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Surgical risk factors for condylar resorption after orthognathic surgery

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Objective. The purpose of this study was to look for surgical risk factors for condylar resorption after orthognathic surgery.
Study design. Seventeen patients of a group of 452 patients who had undergone orthognathic surgery consecutively and who were in accordance with the inclusion criteria of this study showed postoperative condylar resorption (group I). Preoperative cephalometric characteristics and surgically induced movements of this group were compared with a control group of 17 of 452 patients (group II) in whom postoperative condylar resorption and skeletal relapse did not develop, despite mandibular retrognathism (ANB angle >4 degrees) and high mandibular plane angle (>40 degrees).
Results. The kind of osteosynthesis used was not significantly different between the 2 groups. The amount of surgical advancements and the vertical movements of the jaws were not significantly different between the 2 groups. However, the distal ($P = .005$) and proximal ($P = .007$) mandibular segments were rotated significantly further counterclockwise in group I. Surgically induced posterior condylar displacement occurred significantly more frequently ($P = .007$) in group I.
Conclusions. Counterclockwise rotation of the distal and proximal mandibular segments and surgically induced posterior condylar displacement seem to be important surgical risk factors for postoperative condylar resorption. Therefore, these movements seem to be contraindicated in patients who are at high risk.
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Condylar resorption after orthognathic surgery is an important cause of late skeletal relapse.[1-12] However, the causes and pathogenesis of condylar resorption after orthognathic surgery remain unclear.

The development of postoperative condylar resorption is affected both by patient-related risk factors (ie, being a young woman, having preoperative temporomandibular joint dysfunction, having mandibular hypoplasia with a high mandibular plane angle, having short posterior facial height and a small posterior-to-anterior facial height ratio) and by surgical movement and its impact on soft tissues.[2-12] Different surgically induced mechanical forces can contribute to the development of condylar resorption. Forces caused by tension in the surrounding soft tissue after a large mandibular advancement can compress[13,14] or displace[15-17] the condyle. Other relevant surgical factors are counterclockwise rotation of the distal and proximal mandibular segments and intermaxillary fixation (IMF).[3,5-8,11-13,18] Condylar resorption is reported to occur more frequently in cases of intraosseous wire fixation combined with postoperative rigid IMF than in cases of rigid internal mandibular fixation without IMF.[12]

Although several clinical and radiologic features and some hypothetical patient risk factors have been reported in the medical literature, potential surgical factors and the effect of the amount of surgical movement on patients with condylar resorption have been analyzed less thoroughly. This study evaluates preoperative cephalometric characteristics and surgical factors in patients with postoperative condylar resorption after correction of mandibular retrognathism and compares these data with those from patients in whom,

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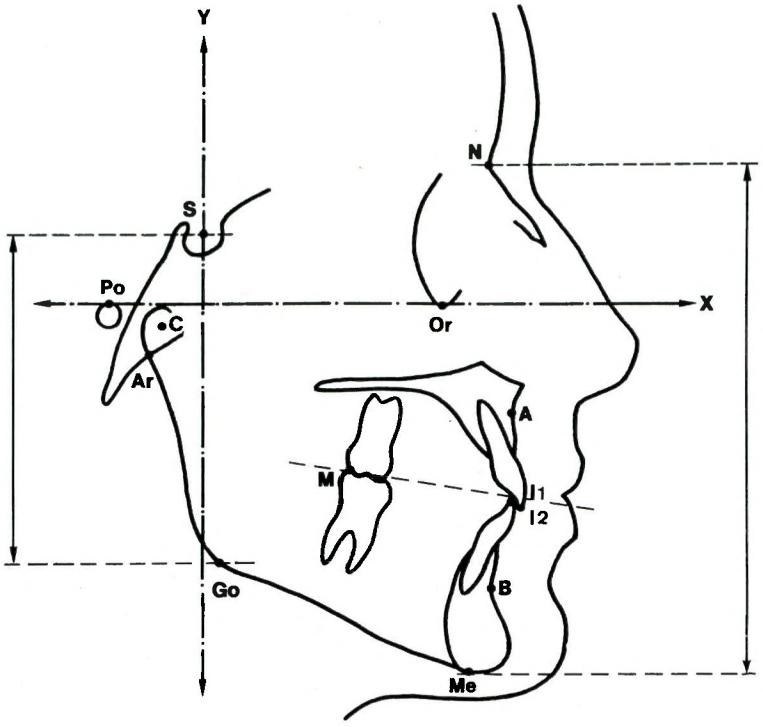


Fig 1. Cephalometric analysis: reference points nasion, porion, and sella were determined, and Frankfurt horizontal line through porion and orbitale was used as the x-axis. Perpendicular line through sella was used as y-axis. Mandibular occlusal plane was defined as line between incisal edge of lower first incisor (I_2) and distal cusp of lower second molar (M). Figure shows 10 selected landmarks (including I_1, upper first incisal edge and I_2, lower first incisal edge) and distances N-Me and S-Go for measuring anterior and posterior facial heights, respectively.

despite mandibular retrognathism with a high mandibular plane angle, postoperative condylar resorption and relapse did not develop. We attempted to assess the statistical significance of the different surgical contributing factors on the development of condylar resorption after orthognathic surgery.

