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Non-surgical risk factors for condylar resorption after orthognathic surgery

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SUMMARY. Background: **Condylar resorption following orthognathic surgery is an important cause of late skeletal relapse. However, its pathogenesis is not well understood. The purpose of this study was to find non-surgical risk factors for condylar resorption after orthognathic surgery.** Patients: **In this retrospective study, 17 patients (Group I) who developed postoperative condylar resorption were selected. These patients were compared with 22 patients (Group II) without postoperative condylar resorption, but who showed mandibular hypoplasia with a preoperative high mandibular plane angle of more than 40°.** Methods: **Possible non-surgical risk factors were sought by analysing clinical and radiological data collected preoperatively and immediately, 6 weeks, and 1 and 2 years postoperatively.** Results: **There was no significant difference of gender distribution between the two groups. Patients in Group I were significantly younger (p=0.02) than those in Group II. The incidence of temporomandibular joint dysfunction in both groups was similar preoperatively, but was significantly higher (p=0.001) postoperatively in Group I. The posterior inclination of the condylar neck in Group I was also significantly greater ($p<0.001$). The preoperative mandibular plane angle in Group I (mean value: 49.4°) was significantly greater (p=0.005) than in Group II (mean value: 44.9°). The preoperative SNB angle, overbite, and posterior facial height and ratio (posterior/anterior facial heights) in Group I were significantly smaller ($p<0.05$).** Conclusion: **The present study suggests that the posteriorly inclined condylar neck should be considered as a relevant non-surgical risk factor.** © **2003 European Association for Cranio-Maxillofacial Surgery.**

INTRODUCTION

Condylar resorption may be described as osteoarthrosis, and can be subdivided into primary (idiopathic) and secondary types (*De Bont* and *Stegenga*, 1993). The degenerative changes of secondary osteoarthrosis are caused by joint afflictions, such as rheumatoid arthritis, or by alteration of joint anatomy following excessive traumatic loading of the temporomandibular joint (TMJ) with or without disc displacement (*De Bont* and *Stegenga*, 1993). They can also result from condylar resorption after orthognathic surgery.

In the past two decades, many studies on this subject have been published (*Phillips* and *Bell*, 1978; *O'Ryan* and *Epker*, 1984; *Arnett* and *Tamborello*, 1990; *Kerstens* et al., 1990; *Bouwman* et al., 1994; *Merkx* and *van Damme*, 1994; *Scheerlinck* et al., 1994; *Arnett* et al., 1996a, b; *Huang* et al., 1997; *Cutbirth* et al., 1998; *Hoppenreijs* et al., 1998; *Hwang* et al., 2000a, b). These papers have reported clinical and radiological features of condylar resorption and proposed contributing factors. Reported predisposing patient factors are preoperative TMJ dysfunction, being a young, female patient, having a high mandibular plane angle with mandibular hypoplasia and a small posterior-to-anterior facial height ratio (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *van Damme*, 1994; *Arnett* et al., 1996a, b; *Huang* et al., 1997; *Hoppenreijs* et al., 1998; *Hwang* et al., 2000a, b). A posteriorly inclined condylar neck has been recently considered another contributing factor (*Hoppenreijs* et al., 1998; *Hwang* et al., 2000a).

Postoperative radiological features include decreases in the posterior facial height, the ratio of posterior-to-anterior facial heights (S-Go/N-Me), and the SNB angle. Postoperative clinical features are TMJ dysfunction, clockwise rotation of the mandible resulting in increased overjet and decreased overbite, and an increase in the mandibular plane angle (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *van Damme*, 1994; *Huang* et al., 1997; *Hoppenreijs* et al., 1998; *Hwang* et al., 2000a, b). However, the real aetiology and pathogenesis of condylar resorption following orthognathic surgery remain unclear.

