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Early changes in condylar position after mandibular advancement: a three-dimensional analysis

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Abstract. The aim of this study was to perform a three-dimensional (3D) assessment of positional changes of the mandibular condyle after bilateral sagittal split osteotomy (BSSO). A prospective evaluation of 22 skeletal class II patients who underwent a BSSO for mandibular advancement was performed. Pre- and postoperative cone beam computed tomography scans were taken. Using the cranial base as a stable reference, the pre- and postoperative 3D skull models were superimposed virtually. Positional changes of the condyles were assessed with a 3D colour mapping system (SimPlant O&O). A Brunner–Langer statistical test was applied to test the null hypothesis that the condylar position remains stable after BSSO. The level of significance was set at 0.05. The mean mandibular advancement in the studied sample was 6.7 ± 1.6 mm. Overall, the condylar positional changes after BSSO for mandibular advancement were statistically significant ($P < 0.05$). A positive correlation was found between the displacement of the left condyle and the amount of mandibular advancement ($P < 0.01$). The results of this study suggest that statistically significant changes of condylar position occur after mandibular advancement. Long-term evaluation is needed to assess the capacity of the temporomandibular joint to adapt to these changes.

Key words: temporomandibular joint; bilateral sagittal split osteotomy; retrognathia; three-dimensional analysis.

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Significant skeletal dysplasia in non-growing patients is efficiently managed with orthognathic surgery and orthodontics. In the particular case of mandibular hypoplasia, the bilateral sagittal split osteotomy (BSSO) is the most common surgical technique for mandibular advancement.[1–7]

A higher prevalence of temporomandibular joint disorders (TMD) has been identified in patients with underlying malocclusion,[8] especially in the context of mandibular hypoplasia and Angle class II malocclusion. While orthognathic surgery will correct a skeletal base discrepancy, there is ongoing concern about its potential beneficial/deleterious effects on the temporomandibular joint (TMJ).

Although many studies have reported an improvement in TMD symptoms after orthognathic surgery,[4,7–10] others have detected postoperative worsening of these symptoms.[5,11] In a systematic review on the influence of orthognathic surgery on TMD, Abrahamsson et al. concluded that there is insufficient scientific evidence to assess TMD before and after surgery and that well-designed studies are needed in this regard.[11]

In this context, the investigation of possible changes in condylar position and in the disc–condyle relationship after orthognathic surgery is particularly relevant. There is currently no consensus in relation to this. Several study groups have claimed that no statistically significant changes in condylar position occur after surgery.[4,6,7,10,12–14] Conversely, Bailey et al. detected condylar position changes after surgery in 5–10% of the patients who underwent surgical advancement of the mandible.[15] The percentage of observable TMJ changes after BSSO was substantially higher in the study by Saka et al., especially when a splint was not used (54%).[16] It has been suggested that if these changes are small enough, they could allow adaptive remodelling without any TMJ damage.[7,17] It seems that physiological adaptation may fit small changes in condylar position, but that this process requires a long time.[7]

At any rate, if positional changes do occur, their significance is poorly understood. Positional modifications could promote relapse, TMJ problems, or condylar resorption.[3–8,10,11,13–22] Regarding the latter, Arnett et al. showed that posteriorization and medial or lateral torquing during orthognathic surgery could cause morphological changes and lead to progressive condylar resoption.[18,19] In order to minimize this possible movement of the condyles, some authors have advocated the use of different condylar positioning devices during surgery.[2,3] However, these devices have not been proven to improve condylar positioning when compared to a control group.[2,3] Consequently, there is currently no scientific evidence to support their use in orthognathic surgery.

The introduction of cone beam computed tomography (CBCT) imaging has provided an accurate tool to evaluate condylar position.[7,14,17,23] X-ray films have important limitations in terms of precision and the assessment of mediolateral movements. Conversely, CBCT enables a comprehensive three-dimensional (3D) evaluation of the TMJ, provides highly accurate linear measurements,[17] and permits superimposition of pre- and postoperative situations.[20]

The aim of the present study was to apply CBCT technology to evaluate postoperative changes in the TMJ condyle after BSSO for mandibular advancement. In addition, the potential effect of several patient-related and process-related variables on condylar displacement was assessed.