PATIENTS AND METHODS

A group of 452 patients who underwent orthognathic surgery consecutively were screened for condylar resorption based on one or both the following criteria: (1) signs of decreased condylar height and volume on postoperative orthopantomogram (OPG) when compared with preoperative OPG, and (2) postoperative occlusal change consisting of an increase of overjet or a decrease of an overbite as seen on postoperative cephalograms.

Patients with facial asymmetry, craniofacial syndromes, a history of condylar fractures, or evidence of condylar resorption caused by systemic diseases were excluded. After cephalometric analysis of the selected patients, those with postoperative occlusal relapse without postoperative condylar changes and those with postoperative condylar remodeling with stable occlusion were excluded. According to the selection and exclusion criteria, 17 patients (group I) were selected for this study.

The control group (group II, n = 17) was selected from the same group of 452 patients. It consisted of patients with mandibular hypoplasia (ANB angle >4 degrees) and a preoperative high mandibular plane angle (>40 degrees) who did not show postoperative condylar resorption and skeletal relapse. The value of the selection criteria has been reported to be critical in studies on condylar resorption.[5,6] These criteria were fulfilled in 22 of 452 patients. Male patients (n = 3) and patients with isolated Le Fort I osteotomy (n = 2) were excluded to reduce the variability in both groups. This was done because group I had no male patients and no patients with isolated Le Fort I osteotomies.

Group I

All patients (n = 17) were female, and the average age at the time of surgery was 19.8 years (range, 15-29 years). The incidence of postoperative condylar resorption was 17 of 452 patients (3.8%), and this amounted to 7.1% of the 240 patients with Angle Class II maloc-

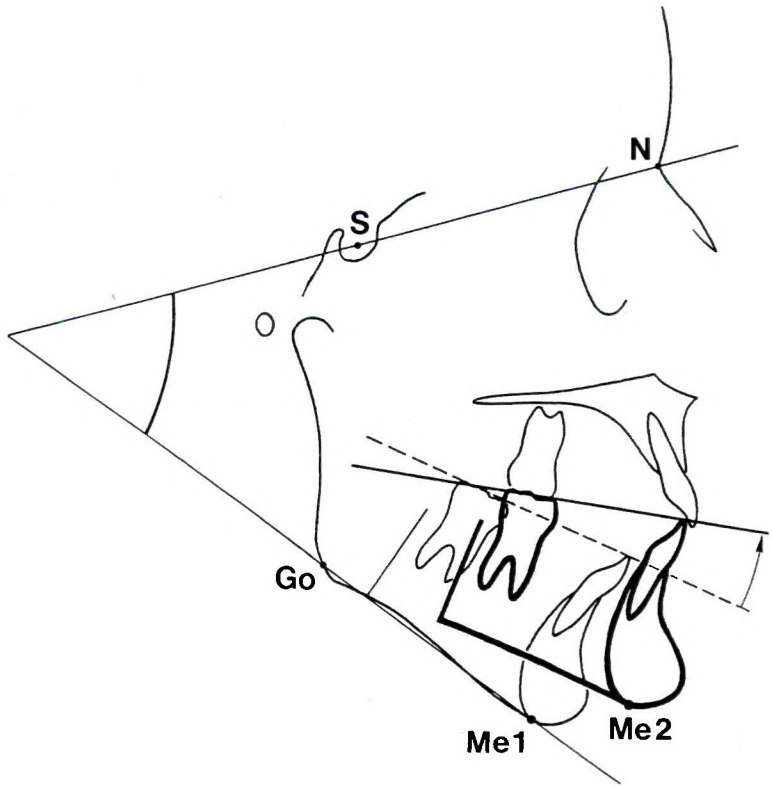


Fig 2. Counterclockwise rotation of mandibular distal segment. *Me1*, preoperative menton; *Me2*, postoperative menton.

clusion. All patients had mandibular hypoplasia and Class II malocclusion. The average mandibular plane angle was 49.4 degrees (range, 40-55.0 degrees), the average SNA and SNB angles were 76.4 degrees and 68.7 degrees, respectively. Twelve patients had an open bite deformity, and the average overbite was –1.1 mm; the average overjet was 7.8 mm. Bimaxillary surgery consisting of a Le Fort I osteotomy and bilateral sagittal splitting osteotomy (BSSO) was performed in 16 cases, and an isolated BSSO was performed in the remaining one. An advancement genioplasty was carried out in 16 cases. Intraosseous wire fixation for stabilizing the maxillary osteotomies was used in 9 cases and rigid internal fixation with titanium miniplates in 7. Postoperative rigid IMF was performed in all 9 cases for a period of 4 weeks, with wire fixation of the maxilla. The BSSOs were stabilized by means of screws in 10 cases and with miniplate in 7 cases.

Group II

Group II consisted of 17 female patients, with an average age of 23.8 years (range, 15.6-43.0 years). The average mandibular plane angle was 44.0 degrees (range, 40-52.5 degrees), the average SNA and SNB angle were 78.3 degrees and 72.0 degrees, respectively. Six patients had a preoperative open bite deformity, and the average overbite was 1.8 mm. The average overjet was 7.0 mm. Bimaxillary procedures were carried out on 16 patients, and an isolated BSSO was done on 1 patient. Advancement genioplasties were performed on 14 patients. Intraosseous wire fixation for stabilizing Le Fort I osteotomies was used on 4 patients and rigid internal fixation with titanium miniplates on 12 patients. In all 4 patients with wire fixation of the maxilla, postoperative rigid IMF was maintained for 4 weeks. The BSSOs were stabilized by means of screws in 6 cases and with miniplates in 11 cases.

