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ORIGINAL ARTICLE

Mandibular setback by sagittal split ramus osteotomy: A 12-year follow-up

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Abstract

Short- and long-term skeletal changes after mandibular setback were analyzed using bilateral sagittal split ramus osteotomy. Twelve patients who had undergone mandibular setback surgery between 1986 and 1990 were available for long-term cephalography on average 12 years after primary surgery. The mean amount of surgical setback had been 6.4 mm. After the first postoperative year, there was skeletal relapse of 1 mm at the B-point and pogonion (Pg), amounting to 14% of the initial skeletal setback. In contrast to condylar displacement and proximal segment rotation, osteotomy slippage was associated with positional changes at the B-point and Pg. From 1 to 12 years postoperatively, the B-point and Pg remained stable. Mandibular ramus and corpus length decreased 2.1 mm and 1.3 mm, respectively, indicating remodeling at the osteotomy sites and probably condylar resorption.

Key Words: *Condylar displacement/resorption, mandibular setback, osteotomy slippage, skeletal relapse*

Introduction

Skeletal relapse is one of the most noteworthy postoperative complications of orthognathic surgery. In the literature, many prior studies regarding skeletal relapse after orthognathic surgery concern only mandibular advancement, whereas a relatively small number of studies have addressed skeletal stability after mandibular setback surgery [1–12]. Moreover, some results in these setback studies are highly controversial (Table I). In fact, the mechanisms by which instability of the bony segments and morphological changes of the mandibular bone lead to postsurgical anterior movement toward the presurgical position (skeletal relapse) after mandibular setback surgery have not been fully identified.

Factors contributing to skeletal relapse after bilateral sagittal split ramus osteotomy (BSSO) include the amount of surgical movement, the action of paramandibular connective tissue, and the method of bone fixation [1,3,5,7,9,13–15]. Early skeletal relapse has been linked to postoperative skeletal changes such as condylar displacement, rotation of the proximal segment, and decreased mandibular body length (osteotomy remodeling and slippage) [1,5,7,8,13,15]. Long-term skeletal relapse has been reported to be caused by progressive condylar resorption with a reduction in mandibular ramus length [16–20].

Condylar resorption is defined as progressive alteration of condylar shape and a decrease in mass [21]. There are several possible factors contributing to such resorptive changes. Surgical compression of the condyle and changed biomechanics in the condylar ramus segment have been mentioned as reasons for condylar resorption [10,21]. It has also been suggested that hyperdivergent class III patients with gracile condylar heads are prone to develop postoperative condylar resorption [22].

Recent reports have documented skeletal stability during the first 1–3 years after mandibular setback surgery [3,5,6–10,12]. From our review, there is only one study reporting long-term skeletal relapse 10 years after mandibular setback surgery [2]. However, this study only analyzed skeletal changes after oblique vertical ramus osteotomy. There have been no long-term studies on skeletal stability after surgical setback

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Table I. Literature review of mandibular setback by bilateral sagittal split osteotomy

Authors	No. of patients	Follow-up period	Amount of setback (mm)	Relapse** mean (%)
Reitzik et al., 1980 [1]	16	1 year	12.5	21.0
Wisth et al., 1981 [2]	44	10 years	Unspecified	7.3*
Kobayashi et al., 1986 [3]	44	1 year	8.4	2.4
Komori et al., 1987 [4]	17	5 weeks	7.4	26.0
Franco et al., 1989 [5]	11	3 years	4.9	44.0
Sorokolit et al., 1990 [6]	25	3.5 years	5.1	10.0
Proffit et al., 1991 [7]	11	1 year	4.6	91.0
Schatz et al., 1995 [8]	13	1 year	7.3	39
Harada et al., 1997 [12]	20	1 year	Unspecified	15.0
Mobarak et al., 2000 [9]	80	3 years	6.9	19.0
Present study, 2004	12	12 years	6.4	14

*SNB (°).
**Relapse: Anterior movement of the mandible.

of the mandible by BSSO, which is one of the most common methods used in the treatment of skeletal class III malocclusion. It is generally unknown whether a progressive process of skeletal relapse will continue, and what types of long-term mandibular skeletal changes will be observed.

We therefore decided to perform a cephalometric follow-up for a group of patients who underwent mandibular setback by BSSO 12 years earlier. The purpose of the study was to determine cephalometrically the extent of long-term skeletal changes of the mandible. Our detailed data analysis placed special attention on the mechanism and localization of the postoperative skeletal changes.

