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INTRODUCTION: *The purpose of this study was to evaluate specific parameters: intra-operative time, facial swelling, degree of pain (VAS scale), recovery time and neurosensory disturbance in patients who underwent orthognathic surgery either using piezo or saw devices.*
MATERIAL AND METHODS: *We designed a retrospective study, which included 100 patients who underwent bilateral sagittal split osteotomy (BSSO) surgery combined with maxillary Le Fort I. They were separated into 2 groups of 50 patients each. The surgeries were performed between September 2015 and April 2017 by the same surgeon.*
RESULTS: *Intra-op time is unchanged but patients operated with the Piezo devices requested fewer painkilling medication and were dismissed on the second day after the surgery. Neurosensory recovery was statistically significant in the Piezo group.*
CONCLUSION: *Far less post-op swelling and the reduction in the use of painkillers lead to a speedier recovery in patients who underwent orthognathic surgery using Piezosurgery. These patients also recovered more sensitivity in the lower lip area.*

KEY WORDS: Orthognatic surgery, Piezosurgery, Saw

Introduction

Piezosurgery technology has been used for a number of years as a surgical tool and it has a widening range of surgical applications: head and neck surgery, hand and spinal surgery [1-13]. Piezosurgery was developed in its surgical fields in 2000 by Dr. Tommaso Vercellotti [14,15].
A Piezoelectric device involves the use of 60 to 200 m/s ultrasonic micro-vibrations at 24 to 36 kHz to cut mineralized tissue. Soft tissues remain unharmed at these frequencies. The piezoelectric effect was described by Pierre and Paul-Jaques Curie in 1880: certain crystals and ceramics acquire an electric polarization in response to mechanical stress. On the contrary, when these materials are subjected to an electric current, they deform: this is knowing as the inverse piezoelectric effect. The application of an electric charge to crystals creates a reversible mechanical deformation. Piezoelectric crystals embedded in the hand-piece rapidly expand and contract. The material produces oscillations of average frequency and ultrasonic waves. The vibrations are amplified and transferred to a vibrating tip which, when applied with slight pressure on bone tissue, results in a cavitation phenomenon – a mechanical cutting effect that occurs exclusively on mineralized tissue [16,17].
A foot switch activates the interchangeable hand-piece tips. The surgeon can adjust the vibration frequency, cut-

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ABBREVIATIONS

VAS: visual analogic scale
BSSO: bilateral sagittal split
NST: neurosensory test

ting capacity and irrigation flow rate. Several tool tips (inserts) of varying sizes, shapes and material are available at present while new ones are in developed. The hand-piece is guided by the surgeon, firmly over the bone, but without excessive force. In contrast to conventional saws or drills, to which the surgeon must apply a certain degree of pressure, the Piezosurgery device requires only minimal pressure, permitting a precise cut. The purpose of this study was to evaluate the difference in terms of recovery time between patients underwent orthognathic surgery either using piezo or saw devices. Additionally, we studied intra-operative time, neurosensory disturbance and the pain reported by the patients.

Materials and Methods

One hundred patients, 61 males and 39 females, were included in this study. All the patients were diagnosed with II and III malocclusion classes that required orthognathic surgery.
The surgery was a combination of BSSO and Le Fort I. These surgeries were performed between September 2015 and April 2017. All the patients were older than 21 years, with an average age of 28.5 at the time of surgery (range, 21-44 years).
Inclusion criteria: patients with either II or III malocclusion class, patients undergoing orthognathic surgery, signed informed consent, patients older than 21 years.
Exclusion criteria: previous orthognathic surgery, other orthognathic procedures including genioplasty, as well as simultaneously wisdom teeth extractions, history of facial trauma.

Table I - *The British Medical Research Council (MRC) developed a clinical scale for grading sensory recovery after peripheral nerve injury.*

Clinical Findings	Grade
no sensibility (no sensation)	S0
recovery of deep cutaneous pain sensibility	SI
some degree of superficial cutaneous pain and tactile sensibility	S2
return of superficial cutaneous pain and tactile sensibility throughout the autonomous area with disappearance of over-reaction	S3
return of superficial cutaneous pain and tactile sensibility with some recovery in 2-point discrimination	S4
complete recovery	S5

Clinical examinations include:
– Photographs: frontal, oblique, and lateral views of the face and pictures of the dental occlusion in frontal, oblique, and lateral vision;
– Radiographies: orthopantomogram, craniofacial frontal and profile teleradiographies or cone-beam computed tomography, before and after surgery;
– Analysis of the cephalometric skeletal and dental characteristics;
– Prospective 3D orthognathic surgery planning using Dolphin Imaging® Program.