Statistically significant patient factors have been identified only in some studies (*Cutbirth* et al., 1998; *Hoppenreijs* et al., 1998). Little detailed data are available on cephalometric or radiological changes in the orthopantomogram (OPG) (*Lanigan* et al., 1979; *Kerstens* et al., 1990; *Merkx* and *van Damme*, 1994; *Huang* et al., 1997; *Hoppenreijs* et al., 1998; *Cutbirth* et al., 1998; *Hwang* et al., 2000a, b). In this paper cephalometric parameters and other clinical and radiological characteristics of 17 cases of postoperative condylar resorption were evaluated and compared with data collected in 22 cases of mandibular

hypoplasia and high mandibular plane angle without condylar resorption and ensuing postoperative relapse. The postoperative clinical and cephalometric features are described, and possible contributing non-surgical factors were sought and analysed statistically.

MATERIAL AND METHODS

A group of consecutive 452 patients (286 females (63.3%), 166 males (36.7%), female/male = 1.7) who underwent orthognathic surgery (bimaxillary osteotomy in 327 cases (72.3%), isolated bilateral sagittal split osteotomy (BSSO) in 84 cases (18.6%) and Le Fort I osteotomy alone in 41 cases (9.1%)) were screened for condylar resorption based on one or both of the following criteria:

(a) Decreased condylar height and bone of the condylar head in the postoperative OPG compared with the preoperative OPG.
(b) Postoperative occlusal changes consisting of an increased overjet or decreased overbite as seen in postoperative lateral cephalograms.

Patients with facial asymmetry, craniofacial syndromes, a history of condylar fractures, or evidence of condylar resorption due to systemic diseases were excluded. Following cephalometric analysis of the selected cases, those with postoperative occlusal relapse without postoperative condylar changes and those with postoperative condylar remodelling with stable occlusion were eliminated. Using the selection and exclusion criteria, 17 patients (Group I) were selected for this study.

The control group (Group II) consisted of 22 patients with mandibular hypoplasia and a high mandibular plane angle (more than 40°) preoperatively, who did not show skeletal relapse or condylar resorption postoperatively. A mandibular plane angle exceeding 40° was used as the selection criterion, since this value has been reported to be critical for condylar resorption (*Moore* et al., 1991; *Merkx* and *van Damme*, 1994; *Hwang* et al., 2000a, b).

In addition to radiological data, clinical findings of pre- and postoperative TMJ dysfunction were obtained from the existing clinical records, and the evaluation was performed retrospectively. It was especially looked for TMJ sounds, such as clicking and crepitation, and TMJ pain.

Group I

All cases ($n = 17$) had mandibular hypoplasia and class II malocclusion and underwent preoperative orthodontic decompensation. Twelve had an anterior open bite. Bimaxillary surgery consisting of a Le Fort I osteotomy and BSSO was performed in 16 cases, and an isolated BSSO in the remaining case. An additional advancement genioplasty was carried out in 16 cases. Intraosseous wire fixation was used to stabilize the maxillary osteotomies in nine cases, and rigid internal fixation with titanium miniplates in seven. Postoperative rigid intermaxillary fixation (IMF) was performed in all cases with internal wire fixation for a period of 4 weeks. The BSSO was stabilized with bicortical screws in 10 cases and with a monocortically fixed miniplate in seven cases.

Group II

Six patients had a preoperative anterior open bite deformity. Preoperative orthodontic decompensation or alignment was performed in 18 cases. Bimaxillary procedures were carried out in 18 cases, an isolated BSSO was performed in two cases, and a Le Fort I osteotomy alone in two cases. Advancement genioplasties were performed in 15 cases. Intraosseous wire fixation was used to stabilize the Le Fort I osteotomy in six, and rigid internal fixation with titanium miniplates in 14 cases. Postoperative rigid IMF was maintained for 4 weeks in all cases with internal wire fixation. The BSSO was stabilized with bicortical screws in six cases and with monocortically fixed miniplates in 14 cases.

