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The role of a posteriorly inclined condylar neck in condylar resorption after orthognathic surgery

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SUMMARY. **Recently, it has been reported that a posteriorly inclined condylar neck is associated with condylar resorption following orthognathic surgery, although its role in resorption remains unknown. By cephalometric screening of 240 patients with Angle Class II occlusion 2 years after orthognathic surgery, 11 patients with postoperative condylar resorption were identified. The preoperative posterior inclination of the condylar neck and the surgical risk factors mentioned in the literature, particularly surgically induced counterclockwise rotation of the mandibular proximal segment were evaluated. In all 11 cases, the condylar neck was clearly inclined posteriorly. Counterclockwise rotation of the proximal segment was also observed in all cases, and it amounted to 6.7° (2.5–12°) on average. The contributing role of a posteriorly inclined condylar neck in connection with surgical mandibular movement in postoperative condylar resorption is discussed.** © **2000 European Association for Cranio-Maxillofacial Surgery**

INTRODUCTION

Condylar resorption is an irreversible complication and a factor in the development of late skeletal relapse following bilateral sagittal splint osteotomies, Le Fort I osteotomies, or bimaxillary osteotomies. In the past two decades, several clinical and radiological features and some hypothetical contributing factors have been reported in the literature, but aetiology and pathogenesis of condylar resorption after orthognathic surgery remain unclear.

Several risk factors have been reported. Preoperative factors are mandibular hypoplasia with a high mandibular plane angle and temporomandibular joint (TMJ) dysfunction (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *Van Damme*, 1994; *Bouwman* et al., 1994; *Arnett* et al., 1996a,b; *Hoppenreijs* et al., 1998). Condylar resorption after orthognathic surgery occurs more frequently in young (15–30 years) female patients than in male or older female patients (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *Van Damme*, 1994; *Arnett* et al., 1996a,b; *Hoppenreijs* et al., 1998). Contributing surgical factors are major surgical mandibular advancement, counterclockwise rotation of the mandibular proximal segment and intermaxillary fixation (*Huang* and *Ross*, 1982; *Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *Van Damme*, 1994; *Bouwman* et al., 1994; *Cutbirth* et al., 1998; *Hoppenreijs* et al., 1998). Avascular necrosis of the condyle (*Schellhas* et al., 1989) and postoperative condylar compression by hypertonic musculature (*Huang* and *Ross*, 1982; *Ellis* and *Carlson*, 1983) have also been reported as hypothetical contributing factors.

Postoperative clinical features of condylar resorption include postoperative TMJ dysfunction and clockwise rotation of the mandible leading to Angle Class II malocclusion with increasing overjet and decreasing overbite (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *Van Damme*, 1994; *Arnett* et al., 1996a,b; *Cutbirth* et al., 1998; *Hoppenreijs* et al., 1998). Postoperative cephalograms typically show an increase in the mandibular plane angle and a decrease in the angle SNB, in addition to decreases in the posterior facial height and posterior/ anterior facial height ratio (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *Van Damme*, 1994; *Arnett* et al., 1996a,b; *Hoppenreijs* et al., 1998).

Recently, *Hoppenreijs* et al. (1998) reported a high incidence of posteriorly inclined condylar neck in patients with postoperative condylar resorption; how this contributes to condylar resorption remains unknown. This study evaluated the inclination of the condylar neck in the preoperative orthopantomogram and the surgical mandibular movements, especially counterclockwise rotation of the proximal mandibular segment, in 11 patients with condylar resorption following orthognathic surgery, and attempts to illustrate their role in condylar resorption.

MATERIALS AND METHODS

Of 240 patients (178 females, 62 males) with Angle Class II deformity who underwent orthognathic surgery, patients with the following characteristics were selected for this study:

(a) postoperatively decreased condylar height and volume by comparing pre- and postoperative orthopantomograms, and
(b) postoperative increase in overjet and/or decrease in overbite seen on the postoperative cephalograms.

