# Critical Evaluation of Piezoelectric Osteotomy in Orthognathic Surgery: Operative Technique, Blood Loss, Time Requirement, Nerve and Vessel Integrity

*Constantin A. Landes, MD, DMD, PhD,**
*Stefan Stübinger, DMD,† Jörg Rieger, DMD, MD,‡*
*Babett Williger, DMD, MD,§ Thi Khanh Linh Ha, DMD, MD,#*
*and Robert Sader, MD, DMD, PhD***

**Purpose:** Piezo-osteotomy feasibility as a substitute for the conventional saw in orthognathic surgery was evaluated regarding operative technique, blood loss, time requirement, and nerve and vessel integrity.

**Patients and Methods:** Fifty patients had orthognathic surgery procedures in typical distribution using piezosurgical osteotomy: 22 (44%) monosegment, 26 (52%) segmented Le Fort I osteotomies; 48 (48%) sagittal split osteotomies, 6 (12%) symphyseal, and 4 (4%) mandibular body osteotomies. Controls were 86 patients with conventional saw and chisel osteotomies: 57 (66%) monosegment, 25 (29%) segmented Le Fort I osteotomies, 126 (73%) sagittal split, and 4 (5%) symphyseal osteotomies.

**Results:** Piezosurgical bone osteotomy permitted individualized cut designs, enabling segment interdigitation after repositioning. Angulated tools weakened the pterygomaxillary suture; auxiliary chisels were required in 100% of cases for the nasal septum, and lateral nasal walls as 46% pterygoid processes. After downfracture, the dorsal maxillary sinus wall and pterygoid processes were easily reduced. Hemorrhage was successfully avoided with average blood loss of 541 ± 150 mL versus 773 ± 344 mL ($P$ = .001) for a conventional bimaxillary procedure. Sagittal mandibular osteotomy required considerable time (auxiliary saw in 13%); the lingual dorsal osteotomy was mostly performed tactile. Time investment remained unchanged: 227 ± 73 minutes per bimaxillary standard osteotomy versus 238 ± 61 minutes ($P$ = .5); clinical courses and reossification were unobtrusive. Alveolar inferior nerve sensitivity was retained in 95% of the study collective versus 85% in the controls ($P$ = .0003) at 3 months postoperative testing.

**Conclusions:** Piezoelectric osteotomy reduced blood loss and inferior alveolar nerve injury at no extra time investment. Single cases require auxiliary chiseling or sawing. Piezoelectric drilling for screw insertion and complex osteotomy designs may be developed to maintain bone contact or interdigitation after repositioning and minimize need for osteofixation.

*J Oral Maxillofac Surg 66:657-674, 2008*

Within the field of oral and maxillofacial surgery and dentistry, ultrasound was established mainly as a diagnostic,[1] periodontal, and endodontic treatment option.[2-4] The direct piezo-effect, mentioned first by French physicists Jean and Marie Curie in 1880, referred to certain crystals generating electrical current

Received from the Department of Oral, Maxillofacial and Plastic Facial Surgery, Frankfurt University Medical Center, Frankfurt, Germany.

*Assistant Professor.

†Consultant.

‡Resident.

§Resident.

#Resident.

**Professor and Chairman.

Address correspondence and reprint requests to Dr Landes: Klinik für Mund-, Kiefer- und Plastische Gesichtschirurgie, der Johann Wolfgang Goethe Universität Frankfurt, Theodor-Stern-Kai 7, 60596 Frankfurt am Main, Germany; e-mail: c.landes@lycos.com



0278-2391/08/6604-0008$34.00/0
doi:10.1016/j.joms.2007.06.633

under mechanical pressure. The reciprocal effect concerns in their deformation under electrical current was discovered later. Handpieces operated by so-called reciprocal or indirect piezo effect are used, which work upon deformation of piezoelectric crystals within electric fields. Polarized piezo ceramic expands in direction of the polarity with perpendicular contraction once voltage is applied. In recent years, in line with a tendency toward minimally invasive surgery, the use of ultrasonic waves for bone processing was introduced. The general result is a lack of visible injury to adjacent soft tissues from generated micromovements. Incidental irritation of neighboring hard substances cannot be completely excluded from such procedures,[5] such as noninvasive ultrasound osteotomy[6] and ultrasonic vibration drills.[7] Also called piezo-osteotomy or piezosurgery, the method confirmed its advantages in dentoalveolar osteotomy sparing the nerve during complicated third molar removals or lateralization of the inferior alveolar nerve and preservation of the sinus membrane during elevation of the maxillary sinus floor. Microvibrations of 60 to 200 $\mu$m/sec at 24 to 29 kHz are applied to cut in elastic mineralized tissue while elastic soft tissue remains unharmed that would become endangered with frequencies above 50 kHz.[8,9] Furthermore, the cavitation effect of currently available equipment does not appear to harm cell viability and differentiation more than conventional methods, and therefore normal reossification may be expected.[10]

