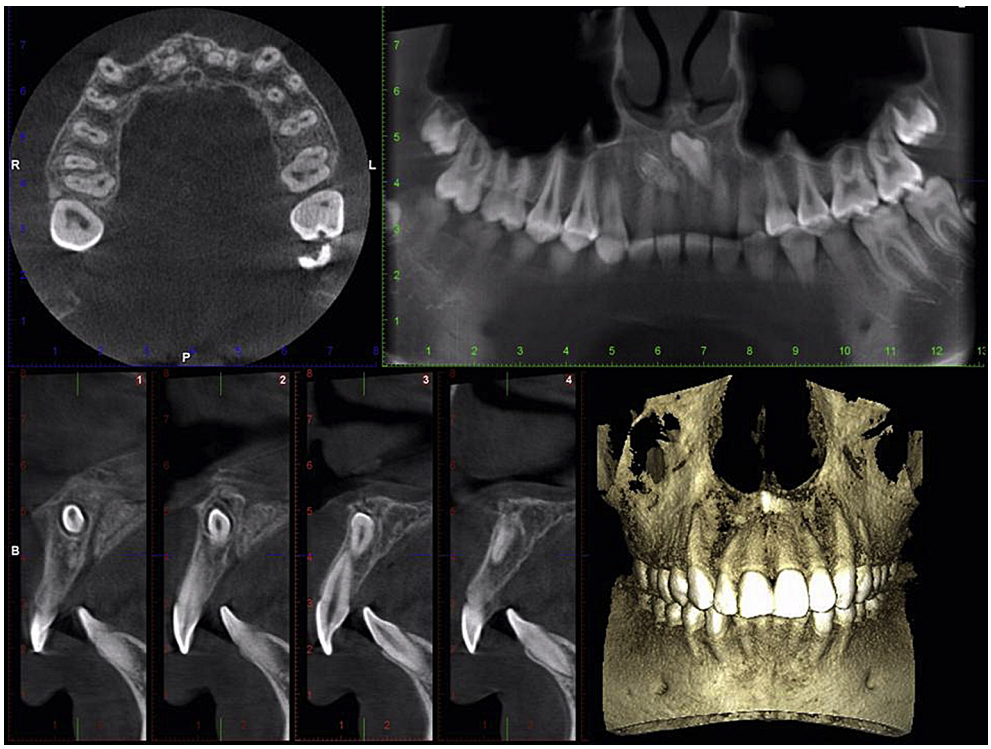

Fig. 2. Three-dimensional location of the supernumerary tooth with CBCT (Cone Beam Computed Tomography).

block was relocated and fixed with a titanium mini-plate (Fig. 3E). Finally, the mucoperiosteal flap was sutured in tight alignment (Fig. 3F).

In the control group, bone chisels and mallets were used for fenestration. The supernumerary tooth was elevated with an elevator and removed; the bone cavity was curettaged and the margin was finished with osteotribe. For small bone window, it was filled with blood clot after washing with normal saline; for large bone window, it was filled with gelfoam; finally, the mucoperiosteal flap was sutured in tight alignment (Fig. 4).

2.4. Index evaluation

To compare the Surgybone with the traditional bone chisels method, we analyzed the following indexes/parameters:

- the operative time (from starting incision to wound closure);
- the amount of bleeding (corresponding to the subtraction of normal saline from total fluid content in the aspirator);
- the post-operative pain, according to visual analogue scale pain score (Table 1);
- other post-operative complications (the post-operative swelling, damage adjacent teeth, root fracture, penetrating nasal floor or maxillary sinus, etc.).

2.5. Statistical analysis

Statistical analysis was performed using SPSS 18.0 software. Two independent samples *t*-Test was used to compare the operative time, the amount of bleeding and the post-operative pain between

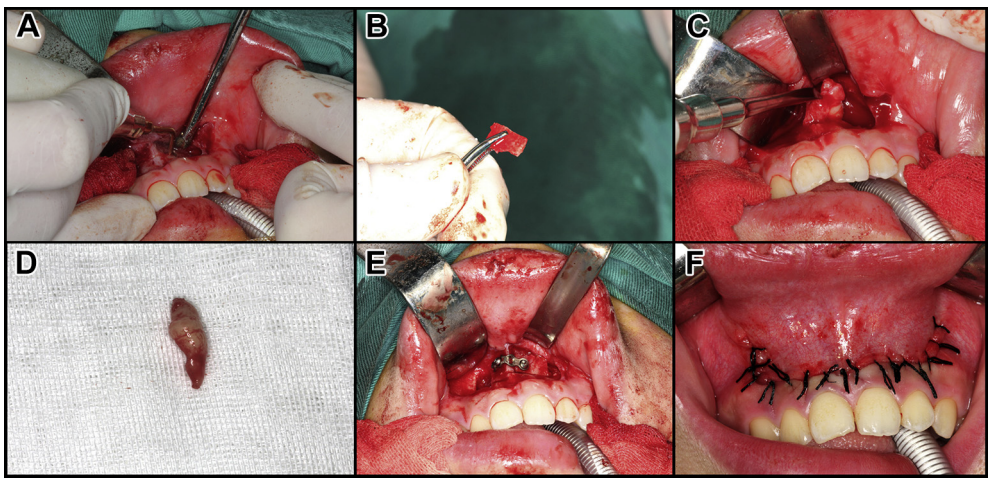

Fig. 3. A) Application of ultrasonic bone surgery system Surgybone in bone fenestration in combination with a multifunctional aspirator; B) removal of a complete free bone block; C) the diseased tooth was elevated with a dental elevator; D) a complete tooth was pulled out; E) the free bone block was re-located and fixed; F) suture was made.