The evaluation examined medical records, cephalograms, and preoperative and postoperative (at least one year) orthopantomograms. Patients suffering from craniofacial syndromes, a past history of condylar fractures, and condylar resorption due to systemic diseases such as rheumatoid arthritis, scleroderma and systemic lupus erythematosus were excluded. After cephalometric analysis of the selected cases those with occlusal and skeletal relapse without postoperative condylar changes, and those with postoperative condylar remodelling without occlusal and skeletal relapse were eliminated. Cases with preoperative condylar flattening were eliminated in order to evaluate the inclination of the condylar neck before any resorptive changes. In the end, 11 patients were selected. All the patients were female with an average age of 19 years (range: 16–28 years), and all had mandibular hypoplasia, eight of them with an anterior open bite. In all patients, surgical correction was performed following orthodontic decompensation.

Surgical method

Ten patients had undergone bimaxillary surgery (Le Fort I osteotomy and bilateral sagittal split osteotomy [BSSO], one patient had only a BSSO, while nine had additional genioplasties. The maxilla was stabilized with titanium miniplates in five patients, and with intraosseous wire fixation plus postoperative intermaxillary fixation (IMF) for 4 weeks in the other five patients. The mandibular osteotomies were stabilized with monocortically fixed titanium miniplates in five patients and three bicortical positional screws per side in six patients. The condyles were repositioned manually in the fossa without the use of a special device. The surgical procedures were otherwise similar in all the patients, but different surgeons performed the surgery.

Radiological evaluation

The radiological data consisted of orthopantomograms (OPG) and lateral cephalograms taken preoperatively (OPG_1, C_1), and immediately (OPG_2, C_2), one year (OPG_3, C_3), and 2 years (OPG_4, C_4) postoperatively.

The posterior inclination of the condylar neck seen on OPG_1 was evaluated, as a hypothetical contributing factor to postoperative condylar resorption. The condylar neck was examined to determine whether it was anteriorly inclined, posteriorly inclined, or vertical and parallel with the vertical axis of the ascending ramus (Figs. 1 and 2).

The cephalometric reference points (Porion, Sella, Nasion) were located on C_1, and traced on acetate sheets along with the surrounding bony structures in order to locate the same reference points in all four cephalograms. Then, selected landmarks in C_1–C_4 were marked on each of the acetate sheets (Fig 3). The Frankfurt horizontal line through **P**orion and **O**rbitale was used as the x-axis. A perpendicular line through **S**ella was used as the y-axis. The SN mandibular plane angle was defined as the angle between the line through **N**asion and **S**ella and the