The surgical procedures were similar in all cases. Although several surgeons were involved, the repositioning of the condyle and the osteosynthesis was done exclusively by 2 experienced surgeons. The mandibular distal segments were immobilized after manual repositioning of the condyle in the fossa, without the use of any special repositioning device.

Radiologic analysis

The radiologic data consisted of OPGs and lateral cephalograms taken after surgery (OPG_1, C_1), immediately after surgery (OPG_2, C_2), 1 year after surgery (OPG_3, C_3), and 2 years after surgery (OPG_4, C_4). The

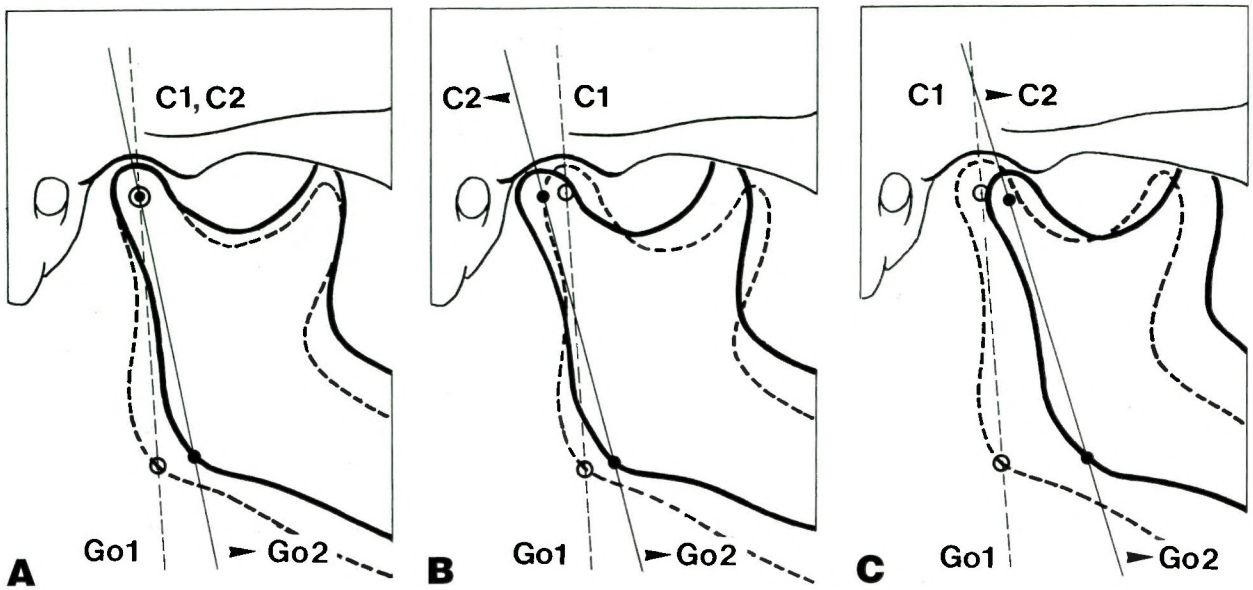


Fig 3. Illustration of counterclockwise rotation of mandibular proximal segment after mandibular movement anteriorly and superiorly, and 3 types of condylar displacement. **A**, Only posterior rotation of condyle, **B**, posterior displacement, and **C**, anterior displacement. *Go1*, Preoperative gonion; *Go2*, postoperative gonion; *C1*, preoperative center of condyle; *C2*, postoperative center of condyle.

last follow-up radiographs (OPG_4, C_4) of 1 patient in group I and 2 patients in group II could not be made, so cephalometric analysis of C_4 was performed in 16 of 17 patients in group I and 15 of 17 patients in group II. In all cases, the same radiograph machines were used for OPGs and cephalograms.

The area of the condylar resorption seen on OPG_3 and OPG_4 was classified as superior or anterior-superior surface. The amount of condylar resorption on both sides of the same OPG was compared to determine whether there was more resorption on one side or the same amount of resorption on both sides.

Cephalometric analysis was done according to the superposition method. The cephalometric reference points (nasion, orbitale, porion, sella) were determined on C_1 and, together with the surrounding bone structures, were traced on acetate papers in order to localize the reference points in all 4 cephalograms. The same was done with 9 selected landmarks (Fig 1) in C_1 through C_4. The Frankfurt horizontal line through porion and orbitale was used as the x-axis. A perpendicular line through sella was used as the y-axis. All points on the 4 cephalograms were digitized on a Numonic digitizer (Montgomeryville, Pasadena, Calif), and the following variables were measured: overbite, overjet, mandibular plane angle (SN-MeGo), SNA and SNB angles, and anterior and posterior facial height (N-Me, S-Go). The ratio of total posterior facial height to total anterior facial height ratio (S-Go/N-Me) was calculated. The projection on the x-axis and y-axis of the displacement of points A and B between C_1 and C_2 was used to measure surgical maxillary and mandibular movements. The mandibular occlusal line was defined as a line between the incisal edge of the lower first incisor and the distal cusp of the lower second molar. The amount of rotation of the distal mandibular segment was determined by measuring the angle between the mandibular occlusal line in C_1 and C_2 (Fig 2). An angle less than 2 degrees was deemed