The surgical procedures were similar in all cases. In all cases of Angle's Class II open bite, an overcorrection splint was used to establish a maximum overbite and posterior open bite. The vertical surgical movement of the maxilla consisted of clockwise rotation with a more pronounced intrusion in the posterior maxilla than in the anterior part, in order not to elongate the masseteric sling and to avoid increased loading on the condyle. This was used to avoid relapse in all cases of anterior open bite (9/17 in Group I and 15/22 cases in Group II). The mandibular distal segments were immobilized following manual repositioning of the condyle in the fossa without the use of any special repositioning system.

Radiological analysis

The radiological data consisted of OPGs and lateral cephalograms taken preoperatively (OPG_1, C_1), 6 weeks (OPG_2, C_2), 1 year (OPG_3, C_3), and 2 years (OPG_4, C_4) postoperatively. The OPG_2 and C_2 were used as the first postoperative radiological data in order to exclude early postoperative skeletal relapse. The last follow-up X-ray pictures (OPG_4, C_4) of one patient in Group I and three patients in Group II were not taken. Thus, the cephalometric analysis of C_4 was only performed in 16 out of 17 patients in Group I, and 19 out of 22 patients in Group II. The sagittal inclination of the condylar neck seen on OPG_1 was evaluated. The method of measurement is described in Fig. 1.

The cephalometric analysis used the superimposition method. The cephalometric reference points (Porion, Sella, Nasion) on C_1 were identified, and the points and surrounding bony structures were traced on four acetate papers in order to locate the reference points in all four cephalograms. The same was done with six selected landmarks (Orbitale,

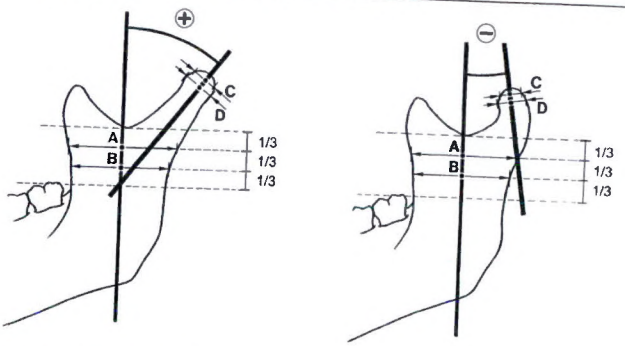


Fig. 1 – Illustration of sagittal inclination of the condylar neck as seen in an OPG: the height of the ascending ramus was defined as the distance between the lowest point of the sigmoid notch (semilunar incisure) and the level of the mandibular occlusal plane. The condyle and ascending ramus were traced on both sides of the OPG, and the midpoints of the width of the superior border (A) and the inferior border (B) of the middle third of the ascending ramus were determined. A vertical line was drawn through the two midpoints. The centre of the width of the upper (C) and middle (D) thirds of the condyle were marked, and another line was drawn through these two points. The sagittal inclination of the condylar neck was defined by the angle between these two lines. The angle was defined as positive (left) if the two lines intersected below the condyle and negative (right) if they intersected above the condyle.

upper and lower first incisal edges, B point, Menton, Gonion) in C_1–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 (Fig. 2). All points were digitized using a Numonic digitizer (Numonics Corporation, Montgomeryville, PA, USA). The following variables were measured: mandibular plane angle (SN-MeGo), SNB angle, overbite, overjet, and anterior (N-Me) and posterior facial height (S-Go). The ratio of the posterior to anterior facial heights (S-Go/N-Me) was calculated. The data were analysed with the Zurich Cephalometric Analysis System (developed by the Department of Orthodontics and Paedodontics in the University of Zurich Dental School).

