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Three-dimensional fracture pattern analysis of the Obwegeser and Dal Pont bilateral sagittal split osteotomy

T. Dreiseidler, J. Bergmann, M. Zirk, D. Rothamel, J. E. Zöller, M. Kreppel
Department of Craniomaxillofacial and Plastic Surgery, University of Cologne, Cologne, Germany

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Abstract. The Obwegeser and Dal Pont modification of the bilateral sagittal split osteotomy (BSSO) is a well-established procedure in orthognathic surgery. The purpose of this retrospective study was to analyze the actual fracture patterns achieved with BSSO by Obwegeser and Dal Pont modification using postoperative cone beam computed tomography (CBCT) datasets from 100 patients. A total of 200 split osteotomies were assessed, which could be categorized into nine different split patterns. Only one of the observed split fractures (0.5%) followed exactly the fracture line described by Obwegeser and Dal Pont, whereas 40% followed the fracture line according to the Hunsuck and Epker modification and 13.5% were seen as unfavourable splits mainly running over the buccal plate. A significant correlation was found between unfavourable buccal splits and both horizontal osteotomies reaching the buccal surface at the dorsal ramus ($P = 0.001$) and a vertical caudal bone cut end at the corpus with a buccal position ($P < 0.001$). These results show that a complete antero-posterior horizontal osteotomy at the mandibular ramus does not lead to the intended fracture pattern, which rebuts the argument of a greater amount of bony overlap using the Obwegeser and Dal Pont modification.

Key words: bilateral sagittal split osteotomy; BSSO; fracture pattern; Obwegeser and Dal Pont osteotomy.

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The surgical correction of mandibular displacements was addressed early in orthognathic surgery. The bilateral sagittal split osteotomy (BSSO) procedure evolved in a step by step manner following the first breakthrough described by Schuchardt, in which three osteotomies were utilized to weaken the bone for later controlled chisel-driven splitting in the sagittal plane.[1] In 1957 Trauner and Obwegeser improved Schuchardt's technique, describing it as his operation technique No. 2, and naming it 'the vertical splitting of the ascending ramus'.[2] The most important change in this technique was the expansion of the span from the inner cortical plate cut to a much more caudally positioned inferior osteotomy of the external cortical plate, referred to as 'just above the angle of the jaw'. This alteration allows for a greater bone surface contact after the split osteotomy and is

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regarded to facilitate osseous healing. The next evolutional change in BSSO was the method of Dal Pont, introduced in 1961 and named the 'sagittal retromolar osteotomy'.[3] The buccal cortical plate osteotomy was described as a vertical cut 'reaching from the linea obliqua at the level of the second molar area up to the lower border of the mandible'. The modification described by Hunsuck in 1967 illustrates a horizontal lingual osteotomy through the cortical bone above the lingula 'at the confluence of the temporal crest and ridge of the mandibular neck' ending 'above the mandibular foramen'.[4] In addition to this, the Epker modification of 1977 emphasized the demand for a complete osteotomy of the inferior mandibular cortex with the vertical cut to reduce the risk of undesired fracture patterns during the split, also referred to as 'bad splits'.[5] A detailed summary and literature review of the historical modifications of the BSSO was published by Böckmann et al. in 2015.[6]

Until recently the historical theories of lingual fracture patterns arising from cortical osteotomies and defined chisel forces could not be evaluated sufficiently *in vivo* due to a limited intraoperative view and the availability of only conventional two-dimensional (2D) projection radiographs. With the introduction of cone beam computed tomography (CBCT), a relatively low radiation dose three-dimensional (3D) imaging technology is now available for 3D analysis of the lingual fracture pattern arising in BSSO procedures.[7] In 2009, Plooij et al. showed that CBCT is a sufficient means for lingual fracture line analysis in BSSO procedures.[8] Other researchers have since used the 3D CBCT technology to analyze lingual fracture patterns.[9,10]

All of these previous publications investigated the Hunsuck and Epker modification. The more traditional Obwegeser and Dal Pont technique has not yet been evaluated by means of 3D imaging. Thus, the aim of the present study was to evaluate the impact of the complete anteroposterior horizontal osteotomy of the lingual cortical plate from the Obwegeser and Dal Pont technique on the resulting fracture patterns and to contrast them with the previously published results of the Hunsuck and Epker technique.