Table I. Methodical errors

Reference points and landmarks	*X*	*Y*
N	0.082	0.079
Or	0.132	0.000
S	0.000	0.116
Po	0.141	0.000
C	0.314	0.435
Ar	0.091	0.102
Go	0.276	0.318
Me	0.089	0.097
A	0.083	0.099
B	0.101	0.093
I1	0.081	0.079
I2	0.128	0.116
M	0.152	0.148

Difference of distance from x- and y-axis, determined by double measurement of reference points and selected landmarks in all cases (calculated by common formula for middle square error, $S^2=\Sigma d^2/2n$; d, difference in millimeters between C_1 and C_2; n, number of double measurements).

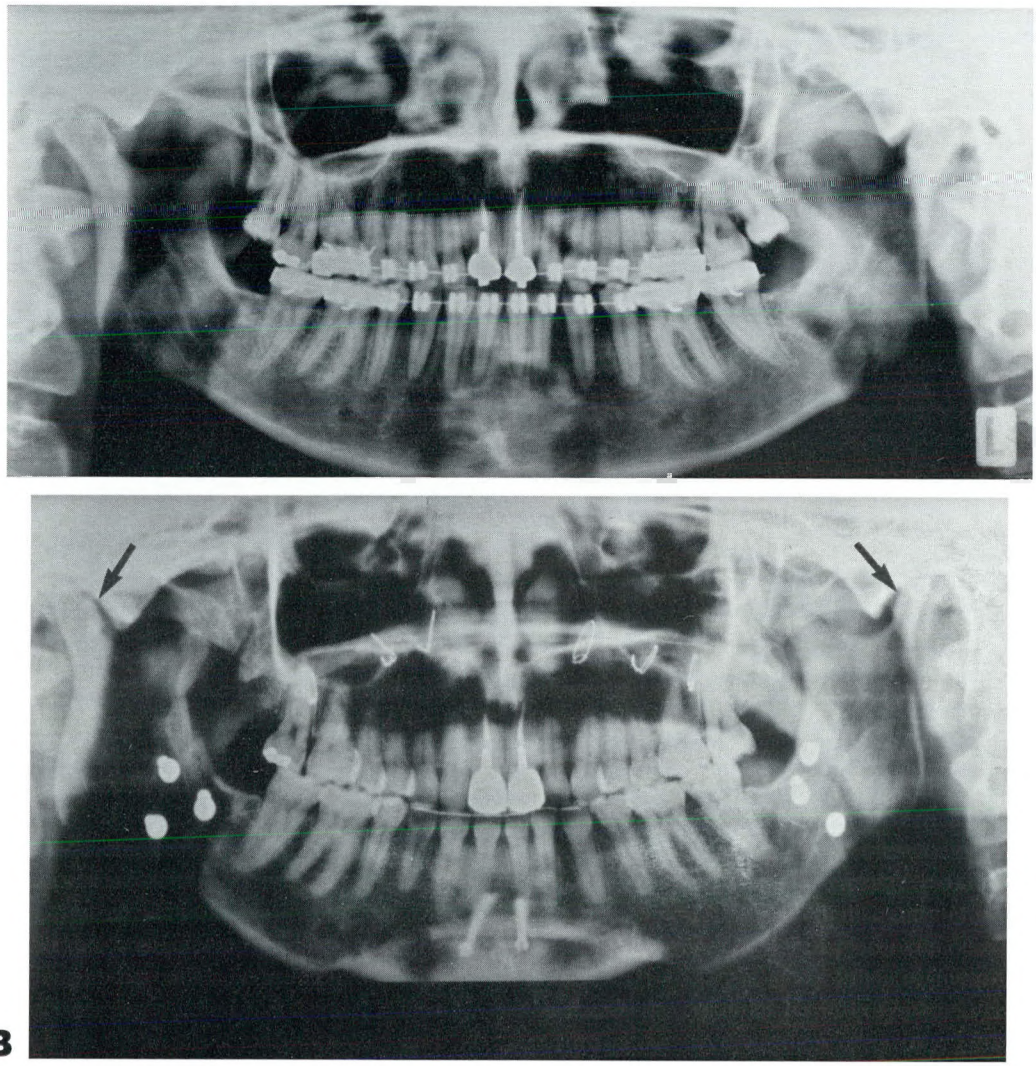


Fig 4. Illustration of asymmetric condylar resorption. Orthopantomograms show condyles of 18-year-old woman with postoperative condylar resorption after bimaxillary osteotomy. **A**, Preoperative situation. **B**, condylar resorption on anterior-superior surface seen 2 years after surgery, which is more pronounced on left side.

unchanged. The rotation of the proximal segment was determined by measuring the angle between a line through the condylar center and gonion in C_1 and C_2 (Fig 3). The center of the condyle was defined as the middle of the broadest part of the condyle in the cephalograms. To evaluate the surgically induced condylar displacement, the outline of the condyle was traced on C_1 and C_2. Condylar displacement was classified as anterior or posterior displacement or as unchanged (Fig 3). A change in the position of the condylar center of less than 2 mm was considered unchanged. The data were analyzed with the Zurich Cephalometric Analysis System, which was developed by the Department of Orthodontics and Paedodontics in the Dental School of the University of Zurich to calculate coordinates, distances, and angles defined by the examiner.

