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Analysis of the Complications in Patients Undergoing Orthognathic Surgery by Piezosurgery®: A 13 Years Retrospective Study

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Abstract: Orthognathic surgery is a branch of maxillo-facial surgery increasingly in demand, which deals with the correction of skeletal deformities. The aim of the present study is to identify the most common post-operative complications following orthognathic bimaxillary surgery performed by means of Piezosurgery®. Furthermore, through an examination of the available scientific literature, we wanted to establish whether the frequency of postoperative complications were consistent with those already reported. A retrospective study on 58 patients who underwent orthognathic surgery with a bilateral sagittal osteotomy (BSSO) of the mandibular bone branch, maxillary surgery with Le Fort I mono-segmented or multi-segmented approach, and genioplasty technique using Piezosurgery®. The complications taken into consideration were disorders of the temporomandibular joint (TMJ), paraesthesia and hypoesthesia, asymmetries, nose enlargement, nasal septum deviation, nasal obstruction, dental discolorations, pulpal necrosis, occlusion and masticatory efficiency, gingival recession, periodontal problems, dysgeusia, nausea and vomiting, weeping alterations, hearing problems, delayed healing, superinfection, removal of synthesis means, reoperation, cicatricial outcome, and bilateral pneumothorax. It has been highlighted that a number and type of postoperative complications matched those reported by the most recent literature reviews. Temporomandibular disorders and paraesthesia were the most common ones. The only complication rate that differed from the literature was nerve damage, which was significantly lower. Post-surgical complications depend on the used surgical techniques, clinical work, and treatment methods. The use of piezoelectric devices in orthognathic surgery operations provides an innovative, safe, and effective technique compared to traditional methods.

Keywords: orthognathic surgery; piezosurgery; complications; bilateral sagittal osteotomy; Le Fort

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1. Introduction

The aims of orthognathic surgery are numerous: correction of malocclusions, health of the temporomandibular joint, maintenance or increase of upper airway space, improvement of dental relationships, correction of reverse bites, improvement of muscle function, facial aesthetic harmonization, and patient satisfaction. It is also important to ensure adequate stability of the long-term results [1–5]. Such complex therapies may present

complications, the most common are temporomandibular disorders (TMD), paraesthesia, and hypoesthesia [1].

Despite careful planning and the low risk associated with this type of intervention, we can register many mild or more severe complications. Therefore, we performed this retrospective study in order to identify their onset and frequency during or following orthognathic surgery and their severity, assess patient perception about the problem, and determine whether the frequency of our postoperative complications are consistent with those reported in the literature [6,7].

2. Materials and Methods

This retrospective study involved all patients accepted in the Department of Maxillofacial Surgery and Dentistry of the University Hospital (AOUI) of Verona from 2004 to 2017 that fulfilled the following inclusion criteria: age $\geq$18 years, intervention made by the same surgical team, intervention of bilateral sagittal split osteotomy (BSSO) of the mandibular branch, and/or maxillary or multi-segmented Le Fort I surgery. The group of patients consisted of 27 women (46.55%) and 31 men (53.45%). The average age at the time of surgery was nineteen years. Eighteen patients underwent an osteotomy of Le Fort I multi-segmental, while the remaining forty were submitted to single-sided Le Fort. Thirteen patients were also subjected to genioplasty [8–11]. All patients underwent orthognathic surgery following a dento-skeletal deformity; 29.31% of patients presented an Angle's second class, while the remaining 68.97% was affected by a third-class deformity. One patient presented a malocclusion with Angle's first class. A total of 6.90% of patients presented a latero-deviation; in one case, it was a deviation to the right in an Angle's third-class patient, in three other cases, it was a deviation to the left in two patients in the third class and in a patient in the Angle's first class. A total of 8.62% of patients also had an open front bite [12].

This study was approved by the Verona Hospital IRB and all participants signed an informed consent agreement. This study followed the Declaration of Helsinki on medical protocol and was approved by the Ethical Committee (107,1NT) in 2017. Exclusion criteria were a history of previous orthognathic surgery, osteogenic distraction, maxillofacial trauma, oral implant surgery, facial reconstructive surgery, a history of bone disease, use of drugs that might interfere with bone healing, history of psychiatric disorders, and pregnant or breastfeeding women [13].