Statistical analysis

The statistical analysis was performed using the statistical software SPSS (version 6.11 for Macintosh). Changes of the cephalometric parameters within Groups I and II were analysed using the Wilcoxon signed rank test. Differences between the two groups were analysed using the Mann–Whitney test for continuous variables (radiological data) and Fisher's exact test for nominal variables (gender, TMJ dysfunction). When the p value was smaller than 0.05, the differences were defined as statistically significant. The influence of preoperative cephalometric variables and the sagittal inclination of the condylar neck on the occurrence of condylar resorption was analysed using univariate and stepwise logistic regression.

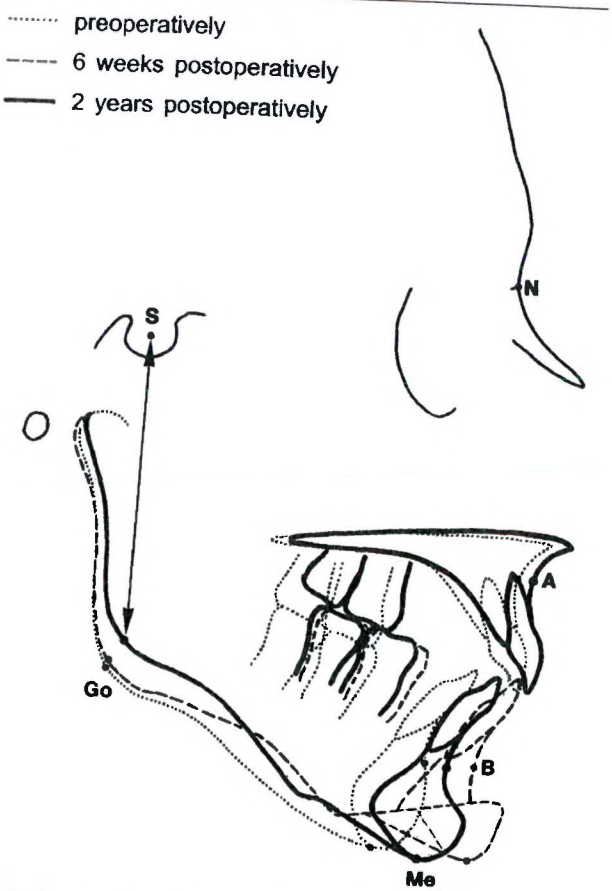


Fig. 2 – Preoperative, and 6 weeks and 2 years postoperative cephalometric analyses of a representative case with postoperative condylar resorption. This illustrates the surgical changes and ensuing development of cephalometric characteristics due to condylar resorption, consisting of progressive postoperative mandibular retrusion, clockwise rotation of the mandible, increasing mandibular plane angle, decreasing SNB angle and decreasing posterior facial height.

RESULTS

Non-surgical risk factors

The statistically significant differences between the two groups related to gender, age, TMJ dysfunction, and sagittal inclination of the condylar neck are presented in Table 1. All patients in Group I 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 in all the patients was 3.8% (17/452 patients), and this being 7.1% of all the 240 cases with Angle's Class II malocclusion. Group II consisted of 19 female patients and three male patients, with an average age of 25.4 years (range 15.6–43.0 years). There was no significant difference of gender distribution between the two groups, so that a sex predilection for condylar resorption was not found. But the patients in Group I were significantly younger ($p = 0.02$).

TMJ sounds were observed preoperatively in 13/17 cases in Group I and in 10/22 cases in Group II; whilst postoperatively in 14/17 cases in Group I and

Table 1 – Gender, age, TMJ dysfunction, and sagittal inclination of the condylar neck of patients

Variables	Group I	Group II	*p*
Female/male	17/0	19/3	NS
Age (yr)	19.8±3.8	25.4±8.5	0.02
TMJ dysfunction preoperatively	13/17	10/22	NS
TMJ dysfunction 2 years postoperatively	14/17	6/22	0.001
Left condylar inclination (deg)	+24.8±6.9	+10.6±14.7	<0.0001
Right condylar inclination (deg)	+27.6±6.9	+13.4±13.4	0.0001