Patients and methods

A prospective radiological evaluation of 22 consecutive patients who underwent BSSO for mandibular advancement at a maxillofacial surgery institute in Barcelona, Spain was performed. The usual imaging protocol for orthognathic surgery cases was followed: CBCT scans were taken pre- and postoperatively (15 days after surgery). This study followed the Declaration of Helsinki on medical protocol and ethics and was approved by the necessary ethics committees.

Patients were selected on the basis of the following inclusion criteria: age ≥18 years, skeletal class II profile in need of surgical correction, no history of TMD, and signed informed consent. Exclusion criteria were skeletal dysplasia requiring additional surgical procedures (i.e., maxillary Le Fort I osteotomy, surgically assisted rapid palatal expansion, etc.), asymmetry, congenital anomalies, history of trauma, and absence of or disagreement with informed consent.

For each patient, the following variables were recorded: age at the time of surgery, sex, amount of mandibular advancement (mm), and type of occlusal plane rotation (clockwise vs. counter-clockwise).

All patients were operated on under general anaesthesia and controlled hypotension. The mandibular advancement procedure was performed according to the standardized BSSO technique defined by Trauner and Obwegeser[24] and incorporating the modifications of Hunsuck[25] and Dal Pont.[26] The proximal (condyle-bearing) fragments were repositioned into the uppermost-anterior part of the fossa with a bidirectional manoeuvre. One single straight miniplate with two screws on each side was used to achieve fixation of the fragments. Patients left the operating room without any rigid intermaxillary fixation apart from two guiding elastics. At 15 days postoperative, a clinical examination of the TMJ was performed. At this time point, patients initiated active physiotherapy and were instructed to do maximum mouth opening exercises with the aim of gaining normal joint function.

CBCT scans were taken with an i-CAT Vision device (Imaging Sciences International, Hatfield, PA, USA). Standard scanning conditions for orthognathic surgery patients were ensured: patient breathing quietly, sitting upright, with the clinical Frankfort horizontal plane parallel to the floor, and biting on a wax-bite in centric occlusion. Preliminary data were saved in DICOM format. For image processing, a computer with the following characteristics was used: Pentium 4 Processor, 3.8 GHz, W/SP5 Windows XP Professional, 120 GB of memory, 2 GB of RAM, and a screen of 20 inches minimum. i-CAT Vision (version 1.8.0.5; Imaging Sciences International) and SimPlant O&O (Materialise Dental SL) software programs were installed on this computer for image viewing and processing, respectively.

A 3D simulation of the pre- and postoperative anatomy was performed. An appropriate mask and region of interest were defined for this purpose. Through automatic segmentation, a preview image was obtained. This was later optimized by manual segmentation, eliminating possible artefacts.

Once the 3D reconstructions of the pre- and postoperative conditions had been obtained, they were superimposed virtually in order to evaluate possible changes in condylar position in all three planes of space. Superimpositions were done using the cranial base as a stable anatomical reference, since it is assumed to remain unchanged after surgery. The software allowed for proper adjustment of the superimposed images in the three views (sagittal, coronal, and axial) in every single slice (Fig. 1). Once the correct superimposition had been obtained, the relationship was saved as the ‘home position’, such that the program would always connect the two 3D reconstructions in the same relationship. Following this methodology, the program created a coded overlay colour map that enabled visual analysis and objective quantification of the changes in three dimensions (Fig. 2).

The 3D analysis of condylar position was systematized as follows: five points were defined on each condyle; these points were named anterior, posterior, superior, medial, and lateral (Fig. 3).

Positional changes were evaluated separately for each point. Because each colour indicates an interval of change in the colour map, it was decided that the highest value of each corresponding interval would be recorded. This methodology assumed that the value ‘0’ is not possible and ensured that the highest possible change – in other words, the ‘worst possible