We designed a retrospective study; all patients were informed of its scope and signed an informed consent. The patients were divided into two groups 50 patients each, group 1 (saw osteotomies performed with Stryker® devices) underwent surgery before the piezo devices used and group 2 (piezo-ostetomies performed with piezo devices which is a trademark Italian company, Mectron®). All the patients underwent surgery by the same surgeon. Our protocol in the Maxillofacial Department of “Le Scotte Hospital”, Siena, included specific post-op recovery time: 3 days taking into account the majority of patients live outside Tuscany (minimum 2 hours and 30 minutes by car). Therefore, the check-up following surgery is after 7 days, when patients should no longer need without further medication.
We evaluated the following parameters:
– Intra-op time used to perform osteotomies of the upper and lower jaw with piezo and saw devices were calculated;
– Surgical precision of the devices was evaluated subjectively by the surgeon;
– Facial swelling was not studied at the beginning of this study because the lack of standard evaluation scales;

Table II - *NST scale in patients operated with saw*

Patients	1 month	3 months	6 months
Group 2	S0=0 S1=40 S2=10	S0=0 S1=0 S2=27 S3=18 S4=5	S0=0 S1=0 S2=2 S3=21 S4=17 S5=10

Table III - *NST scale in patients operated with piezo devices*

Patients	1 month	3 months	6 months
Group 2	S0=0 S1=40 S2=10	S0=0 S1=0 S2=27 S3=18 S4=5	S0=0 S1=0 S2=2 S3=21 S4=17 S5=10

– However, we appreciated some differences of the facial swelling among patients;
– Visual analogue score (VAS a 0-10 scale, 0 standing no pain, 10 maximum pain) was recorded during post-op hospitalization, day 1(Th1), day 2(Th2), and day 3(Th3) before discharge in relation to painkillers used.
Post-op recovery time.
Neurosensory deficit was recorded with standardized neurosensory tests (NST), a 0-4 scale, before surgery (all patients resulted 4 before the operation) and after surgery after 1 month (t1), after 3 months (t2), after 6 months (t3). The NST evaluation included response to painful stimuli, static light touch, moving brush strokes, stimulus localization, and static 2-point discrimination. Thus, sensory recovery was measured using the guidelines established by the Medical Research Council scale (Table II) [18,19].
The differences between group 1 and group 2 were evaluated using the Friedman test, the degree of statistical significance was considered at $P< 0.05$.
The Friedman test is a non-parametric test, used to evaluate the difference between groups. We considered the timing effects and the devices used as the studied variables.

Results

The intra-operative time evaluation reveals that the BSSO surgical procedures performed with piezo-devices took more time than those using the saw technique. The average time to perform piezo osteotomy was 98 ± 27 min. instead saw osteotomy intra-op time was 76 ± 23 min. The mean duration to perform Le Fort I surgery for group 1 was 97 ± 26 which was shorter than 81 ± 21 min. for group 2. The total surgical time took at the end and average time of 203 ± 49 min. for group 1 and 235 ± 48 min for group 2.

The accuracy was evaluated subjectively, the ultrasonic device was more precise when compared to the traditional saw for the intra-operative incisions.
Regarding the VAS evaluation, according to our protocol patients with VAS>3 receive a painkiller as paracetamol. During the first day post op, all the patients were constantly under morphine infusion so no other painkiller was requested. Starting on the second day (Th2) (Figs. 2, 3), patients asked for painkillers. Twenty-one patient who underwent saw osteotomies, requested one painkiller and twenty-nine demanded two painkillers. The other group, instead, operated on using piezo, only 15 patients asked for a single painkiller and three just patients requested two painkillers. On the third days the demand for painkillers dropped: 33 patients from group 1 asked for one painkiller while 2 others asked for 2 painkillers. From group 2, the piezo group, only 2 patients requested a single painkilling drug and no one from that group had more than one painkiller 3 days out.
As result of all the data collected, 48 patients operated with piezo surgery were dismissed after just two days post-surgery and 2 patients on the third day, compared to the patients who underwent orthognathic surgery with saw devices: 35 patients were dismissed after three days post-op, and 15 patients after 2 days.
The neurosensory disturbance was studied with the NST 0-4 scale (Tables IV, V). None of the patients had impaired function of the Inferior Alveolar Nerve (IAN) in any of the four sites of the lower lip and mental areas during the pre-operative evaluations. Nerve continuity was preserved in all 100 BSSO cases.
The Friedman test compares the single sensory evaluation between the 2 groups at 1 month, 3 months and 6 months to demonstrate how the two different devices influenced the nerve recovery time. The results were significant with a P=0.001 after one month and P=0.00001 at three and six months.

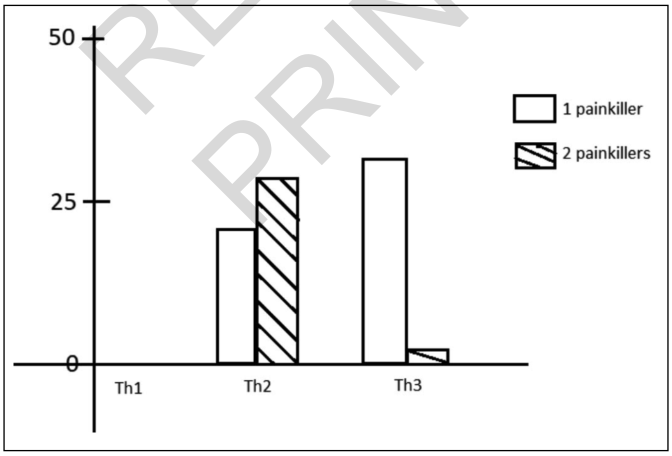

Fig. 1: Group 1: patients operated with saw who asked for painkillers during hospitalization.