Data are presented as the mean±standard deviation (SD).

in 4/22 cases in Group II had TMJ noise. In each group, five patients without preoperative TMJ sounds had TMJ sounds postoperatively. On the other hand, two cases in Group I and eight cases in Group II with preoperative TMJ sounds did not have postoperative TMJ sounds. Preoperatively, six patients in Group I and two patients in Group II complained of TMJ pain during mastication. Postoperatively, this increased to eight cases in Group I and three cases in Group II. The difference in the preoperative incidence of TMJ dysfunction, including pain and sounds, in the groups was not significant statistically. However, significantly more ($p = 0.001$) postoperative TMJ dysfunction was observed in Group I.

All cases in Group I showed the typical postoperative radiological and clinical changes mentioned in the introduction and in Figs. 2 and 3. Fig. 2 shows the postoperative cephalometric changes in the mandible. The statistical analysis of the postoperative cephalometric changes within Groups I and II, and the statistical comparison of the differences between the two groups are shown in Table 2.

The average sagittal inclination of the condylar neck in Group I was 27.6° (13.0–49.5°) on the right side and 24.8° (12.0–36.5°) on the left (Table 1). In Group II, the sagittal inclination of the condylar neck was 13.4° (−13.0 to 42.5°) on the right side and 10.6° (−20.0 to 47.0°) on the left. The sagittal condylar inclination on both sides in Group I was significantly ($p<0.0001$) greater than in Group II.

Cephalometric changes

The pre- and postoperative cephalometric values and changes with statistical significances were demonstrated in Table 2.

All cases in Group I had a high mandibular plane angle in C_1 that increased in C_3 and C_4. The average preoperative mandibular plane angle was 49.4° (40.0–55.0°). While the decreases in the posterior facial height, posterior-to-anterior facial height ratio (S-Go/N-Me) and SNB angle, the increase in overjet in C_3 and C_4, in overbite in C_4 were unequivocal, the postoperative decrease in the overbite in C_3 was not significant.

The average preoperative mandibular plane angle in Group II was 44.9° (40–55°), and the mandibular plane angle in four patients was greater than the average in Group I (49.4°). It remained almost unchanged in C_3 and C_4. Overbite, overjet, SNB angle, posterior facial height, and the posterior to anterior facial height ratio (S-Go/N-Me) were stable postoperatively.

Cephalometric comparison between groups

The preoperative mandibular plane angle (SNMP) in Group I was significantly ($p = 0.005$) greater than in Group II. The preoperative values of SNB angle, overbite, posterior facial height, and the posterior to anterior facial height ratio in Group I were significantly ($p<0.01$) smaller than in Group II. There were no significant differences in the preoperative overjet between the two groups.

The postoperative differences in the mandibular plane angle, SNB angle, posterior facial height, and posterior-to-anterior facial height ratio between the two groups were significant ($p<0.01$). The difference in the decrease in the overbite between the two groups in C_3 was not significant ($p = 0.053$), as was the difference in the change of overjet in C_3. Nevertheless, the overbite decreased significantly in C_4 in Group I ($p = 0.009$), but there were no significant differences in the overjet in C_4.

The univariate logistic regression and stepwise logistic regression of condylar resorption versus the preoperative cephalometric variables and sagittal inclination of the condylar neck are presented in Tables 3 and 4, respectively. A significantly increased risk of condylar resorption was associated with decreases in age, SNB angle, posterior facial height, and overbite, and with increasing mandibular plane angle and posterior inclination of the condylar neck. Stepwise logistic regression selected preoperative SNB, overbite, and posterior inclination of the condylar neck on the left side. When the stepwise logistic regression was performed without the inclination of the condylar neck on both sides, age, preoperative mandibular plane angle, overbite, and overjet were selected.