Variable errors of identification of landmarks, tracing, and digitizing were estimated by repeating the whole process in the first 2 cephalograms (C_1 and C_2) of all patients 3 months later. The cephalograms were all placed at the center of the digitizing table, where the contour of the cephalograms was marked. The cursor position relative to the x-axis and y-axis and the tablet border was maintained throughout the whole study. The methodical errors were calculated with the common formula for the middle square error: $S^2=\Sigma d^2/2n$ (d, difference between C_1 and C_2; n, number of double measurements). The maximum error was 0.141 mm for the reference points and 0.435 mm for the examined landmarks (Table I).

Table II. Preoperative cephalometric values (C_1) and surgically induced changes of cephalometric variables

Variables		*Group I*	*P in group I*	*Group II*	*P in group II*	*P group I vs II*
SN-MeGo (°)	in C_1	49.4 ± 4.1	–	44.0 ± 4.2	–	.001
	in C_2 - C_1	–5.3 ± 1.9	< .001	–3.2 ± 2.3	< .001	.012
SNA (°)	in C_1	76.8 ± 2.4	–	78.3 ± 4.0	–	NS
	in C_2 - C_1	2.7 ± 1.5	.004	3.8 ± 2.6	.001	NS
SNB (°)	in C_1	68.7 ± 3.0	–	72.0 ± 3.6	–	.004
	in C_2 - C_1	5.7 ± 1.9	< .001	4.6 ± 1.8	< .001	NS
S-Go (mm)	in C_1	69.7 ± 6.1	–	73.1 ± 5.3	–	NS
	in C_2 - C_1	–0.7 ± 1.5	NS	–0.4 ± 1.2	NS	NS
overbite (mm)	in C_1	–1.1 ± 2.1	–	1.8 ± 2.8	–	.003
	in C_2 - C_1	3.5 ± 2.0	< .001	0.6 ± 3.0	NS	.002
overjet (mm)	in C_1	7.9 ± 2.8	-	7.0 ± 3.6	–	NS
	in C_2 - C_1	–5.6 ± 2.7	< .001	–4.3 ± 3.6	< 0.001	NS
S-Go/N-Me (%)	in C_1	54 ± 3	-	58 ± 4.0	–	.045
	in C_2 - C_1	1.5 ± 1.5	.007	0.7 ± 2.0	NS	NS

Data presented as mean ± SD.
Difference between cephalometric value immediately postoperatively (C_2) and preoperatively (C_1).
Wilcoxon signed rank test for changes within groups I and II.
Mann-Whitney test for differences between groups I and II.
NS, Not significant.

Table III. Surgical movements, surgically induced condylar displacement, and osteosynthesis materials (OSM) in group I and group II

Variables	*Group I*	*Group II*	*P*
Mandibular movement			
to anterior (mm)	9.0 ± 3.6	7.9 ± 3.0	NS
to superior (mm)	5.4 ± 2.8	3.7 ± 3.2	NS
Maxillary movement			
to anterior (mm)	2.6 ± 2.0	3.5 ± 2.4	NS
to superior (mm)	2.9 ± 2.1	2.2 ± 2.2	NS
Counterclockwise rotation			
of mandibular distal segment (°)	5.9 ± 3.4	2.3 ± 3.3	.005
Counterclockwise rotation			
of mandibular proximal segment (°)			
(rotation of gonion)	6.4 ± 3.3	3.4 ± 1.9	.007
Condylar displacement			
to posterior (n)	9	1	.007
to anterior (n)	2	1	NS
unchanged (n)	6	15	.004
OSM in maxilla			
wire (n)	9/16	4/16	NS
plate (n)	7/16	12/16	NS
OSM in mandible			
screw (n)	10/17	6/17	NS
plate (n)	7/17	11/17	
IMF (n)	9/17	4/17	NS

Data presented as mean ± SD.
Mann-Whitney test for differences between groups I and II.
NS, Not significant.

Statistical analysis

The statistical analysis was performed with SPSS statistical software (version 6.11 for Macintosh; Apple Computer, Inc, Cupertino, Calif). A correlation between surgically induced mandibular movements and postoperative changes of the cephalometric variables caused by skeletal relapse in group I was performed. Changes of cephalometric parameters within group I and group II were analyzed with the Wilcoxon signed rank test. Differences between the 2 groups were analyzed with the Mann-Whitney test for continuous variables (radiologic data) and Fisher's

