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Skeletal stability in orthognathic surgery: evaluation of methods of rigid internal fixation after counterclockwise rotation in patients with class II deformities

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Abstract

Our aim was to assess the influence of internal fixation in skeletal stability on patients who had had counterclockwise rotation of the maxillomandibular complex and mandibular advancement procedures. We studied 60 records of 20 patients (14 female, 6 male), mean (range) age at operation 29 (16-50) years. The mean (range) postoperative follow-up was 15 (8-24) months. Sixty standard lateral cephalometric radiographs were randomly traced and digitised by one senior radiologist to estimate surgical and postoperative changes. Patients were divided into two groups, the first group ($n = 10$) of which had fixation with only 2.0 system plates (2 plates with monocortical screws alone) and the second ($n = 10$) of which had hybrid fixation (1 plate with monocortical screws and 2 or 3 bicortical bone screws). During operation the change in the mean occlusal plane with counterclockwise rotation was 9.4° (range -17.3 to -2.5 mm). The maxilla moved forward and upward. All the anterior mandibular measurements had advanced horizontally, the mean (range) being 17 (6.4 to 9.9) mm for the pogonion, and 17.6 (6.0 to 30.7) mm for the menton. At the longest follow-up period, there were significant long-term changes, but these were clinically acceptable (<2 mm). There was no significant difference between the two groups in postoperative stability or in the magnitude of the advancement and stability.

Keywords: Orthognathic surgery; Occlusal plane; Stability; Bone fixation

Introduction

One of the biggest challenges in orthognathic surgery is the stability of the result after large counterclockwise rotation of the maxillomandibular complex (MMC) as a result of stretching of the supra-hyoid muscles and adaption of the

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temporomandibular joints (TMJ).[1] The technological development of bony fixation and technical improvements in operative techniques have led to expansion of the systems of orthognathic surgery and have made it possible to provide proper treatment for patients who present with dentofacial deformities.

The principle of changing the occlusal plane has enabled improvements in function and aesthetic results for the correction of such deformities in which bimaxillary surgery is indicated. The handling of the occlusal plane can be defined as rotation of the MMC around a preselected point either clockwise or counterclockwise, which results in changes in its angle.[2,3] This surgical movement is well suited to patients with Class II deformities associated with an increased occlusal plane They usually present with micrognathia, vertical maxillary excess, increased lower anterior facial height, decreased posterior height, class II malocclusion, labial incompetence, reduced upper airway space, and sleep disorders such as snoring, daytime fatigue, and apnoea.[4]

According to Wolford et al., [5] selective modification of the occlusal plane during bimaxillary orthognathic surgery with rigid fixation in a patient with a healthy TMJ is a stable procedure. Patients in whom a change in the occlusal plane is indicated can be classified into those with a low occlusal plane (<4°), who are usually treated by clockwise rotation downwards and backwards, and those with a high occlusal plane (>12°), who are usually treated by counterclockwise rotation upwards and forwards. However, the few existing studies that we know of have reported that the stability of these rotations differs. Epker and Schendel,[6] and Proffit et al.,[7] found that the bone was unstable after rotation of the occlusal plane.

There are different techniques of rigid internal fixation that are commonly used to stabilise the bilateral sagittal split ramus osteotomy (SSRO), but little is known about the mechanical characteristics and differences in stability when these techniques are used.[8]

The objective of this study was therefore to assess the influence of rigid internal fixation in skeletal stability after counterclockwise rotation of the MMC and mandibular advancement.

Patients and methods

This retrospective study was approved by the Research Ethics Committee (Protocol No. 58/11). Thirty-five patients with preoperative skeletal Class II deformities[9] who had had orthognathic surgery with maxillomandibular counterclockwise rotation and mandibular advancement were selected. The diagnosis was established according to standard clinical and radiographic criteria.

