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Idiopathic condylar resorptions: 3-dimensional condylar bony deformation, signs and symptoms

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Introduction: Our aim was to describe 3-dimensional condylar deformation of the temporomandibular joint (TMJ) and symptoms and signs of temporomandibular dysfunction (TMD) in patients with idiopathic condylar resorption (ICR). **Methods:** We included 25 patients with ICR and 25 controls. We performed cone-beam computed tomographic scans and analyzed condylar width, length, and height as well as the condylar axial angle and the condylar neck angle. TMJ cross sections were evaluated for degenerative characteristics and location of bony deformations. Furthermore, symptoms and signs of TMD were described in the ICR group. **Results:** In the ICR group, we found statistically significantly reduced condylar width (mean difference, 2.0 mm), height (mean difference, 4.9 mm), and condylar axial angle (mean difference, 10.6°); 84% of the TMJs had a posterior condylar neck angle (control group, 22%). The most common degenerative changes were noncongruent shape of the condyle-fossa relationship (72%), condylar resorption (56%), and nonintact cortex (40%). More than 70% of the joints with bony deformations showed changes along the entire condylar head. Most patients with ICR showed symptoms and signs of TMD; nevertheless, 12% had no signs or symptoms of TMD. **Conclusions:** ICR in the TMJ changes the shape and reduces the size of the condyle. Deformity locations are unspecified, and the entire condyle is often affected. Most patients with ICR have signs or symptoms of TMD; however, a small group was asymptomatic and without clinical signs. (Am J Orthod Dentofacial Orthop 2017;152:214-23)

Idiopathic condylar resorption (ICR) is a pathologic condition of unknown origin that affects the temporomandibular joint (TMJ). It is characterized by bony deformation of the mandibular condyles causing loss of condylar volume and mass.[1-6] Maxillofacial morphologic changes comprise sagittal and posterior vertical deficiency of the lower facial third, most likely causing decreased ramus height and reduced mandibular length combined with posterior mandibular rotational growth bringing about a retrognathic profile and an open bite.[7] In a growing patient, condylar growth may be affected, leading to a change in mandibular morphology.[8,9]

The etiology of ICR is unknown but is often classified as severe forms of degenerative joint disease, osteoarthritis, osteoarthrosis, and arthrosis deformans or dysfunctional remodeling.[1-3,9-12] Several studies on condylar resorption have used the terms progressive condylar resorption, aggressive condylar resorption, and condylysis.[5,7] However, these studies often included patients who developed condylar resorptions after maxillofacial surgery; therefore, these patients did not have ICR. Other less commonly used names include avascular necrosis,[11,13] osteonecrosis,[11,14] condylar atrophy,[10] and condylar osteolysis.[15]

ICR is commonly classified under low-inflammatory arthritic disorders and is considered to be a severe form of osteoarthritis.[5,12,16] The group of low-inflammatory arthritic disorders (noninflammatory arthritic disorders) also comprises osteoarthritis, arthrosis, and degenerative joint disease.[12,16] The group of high-inflammatory arthritic disorders (inflammatory arthritic disorders) includes rheumatoid arthritis, juvenile idiopathic arthritis,

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and other arthritic conditions that affect the TMJ with a similar clinical picture.[12,16] Others classify ICR in a TMJ category of its own to stress its idiopathic etiology.[4,17]

ICR occurs more frequently in females than in males; according to Wolford,[4] the female-to-male ratio is 9:1. Since ICR frequently affects adolescent girls, it has been coined the "cheerleaders' syndrome."

The symptoms of temporomandibular dysfunction (TMD) may be severe, mild, or nonexistent; 25% of patients with ICR have no symptoms of TMD.[18] Handelman and Greene[19] observed that a high percentage of ICR patients reported pain or another symptom of TMD. However, no data were presented to support either of these clinical observations.

The aims of this article were to describe the condylar morphologic changes and localization of these changes in a group of ICR patients and to describe symptoms and signs of TMD and mandibular function.