DISCUSSION

It is difficult to define radiologically the crossover between condylar remodelling and resorption. This is an arbitrary point, since there is no strict definition (*Moore* et al., 1991). Condylar remodelling is considered to be an adaptive osseous response to

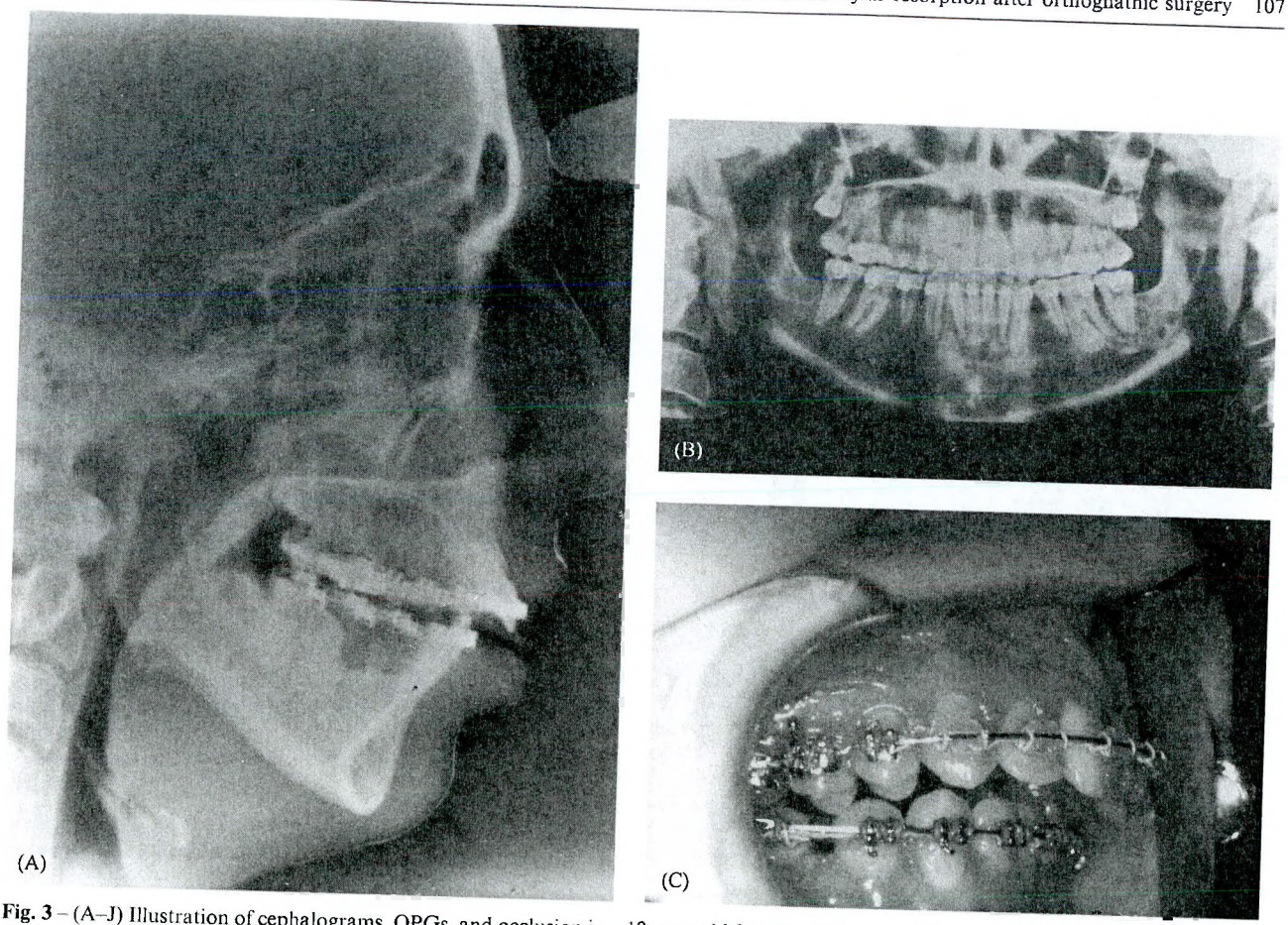


Fig. 3 – (A–J) Illustration of cephalograms, OPGs, and occlusion in a 19-year-old female with preoperative mandibular hypoplasia and TMJ dysfunction. (A–C) Preoperative situation. The cephalogram shows a high mandibular plane angle and a short posterior facial height. The posteriorly inclined condyles are also observed in the OPG. (D–F) Six weeks following bimaxillary osteotomy for bimaxillary upward and forward movements and genioplasty. (G–I) Two years postoperatively. The overjet has increased. Condylar resorption can be observed on the anterior–superior region of the condylar head on the right side, and on the superior region on the left.

new external functional and passive forces placed upon the TMJ following orthognathic surgery (*Moore* et al., 1991; *De Bont*, 1996). *Habets* et al. (1987, 1988) demonstrated that condylar asymmetry with more than a 6% difference in the vertical dimensions on the right and left sides is discernible. *Habets* et al. (1987, 1988) are frequently cited to differentiate between condylar remodelling and resorption (*Moore* et al., 1991; *Hoppenreijs* et al., 1998). However, it is very difficult to use this 6% difference as a crossover point in the radiological evaluation, because technical errors during measurement may induce changes of more than 6% due to magnification, especially in cases of mandibular hypoplasia with a short ascending ramus. Condylar remodelling should not be diagnosed solely by an arithmetic value, because it is a functional process. Therefore, condylar resorption was defined in this paper as a change in condylar form with simultaneous cephalometric skeletal changes. Condylar changes combined with stable skeletal cephalometric results were classified as condylar remodelling, and such cases were excluded from Group I.