The criteria for inclusion in the study were: preoperative diagnosis of skeletal Class II deformity with a similar degree of surgical changes; a minimum age of 16 years for female patients and 17 years for male patients; bimaxillary surgery for counterclockwise rotation of the MMC and occlusal plane with mandibular advancement; and the use of rigid fixation. Patients were excluded if they had any operation on the temporomandibular joint (TMJ). In addition, the operations had to have been done by the same team using the same techniques. The operations were done in the same sequence starting with the mandible and then the maxilla.[10] Orthodontic treatment was given before and after operation and there was no postoperative trauma. Fifteen patients were rejected because they had craniofacial syndromes and their records were inadequate.

In this retrospective study, therefore, we evaluated 60 records of 20 patients (14 female and 6 male) from a single private clinic in Salvador, BA, Brazil, from 2008 until 2012.

The patients' age range at operation was 16 at 50 years. Preoperative records (T1) were taken, followed by those immediately postoperatively (T2), which were taken up to 30 days afterwards. The longest follow up records (T3) were taken at a range of 8 at 24 months postoperatively. The mean advancement of the pogonion was 16.06 mm for group 1 (SD = 3.71) and 17.89 mm for group 2 (SD = 7.32).

Evaluation

Patients were divided into two groups. The first group ($n = 10$) had internal fixation of the mandible with system plates (2.0 mm thick) – two, four-hole, straight plates on each side, using two monocortical screws for the proximal segment and two for the distal segment (monocortical alone group). The second group ($n = 10$) had internal fixation of the mandible with system plates (2.0 mm thick) – one four-hole straight plate, using two monocortical screws for the proximal segment and two for the distal segment associated with two or three bicortical bone screws (2.0 mm thick), placed at each side (hybrid fixation group). The maxillary fixation was the same for both groups.

The first choice for fixation of the jaw bone was monocortical plates and screws following the principles of fixation with minimal risk of condylar torque and compression of the TMJ. Patients in the study had micrognathia, small condyles, and an increased occlusal plane. The decision to give additional stability to the installation with bicortical screws was made during operation in the hybrid fixation group based on the judgement of the surgeon, when mobility and transverse spacing were noted between the proximal and distal segments after fixation with plates. The bicortical screw was installed after the plate had been inserted to avoid condylar torque.

Evaluation of images

Standard lateral cephalometric radiographs (Kodak 8000, Trophy, Pelloutier – Croissy-Beaubourg, France) were randomly traced and digitised by one investigator (a senior radiologist) (Figs. 1–2). Sixteen landmarks were identified and digitised using the Radiocef 5.0 software program

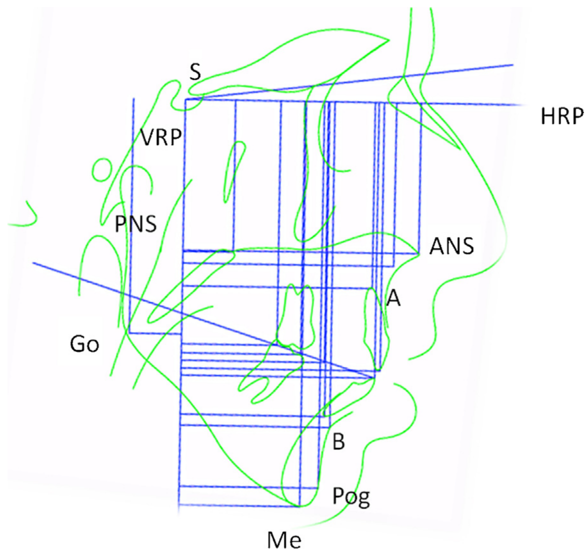

Figure 1. Reference landmarks and lines measured on a lateral cephalogram during the preoperative period (T1). Landmarks were identified and digitised using Radiocef 5.0 software.