Material and methods

In our department, 32 consecutive patients had combined orthodontic and surgical treatment for skeletal class III malocclusion between 1986 and 1991, and 12 (38%) of these patients were available for long-term cephalography in 2002. The mean time between the primary orthognathic surgery and the final cephalometric examination was 12 years (range 11 to 16 years). There were 3 women and 9 men with a mean age of 28 years (range 18 to 56 years) at surgery and 40 years (range 30 to 68 years) at the final 12-year follow-up.

Preoperatively, all patients had skeletal prognathia, with mean Sella-Nasion-B-point angle (SNB) of 83.6° (range 72° to 94°). The mean preoperative mandibulonasal plane angle (ML-NL) was 25.3° (range 17° to 37°). The patients were surgically treated by BSSO and mandibular setback according to the Obwegeser/Dal-Pont method. Patients who had genioplasty and surgery of the maxilla were excluded from the study. After the osteotomies had been completed, the proximal fragment was grasped with a clamp and gently pushed upwards and backwards into the glenoid fossa. At each osteotomy site, the bony fragments were stabilized with three positioning screws (2 mm in diameter) inserted through a transbuccal trocar. Rigid intermaxillary fixation was maintained for between 4 and 6 days postoperatively, followed by functional training with light-guiding elastics. All patients had pre- and postoperative orthodontic treatment. The mean duration of postoperative orthodontic treatment was 14 months (range 11 to 20 months) and included the retention period. Lower incisors were fixed by a retainer.

Cephalometric radiographs were obtained 1 to 2 days prior to the operation (T0), 1 week after surgery with intermaxillary fixation (T1), 6 months after surgery (T2), upon postoperative orthodontic treatment completion at 14 months on average (T3), and finally long-term follow-up at 12 years on average (T4). In order to minimize variability in measurement errors, all radiographs were taken in centric occlusion and in the same cephalostat using a cephalometric headholder.

All cephalograms were traced and analyzed by the same investigator. To standardize measurements, an x–y cranial base coordinate system was constructed on the radiographs. A horizontal reference line (x-axis) was drawn 7° to the Sella-Nasion line (Se-N-line). A vertical reference line was drawn perpendicular to this line at the sella (y-axis). The cephalometric landmarks identified and the reference lines used are shown in Figure 1. Definitions of the landmarks are listed in Table II. Magnification for linear measurements was 3.3% and was similar in all patients. The magnification was not corrected. Standard statistical parameters and tests were used to evaluate the results. The systematic and accidental errors of the cephalometric analysis have been described elsewhere [23]. From 21 cephalograms, 7 were selected at random. These were retraced and the determinations re-measured. The values were then analyzed using a paired t-test, which revealed no systematic errors. Accidental errors (si) were calculated using the formula

$$si = \sqrt{\frac{\Sigma d^2}{2n}},$$

where d is the difference between the repeated measurements and n the number of duplicate determinations. For most of the angular variables and linear

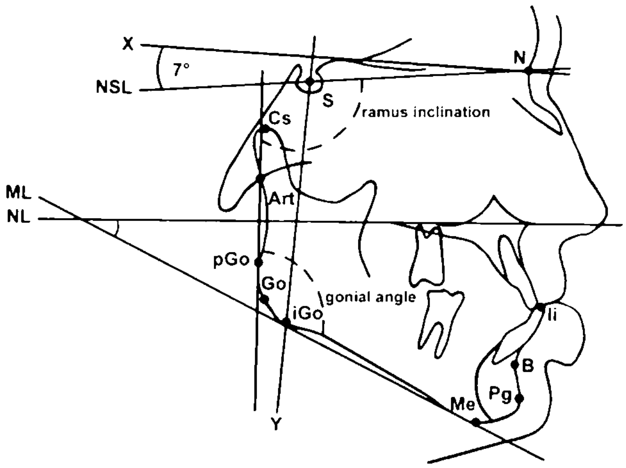

Figure 1. Hard and soft tissue landmarks used in cephalometric analysis.

coordinates of the skeletal reference points, the accidental errors were less than 1.0° and 1.0 mm, respectively.

Horizontal and vertical movements of the skeletal chin were cephalometrically measured at the B-point, pogonion (Pg), and menton (Me), supported by the measurement of the SNB (Sella-Nasion-B-point) angle. The horizontal and vertical movements of Go were also measured. Skeletal changes of the proximal segment (mandibular ramus length) were recorded by analyzing variance in the distance between the superior condyleon and inferior Go (Cs-iGo). Changes in the gonial angle and ramus inclination were also evaluated. The mandibular corpus length was defined as the distance between posterior Go and Pg (pGo-Pg). Skeletal relapse was defined as postoperative forward movement of the mandible.