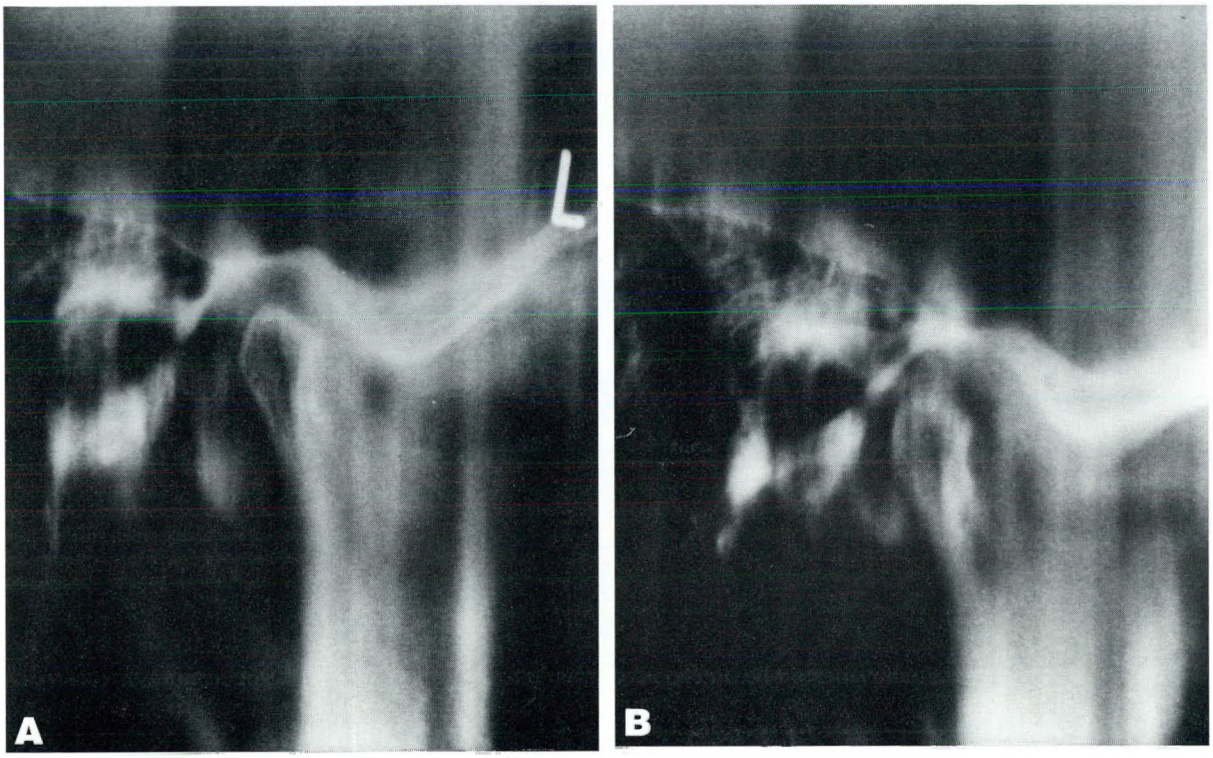


Fig 5. Tomographic illustration of postoperative posterior condylar displacement posteriorly from patient with postoperative condylar resorption. In this case, bimaxillary osteotomy with anterior and superior movement of mandible was performed. **A**, Preoperative situation. **B**, Six weeks after surgery.

exact test for nominal variables (condylar displacement, osteosynthesis materials, and IMF). The influence of surgical movements on the occurrence of condylar resorption was analyzed with univariate and stepwise logistic regression.

RESULTS

In group I, condylar resorption seen on the last OPG occurred on 1 side in 4 cases and on both sides in 13. The amount of condylar resorption in the 13 patients was not always symmetrical. In 16 of 17 cases, the resorption was seen on the anterior-superior condylar surface (Fig 4). The remaining patient had resorption on the superior aspect of the condylar head on the left side and on the anterior-superior aspect on the right. Condylar resorption observed in the OPG had already occurred 1 year after surgery in all patients and was observed 2 years after surgery in 13 of 17 patients.

A correlation between surgically induced mandibular movements and postoperative changes of the cephalometric variables caused by skeletal relapse in group I was performed. Counterclockwise rotation of the proximal mandibular segment was statistically correlated with changes in the SNB (r [coefficients] = –0.622, P = .008) and mandibular angle plane (SN-MeGo) (r = 0.576, P = .016) in $C_3 - C_2$. There was a significant correlation between mandibular advancement and change in the overjet in $C_4 - C_3$ (r = 0.629, P = .009).

Group I

The average surgical reduction of the mandibular plane angle was –5.3 degrees ($P < .001$). The SNA (P = .004) and SNB angle ($P < .001$), overbite ($P <$ .001), overjet ($P < .001$), and posterior-to-anterior facial height ratio (P = .007) were significantly changed surgically, whereas there was no difference between the posterior facial height (S-Go) in C_1 and C_2 (Table II).

The average mandibular advancement was 9.0 mm (3.5-17.5 mm), but less than 7 mm in 4 cases. The average cranial movement of the mandible was 5.4 mm (0-9.0 mm). The average maxillary advancement was 2.6 mm (–1.0-7.5 mm), and the average intrusion 2.9 mm (0-6.0 mm) (Table III).

Counterclockwise rotation of the distal mandibular segment (2.5-9.5 degrees) was seen in 15 cases, with an average of 5.9 degrees. This segment rotated clockwise in 1 case (2.5 degrees). Counterclockwise rotation of the proximal segment was seen in all cases, with an average of 6.4 degrees (2.0-12.0 degrees). The postop-

Table IV. Univariate logistic regression of occurrence of condylar resorption versus surgical movements

Surgical movements	*Odds ratio*	*P*
Counterclockwise rotation of mandibular distal segment (°)	1.36	.011
Counterclockwise rotation of mandibular proximal segment (°)	1.59	.015
Condylar displacement to posterior (n)	18.0	.011
Unchanged (n)	0.073	.0039

Table V. Stepwise logistic regression of occurrence of condylar resorption versus surgical movements

Surgical movements	*Odds ratio*	*P*
Counterclockwise rotation of mandibular distal segment (°)	1.34	.018
Condyle unchanged (n)	0.063	.008

erative condylar position was unchanged (only autorotation of condyle) in 6 cases, displaced posteriorly in 9 cases, and displaced anteriorly in 2 cases (Table III).