MATERIALS AND METHODS

The ICR group comprised 25 patients from the Section of Orthodontics, Faculty of Health Sciences, Aarhus University, and the Department of Oral and Maxillofacial Surgery, Aarhus University Hospital, in Denmark. They had been referred for diagnosis or treatment of malocclusions, skeletal deviations, or TMD, and were included in this study if they appeared to have changes of the mandibular condyle evaluated on cone-beam computed tomography (CBCT). The patients were included from November 2005 to January 2014. Those with any of the following characteristics were excluded: (1) history of arthritis, immune disease, or systemic disease confirmed by a rheumatologist, or patients under investigation for such diseases; (2) congenital syndrome; (3) craniofacial trauma; and (4) previous orthognathic surgery.

The control group included age- and sex-matched patients enrolled for general orthodontic treatment at the Section of Orthodontics, Faculty of Health Sciences, Aarhus University. Only patients who had a full-face CBCT image in their diagnostic records were included. Excluded were patients with (1) history of orofacial pain or TMD; (2) history of arthritis, immune disease, or systemic disease confirmed by a rheumatologist, or patients under investigation for these diseases; (3) congenital syndrome; (4) craniofacial trauma; and (5) previous orthognathic surgery.

Full ethical approval was obtained from the Danish Data Protection Agency (reference 1-16-02-36-15) and the Danish Health Authority (reference 3-3013-848/1); the study was conducted according to the Helsinki declaration.

A CBCT with a 12-in field of view was conducted in all patients (model 3G or 5G; NewTom, Verona, Italy).

Table I. Landmarks and constructed points used for radiologic assessments with definitions and outcome variables

Landmarks and constructed points	*Definition*
Nasion, N	Most anterior point of the fronto-nasial suture, axial plane
Basion, B	Most posterior point of the occipital bone, anterior border of foramen magnum, axial plane
Lateral condylar point, LCo	Most lateral point of the condyle
Medial condylar point, MCo	Most medial point of the condyle
Anterior condylar point, ACo	Most anterior point of the condyle
Superior condylar point, SCo	Most superior point of the condyle
Posterior condylar point, PCo	Most posterior point of the condyle
Constructed lines	
Midsagittal reference line, NB	Line from N to B
Condylar axis, LCo-MCo	Line from LCo to MCo
Ramus tangent line, R-tan	Tangent to the posterior border of the ramus
Ramus tangent line perpendicular, R-tan-P	Line perpendicular to R-tan tanging the deepest point of the mandibular incisura
Radiologic outcome variables	
Condylar width	Distance from LCO to MCo
Condylar length	Distance from ACo to PCo
Condylar height	Distance from SCo perpendicular to R-tan-P
Condylar axial angle	Angle between LCo-MCo and N-B

Radiographic material was obtained from the Section of Orthodontics of Aarhus University and from the Oral and Maxillofacial Department of Aarhus University Hospital. Primary scans and subsequent study reconstructions of volumetric data were performed according to the indications and standard protocol of the Section of Radiology of Aarhus University and Aarhus University Hospital, respectively. Secondary CBCT study reconstructions were made for each patient to conduct a radiologic assessment suitable for this study.

Three-dimensional reconstructions were processed and analyzed using the NewTom software NNT (version 4.6; Newtom). The reconstructions were standardized and reorientated in the frontal view to the upper orbital crest, and in the sagittal view according to the horizontal occlusal plane.

All landmarks and radiologic outcome variables were identified and verified in 3 planes of space. Table I