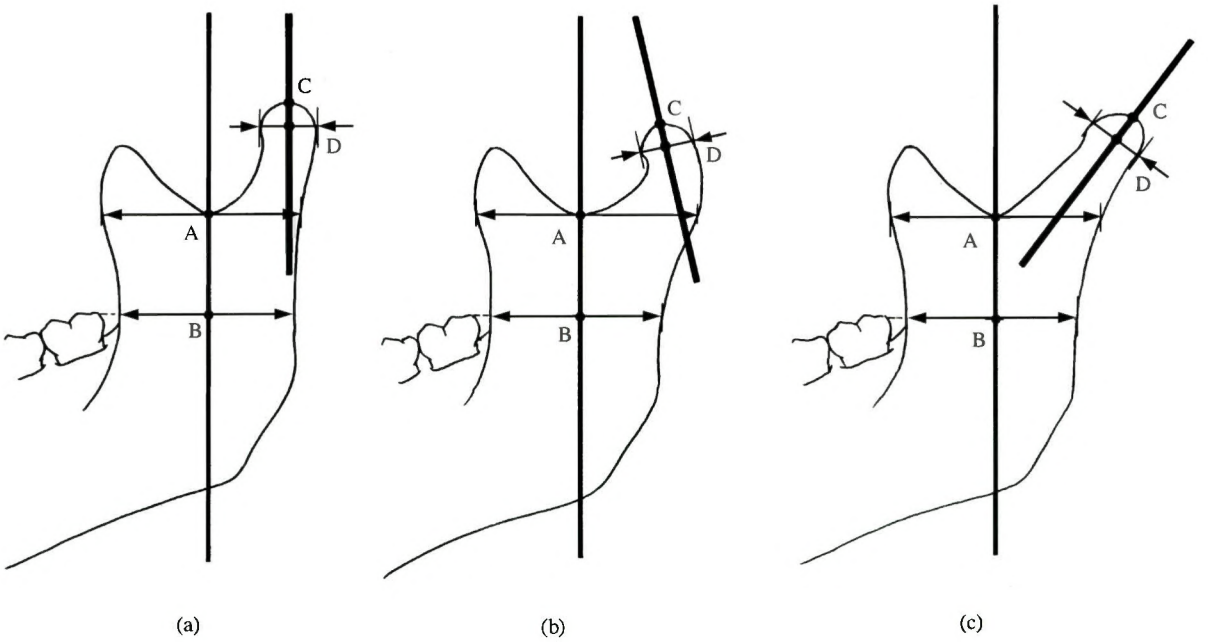


Fig. 1 – Inclination of condylar neck in orthopantomogram: the condyle and ascending ramus were traced on both sides of the radiograph. The midpoints of the width of the ascending ramus below the semilunar incisura (A) and at the level of the mandibular occlusal plane (B) were determined. A vertical line was drawn through both midpoints. The top of the condylar head (C) and centre of the broadest part of the condyle (D) were marked, and another line was drawn through these two points. The sagittal inclination of the condylar neck was classified as (a) vertical or parallel with the vertical axis of the ascending ramus, (b) anteriorly inclined or (c) posteriorly inclined.

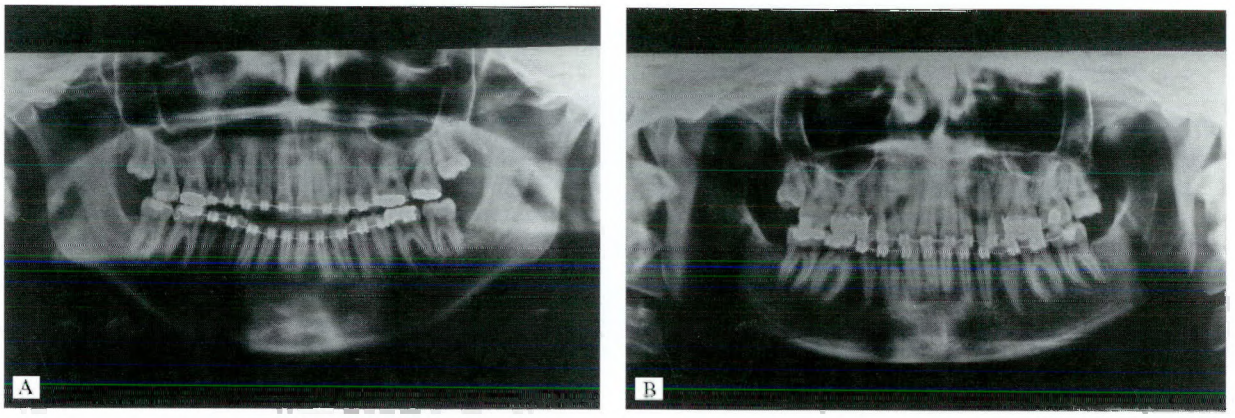


Fig. 2 – Preoperative radiographs in patients with mandibular hypoplasia and Angle Class II malocclusion: (A) posteriorly inclined condyle of patient with anterior open bite who showed postoperative condylar resorption, (B) anteriorly inclined condyle of patient with anterior deep bite.