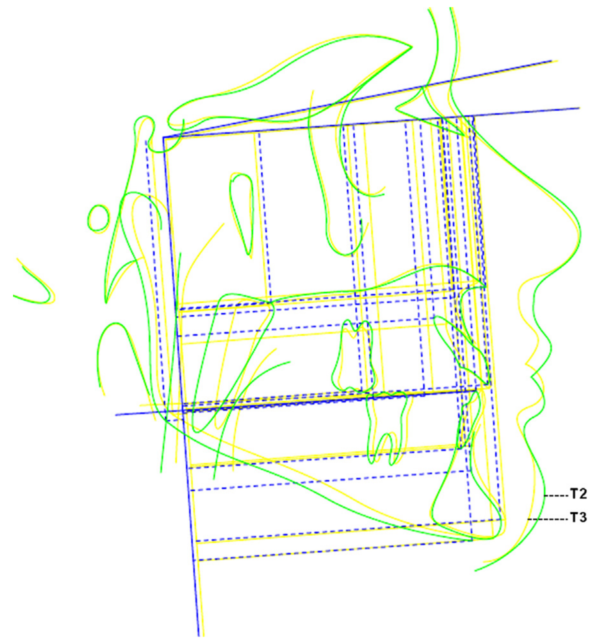

Figure 2. Superimposition of immediate postoperative (T2) and longest follow up (T3) cephalograms showing the degree of skeletal stability achieved. Landmarks were identified and digitised using Radiocef 5.0 software.

(Radiomemory Ltda., Belo Horizonte, MG, Brazil). The landmarks were used to compute 27 measurements (Table 1). S–N minus 7° was used as the horizontal reference plane and a perpendicular line through the sella as the vertical reference plane. Horizontal and vertical changes were evaluated for each landmark. Surgical changes were computed as the differences between T2 and T1 values and postoperative changes between T3 and T2 values. [11]

Statistical analysis

All data were transferred to IBM SPSS Statistics for Windows (version 20; IBM Corp, Armonk, NY) for statistical analysis. Paired *t* tests were used to evaluate the significance of differences in the operative (T2–T1) and postoperative changes (T3–T2), and probabilities of less than 0.05 were accepted as significant. For between-groups comparisons we used Student's *t* test for normally distributed data and the Mann-Whitney *U* test for skewed data. This affected only 3 landmarks: U1T, PNS, and U6T (Table 1). To assess the significance of the relation between the measures according to the group we used Spearman's rank correlation.

Table 1
Cephalometric landmarks.

Abbreviation	Landmark	Position
S	Sella	The midpoint of fossa hypophysalis
ANS	Anterior nasal spine	The most anterior point of the hard palate
PNS	Posterior nasal spine	The most posterior point of the hard palate
A	Point A	The most posterior point in the concavity between ANS and the maxillary alveolar process
B	Point B	The most posterior point in the concavity between the chin and mandibular alveolar process
Pog	Pogonion	The point on the symphysis tangent to the facial plane
Me	Menton	The most inferior point of the bony chin
Go	Gonion	A mid-plane point at the gonial angle located by bisecting the posterior and inferior borders of the mandible
U6T		Tip of the upper molar mesial cusp
L6T		Tip of the lower molar distal cusp
L5T		Tip of the lower premolar cusp
U1T		Tip of the upper incisor
U1A		Apex of the upper incisor
L1T		Tip of the lower incisor
L1A		Apex of the lower incisor

Figure 3. Preoperative facial profile of a patient who had bimaxillary surgery and advancement of pogonion (published with the patient's consent).

Figure 4. Facial profile during the later postoperative period of a patient who had bimaxillary surgery and advancement of pogonion, showing good skeletal stability (published with the patient's consent).