Condylar resorption is a radiological diagnosis and is evaluated mainly using OPG in the practice. However, there are some drawbacks of the OPG for the interpretation of condylar form, because the outline of the condyle in the image is magnified and an oblique section of the articulating surface of the condyle is shown (*Scheffer*, 1984). Also, the dimension of this cross-section is dependent on the position of the patient in the head holder in relation to the Frankfurt horizontal plane, in relation to the central beam, and to the form of the condyle (*Habets* et al., 1988). Therefore, it may be possible in this study that the wide range of the condylar inclination on the OPG was influenced by these factors. CT, TMJ tomogram and transcranial TMJ projection would be more accurate for condylar images than OPG, but CT was not available in this retrospective study and the others were not useful for the estimation of the condylar inclination, because the ascending ramus was not depicted in the radiographs.

Condylar resorption is reported to occur in systemic diseases such as rheumatoid arthritis (*Lanigan* et al., 1979; *Huang* et al., 1997), scleroderma, systemic lupus erythematosus (*Haers* and *Sailer*, 1995; *Huang* et al., 1997), and other vascular collagen diseases (*Kerstens* et al., 1990) involving the condyle. Therefore, patients with these diseases have been excluded from this study.

1986; *Yamshiro* and *Takano-Yamamoto*, 1998) and humans (*Abubaker* et al., 1993). In a study of the human TMJ, *Abubaker* et al. (1993) reported that immunodetectable oestrogen receptors were found five times more often in symptomatic females than in asymptomatic females. This implies that symptomatic females may have different responses to oestrogen levels, based on target receptors within the TMJ.