All analyzed patients underwent bimaxillary orthognathic surgery and in all cases, the osteotomies were performed through a piezoelectric instrument with a MT1–10 tip, and the bone splitting was done with an osteotome. Le Fort I osteotomy was performed with an MT1–10 tip. In order to release the palatine arteries, the osteotomies of the pterygoid processes were made with a UNIVR tip [11]. Septal and para-lateronasal osteotomies were performed with osteotomes after piezosurgical procedures. In the case of regular postoperative course, all patients were discharged with the following indications: Amoxicillin + Ac. Clavulanic 1 g: 1 every 8 h for six days; Fluimucil aereosol, 1/2 vial every 12 h for 10 days; careful oral hygiene followed by rinsing with chlorhexidine mouthwash 0.12% after main meals, semi-liquid diet until further notice; maintenance of the elastic block until further indication; warm-moist compress application for 20 min 3–4 times a day until the resolution of the edema; avoidance of traumas, smoke, dusty environments, intense physical exertions, and excessive temperature changes, nose blowing and sneezing for 15 days, rest for 15 days.

3. Results

The postoperative courses of 58 patients who underwent orthognathic surgery between 1 January 2004 and 31 December 2017 were analyzed. Each different complication prevalence rates are presented in Table 1. A total of 6.90% of patients were preoperatively affected by a temporomandibular disorder; this consisted of bilateral joint pain in three patients, in joint clicks at the left TMJ level in one patient. Globally, this group consisted of

three women and a man. Initial diagnoses were Angle's third-class malocclusion in three patients, Angle's second class in one patient. One patient also presented latero-deviation to the right. None of the patients in this study had obstructive sleep apnea syndrome (OSAS) prior to surgery. In 18 patients, no complications occurred (31.03%). Forty postoperative complications were identified in the remaining cohort.

Table 1. Complication prevalence rates after orthognathic surgery.

	Number of Patients	Percentage (%)
TMJ and TMD Disorders	14	24.14
Paraesthesia	13	22.41
Hypoesthesia	7	12.07
Asymmetries	8	13.79
Enlargement of the Wing of the Nose	0	0
Septal Deviation	0	0
Nasal Obstruction	1	1.72
Dental Discromies and Pulpal Necrosis	4	6.89
Occlusion and Masticatory Dissatisfaction	4	6.89
Gingival Recessions	1	1.72
Periodontal Problems	1	1.72
Dysgeusia	1	1.72
Nausea and/or Vomiting	1	1.72
Alteration of Crying	0	0
Hearing Problems	1	1.72
Delay Healing	2	3.45
Superinfection without necessity to remove of Osteosynthesis Devices	8	13.79
Superinfection and Removal of Osteosynthesis Devices	5	8.62
Reoperation	4	6.89
Cicatricial Outcomes	3	5.17
Bilateral Pneumothorax	1	1.72

TMJ Disorders: Fourteen patients (24.14%) developed a disorder related to the temporomandibular joint. TMJ disorders occurred mainly in male subjects (57.15%) and with an initial diagnosis of Angle's third-class malocclusion (71.42%). Of these patients, pain within the TMJ was reported in five cases. The presence of joint noises, also called joint clicks, was reported in eight patients out of fourteen with TMJ disorders (M:F = 2:6). Of these, 75% had an initial diagnosis of Angle's third-class malocclusion, the remaining 25% were affected by Angle's second-class malocclusion. In two patients, there was a limitation during mouth opening, while in only one patient, a left lateral restriction occurred, associated with a left click. In four patients, joint disorders were present before orthognathic surgery (6.90%). Two of these cases were solved by the intervention.

Paraesthesia: The presence of postoperative paraesthesia was highlighted in thirteen patients (M:F = 9:4). The prevalence was 22.41%. Only three of these patients underwent genioplasty as an ancillary procedure of orthognathic surgery. In eight cases, the paraesthesia was present at the jaw level; in the remaining five patients, it was localized at the maxilla. A case of temporary paraesthesia at the level of the half palate and one at the level of the auricle were also reported. In seven patients, paresthesia disappeared spontaneously: within one year of operation for four subjects and after more than one year for the three other subjects.

Hypoesthesia: We found a prevalence of cases of hypoesthesia equal to 12.07% (M:F = 5:2). In all cases, it was located at the jaw level. It was solved in five patients, while it was still present in two of them at the time of follow-up, eight and four years after the intervention, respectively.

Asymmetries: Eight patients (13.79%) reported perceiving their face as asymmetric. All patients rated this asymmetry as mild. It seemed to be perceived by patients on average 50 months after surgery.

Enlargement of the Nasal Wing: No cases of enlargement of the nasal wing were reported.