Values measured were compared between the six different time intervals T0–T1, T1–T2, T2–T3, T3–T4, T1–T4, and T0–T4. Changes in linear and angular parameters were also compared to the magnitude of surgical setback and to the amount of skeletal relapse.

Statistical analysis was next completed to compare and correlate the linear and angular relationships. The Wilcoxon matched-pairs, signed-rank test was utilized to test statistical variance, with significance being defined as $p<0.05$. Spearman's correlation analysis was used to test significant relationships between variables. The degree of correlation (r) was classified as strong if greater than 0.8, moderate if between 0.5 and 0.8, and weak if less than 0.5.

Results

Changes as an immediate result of surgery (T0–T1)

The surgical setback of the mandible (posterior movement) was accompanied by a decrease in the vertical plane (Table II). Mandibular ramus (Cs-iGo) and corpus (pGo-Pg) length both decreased during surgery (Figure 2).

Changes during the first 6 months after surgery (T1–T2)

There were no significant changes from T1 to T2 in the horizontal and vertical planes (Table II). The upward 1.7 mm change in the Go (Table II) was accompanied by a 1.1 mm reduction of mandibular ramus length (Cs-iGo) (Figure 2). Mandibular corpus length (pGo-Pg) increased about 0.4 mm (Figure 2), showing a weak correlation to skeletal changes at the B-point and Pg ($r=0.2$).

Changes after the first year of observation (T1–T3)

From T1 to T3 there was skeletal relapse of about 1 mm at the B-point and Pg, representing 14% (range

Table II. Definitions of skeletal landmarks

Landmark	Definition
N	Nasion: the most anterior point of frontonasal suture
S	Sella: the center of sella turcica
B	B-point: innermost point on contour of mandibula between incisor tooth and bony chin
Pg	Pogonion: most anterior point on osseus contour of chin
Me	Menton: most inferior midline point on mandibular symphesis
Go	Gonion: a point on the curvature of the angle of the mandible made by the tangent to the posterior ramus and inferior border of the mandible
pgO	Posterior Gonion: a point superior to Go on the curvature of the angle of the mandible made by the tangent to the posterior border of the mandible
igO	Inferior Gonion: a point anterior to Go on the curvature of the angle of the mandible made by the tangent to the inferior border of the mandible
Cs	Superior Condyleon: the most superior point of the condyleon
Art	Articulare: the point of intersection between the posterior border of the mandibular ramus and the inferior border of the posterior cranial base
Ramus inclination	The angle made by the intersection of the line connecting points posterior gonion and articulare and the x-axis
Gonial angle	The angle made by the intersection of the lines connecting the posterior gonion and articulare and the tangent to the inferior border of the mandible
ML-NL	Mandibulo-nasal plane angle: angle between the mandibular plane and the nasal plane
Ii	Incisor inferior: The most superior point of the incisor inferior

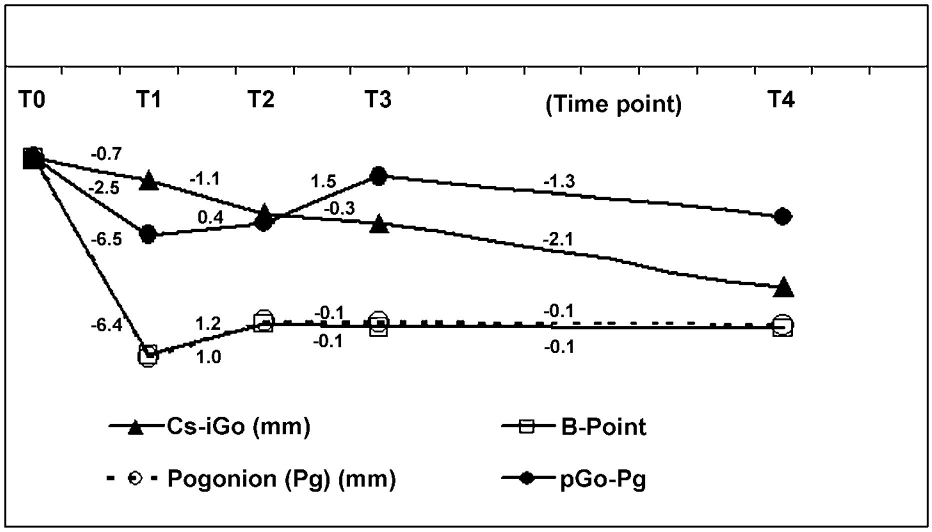

Figure 2. Horizontal changes (x-axis) in the positions of B-point, pogonion (Pg), mandibular ramus (Cs-iGo) and corpus (pGo-Pg) length.