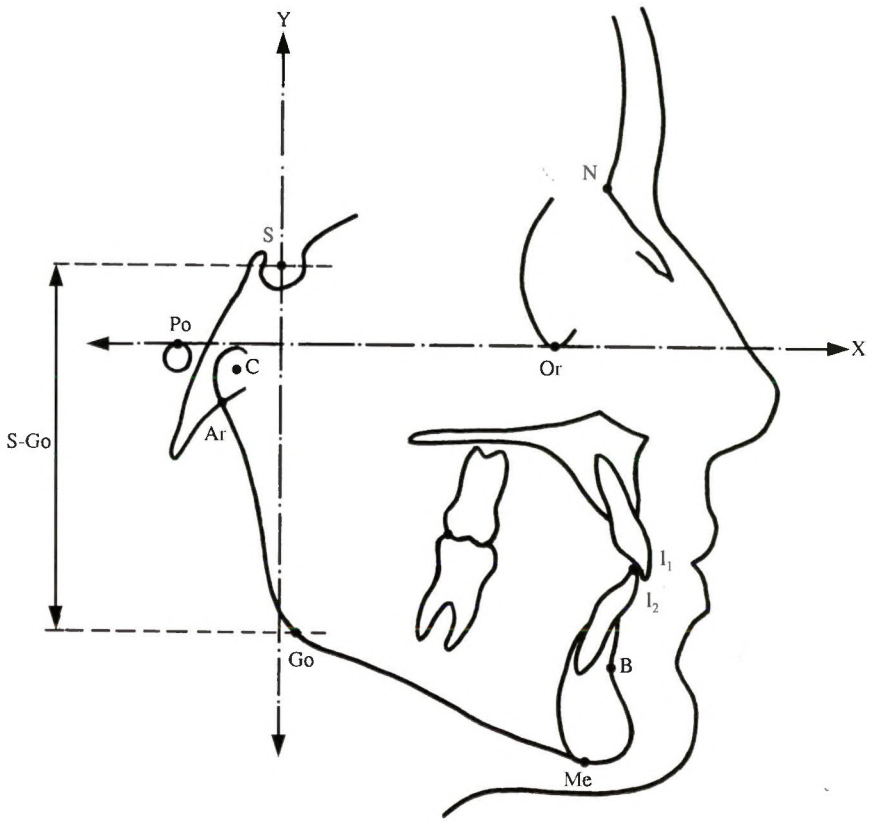


Fig. 3 – Cephalometric analysis: x-axis, y-axis and selected landmarks (including I_1: upper first incisal edge, I_2: lower first incisal edge) as well as the distance S-Go for measuring posterior facial height are illustrated.

line through Menton and Gonion. All points on the four cephalograms were digitized using a Numonic digitizer (Numonics Corporation, Montgomeryville, PA 18936), and the following variables were measured: mandibular plane angle (SN-MeGo), SNB angle, overbite, overjet, and total posterior facial height (S-Go). Six landmarks (B, I_1, I_2, Me, Go, C) were transferred from C_1 and C_2 by superimposing the corresponding structures, and digitized to measure the surgical movement. The displacement of point B on the x- and y-axes between C_1 and C_2 was used to measure the surgical mandibular movements.

The amount of counterclockwise rotation of the proximal segment was defined by measuring the angle between a line through the condylar center(c) and gonion in C_1 and C_2 (Fig 4). Movements directed anteriorly and superiorly were given positive values, and those directed posteriorly and inferiorly negative values. The data were analyzed with the Zurich cephalometric analysis system, developed by the Department of Orthodontics and Paedodontics of the University of Zurich Dental School. This calculates coordinates, distances, and angles as defined by the user.