Septal Deviation: No cases of septal deviation were reported.

Nasal Obstruction: Only one case of nasal obstruction was detected; it resolved spontaneously.

Dyschromia: Mild dyschromia was reported on the upper right canine, associated with a fracture line close to the canine root that could be detected by CT (Figures 1–3).

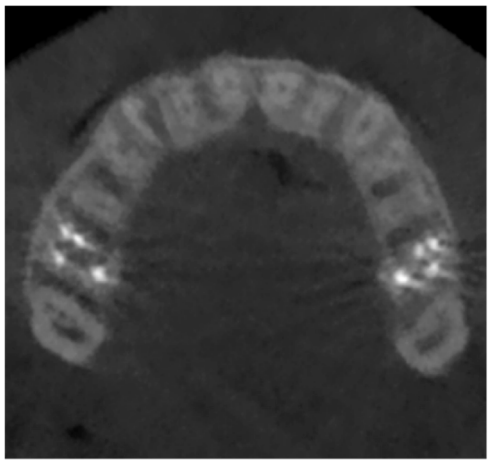

Figure 1. CT, one month after the Le Fort I, which shows a fracture line close to element 13.

Figure 2. Postoperative x-ray of element 13 fractured.

Figure 3. Element 13 one year after surgery.

Tooth necrosis: Four patients (6.89%) experienced the necrosis of a dental element following osteotomy (Figures 4 and 5).

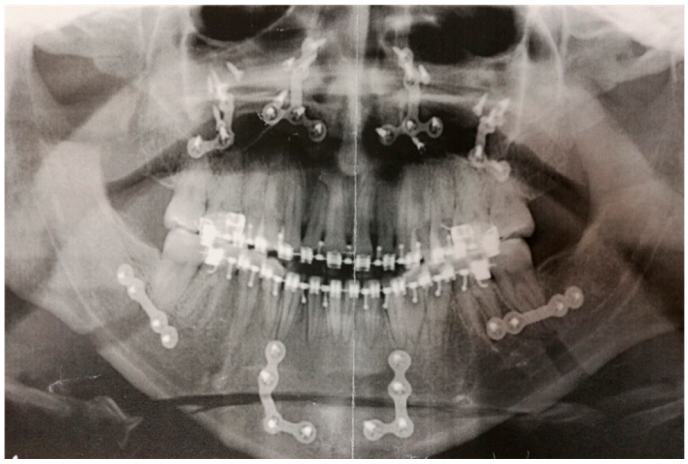

Figure 4. OPT, one year after the BSSO.

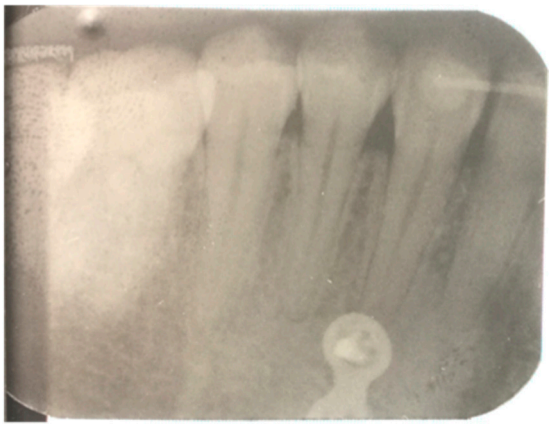

Figure 5. The same patient, four years after BSSO surgery, x-ray performed because of odontalgia of element 4.3 in contact with the synthesis media.

Occlusion and masticatory efficiency: Four patients (6.89%) reported mild dissatisfaction with their masticatory efficiency. For two of them, a dental relapse was detected. In one case, this was related to the recurrence of anterior open bite, six years after surgery. In the second case, it was a female patient with an initial diagnosis of Angle's third-class malocclusion who relapsed one year after the operation.

Gingival Recessions: In the course of our retrospective investigation, a case of gingival recession was detected, occurring two weeks after surgery, at the level of the dental element 4.7, in a man with an initial diagnosis of Angle's third-class malocclusion.

Periodontal Problems: The presence of grade 1 dental mobility was detected in one patient eight months after orthognathic surgery (1.72%). The increase in mobility was associated with the cross-bite of this element (3.5) and an excess of graft material. The patient underwent the removal of the synthetic means with the maintenance of the dental element and resolution of the clinical situation.

Dysgeusia: In this study, there was only one case of dysgeusia, which is a decrease in the sense of taste. This complication was localized at the level of the right-hand half face in a female patient.