Surgical technique

All the patients in the sample (both groups) had a LeFort I osteotomy (one or three segments of the maxilla), in which the segments were stabilised by miniplates and screws. At least four plates were inserted, with two miniplates and two screws on either side of the cut bone to provide stability in each case.[12] The operation on the mandible was a modified bilateral SSRO.[12,13]

Results

All the patients in the study had maxillary and mandibular osteotomies to rotate the MMC (Figs. 3–4). A one-piece Le Fort I osteotomy was done for 9 patients, and 1 patient had a 3-segment Le Fort I osteotomy. All the patients had bilateral SSRO. In addition, 10 patients had chin adjustment surgery: 8 had a standard genioplasty, and 2 had alloplastic augmentation (Medpor implant; Porex Surgical Inc, Newnan, GA).

Initial values, operative changes, and those at the longest follow up are listed in Table 2.

About 30% of patients had anterior open bite preoperatively, and there was no significant recurrence of this vertical malocclusion.

Discussion

The definition of recurrence in orthognathic surgery is still controversial. According to Joss and Vasalli,[14] horizontal shifts of 2-4 mm are acceptable, as postoperative orthodontic treatment can compensate for detrimental variations.

Table 2
Initial values (T1), operative changes (T2–T1), and postoperative changes (T3–T2) (n = 20 patients).

Variable	T1	T2-T1		T3-T2	
	Mean (SD)	Mean (SD)	p value	Mean (SD)	p value
Horizontal (mm):					
ANS	42.8 (3.0)	−2.8 (3.0)	<0.01	0.6 (1.6)	
PNS	42.0 (2.9)	1.8 (2.1)	<0.01	−0.4 (1.1)	
A	46.5 (3.7)	−2.2 (3.4)	=0.01	−0.1 (1.6)	
B	90.4 (4.3)	−1.0 (3.9)		0.2 (4.0)	
Pog	107.7 (4.7)	−6.3 (3.6)	<0.01	2.0 (2.8)	=0.005
Me	113.2 (5.2)	−4.5 (3.5)	<0.01	0.9 (2.8)	
Go	69.1 (4.9)	0.8 (2.1)		−1.3 (3.3)	
L1A	87.5 (4.1)	−2.3 (2.4)	<0.01	0.8 (3.0)	
L1T	73.7 (3.5)	−3.7 (2.6)	<0.01	0.9 (2.5)	
U1A	54.1 (4.0)	−3.2 (3.8)	<0.01	0.7 (1.5)	=0.04
U1T	75.1 (4.1)	−3.8 (3.6)	<0.01	1.0 (2.0)	=0.04
Vertical (mm):					
ANS	73.9 (6.1)	1.3 (3.2)		0.1 (2.8)	
PNS	19.6 (3.7)	1.9 (2.6)	<0.01	0 (2.6)	
A	66.0 (6.1)	1.6 (3.3)	=0.04	−0.4 (1.9)	
B	53.4 (10.0)	9.4 (5.2)	<0.01	−0.6 (3.1)	
Pog	50.3 (11.0)	17.0 (5.7)	<0.01	−1.7 (3.4)	=0.04
Me	43.9 (11.2)	17.6 (6.0)	<0.01	−1.3 (4.1)	
Go	−10.1 (5.2)	3.0 (2.2)	<0.01	−0.4 (2.3)	
L1A	52.5 (9.6)	9.3 (4.7)	<0.01	−1.0 (3.6)	
L1T	64.1 (8.4)	6.1 (4.2)	<0.01	−0.5 (2.5)	
U1A	62.4 (6.5)	2.5 (3.3)	<0.01	0.4 (1.8)	
U1T	68.5 (8.1)	4.2 (3.8)	<0.01	−0.5 (2.4)	
Angle (°):					
SNA	82.0 (5.4)	2.0 (3.2)	=0.01	−0.8 (1.9)	
SNB	75.2 (5.3)	5.4 (2.8)	<0.01	−0.5 (1.7)	
ANB	6.8 (3.1)	−3.5 (3.2)	<0.01	−0.3 (2.0)	
SNPog	74.8 (5.0)	8.4 (2.6)	<0.01	−1.0 (1.7)	=0.01
OPA	13.2 (4.8)	−9.4 (4.5)	<0.01	1.9 (2.6)	<0.01

Note: see Table 1 for an explanation of the abbreviations.
Horizontal vector: plus values=forward movement; minus values=posterior movement.
Vertical vector: plus values=downward movement; minus values=upward movement.