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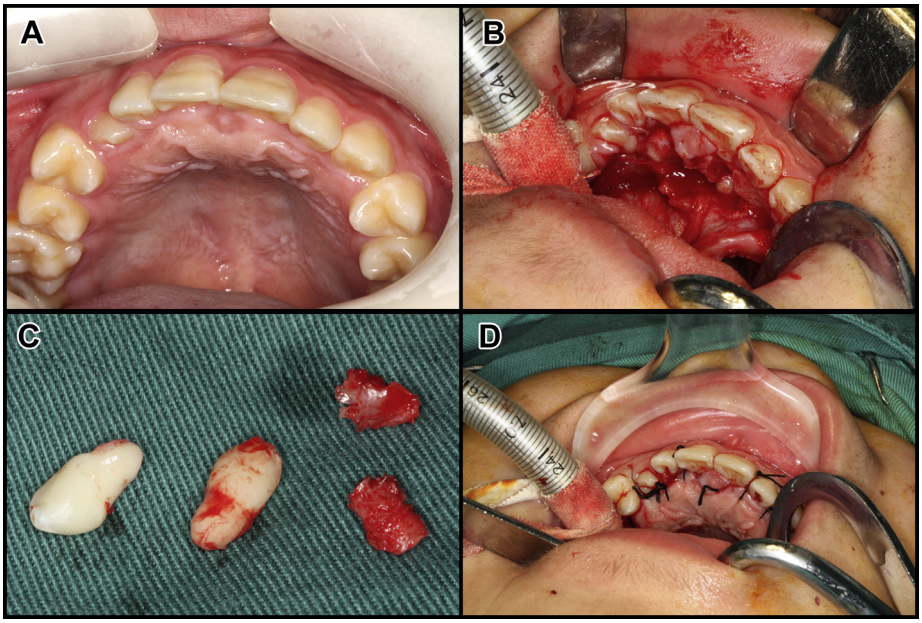

Fig. 4. A) Pre-surgery; B) palatal bone above the supernumerary teeth was removed by bone chisels and a mallet and the supernumerary teeth were exposed; C) the complete teeth were pulled out; D) suture was made.

the two groups. In addition, post-operative pain was compared using Chi-square test.

3. Results

The total number of maxillary anterior supernumerary teeth was 116 among the 60 patients. Majority of supernumerary teeth were mixed (63.79%), whereas the number of permanent teeth (28.45%) and deciduous teeth (7.76%) were lower. Malformed maxillary anterior supernumerary (67.24%) were more than normal shaped teeth (32.76%). Moreover, different orientation of teeth was observed: vertical orientation (43.1%), inverted teeth (18.97%) and transverse teeth (37.93%) (Table 2).

Operative time, amount of bleeding and the VAS value were significantly different between the two groups (Table 3 and Fig. 5). In particular, the operative time was longer in the experimental group than in control group (57.03 ± 2.67 vs 50.83 ± 2.73, $P < 0.01$); the amount of bleeding in the experimental group was less than in the control group (19.03 ± 3.29 vs 21.23 ± 2.59, $P < 0.01$); the post-operative pain (VAS value) was lower in the experimental group than in control group (2.36 ± 1.29 vs 4.56 ± 1.16, $P < 0.01$). In addition, the post-operative swelling resolved earlier in the experimental group. There were no post-operative complications.

4. Discussion

The piezoelectric system is a bone cutting system based on adjustable ultrasound micro-vibration technology. The piezoelectric effect was first described by Jean and Marie Curie in 1880, who showed certain ceramics and crystals deform when an electric current is passed across them, resulting in oscillations of ultrasonic frequency. The vibrations obtained are amplified and transferred to a vibration tip which, when applied with slight pressure on bone tissue, results in a cavitation phenomenon and a mechanical cutting effect that occurs exclusively on mineralized tissue, minimizing the damage to blood vessels, nerves and other soft tissues (Crosetti et al., 2009; Jiang et al., 2011b; Hoffmann et al., 2013). Nevertheless, some studies have reported that the cutting efficiency of this

Table 1
VAS pain score.

Scoring	Pain level	Clinical performance
0	Painless	No obvious pain
1–3	Mild pain	Patients can tolerate
4–6	Moderate pain	Affects sleep and can still tolerate
7–10	Severe pain	It is difficult to tolerate the pain, affecting appetite and sleep

Table 3
Operative time, bleeding amount and VAS value comparison between the control group (CTR) and the experimental group (EXP).