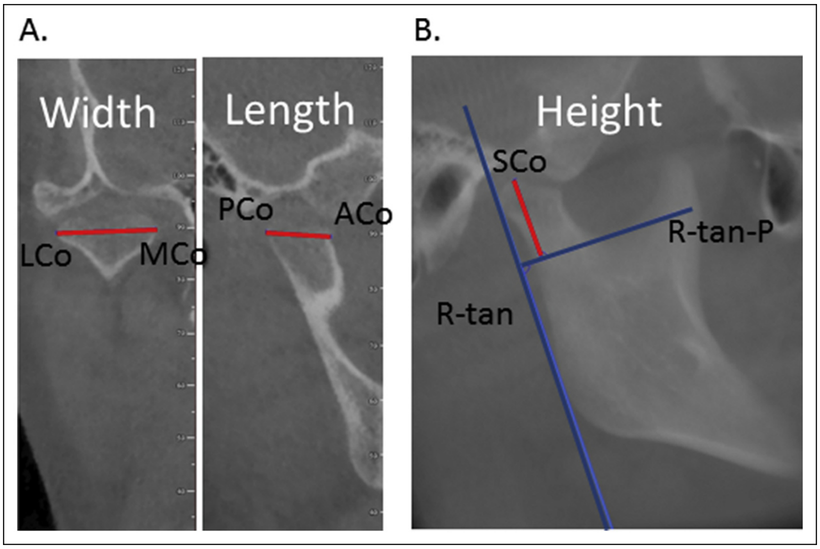

Fig 1. A, Coronal; and **B,** sagittal views showing how condylar width, length, and height were measured. See Table I for landmark definitions and the supplementary material for details about how the study reconstructions were defined.

presents defined landmarks and constructed lines and measurements.

The radiologic outcome variables were analyzed as follows: (1) mandibular condyle width, length, and height (Fig 1); (2) condylar axial angle (Fig 2); and (3) condylar neck angle (Fig 3). Width was defined as the distance from the lateral condylar point to the medial condylar point (LCo-MCo), length as the distance from the anterior condylar point to the posterior condylar point (ACo-PCo), and height as the distance from the superior condylar point (SCo) to the ramus tangent line perpendicular (R-tan-P). The condylar axial angle was the angle between the axial condylar line (lateral condylar point to medial condylar point [LCo-MCo]) and the midsagittal reference line (nasion-basion [N-B]). The condylar neck angle was divided into categorical data in posterior, normal, and anterior inclinations (Fig 3).

Qualitative data from the TMJs were obtained by evaluating 2-dimensional cross sections for the presence or absence of the pathologic characteristics described by Hatcher[5] (Table II). The radiologic assessment was conducted in a blinded fashion.

The condylar characteristics were evaluated in both the sagittal and coronal planes to address the size and localization of the changes. In the sagittal plane, tomographic sections were made at a 90° angle to a line from the coronoid tip and to the anterior external auditor meatus. The condylar head was assessed for structural changes after dividing it into thirds: anterior, superior, and posterior. Likewise, cross sections in the coronal plane were done in a 90° angle to the condylar width line, and the tomographic sections were evaluated after

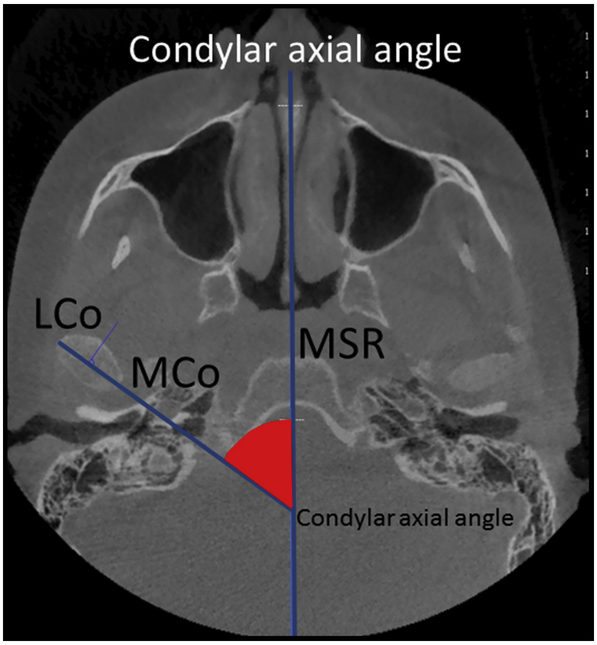

Fig 2. Illustration on how the condylar axial plane (angle between the condylar axis, a line from LCo-MCo) and the midsagittal reference line (line from N-B) was measured. See Table I for landmark definitions and the supplementary material for details about how the study reconstructions were defined.