Based on these findings in the literature and some reports of isolated aspects in orthognathic surgery using piezo-osteotomy,[11-16] this report ventures a critical evaluation of feasibility of piezo-osteotomy as an exclusive method of osteotomy in orthognathic surgery with a control collective of conventional saw and bur osteotomies of a single center. Both collectives had typical distribution of procedures. The benefits and disadvantages of the method as well as the feasibility for the applied osteotomies will be assessed against the background of possibly insufficient power of impact for maxillary and mandibular bone osteotomy.[17]

## Patients and Methods

Piezosurgical equipment ("Piezosurgery"; Mectron Medical Technology, Carasco, Italy) was used, generating micro movements between 20 and 200 $\mu$m/sec at 24 to 29 kHz; output power of 17 W and additional superposed frequency of 30 to 50 Hz for different bone qualities. The oscillation amplitude of the tool depends on the horizontal oscillation of 60 to 200 $\mu$m and vertical oscillations of 20 to 60 $\mu$m. Physiological sodium chloride solution at approximately 18°C (room temperature) was used for generous irrigation. In all cases, the setting was "bone" level 1 to 3 and in accordance with the developer's recommendations, which equals 24 to 29 kHz and 60 to 200 $\mu$m horizontal and 20 to 60 $\mu$m vertical oscillation. The water pump was set at level 4 to 5, which equals 55 to 60 mL per minute.[8] Different tools, screwed onto the handpiece were used: EX1, OP1, OT7, OT8R and L (all Mectron Technologies, for more details see: http://www.mectron.com/piezosurgery.html). The recommendations of the declaration of Helsinki were thoroughly maintained during this evaluation.

### STUDY GROUP

Fifty consenting patients (24 females (48%), 26 males (52%); average age 21 ± 3 years; range, 16 to 46 years) were operated between December 2005 and December 2006 with 106 osteotomies, intentionally using exclusively piezosurgical equipment for bone osteotomy (Table 1). Standard orthognathic surgery procedures included angle Class I = 3 (6%), II = 13 (26%), III = 34 (68%), additional open bite = 18 (36%), and cleft lip and palate = 3 (6%) in typical distribution. Patients required 22 monosegment Le Fort I (LFI) osteotomies (44% of patients), 1 (2%) 2-segment, 1 (2%) segmental (anterior/posterior), 6 (12%) 3-segment LFI; and 18 (36%) modified LFI combined with transversal distraction either in 2 or 3 segments. In the mandible, 48 (48%) sagittal split osteotomies (SSOs) were performed in 24 patients, 6 (12%) symphyseal osteotomies (SOs) in 6, and 4 (4%) mandibular body osteotomies (MBOs) in 2 patients.

The total operation time requirement and blood loss using piezosurgical bone osteotomy were taken from the patients' records as total operation time in an ISO 9001:2000 standardized treatment protocol. The soft tissues were macroscopically inspected for damage; clinical healing and neurosensory deficit were monitored after 3 months.

### OPERATIVE TECHNIQUE

LFI osteotomies with repositioning were performed deliberately adhering to the standard protocol in the beginning. However, as early as the second procedure it was observed that individual complex cut designs enabled osseous interdigitation dependent on the necessary maxillary repositioning. Anterior bone osteotomies were performed using the straight OT7 bone saw. The 90° angulated OP1 tool and OT8R and L bone saws were used in areas of difficult access, such as the pterygoid process. Sagittal maxillary osteotomies included median paraseptal as 3-piece or tripartite osteotomies between the lateral incisive teeth and the canines. Distraction started on the fifth day with 0.6 mm daily activation in 3 steps of 0.2 mm each.

SO for transversal distraction was performed with OT7; however, 1 SO narrowed the mandibular trans-