Group	Operative time (min)	Bleeding amount (ml)	VAS value
CTR	50.83 ± 2.73	21.23 ± 2.59	4.56 ± 1.16
EXP	57.03 ± 2.67	19.03 ± 3.29	2.36 ± 1.29
t	8.89	2.87	6.90
P	<0.01	<0.01	<0.01

Table 2
Classification by type of dentition, by type of the supernumerary teeth (size and shape and orientation) in the control group (CTR) and experimental group (EXP).

Group	Type of dentition			Shape		Orientation		
	Permanent	Deciduous	Mixed	Normal	Malformed	Vertical	Inverted	Transverse
CTR	16	4	38	18	40	27	10	21
EXP	17	5	36	20	38	23	12	23
Total	33	9	74	38	78	50	22	44

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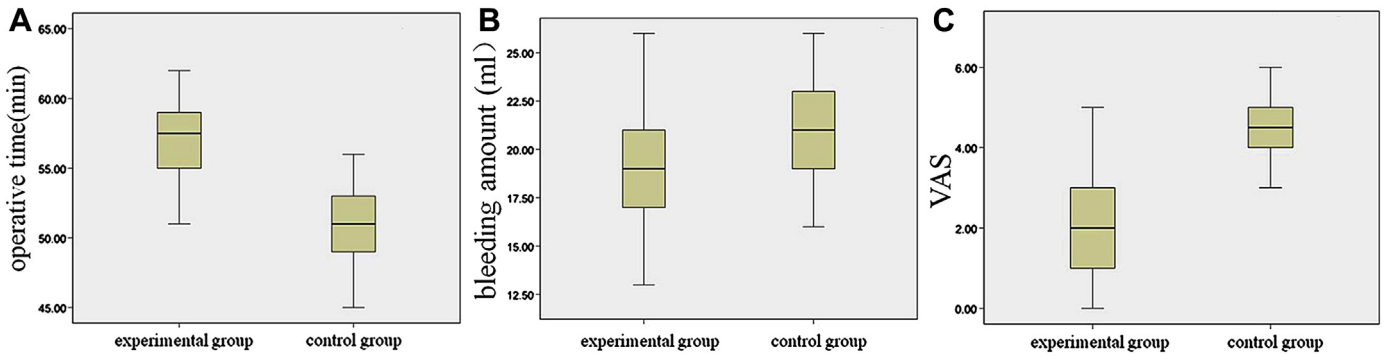

Fig. 5. A) Operative time; B) Amount of bleeding; C) Post-operative VAS values.

system may be low for some thick bone (Eggers et al., 2004; Seshan et al., 2009). Surgybone is also equipped with a wide variety of working heads that can be used depending on the characteristics of the different areas and the types of surgery, thereby improving flexibility and accuracy of the surgery. It has to be used under adequate and constant irrigation in order to avoid bone overheating and consequently bone necrosis (Rashad et al., 2011; Heinemann et al., 2012).

In the extraction of anterior maxillary supernumerary teeth this system seems to allow important advantage respect to the chisel bone methods. In particular, in the present study the results obtained showed a significant decrease in the amount of bleeding and in the post-operative pain. In addition, the post-operative swelling resolved earlier. Our results agree with other studies regarding bleeding, reporting that the cavitation generated by the ultrasonic vibration technology and coolant washing have a certain haemostatic effect, reducing the incidence of some possible complications, such as post-operative wound swelling and infection (Heinemann et al., 2012; Hollstein et al., 2012). In addition the VAS values and the swelling time were reduce compared to the use of traditional bone chisels. Post-operative inflammatory reaction was relatively less, thus significantly reducing the post-operative pain and shortening the post-operative swelling. These results are consistent with studies in which other investigators have reported a decrease of post-operative pain using Surgybone system respect to an ordinary electric drill (Crippa et al., 2011).

An increase in the operative time was seen using Surgybone system. These data are consistent with the consideration of other clinicians, who reported that the use of the Surgybone piezoelectric ultrasonic bone surgery system in maxillary sinus augmentation, mandibular wisdom tooth extraction or other oral and maxillofacial surgery, extended the operative time (Schlee et al., 2006; Baldi et al., 2011; Pavlikova et al., 2011; Sivolella et al., 2011). Taking into account these data, several researchers believe that although the use of Surgybone system increases the time for bone cutting, it has little effect on the overall surgical time because of lack of time required to protect the soft tissues (Beziat et al., 2007).

5. Conclusion

The Surgybone piezoelectric ultrasonic bone surgery system possesses good properties, such as the high cutting precision and good security and the advantage related to its tissue selectivity for mineralized structures, avoiding the possible damage to blood vessels, nerves and soft tissues during the extraction of supernumerary teeth present in the anterior maxillary region, thus reducing trauma, post-operative pain and swelling, as well as inflammation. Despite the increase in the length of the overall surgical procedure reported by the study, the system warrants more widespread use. The authors conclude that the results of the present study suggest that this type of surgery allows almost atraumatic and minimally invasive surgical procedures that were unthinkable with traditional instruments thus reducing pain and complications for the patient.

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