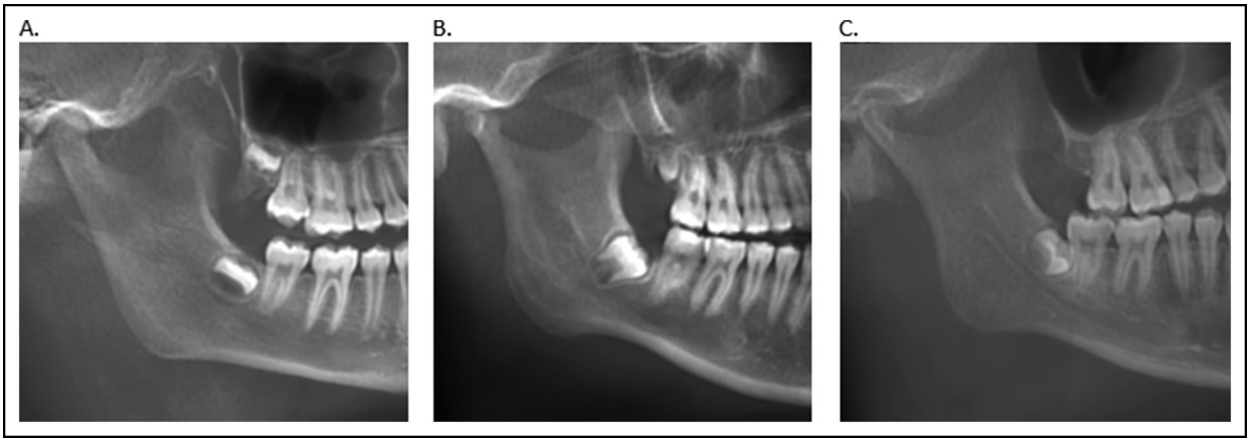

Fig 3. Examples of condylar neck angles: **A,** anterior; **B,** parallel; **C,** posterior.

Table II. Radiologic characteristics and definitions of bony TMJ deformation described by Hatcher[5]

Characteristic	*Definition*	*Presence*
Intact cortical border	Well-defined cortical border	+/−
Nonintact cortical border	Broken cortical border	+/−
Cavitation defect	A cup-shaped defect in the superior surface of the condyle	+/−
Flattening	Superior surface of the condyle is flatted	+/−
Resorption	Loss of condylar volume defined as the imaginary equator circumferential line being superiorly positioned	+/−
Congruency	Congruent shape of the articular surfaces	+/−

dividing the condylar head into medial, middle, and lateral thirds.

Patients were described by age at CBCT, sex, and number of TMJs involved (unilateral or bilateral).

Symptoms, clinical signs of TMD, and mandibular function were obtained from the patients' clinical records (≤6 months before or after CBCT) to evaluate the relationship between ICR and clinical signs of TMD.

The self-reported outcome measures were (1) TMJ: history of locking, clicking, crepitation, or combined; (2) orofacial pain: TMJ pain constant (yes/no), TMJ pain on opening (yes/no), or muscular pain (yes/no); and (3) TMJ function: reduced mouth-opening capacity (yes/no).

The objective outcome measures were (1) sounds: clicking, crepitation, or combined; (2) orofacial pain: TMJ pain on palpation (yes/no), or muscular pain on palpation (yes/no); and (3) TMJ function: maximal incisor opening (adjusting for overbite).[20]

Statistical analysis

To measure intraexaminer reliability, duplicate measurements were done in 10 patients with 20 TMJs at a minimum 2-week interval. The smallest detectable difference (mean difference ± 2 standard deviations) was calculated for all linear data.[21] Continuous data were evaluated using a Bland-Altman plot. The nominal data were evaluated using kappa statistics.

The normal distribution of the data was assessed graphically by Q-Q plots. The unpaired Student t test was used for all continuous data, and the Fisher exact test was used for nominal data.