Nausea and/or Vomiting: One case of postoperative vomit and one case of severe postoperative nausea were reported. Both cases occurred in the immediate days after surgery. The patients were both women with an initial diagnosis of Angle's third-class malocclusion.

Eye dryness: There were no reports of increased or decreased secretions during crying or even cases of altered visual acuity or extraocular dysfunction.

Hearing Problems: A case of bilateral tinnitus was detected, still present at the seven-year follow-up. This was a male patient with an initial class III dentoskeletal malocclusion.

Delayed Healing: Two cases of postoperative healing delay were detected (3.45%). The first one was represented by a delay in the healing of surgical wounds three weeks after surgery, at the level of the mandibular angle, while the second patient presented delayed healing of one-month surgical wounds at the level of the dental elements 2.2 and 2.3.

Super-infection: Eight cases of post-operative wound superinfection occurred. This complication resolved with adequate antibiotic therapy. In three patients, fistulization events took place from plaques or screws inserted during orthognathic surgery.

Devices removal: Five patients (8.62%), following one or more episodes of superinfection and/or fistulism, underwent a second surgical operation to remove the osteosynthesis device.

Recurrence: We found four patients (6.89%) who underwent a second surgical operation to correct the outcomes of orthognathic surgery.

Cicatricial Outcomes: Three patients (5.17%) reported scars following the operation, respectively, at the level of the right genial mucosa, of the mucosa of the right hemimandible and of the upper lip.

Bilateral Pneumothorax: We observed this surgical consequence only once in a 28-year-old woman with a negative clinical history undergoing osteotomy of Le Fort I and BSSO (Figures 6 and 7).

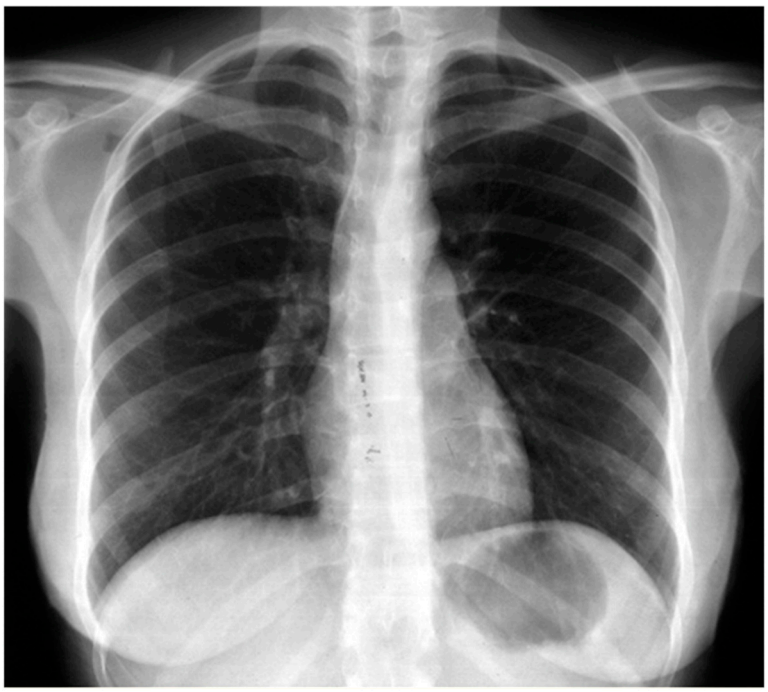

Figure 6. Postoperative thoracic x-ray showing displacement of the mediastinum on the left.

Figure 7. Thoracic Rx performed after the placement of the intercostal drainage (Pleurevac).

4. Discussion

TMJ Disorders. Temporomandibular joint disorders are the most frequent complications following orthognathic surgery, with a prevalence in the literature of 13.64% [6,7,12–14]. They are joint noise, pain, and condylar reabsorption [15,16]. For patients presenting with temporomandibular disorders prior to orthognathic surgery, a unanimous consensus on the influence of orthognathic surgery on TMJ dysfunction has not been reached yet [6]. As reported by the study by Jung et al., the osteotomy of LeFort I does not seem to be associated with direct trauma to the ATM or to the masticatory muscles, so there are only minimal effects on the TMJ dysfunction [17]. The results of our study reported a general prevalence of post-operative TMDs and TMJ disorders of 24.14% (i.e., fourteen patients out of fifty-eight). The prevailing disorder was joint noise, followed by bilateral pain. The patients were mostly men (57.15%) with an initial diagnosis of Angle's third-class malocclusion (71.42%). Among the four patients out of fifty-eight (6.90%) with TMJ disorders prior to surgery, only two had them solved. Therefore, patients who presented temporomandibular disorders before orthognathic surgery or with the above risk factors, a careful evaluation of the patient by the clinician must be carried out before planning any surgical correction. In this regard, the systematic review by Jędrzejewski et al. suggests, on the basis of the available literature, methods that can help clinicians meet these challenges [14]. These methods are as follows: (1) correct intraoperative diagnosis; (2) specific condylar positioning technique; and (3) awakening the patient to a state of sedation to examine the passive and active movements of the jaw to create the correct occlusal relationship.