12.5% to 22.5%) of mandibular setback (Table III) and a total decrease of mandibular ramus length (Cs-iGo) of 1.4 mm (Figure 2).

Changes at the long-term follow-up (T3–T4)

There were no significant changes in the horizontal and vertical planes over the long-term period (Table III), except for the B-point and inferior incisor, which showed significant downward movement in the vertical plane. There was a decrease in both mandibular ramus (Cs-iGo) and corpus (pGo-Pg) length, measuring 2.1 mm and 1.3 mm, respectively (Figure 2).

Total postoperative changes (T1–T4)

There were no significant horizontal and vertical changes of the mandibular parameters (Table III). The gonial angle increased significantly (mean 6.3° ± 5.2°).

Discussion

This study was designed to determine skeletal relapse; the mechanism of skeletal relapse and localization of the postoperative skeletal changes after mandibular setback surgery.

Mandibular setback was performed an average of 6.4 mm at the B-point and Pg. This amount of surgical movement is within the range of previously reported data (Table I). Most previous studies report their results within a follow-up time of 1 to 3 years post-operatively. After a corresponding postoperative period of 14 months average in our study, a skeletal relapse of 14% to the amount of mandibular setback

Table III. Changes (mean and standard deviation) in skeletal variables between different postoperative intervals

Variable	T0–T1	SD	T1–T2	SD	T2–T3	SD	T3–T4	SD	T1–T4	SD	T0–T4	SD
No. of patients	12		12		12		12		12		12	
Horizontal (mm)												
B	−6.4*	5.3	1.0	1.5	−0.1	2.4	−0.1	2.1	1.0	2.8	−5.4*	4.7
Pg	−6.5*	6.6	1.2	2.2	−0.1	2.5	−0.1	2.2	0.9	3.2	−5.5*	6.0
Me	−6.1*	7.2	1.4	2.8	−0.8	2.8	0.8	2.5	1.6	3.3	−4.6	5.1
Go	−6.2*	4.3	1.5	3.1	−1.0	3.3	0.5	2.5	1.0	3.6	−5.2	2.6
Ii	−6.7*	4.2	1.0	1.7	0.0	1.6	−0.3	1.3	0.7	2.1	−6.0	3.9
Vertical (mm)												
B	−0.7	4.0	−0.7	2.9	−0.4	3.2	2.1*	2.4	0.9	3.1	0.1	4.0
Pg	−0.3	2.8	0.0	2.1	0.1	2.2	0.8	2.3	0.9	2.5	0.7	3.9
Me	−0.6	2.7	−0.2	1.3	−0.2	1.4	1.3	1.8	1.0	2.0	0.4	2.7
Go	−0.3	2.2	−1.7	2.3	−0.7	4.1	1.0	3.1	−1.3	2.9	−1.7	1.6
Ii	−0.8	3.1	−0.2	1.4	0.0	1.8	1.8*	2.2	1.5	1.9	0.6	0.3
Angular (°)												
SNB	−4.1	2.6	0.1	1.1	0.2	1.1	0.2	1.4	0.4	1.2	−3.7	2.7
ML-NL	−0.9	3.1	0.0	2.7	0.4	1.4	1.2	3.4	1.6	4.3	0.7	4.4
Ramus inclination	4.5*	3.5	−1.4	2.4	0.7	4.1	−0.3	4.9	−1.0	3.8	3.5	3.8
Gonial angle	−8.3*	4.6	5.7*	5.6	−2.9*	2.0	3.5*	2.2	6.3*	5.2	−2.1*	2.3

SD = Standard deviation.
*$p < 0.05$; statistical significance for time intervals T0–T1, T1–T2, T2–T3, T3–T4, T1–T4, T0–T4.

was measured at the Pg and B-point. Our relapse rate also lies in the range of previously reported results (Table I).