RESULTS

The ICR group comprised 25 patients (22 female, 3 male) with a mean age of 15 years 6 months (range, 5-24 years). Eighteen patients had bilateral TMJ involvement, and 7 patients had unilateral TMJ involvement. The control group was age and sex matched and comprised 25 patients (22 female, 3 male) with a mean age of 15 years 3 months (range, 11-25 years).

We measured condylar width, length, and height and found a significant 2.0 mm (95% confidence interval [CI], −2.9, −1.0 mm) intergroup difference in condylar width, a nonsignificant 0.6 mm (95% CI, −1.2, 0.1 mm) intergroup difference in condylar length, and a significant 4.9 mm (95% CI, −6.4, −3.5 mm) intergroup difference in condylar height (Table III). Intergroup differences in condylar width and height both exceeded the smallest detectable limit for the variables in question (Table S1).

A statistically significant intergroup difference of the condylar axial angle of 10.6° was observed (Table III).

Table III. Condylar width, length, height, and condylar axial angle measurements from the ICR and control groups

n = 50 for each group	Mean (mm)	SD (mm)	95% CI (mm)	P value
Condylar width				
ICR	15.9	2.8	15.1, 16.7	
Control	17.9	1.8	17.4, 18.4	
Difference	2.0		−2.9, −1.0	<0.001
Condylar length				
ICR	8.1	2.1	7.5, 8.7	
Control	8.7	1.1	8.4, 9.0	
Difference	0.6		−1.2, 0.1	NS
Condylar height				
ICR	14.8	4.5	13.5, 16.0	
Control	19.7	2.4	19.0, 20.4	
Difference	4.9		−6.4, −3.5	<0.000
Condylar axial angle				
ICR	54.2	10.9	−51.1, 57.2	
Control	64.6	6.7	−62.9, 66.7	
Difference	10.6		−14.1, −7.0	<0.0000

Condylar length was identical between the groups, but for all other parameters the ICR group had significantly lower values. Statistical analysis used an unpaired *t* test.
NS, Nonsignificant.

This outcome was statistically significant and clearly exceeded the smallest detectable limit for this specific outcome variable (95% CI, –5.6°, 4.7°; Table S1).

A statistically significant difference in distribution of the condylar neck angle was found between the 2 groups; posterior inclination was the most frequent finding in the ICR group, and anterior inclination the most frequent finding in the control group (Table IV).

No other posttests were conducted to further describe significant differences in the condylar neck angles between the 2 groups. The risk of subanalysis bias is present in posttests because of the limited material size.

In the TMJ cross-section evaluation, significantly higher numbers of all characteristics of bony deformations were confirmed in the ICR group compared with the control group (Table V).

For each of the condylar thirds in the sagittal plane, the bony deformations in the ICR group were significantly different from those of the controls (Table VI). In the sagittal plane, the superior part of the condyle was involved in all joints where bony deformations were found in the ICR group. The anterior part was involved in 95% and the posterior part in 81% of the joints. The entire condyle was most often involved sagittally, anteriorly, superiorly, and posteriorly (77%). The combination of the anterosuperior parts of the condyle was less frequent (18%), and the combination of the posterior and superior parts of the condyle was observed only rarely (5%).

Table IV. Condylar neck angles from all joints in both the ICR and control groups

n = 50 in each group	Anterior	Parallel	Posterior	P value
ICR	7	1	42	
Control	24	15	11	<0.001

The condylar neck angles were divided into 3 categories by inclination: anterior, parallel, and posterior. Significantly more joints in the ICR patients had a posterior inclination. Fisher exact test – (2 × 3 posttest).

Table V. Bony deformation characteristics (joint level)

n = 50	ICR	Control	P value
Nonintact cortex	40%	0%	<0.001
Cavitation	22%	0%	<0.001
Flattening	22%	2%	<0.005
Resorption	56%	0%	<0.001
Noncongruency	72%	0%	<0.001

Only positive findings are shown. For all bony deformations, the ICR group had significantly more findings than the control group. Fisher exact test.