Paraesthesia and Hypoesthesia. The total prevalence of paresthesia was 22.41%, while that of hypoesthesia was 12.07%. The review of the literature by Jędrzejewski et al. suggested a prevalence of 50% while that of Kim reported a value even higher than 50% [6,14]. In our study, paraesthesia cases resolved spontaneously in seven patients. Of the cases of hypoesthesia, five resolved spontaneously within the first year after the operation. Our data concerning nerve lesions seemed to be different from those reported in the most recent reviews [18–20]. The reason might be related to the use of piezoelectric instrumentation. The available evidence suggests that piezoelectric surgery has favorable effects on complications associated with orthognathic surgery [11,21].

Asymmetries. We recorded eight cases of patients who perceived their own face as slightly asymmetric (13.79%), and this asymmetry was detected on average four years after

surgery. Patients undergoing orthognathic surgery usually expressed a positive judgment about the aesthetics of their face following combined orthodontic and surgical therapy [22].

Nasal base enlargement. Orthognathic surgery has an influence on the overlying soft tissues of the translated osseous maxillomandibular complex. The most common secondary change in the nasolabial region is the enlargement of the nasal base, particularly on the wingspan and the nasal volume [23–25]. In our study, however, no cases of nasal wing enlargement were observed. For this reason, we recommend the use of piezoelectric devices, and in particular, we suggest Mt1–10 as the surgical tip. Piezoelectric surgery has been crucial to reduce tissue complications.

Septal Deviation. Additionally, the deviation of the nasal septum is possible following osteotomy of LeFort I, which provides procedures for the repositioning of the bone segment [6]. In the present study, however, no cases of deviation of the nasal septum were observed.

Nasal Obstruction. Nasal obstruction is also a possible complication of orthognathic interventions and may depend on the swelling and mucosal congestion around the distal opening of the nasolacrimal duct or the anatomic placement of the medial face structure [26–28]. In our study, we found only one case of nasal obstruction after surgery, corresponding to a prevalence of 1.72% that was solved thanks to medical therapy.

Dental Discromies and Pulpal Necrosis. The main risk factor for dental element lesion during orthognathic surgery is the alteration or interruption of the pulp blood flow, in particular at the osteotomy cutting zones [6,29,30]. Gan et al. reported on how osteotomic cutting should be performed at least 5 mm from the apices of the teeth [31]. According to Gan, osteotomic cuts closer to this size should be avoided as this could lead to the devitalization of those teeth, as also confirmed by Kahanberg and Engstrom [32]. When, however, a repositioning of the maxilla greater than 6 mm is necessary, this margin of 5 mm is not always feasible due to the position of the infraorbital foramen. In our study, we had one case of dyschromia and necrosis in four dental elements.

Occlusion and Masticatory Efficiency. Occlusal forces are usually improved in all patients six months after surgery [33]. In our study, four patients reported mild dissatisfaction with their masticatory efficiency.

Gingival Recessions. Gingival recession is a possible complication mainly related to the osteotomy cutting area. Kramer et al. had a prevalence of 0.8% [34]. In our study, the recession prevalence was 1.72%, that is, only one patient in fifty-eight presented recession on a single tooth. Pre-operative width of the keratinized tissue did not appear to be the critical factor in the development of the recession. The risk of recession appears to increase with mandibular advancement procedures and appears to occur in sites where both the keratinized gingiva and the underlying bone are thin [35].

Periodontal Problems. Possible periodontal problems are represented by an increased probing depth and bone loss with a prevalence of 0.2% [34]. In our study, the prevalence of periodontal problems was 1.72%, with only one patient reporting dental mobility following surgery. In order to minimize periodontal and dental damage, it seems therefore necessary to avoid damaging the dental structure next to osteotomy cutting lines [36].