Early skeletal relapse has been linked to postoperative instability and intersegment movement at the osteotomy site [16,24,25]. This so-called "osteotomy slippage" can occur if the "rigid fixation" is inadequate. It has been reported to occur before bony union has been established, and can be measured as a change in mandibular corpus length. In our study, mandibular corpus length decreased 2.5 mm during surgery but almost fully returned to its preoperative length after the first year of observation. In contrast to Franco et al. [5], who did not find any osteotomy slippage in the first 3 years postoperatively, our results show that there is osteotomy slippage after mandibular setback surgery, probably contributing to early skeletal relapse.

Another mechanism contributing to early relapse is condylar displacement and clockwise rotation of the proximal segment, which occurs in connection with condylar repositioning during surgery [7,15]. This positional change of the proximal segment lengthens the pterygomasseteric muscle sling, stretching the lateral muscle attachments. At the same time, posterior movement of the distal segment places the medial attachments under tension. The stretched mandibular musculature thus tends to return the ramus to its original inclination when function resumes, and therefore skeletal relapse may occur. Cephalometrically, a vertical change of the Go in an inferior direction is indicative of condylar displacement, and the posterior rotation of the ramus segment becomes visible as the ramus inclination increases. Our results show that the Go moved vertically upwards during surgery and remained nearly unchanged between T1 and T3, indicating that there was no condylar displacement in our patients. During surgery, Go also moved significantly posteriorly, with an increase in mandibular ramus inclination indicating a proximal segment rotation. Proffit et al. [7] observed a strong relapse tendency due to condylar displacement 1 year after mandibular setback. Komori et al. [15] found that the degree of proximal segment anteroposterior rotation was a significant factor in distal segment relapse at an early postoperative stage. In those studies [7,15], a cephalometrically measurable increase of the ramus length was associated with rotation of the proximal segment. Subsequently, Mobarak et al. [9] made a similar observation in a 3-year follow-up after mandibular setback, confirming a positive correlation between proximal segment rotation, condylar displacement, and mandibular skeletal relapse.

Our results, and those from the other studies mentioned above, indicate that surgical rotation of the proximal segment occurs in most cases of mandibular setback. In cephalometrical measurements, unless no elongation of the ramus height occurs the rotation of the ramus alone probably does not directly correlate to skeletal relapse. According to the results of the above-mentioned studies, we have to conclude that the proximal segment rotation in our patients probably did not contribute to early skeletal relapse.

In the long term, the results of our study show no further skeletal relapse after the first year of observation. However, there was a continuous decrease of mandibular ramus length in the follow-up. This may have been due to morphological changes of the condyle or to remodeling of the mandibular angle or of the inferior aspect of the ramus. Moreover, our results show a long-term decrease of mandibular corpus length and an increase of mandibulo-nasal plane angle (ML/NL), confirming that a remodeling process occurs at the osteotomy site in the angular region of the mandible.

Several studies on skeletal relapse after mandibular advancement describe progressive condylar resorption as the main etiology for long-term skeletal relapse [16–20]. In a study by Bailey et al. [10], condylar remodeling was shown to occur in the same percentage of patients after both mandibular advancement and setback surgery. Unfortunately, there is only one study in the literature reporting long-term skeletal relapse 10 years after mandibular setback [2]. In that study, significant skeletal relapse was found over the 10-year period, with a 1.7° decrease of the Sella-Nasion-B-point angle (SNB). This was interpreted as being caused by unstable interdigitation of the dentition rather than by mechanisms such as displacement of the proximal segment, remodeling of the osteotomy site, or progressive condylar resorption. Unfortunately, since that study only analyzed patients treated with oblique vertical ramus osteotomy, no direct comparison with our study is possible.

Our results, and those of the other studies mentioned above, indicate that over the long term it is possible that not only the temporomandibular joint, but also a wide area of the mandibular bone is significantly influenced by the surrounding soft tissues, such that the remodeling process comprises the entire proximal segment, including the mandibular angle and the osteotomy site. The postoperative changes of the mandible seem to be part of a continuous process, which is an indication that the prognathic mandible is part of a functional interrelation. These observations may verify Moss's theory that hard-tissue morphology is a result of the functional requirements of an area [26].

In conclusion, skeletal relapse was measurable at the B-point and Pg after the first year of observation. Osteotomy slippage seems to be responsible for this short-term skeletal relapse. In contrast to proximal segment rotation, condylar displacement was not observed. In the long-term follow-up, there was no further skeletal relapse. However, a decrease of mandibular ramus and corpus length was measurable, indicating primarily remodeling at osteotomy sites and probably condylar resorption.

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