Table VI. Bony deformations in the sagittal and coronal views (Fig 1) divided into thirds

n = 50	ICR	Control	P value
Sagittal			
Anterior (+)	82%	2%	<0.0001
Superior (+)	86%	2%	<0.0001
Posterior (+)	70%	0%	<0.0001
Coronal			
Lateral (+)	80%	2%	<0.0001
Middle (+)	86%	0%	<0.0001
Medial (+)	62%	0%	<0.0001

In the sagittal plane: anterior, superior, and posterior; in the coronal plane: lateral, middle, and medial. In the ICR group, 43 of 50 joints (86%) were diagnosed with any bony deformation and ICR. Fisher exact test.

For each of the condylar thirds in the coronal plane, the bony deformations in the ICR group were found to be significantly different from those of the controls (Table VI). The middle part of the condyle was involved in all joints with bony deformations in the ICR group. The lateral part was involved in 93%, whereas the medial part was somewhat less frequently involved (72%). The whole condyle was typically involved (70%). The combination of the lateral and middle parts was seen less frequently (23%), and only rarely was the middle part solely involved (5%) or the combination of the medial and middle parts (2%) involved.

To test intraexaminer reliability, duplicate measurements were made in 10 patients with 20 TMJs.

Table VII. Clinical findings of orofacial pain, TMJ sounds, and TMJ function

	Joint level		*Patient level*	
	Self-reported	*Objective finding*	*Self-reported*	*Objective finding*
Orofacial pain				
Arthralgia	32%	34%	40%	40%
Myalgia	22%	32%	28%	36%
TMJ sounds				
Crepitation	0%	28%	0%	25%
Click	42%	10%	52%	16%
Any TMJ sound	42%	38%	52%	48%
TMJ function				
TMJ locking	20%	-	28%	-
Decreased mouth opening	16%	-	-	-

There were no clinical findings of TMD in the control group (this was an exclusion criterion), so only data from the ICR group are shown.

Table VIII. Maximal mouth-opening capacity in the ICR and control groups

n = 19 for ICR; n = 25 for control	*Mean (mm)*	*SD (mm)*	*95% CI (mm)*	P *value*
ICR	41.6	10.5	36.7, 46.5	
Control	52.5	6.1	49.6, 55.3	
Difference	−10.9		−16.3, −5.4	<0.0003

A clinically and statistically significant reduction was found in the ICR group compared with the control group. The variation in the ICR group was, however, large. The value from the control group corresponded well with findings from an age-matched general population measured using the same protocol.[20] Statistics: unpaired *t* test.

The linear measurements all had high reliability with the smallest detectable difference below ±1.5 mm. Less precision was found for the angular measurements. The condylar axial angle showed moderate agreement with an inaccuracy of about 5.5° (smallest detectable difference) (Table S1).

Joint evaluation intrarater reliability scores were almost perfect for nonintact cortical border ($\kappa = 0.89$) and presence of a cavitation defect ($\kappa = 0.87$). Observations of flattening and resorption had substantial agreement ($\kappa = 0.69$ and $\kappa = 0.60$, respectively), and the reliability for a congruent shape had moderate agreement ($\kappa = 0.57$)22 (Table S2).

Intrarater-reliability agreements for localization of degenerative change were high, with kappa values of 0.61 to 1.0 (Table S3).[22]

For the symptoms and signs of TMD, a standardized, previously used orofacial examination chart was used in 18 of the 25 patients.[23] For the 7 patients for whom no standardized examination form was available, we extracted the data from the general journals.

Self-reported arthralgia was reported in 32% of all joints and by 40% of the patients with ICR. Clinical findings of arthralgia (TMJ pain on palpation) showed similar results with pain from 34% of all joints and in 40% of the patients (Table VII). In the TMJs when patients reported arthralgia, there was a clinical diagnosis of arthralgia for 69%.