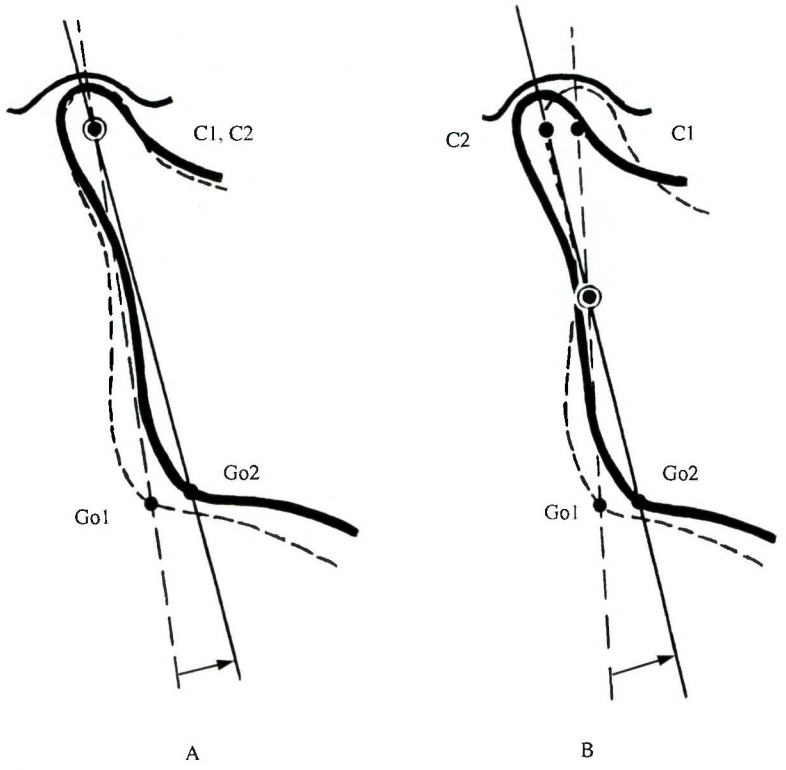


Fig. 4 – Counterclockwise rotation of the proximal mandibular segment after maxillary intrusion and mandibular advancement: (A) only rotation of the condyle without condylar displacement, (B) posterior condylar displacement with or without rotation of the condyle. Go 1: preoperative Gonion, Go 2: postoperative Gonion, C1: peroperative centre of the condyle, C2: postoperative centre of the condyle.

Table 1 – Average pre- and postoperative cephalometric values

Parameters	Preoperatively	Postoperatively		
		Immediate	1 year	2 years
SN-MP (°)	49.0±4.1	43.8±4.4	47.1±4.0	49.1±4.5
SNB (°)	68.6±3.5	74.2±3.4	72.2±3.4	71.2±3.6
Overbite (mm)	−1.3±2.2	2.3±0.6	1.7±1.2	0.8±2.0
Overjet (mm)	8.2±3.4	2.3±0.9	3.6±2.0	4.9±1.9
S-Go (mm)	71.8±6.6	71.4±6.8	67.6±7.1	65.6±7.3

SN-MP: SN-mandibular plane angle, S-Go: posterior facial height.

RESULTS

In all patients, typical postoperative radiological changes were found, as described in the introduction (Table 1).

In all patients, the condylar neck was inclined posteriorly. In no case was it difficult to differentiate between a posteriorly inclined and a vertical condylar neck. Condylar resorption occurred on one side in one patient and bilaterally in 10 patients. In eight of the 10 patients, the amount of condylar resorption was not symmetrical, although the differences were small; the remaining two patients had obvious asymmetric resorption. In all patients, the resorption was seen in the anterior-superior part of the condyles in OPG, except in one condyle in which the resorption occurred in the superior area alone. Condylar resorption was observed on OPG_3 in all patients, and persisted for 2 years postoperatively in 10 of the 11 patients.

The average mandibular advancement was 9.1 mm (3.5–17.5 mm). The average mandibular cranial movement was 5.5 mm (1.0–9.0 mm). The average counterclockwise rotation of the proximal segments was 6.7° (2.5–12.0°), and this counterclockwise rotation was observed in all patients (Table 2).