Studies of the hierarchy of stability and predictability in orthognathic surgery when rigid fixation is used consider postoperative changes of less than 2 mm acceptable and clinically unimportant.[15,16] These authors also emphasised that the procedures typically used for the treatment of Class II disorders/long-faced patients, the superior repositioning of the maxilla together with mandibular advancement, are quite stable during the first postoperative year. However, these patients may develop relevant skeletal changes (more than 2 mm) during postoperative years 1–5.[15,16] In the present study, structural alterations to the face were considerable, with advance of 17.0 mm (SD = 5.7) for the pogonion, and 17.6 mm (SD = 6.0) for the menton, and although the results were significant, all the changes were less than 2 mm. We can suggest adaptation of the TMJ, as at the end of occlusal adjustment the changes generated were close to 2 mm.

The stability of selective changes in the occlusal plane by bimaxillary surgery with clockwise or counterclockwise rotation in healthy patients with stable TMJ have been confirmed by several studies.[17–19] The results showed significant angular changes in the occlusal plane, showing a loss with a mean (SD = 2.6) change of 1.9° in the angle of the occlusal plane, and clockwise rotation of the occlusal plane in the long term.

Factors that may contribute to skeletal relapse and condylar resorption include articular diseases, age and sex of the patient, a high angle of the mandibular plane, preoperative orthodontic treatment, bony health, condylar position, neuromuscular adaptation, instability of the segments, and the amount of forward advancement.[19,20] It is noteworthy that one patient (a 20-year-old woman in the monocortical alone group) had a major relapse (7.5 mm) in the Pog position, which was possibly caused by an erosive response in the condyles and clockwise rotation of the occlusal plane of 7°. The condylar resorption reduced the volume of the condyle, but the height did not change, so there was no loss of occlusal result. The dental relations remained stable, with 2 mm overjet at the end of treatment, but there was a significant increase in the angle of the occlusal plane. We think that the strength of the suprahyoid muscles and the stretching of the pterygomasseteric sling also contributed to the recurrence of the occlusal plane, but the deciding factor was the unfavourable response of the condyles postoperatively. This change was evaluated long term, and there were no significant differences in her dental occlusion. This suggests slow, gradual, and asymptomatic changes.

Using computer simulation with the use of a finite element model, Chuong et al[8] compared the mechanical properties of two techniques for fixation of bilateral SSRO and concluded that the use of 3 bicortical screws provided more stability than skeletal fixation with monocortical plate and screws.

When they evaluated in vitro biomechanical characteristics of different methods of fixation, research workers concluded that the placement of one bicortical positional screw in the retromolar region may significantly optimise the resistance of the miniplate and monocortical screw fixation, and may also be a simple and stable technique for osteosynthesis.[21,22] We found no significant differences in stability in the group given an additional bicortical screw, which may be related to fixation with two plates and monocortical screws, not a plate alone, as is usually described when the techniques are compared. Similar stability between the techniques of fixation studied were shown here, with no tendency to greater stability for either.

The present study has shown that orthognathic surgery with counterclockwise rotation and advancement of MMC is a stable procedure, although there were significant long-term postoperative changes (Pog, U1A, U1T). However, they were clinically acceptable (< 2 mm). There was no significant difference between the 2 groups with respect to postoperative stability, and no significant difference between the magnitude of advancement and stability.

In conclusion we emphasise that this was a small non-randomised sample, and recommend that larger studies should randomly allocate patients to each group to find out whether there is any significant difference, and to identify the main determinants of loss of stability in orthognathic surgery.

Conflict of Interest

We have no conflict of interest.

Ethics statement/confirmation of patients' permission

The work was approved by the ethics committees of the hospitals. The patients gave informed consent for publication in print and electronic form.

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