Group II

The surgical changes in the mandibular plane angle ($P < .001$), SNA ($P = .001$) and SNB angle ($P < .001$), and overjet ($P < .001$) were statistically significant, but changes in the overbite, posterior facial height, and posterior-to-anterior facial height ratio were not significant (Table II).

The average mandibular advancement was 7.9 mm (1-13.5 mm) but less than 7 mm in 7 cases. The average cranial mandibular movement was 3.7 mm (0-8.5 mm), although the movement was inferior in 3 patients (0.5-2.5 mm). The average maxillary advancement was 3.5 mm (0-10 mm), and the average intrusion was 2.2 mm (0–5.5 mm) (Table III). Maxillary extrusion (0.5 and 1.5 mm) was observed in 2 patients.

Counterclockwise rotation of the distal segment (2.5-9.5 degrees) was seen in 9 patients, with an average value of 2.3 degrees. Clockwise movement of this segment was observed in 1 patient (3 degrees). The average counterclockwise rotation of the proximal segment was 3.4 degrees (1-10 degrees), and counterclockwise rotation was observed in all patients (Table III). After surgery, the condylar position was unchanged in 15 patients, displaced posteriorly in 1 case, and displaced anteriorly in another.

Comparison between groups I and II

The preoperative mandibular plane angle (SN-MeGo) in group I was significantly greater ($P = .001$) than in group II. The preoperative values of SNB angle ($P = .004$), overbite ($P = .003$), and the posterior-to-anterior facial height ratio ($P = .045$) in group I were significantly smaller than in group II. There were no significant differences in the preoperative SNA angle, posterior facial height, and overjet between the 2 groups. The surgical changes in the mandibular plane angle ($P = .012$) and overbite ($P = .002$) in group I were significantly greater than those in group II. The differences in the SNB angle, overjet, posterior facial height, and posterior-anterior facial height ratio were not significant (Table II). Neither the type of skeletal fixation used to stabilize the maxillary and mandibular osteotomies nor the application of postoperative rigid IMF differed significantly between the groups (Table III).

There was no significant difference in the mandibular and maxillary advancement or vertical movement between groups I and II. The counterclockwise rotation of the distal ($P = .005$) and proximal ($P = .007$) mandibular segments in group I was significantly greater than in group II. Posterior condylar displacement occurred more frequently ($P = .007$) in group I than in group II. On the other hand, the condylar position remained unchanged (apart from autorotation) more frequently ($P = .004$) in group II. The incidence of condylar displacement anteriorly was statistically not significant (Table III). An example of the condylar posterior displacement in a case of postoperative condylar resorption is illustrated in tomograms of a temporomandibular joint in Fig 5.

Univariate logistic regression (Table IV) showed that the risk of condylar resorption increases significantly with increased surgical counterclockwise rotation of the distal (odds ratio, 1.36; $P = .011$) and proximal (odds ratio, 1.59; $P = .015$) mandibular segments. It was also more likely with posterior condylar displacement (odds ratio, 18.0; $P = .011$) or unchanged postoperative condylar position (odds ratio, 0.073; $P = .0039$). Stepwise logistic regression (Table V) selected counterclockwise rotation of the distal mandibular segment (odds ratio, 1.34; $P = .018$) and a posteriorly displaced condyle postoperatively (odds ratio, 0.063; $P = .008$).

Discussion

Group II is considered to be a risk group because the average mandibular plane angle in group II is

higher than in most reported cases[5,6] with condylar resorption.

The first radiographic signs of condylar resorption can be seen 6 months after surgery.[5,12] Clinical signs of occlusal relapse and symptoms of temporomandibular joint dysfunction develop before the radiologic findings of condylar resorption.[5,19] Clinical examination alone does not always indicate that relapse has occurred.[8,11] Because the resorptive process is not limited to the first postoperative year and may occur unilaterally or bilaterally,[11,12] long-term follow-up is necessary.[12]

Tension in the surrounding soft-tissue components after mandibular advancement produces a posteriorly directed force.[13,14,16] This force causes the condyle to be retruded forcefully into the fossa, which generates pressure on the condylar head. However, the role of mandibular advancement in condylar resorption is controversial. Some authors report increasing condylar resorption with marked mandibular advancement.[8,11] Hoppenreijs et al[12] reported that the magnitude of mandibular advancement had no effect on the incidence of postoperative condylar resorption, which agrees with our findings. After mandibular advancement, the posteriorly directed force does not appear to have a direct influence on the development of condylar resorption, because condylar resorption usually occurs on the anterior-superior surface of the condyle,[3,5,12] not the posterior surface.