Fig. 2: Group 2: patients operated with piezosurgery who asked for painkillers during hospitalization

Discussion

The present study compared orthognathic surgery performed using piezoelectric technique and conventional saw procedure.
The introduction of piezo devices has brought awareness of the possible benefits in Oral and Maxillofacial surgery. The piezoelectric scalpel represents a less invasive cutting system and in orthognathic surgery it allows precision and safety. In this study the post-op swelling was studied once the project has already started and we visually appreciated a reduction. This condition has no statistical significance and can't be consider occurring in fact but several articles are in line with this result. Many authors reported a reduction of the post-op swelling such as Pagotto et al. who stated that at one week after surgery the swelling lasted in only the 16,6% of patients operated with piezo instead of 66.6% [20].
The manual control of piezoelectric and saw devices differs: excessive pressure on the ultrasonic tip could prevent its vibration and lead to reduced cutting precision [21,22].
A surgeon'sexperience is important the reduction of time in surgery. In our study, surgeon was trained in both the techniques so the time and the evaluation of the device's precision should not be an influencing factor. The time to perform BSSO with piezosurgery was longer than the saw osteotomy but, as we know, the mandibular ramus has a thick outer cortex, which requires extra time to perform accurate bone cutting. Furthermore, at the time of the study we didn't use piezosurgery plus® devices (Mectron®) which noticeably reduces the intra-op time. By the conclusion of the operative time of both Piezosurgery and conventional saw osteotomies the total time was longer using piezo. However, we could appreciate that Le Fort I surgery was faster in group 2. This result is also supported by other authors who affirmed that the total orthognathic surgical time performed with piezo or saw was unchanged [20,23,24].
Pain is part of every surgical procedure and can be anticipated and satisfactorily controlled with analgesic medications.
In our study patients underwent piezo osteotomies who asked for some painkillers during the second day post-op were fewer than those patients who had been operated on using a saw. Consequently, the post-op recovery is less painful for the piezo group. The reduction of analgesic drugs and the reduction of pain were consistent with the literature [25,26].
The majority of patients live outside Tuscany and we used to dismiss them during the third day post-op. Furthermore, the Italian health care system established that to dismiss the patient, he should be healthy and he should not require any treatment. Almost all the patients in group 2, who went under surgery using piezo-devices were dismissed during the second day post-op. This is related to the piezosurgery biological response of the tissues: faster bone regeneration and healing compared to the results obtained with saw devices. Piezo devices have other advantages: reduce nerve impairment, enhanced visibility of the surgical field, accurate cutting [16-17,27-36]. The earlier dismission allowed us to save one day of recovery.
The main advantage of piezosurgery during BSSO is the improved protection of the inferior alveolar nerve (IAN)[37]. Orthognathic surgery of the mandible is difficult to perform and the risk of nerve damage to the IAN is high [38,40]. The damage may be caused by direct mechanical injury, postoperative oedema or compressions through the fixation. Nerve damage may cause postoperative pain and sensory disturbances. Neverthless, nowadays effective microsurgical techniques can be adopted to repair trigeminal nerve lesions [40,41]. Using ultrasonic vibrations that cut only the bone, piezoelectric devices will not cause any soft tissue damage because it ceases the surgical cutting when the scalpel comes in contact with non-mineralized tissue.
The incidence of neurosensory disturbances of IAN after bilateral sagittal split osteotomy (BSSO) reported in literature, was between 9% to 85% and the incidence of some form of long-term neurologic deficit is reported in 10 to 30% of patients [42].
In addition, neurosensory disturbance is correlated to nerve intraoperative exposure: more exposure of the nerve leads to a lower recovery time in sensibility [43].
The influence of the piezo devices on the nerve sensibility recovery was statistically significant. The nerve recovery rate was higher following piezosurgery osteotomies leading to a significantly decreased of damaged nerve than in traditional procedures.
Similar results have been reported by different authors: GEHA et al. observed 75-80% recovery of inferior alveolar nerve sensory functions after BSSO performed by piezosurgery [45]; Beziat et al. and Gruber et al. described a higher sensation recovery of the V3 innervated area following ultrasonic osteotomy [29,45].

Conclusion

The present study has shown the benefits of piezosurgery technique for orthognathic surgery. With regards to our experience in orthognathic surgery, the piezoelectric device guaranteed a clean bone cut; post-operative swelling was visually reduced using piezosurgery with a faster healing rate when compared to the use of saw. However, the intra-op time was higher using the piezo devices than the saw ones.
In particular we highlight how the request for painkillers and was significantly higher and hospital stay was longer among the patients who had been operated on using the saw when compared to those who underwent piezosurgery. Moreover, the use of piezo-surgery had a positive influence on neurosensory recovery.

We also demonstrate that, due to the general conditions, patients treated with the use of piezo devices were dismissed one day earlier than patients who underwent surgery using saw technique.

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