Dysgeusia. The alteration of taste is a possible complication, both at the lingual and the palatal level, with sensory changes at the lingual level in 19.4% of the subjects; in the present study, only one case of dysgeusia (1.72%) was reported in the left hemiplate of a patient; this spontaneously solved within the first postoperative year [37].

Nausea and/or Vomiting Nausea and vomiting are postoperative complications that may occur after general anesthesia [6]. In our study, only two cases were recorded, for a prevalence of 3.45%. Postoperative pain can be effectively controlled with non-steroidal anti-inflammatory drugs such as NSAIDs or COX-2 inhibitors [38].

Alterations of Crying. Nasolacrimal duct obstruction and tear reflex loss are two rare consequences after bimascellar orthognathic surgery [39,40]. In our study, there were no cases of tear change or complications related to visual acuity and/or to extraocular structures.

Hearing Problems. The alteration of the auditory valvular function and auditory problems have been cited as between 6.82% and 7% [6,14]. In our study, there was only one case of bilateral post-surgical tinnitus, which still occurred sporadically at the time of seven-year follow-up.

Delay Healing. Risk factors for delayed recovery appear to be smoking, the presence of third molars, and diabetes [14]. Additionally, synthesis media position can be a contributing factor to the greater incidence of healing delay [14,41]. In our study, we reported two cases of subjects with delayed surgical wound healing (prevalence of 3.45%),which was solved with antibiotic therapy.

Superinfection and Removal of Osteosynthesis Devices. The cases of infection following orthognathic surgery have been reported as being between 6.82% and 8% of all interventions [14,42]. Postoperative infections include cellulitis, abscesses, fistulae, and osteomyelitis. In our study, the rate of postoperative infections was 13.8% (i.e., eight cases of which three were solved with antibiotic therapy alone (5.17%)), while for the remaining five cases, the removal of the osteosynthesis device became necessary (8.62%).

Recurrence. A certain rate of recurrence is possible [43,44]. In some cases, the risk of recurrence may require a second orthognathic surgery. In our study, we recorded four patients out of fifty-eight (6.90%) who underwent secondary orthodontic surgery.

Cicatricial Outcomes. In the present study, oral mucosa scars were found in three patients and solved only in a single subject (5.17%). Cicatricial outcome could be improved by various cosmetic surgery methods such as fractional non-ablative lasers, fillers, and botox, but this topic still needs to be adequately developed by the current scientific literature, in order to understand the most appropriate method to correct each cicatricial outcome [45,46].

Bilateral Pneumothorax. Postoperative thoracic emphysema is very rare and appears to be due to a progression of high pressure air penetration through the deep fascia of the neck. In our case, the situation was complicated by a bilateral pneumothorax secondary to emphysema. In orthognathic surgery, pneumothorax may result during tracheal intubation [47,48].

5. Conclusions

Our study recorded forty post-operative complications. The temporomandibular joint disorders and mandibular paraesthesia were the most common. The complications that differed most from the available literature are represented by nerve damage (22.41% versus 50% or more) [6,11,20]. The evaluation of the results obtained from other studies and/or reported by the most recent literature reviews indicates that despite a large number of possible complications associated with orthognathic surgery procedures, the vast majority of them do not affect aesthetic and functional results [21,49]. Literature data suggests how these complications can be solved thanks to the joint work of surgeons, orthodontists, and operational teams [50–56]. The analysis of the literature and our clinical experience also led to evidence that the piezoelectric device might provide an innovative safe and effective technique compared to other rotating instruments due to the absence of macrovibrations; moreover, it is easy to be used and may provide safer control and cutting, especially in complex anatomical areas [8,11]. Its physical and mechanical properties have clinical advantages: precise cutting, saving of vital structures, and better visualization of the surgical field with time reduction [11]. Another point that we want to emphasize is that many reviews have indicated that most of the studies were obtained through case reports or case series [7,40]. These types of studies currently do not provide reliable evidence. Therefore, more controlled clinical trials and good quality randomized controlled trials are required to provide better evidence in this field. Finally, the complication rate might be further reduced with an in-depth understanding of the pato-physiological aspects of the possible complications, careful patient assessment and treatment planning, and the use of proper surgical technique and instrumentation.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and was approved by the Ethical Committee of San Raffaele Hospital, Milan, Italy ethics and the regional Ethical Review Board of Verona approved the study (107/1NT/2017).

Informed Consent Statement: Written informed consent has been obtained from all the patients to publish this paper.

Conflicts of Interest: The authors declare no conflict of interest.

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