Materials and methods

One hundred patients (64 female and 36 male) with a mean age of 24.8 ± 7.4 years, who underwent either BSSO or combined BSSO and maxillary Le Fort I osteotomies between March 2012 and February 2015, were included in this retrospective study. A total of 200 mandibular split osteotomies were assessed. The mandible was moved posterior to correct a class III occlusion in 62 cases, an anterior shift was performed to correct a class II occlusion in 29 cases, and an asymmetric malocclusion of the mandible was corrected by rotation in nine cases. None of the patients had undergone previous mandibular orthognathic surgery or had a history of mandibular fracture. The study protocol was approved by the necessary medical ethics committee.

Surgical technique

All BSSO procedures were performed with the Obwegeser and Dal Pont modification by senior residents or senior surgeons; surgery was performed under general anaesthesia and nasal intubation. The procedure was associated with a Le Fort I maxillary osteotomy in 73 cases; an additional anterior segmental maxillary osteotomy was necessary in one case. The horizontal osteotomy (medial osteotomy) on the lingual cortical plate of the ramus was positioned just above the mandibular foramen. Osteotomies were intended to be monocortical, extending from the ventral to the dorsal border of the ramus. The vertical osteotomy (lateral osteotomy) was positioned in the area of the second molar. Specialized BSSO miniplates with a slider function were fixed temporarily between the vertical osteotomy and chisel splitting stages in order to enable optimization of the temporomandibular joint (TMJ) positioning after splitting. For split separation, specialized chisels (Leibinger Orthognathic; Stryker, USA) were applied for force impulse fracturing and dilation. After positioning with an occlusal wafer, the positions of the TMJs were checked and the BSSO fixed with miniplates. One week of rigid maxillomandibular fixation (MMF) and 1 week of loose MMF was applied after the procedure in a standardized manner.

Postoperative analysis

Postoperative control CBCT scans were performed for all patients within 1 week after surgery (GALILEOS CBCT device; Sirona, Bensheim, Germany). Standardized scanning parameters were set to 85 kV and 28 mA s. Two hundred single X-ray raw projections per scan were acquired within 14 s. The reconstructed cubic 3D volume had an edge length 15 cm, which resulted in a matrix of 512 × 512 × 512 pixels in an isotropic spatial resolution of 300 μm or 2.5 line-pairs per millimetre.

Using the 3D dataset and fracture plane aligned 2D views (secondary reformats), the split patterns of the lingual cortical plate were analyzed and categorized according to a newly developed scheme (Fig. 1). The scheme works on the basis of three different horizontal height levels (referred to as A, B, and C) and three different antero-posterior areas (referred to as 1, 2, and 3). In the cranio-caudal direction, level A corresponds to the horizontal osteotomy and level C to the inferior border of the ramus, while level B is defined as the level exactly bisecting the distance between A and C. Fracture area 1 corresponds to the course of the mandibular canal in position A and B and the juncture with the vertical osteotomy at level C. The corresponding area is categorized as the course of the mandibular canal and absence of direct contact with the inferior border of the corpus. Fracture area 2 comprises the space posterior to area 1, namely the mandibular canal and the caudal juncture of the vertical osteotomy extending to the mandibular angle and dorsal border of the ramus. Fracture area 3 corresponds to the massive rim bone at the mandibular angle and dorsal border of the ramus. This fracture scheme thus allows the categorization of up to 27 different fracture patterns, with the original Obwegeser and Dal Pont description corresponding to a 3–3–3 (A3/B3/C3) fracture pattern: the fracture reaches the dorsal border of the mandibular ramus at levels A and B and follows the distal ramus to level C at the caudal mandibular angle. From

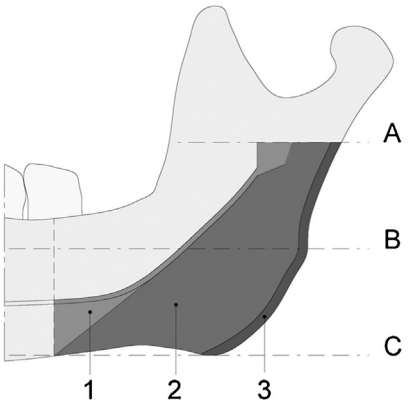

Fig. 1. Split patterns are measured at the level of the osteotomy 'A', the inferior border of the mandibular corpus 'C', and in between 'B'. They are categorized as '1' if running through the mandibular canal with no direct contact with the inferior border of the corpus, as '3' if running through the posterior border of the ramus, or as '2' if in between.