The morphology of the condyle is related to the facial form (*Björk*, 1963), and may also influence condylar resorption (*O'Ryan* and *Epker*, 1984; *Burke* et al., 1998; *Hwang* et al., 2000a). *Burke* et al. (1998) showed that patients with long face characteristics had smaller superior joint spaces and posteriorly angled condyles. Based on variation in the trabecular bone pattern of the condyle, *O'Ryan* and *Epker* (1984) suggested that there is substantially less condylar loading in Angle's Class II open-bite cases than in Class II deep-bite configurations, especially on the anterior–superior condylar surface. In a Class II open-bite configuration, the trabeculae in this area were less dense and less oriented to the anterior–superior condylar surface (*O'Ryan* and *Epker*, 1984). With posteriorly inclined condylar necks, following surgically induced posterior rotation of the condyle, the anterior–superior condylar surface is more exposed to loading, which may lead to condylar resorption (*Hoppenreijs* et al., 1998). In our previous study (*Hwang* et al., 2000a), condylar resorption was observed more frequently in cases with a posteriorly curved condylar neck. *Hoppenreijs* et al. (1998) reported similar results. However, a statistical analysis was not performed in these studies. The statistical results in the present study is in agreement with this finding. However, the range of condylar inclination in this study was very wide, so the greatest inclination of the condylar neck in the group without condylar resorption was almost twice as great as the average inclinations in the group with condylar resorption, which implies that condylar resorption is not caused by the posteriorly inclined condylar neck alone.

Pre-existing TMJ dysfunction can contribute to the development of postoperative condylar resorption (*Moore* et al., 1991; *Cutbirth* et al., 1998). In this study, 13 of 17 cases in Group I showed preoperative TMJ dysfunction, but there was no statistically significant difference in preoperative TMJ dysfunction between Groups I and II. In the study of *Hoppenreijs* et al. (1998), there were no significant correlations between the intensity of preoperative TMJ sounds and radiological condylar changes, or between mouth opening and condylar changes. An increased rate of TMJ dysfunction after orthognathic surgery has been reported in patients with mandibular hypoplasia and a high mandibular plane angle (*Kerstens* et al., 1990; *De Clercq* et al., 1995), although some authors report an improvement in TMJ dysfunction in patients with condylar resorption after orthognathic surgery (*Hoppenreijs* et al., 1998; *Cutbirth* et al., 1998). In this study, postoperative TMJ dysfunction was significantly more frequent in Group I than in Group II.

Preoperative cephalometric factors, such as a high mandibular plane angle, a small SNB angle, a short posterior facial height, and a small posterior-to-anterior facial height ratio, were reported to be risk factors for developing condylar resorption after orthognathic surgery (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *van Damme*, 1994; *Arnett* et al., 1996a, b; *Huang* et al., 1997; *Hoppenreijs* et al., 1998). These factors differed significantly between Groups I and II of this study, and were significant in the univariate logistic regression of the occurrence of condylar resorption. These results should be carefully interpreted, because the mandibular plane angle in Group I was significantly greater than in Group II. Therefore, other cephalometric factors were also significantly greater. However, the average mandibular plane angle in Group II was still higher than in most reported cases (*Moore* et al., 1991; *Merkx* and *van Damme*, 1994; *Hwang* et al., 2000a) with condylar resorption.

A postoperative increase in mandibular plane angle and decrease in the SNB angle, posterior facial height and posterior-to-anterior facial height ratio are cephalometric features which can be associated with postoperative condylar resorption. These postoperative cephalometric changes seen with condylar resorption concurred with the literature (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *van Damme*, 1994; *Arnett* et al., 1996a, b; *Hoppenreijs* et al., 1998). In contrast with reported cases (*Merkx* and *van Damme*, 1994; *Hoppenreijs* et al., 1998) with significant postoperative changes in overbite and overjet, the non-significance of the postoperative changes in the overjet seen in this study may result from dental movement due to postoperative orthodontic treatment and to the use of an overcorrection splint producing a posterior open bite.

CONCLUSION

Condylar resorption following orthognathic surgery is a multifactorial phenomenon, and some of the risk factors are interrelated. In the present study, risk factors were young patients with mandibular hypoplasia, a posteriorly inclined condylar neck, a high mandibular plane angle, short posterior facial height and, a small posterior-to-anterior facial height ratio. It is recommended that patients with these characteristics should be given explicit preoperative information on the risk of condylar resorption with skeletal relapse.

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