DISCUSSION

Biomechanical changes in the TMJ following orthognathic surgery, particularly in cases of mandibular hypoplasia with or without anterior open bite, may be the main pathogenetic explanation for condylar

Table 2 – Surgical movement

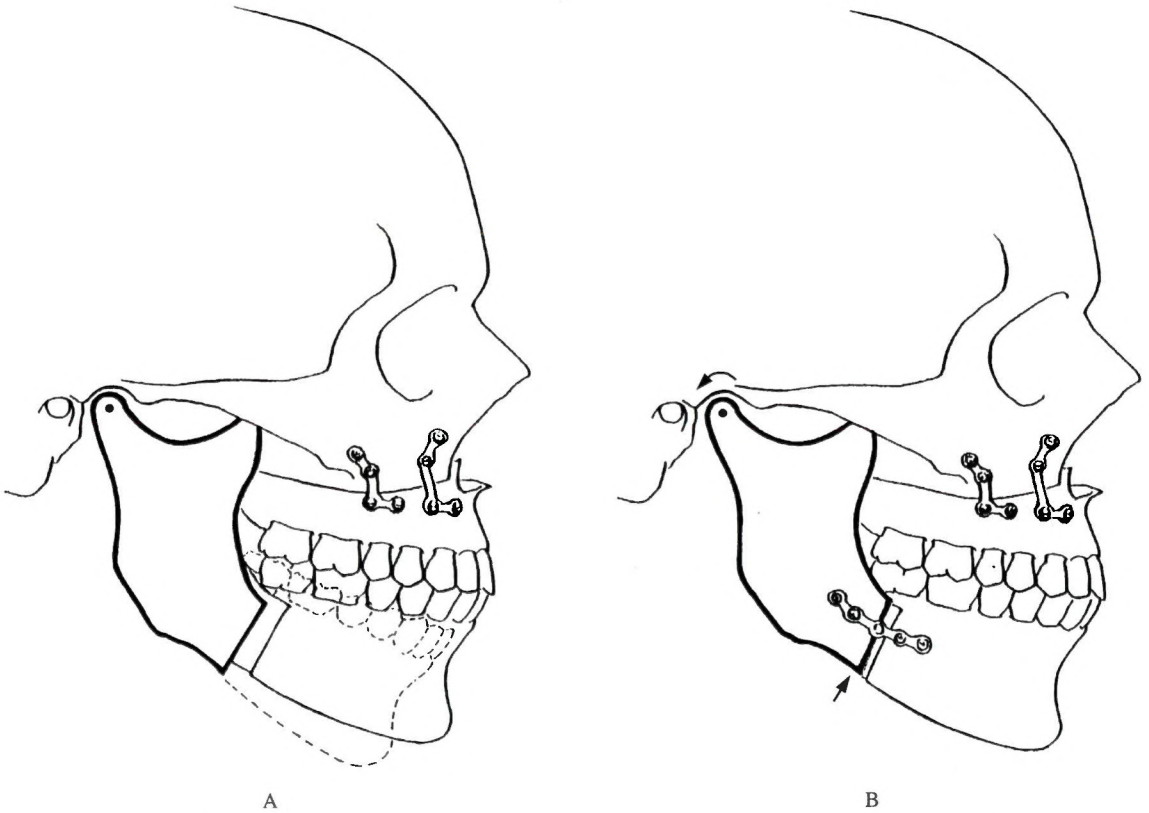
Parameters	Values
Counterclockwise rotation of mandibular proximal segment (rotation of Gonion)	6.7±3.2
Mandibular advancement	9.1±4.0
Mandibular cranial movement	5.5±2.8

resorption. The results in this study and the data in the literature support this hypothesis. Several authors (*Kerstens* et al., 1990; *Moore* et al., 1991; *Merkx* and *Van Damme,* 1994; *Hoppenreijs* et al., 1998) have hypothesized that alteration of the biomechanics, i.e. altered loading of the condyle, leads to the resorptive process.

Hoppenreijs et al. (1998) reported that condylar resorption was observed more frequently when the superior part of the condylar neck is curved posteriorly, which is in agreement with the present study. A posteriorly inclined condylar neck seems to contribute to the development of postoperative condylar resorption, and this can be explained by (1) the anatomical structure of condyle, (2) surgically-induced rotation of the condyle, and (3) surgical mandibular advancement with cranial movement.