To evaluate condylar resorption, one must consider the role of surgical cranial movement of the distal mandibular segment. With mandibular cranial movement to close an open bite or to reduce anterior facial height in a long face, the vector of tension in the suprahyoidal soft tissues is increased in an inferior-posterior direction. Such a mechanical vector leads to prolonged compressive loading on the superior surface of the condyles. When the condyle is autorotated posteriorly with counterclockwise rotation of the proximal mandibular segment,[3,5,12,20] the anterior-superior surface of the condyle is located more superiorly. This surface of the condyle, originally unloaded, is less dense because no trabeculae extend from the anterior aspect of the articular condylar surfaces in Angle Class II malocclusion.[21] When mechanical stimuli exceed the adaptive capacity of the condyle, the remodeling process becomes resorptive.[9,10,13] Although the cranial mandibular movement in patients with condylar resorption was not significantly different compared with the control group in our study, the biomechanical factors above mentioned may influence on the development of postoperative condylar.

There is little data in the literature on the effect of counterclockwise rotation of the distal mandibular segments on the onset of condylar resorption.[7,18] Moreover, the amount of movement in cases of condylar resorption has not been reported. Worms et al[18] reported that condylar resorption was most apparent in mandibular advancement procedures that rotate the mandible in a counterclockwise direction. Such rotational movement produces a similar effect on the condylar head as cranial mandibular movement.

Condylar resorption after isolated Le Fort I osteotomies or bimaxillary osteotomies with maxillary intrusion is reported to be caused by posterior rotation of the condyle.[4,12,22,23] In our study, counterclockwise rotation of the proximal mandibular segment was combined with posterior rotation of the condyle (Fig 3, type 1), sagittal condylar displacement (Fig 3, types 2 and 3), or both, depending on the location of the center of rotation. In group I, rotation of the proximal segment was observed significantly more often than in group II.

Sagittal condylar displacement has been reported after orthognathic surgery,[15-17,24] but its role in postoperative condylar resorption is unknown. Harris et al[24] demonstrated condylar displacement after BSSO in which the condyle was displaced medially, posteriorly, and superiorly after mandibular advancement. The significantly high incidence of condylar displacement in patients with condylar resorption in the present study suggests that posterior condylar displacement may be connected with postoperative disk displacement. A superiorly and posteriorly displaced condyle, with superior-posterior directed loading after surgical movement, will compress the posterior part of the disk band, which can be seen in radiographs as a narrowing of the posterior joint space.[15,25] The condyle may push the articular disk anteriorly during mouth opening, and internal derangement can occur[26] because the superior and anterior loading increases during mouth opening. There is an association between posteriorly located condyles in centric occlusion and anterior disk displacement.[27,28] Animal models have demonstrated that surgically created disk displacement can cause arthrosis,[16,29] and clinical studies in humans support a close causal relationship between condylar resorption and advanced internal derangement.[30] Some special devices for maintaining the normal or presurgical anatomic position of the mandibular condyles after orthognathic surgery have been reported.[31-33] However, the necessity of these condylar repositioning devices in orthognathic surgery is controversial,[31-33] and the prophylactic use of such special devices in patients with risk factors for condylar resorption has not yet been reported. Therefore, the effect of the use of special devices to prevent condylar resorption remains unclear. To fully elucidate the role of condylar displacement in the development of condylar resorption and the relationship between the articular disk and

arthrosis, further radiologic studies, such as magnetic resonance imaging, are needed.

Some authors have focused on the role of condylar torque after mandibular advancement in the development of condylar resorption.[9,10,34] However, the role of condylar torque is controversial. Although Arnett and Tamborello[4] found that intraoperative condylar torque leads to condylar resorption, Hackney et al[35] and Harris et al[24] reported no correlation between the magnitude of advancement and the percentage of change in intercondylar width and angle after mandibular advancement. The amount of the torque is connected with the type of osteosynthesis material. The use of miniplate fixation for BSSO offers the advantage of minimizing the torsional forces on the proximal fragment caused by the ability to bend and adapt plates to uneven surfaces.[5,36] A major disadvantage of rigid fixation with positional screws is that tightening the screws often provokes lateral condylar displacement, particularly medial rotation, thus inducing considerable pressure on the condyle, resulting in condylar remodeling or resorption.[9,10,15,37] However, Hoppenreijs et al[12] reported that in BSSO fixation with wires, positional screws, or miniplates had no significant effect on the corresponding condylar changes, as in our study. Therefore, it seems likely that condylar torque does not have a great influence on the development of postoperative condylar resorption. Further radiologic studies should be performed to evaluate the effect of condylar torque on the development of postoperative resorption.

The effect of postoperative rigid IMF on the condyle is controversial in the medical literature. IMF for 4 to 6 weeks may give the temporomandibular joint time to adapt to its new position[12] but deprives the condyle of its essential nutrition and function,[7,12] and the articulating cartilage becomes thinner and disorganized.[38] Condylar resorption after orthognathic surgery has been reported to occur more often in patients with IMF than in patients without IMF.[7,12] Hoppenreijs et al[12] found that postoperative condylar resorption occurs less frequently in patients with rigid fixation than in patients with wire fixation for stabilization after Le Fort I osteotomies or bimaxillary osteotomies. In our study, postoperative condylar resorption was observed almost as frequently in patients with IMF (n = 9) as in patients without IMF (n = 8).

This study evaluated surgical risk factors on the development of postoperative condylar resorption. Surgical movements, such as counterclockwise rotation of the proximal and distal mandibular segments, and surgically induced posterior condylar displacement are considered to be risk factors in patients with an extremely high mandibular plane angle. In these patients, such movements seem to be contraindicated, and condylar repositioning must be done precisely and gently.

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