The anatomical structure of the condyle depends on the facial form (*O'Ryan* and *Epker*, 1984; *Burke* et al., 1998) (Fig. 2). Based on variation in the pattern of trabecular bone in the condyle, *O'Ryan* and *Epker* (1984) suggested that Class II patients with anterior open-bite have substantially less condylar loading than Class II deep over bite patients, especially on the anterior-superior condylar surface. The trabeculae on this surface in the former group were less dense and less oriented as compared with the latter group. *Burke* et al. (1998) reported that patients with long facial morphologic characteristics had decreased superior joint space and more posteriorly-angled condyles.

With counterclockwise rotation of the mandibular proximal segment, rotation of the condylar head occurs (*Epker* and *Wylie*, 1989). This leads to exposure of the less dense, previously unloaded anterior-superior condylar surface (*O'Ryan* and *Epker*, 1984) to compressive loads (*Kerstens* et al., 1990; *Moore* et al., 1991). When the condylar neck is inclined posteriorly, the less loaded anterior-superior area of the condyle is more exposed to loading. The condylar resorption following isolated Le Fort I osteotomies with maxillary intrusion to correct long-face deformity combined with mandibular hypoplasia has been explained by this rotation of the condyle (*O'Ryan* and *Epker*, 1983; *de Mol van Otterloo* et al., 1993; *Hoppenreijs* et al., 1998). In the experimental study of *Legan* and *Nanda* (1978) on monkeys undergoing Le Fort I osteotomies, the anterior aspect of the condylar head became atrophic, where it came



A B

Fig. 5 – (A) Formation of a step at the buccal osteotomy site of the mandible after moving the mandible anteriorly and superiorly, (B) counterclockwise rotation of the condyle caused by cranial repositioning of inferior border of the proximal segment in order to avoid postoperative antegonial notch.

into contact with the articular eminence following rotation of the condyle.

Mandibular advancement with mandibular cranial movement, as used to surgically correct mandibular hypoplasia with or without vertical maxillary hyperplasia in our study, stretches the surrounding soft-tissue components and the increased suprahyoid muscular tension produces an inferior-posteriorly directed force on the distal segment of the mandible (*Phillips* and *Bell*, 1978; *Huang* and *Ross*, 1982; *Ellis* and *Carlson*, 1983; *Sesanna* and *Raffaini*, 1985). This force causes pressure on the less dense, preoperatively unloaded superior-anterior surface of the condylar head (*O'Ryan* and *Epker*, 1984) following surgically induced counterclockwise rotation of the condyle. This may cause condylar resorption when mechanical stimuli exceed the adaptive capacity of the condyle (*Huang* and *Ross*, 1992; *Arnett* et al., 1996a,b). This hypothesis is supported by several authors, who showed that condylar resorption occurs on the anterior-superior surface of the condyle (*Kerstens* et al., 1990; *Moore* et al., 1991; *Hoppenreijs* et al., 1998).

The surgeon's experience and the surgical manoeuvre may also contribute to changes in the condyle. In cases of maxillary intrusion and mandibular advancement with cranial movement, a step is created at the inferior border of the buccal osteotomy site, because the inferior border of the proximal segment is lower than that of the distal segment. When the inferior border of the distal end of the proximal segment is moved anteriorly and thus cranially during osteosynthesis in order to avoid creating an osseous step at the site, the condyle rotates further in counterclockwise direction. When the condyle is also repositioned forcefully, it may be displaced posteriorly (Fig. 5).

We evaluated the role of a posteriorly inclined condylar neck in connection with the surgical mandibular movement, especially rotation of the condyle, in patients with condylar resorption following orthognathic surgery. When the condylar neck is posteriorly inclined, the anatomically less dense, preoperatively unloaded anterior-superior surface of the condyle is subjected to increased loading following surgery, due to an increase in soft tissue tension and rotation of the condyle. In patients with preoperative risk factors for condylar resorption, it is mandatory to perform screening for TMJ dysfunction, cephalometric characteristics and condylar morphology. Preoperatively, it is recommended that these patients be given explicit information regarding the possibility of relapse and condylar resorption. It is even questionable whether the surgical movements described above should be performed at all in patients with the typical risk factors for postoperative condylar resorption, including a posteriorly inclined condylar neck.

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