Masticatory muscle myalgia was reported by 28% of all patients. Clinically, myalgia was slightly more frequent (36%). All patients with self-reported muscle pain also had clinical myalgia, indicating that self-reported myalgia has a higher specificity to clinical findings than arthralgia.

Self-reported TMJ sounds were found in 42% of all joints and reported by 52% of the patients with ICR. No patient reported crepitation. Objective findings of TMJ sounds showed similar results, with sounds from 38% of all joints and in 48% of the patients (Table VII). In contrast to the self-reported sounds, joint crepitation was the most frequent TMJ sound diagnosed from the clinical examinations.

Decreased mouth opening was reported by 16% of the patients (Table VII). Of these 4 patients, 3 had arthralgia. Furthermore, 28% of the patients had experienced TMJ locking (20% of all TMJs). Reduced translation was diagnosed in 53% of the joints.

Interestingly, 20% of the patients had no arthralgia, myalgia, or sounds from their TMJs. Of these 5 patients, 1 had reduced translation of the joints as the only clinical finding, and 1 had reduced translation and reduced mouth opening as the only signs of TMD. The remaining 3 patients, or 12% of the ICR group, had no signs or symptoms of TMD despite the ICR.

A statistically significant reduction of mouth-opening capacity was found for the ICR group compared with the control group, with the former having an almost 11-mm (95% CI, −16.3, −5.4 mm) reduced mouth-opening capacity (Table VIII).

DISCUSSION

ICR and its consequences, including dentofacial growth disturbances, poor effect of orthopedic treatment, and relapse after orthodontic and orthognathic surgical treatment, are profound orthodontic therapeutic challenges.[4,11,13,15,19,24,25]

Our patient cohort's epidemiologic characteristics resembled those of previously described cohorts (predominantly adolescent girls with bilateral joint involvement).[4,11,19] Condylar deformation onset occurred at a relatively young age (mean age, 15.5 years at diagnosis), and most patients had a longstanding history of TMJ disorder. The high frequency of bilateral as opposed to unilateral joint involvement may suggest a systematic etiology, possibly hormonal.[1-3,14,26,27] The mandibular condyle is an important site for growth and development of the mandible and also for mandibular (TMJ) function.[28] Considering the age of the ICR group, the condylar deformity could be the net result of pathologic bone modeling during growth.[3] The etiology remains unknown, but a combination of TMJ disorders inducing a low inflammatory condition and a change in hormonal activity may be involved in some patients. Still, the term resorption continues to be used to describe severe condylar and eminence deformities. Although the typical patient in this study was an adolescent, ICR was also found in young persons before puberty; hence, 3 of the 25 patients were 9 years old or younger.

We found a reduction in both condylar width and height in patients with ICR, but somewhat unexpectedly, condylar length was not decreased. This may partly be explained by the method used to assess condylar length. In patients with severe condylar deformities, an increase in condylar length might even have been measured since the condylar neck fuses with the ramus, and the length becomes a measurement of the superior part of the ramus and not the condylar head. This would blur a difference between the 2 groups. The line dividing the condyle and the ramus is arbitrary, and the use of a different and more superiorly positioned cutoff point may influence the results.

We are the first to quantify condylar dimensions in patients with ICR, so we cannot directly compare our results those of others. Park et al[29] retrospectively measured condylar dimensions before and after orthognathic surgery in healthy subjects without TMD symptoms, finding a minor reduction in condylar height of 0.5 mm after surgery and no difference in condylar width or length. This is considerably less than the -4.9 mm (95% CI, −6.4, −3.5 mm) condylar height reduction we reported. The size of this reduction is clinically important because it enhances the retrognathic position and backward mandibular rotation in patients with ICR.[4,11,13,14,30,31]

Condylar width, length, and height measured in our control group are comparable with measurements obtained on dry skulls by Hilgers et al.[32] Although our study and that of Hilgers et al were not matched with respect to age, we found minimal differences between the condylar length and height values, which differed by only 0.1 mm. Condylar width, however, was 0.9 mm greater in the study of Hilgers et al than in ours.

A smaller condylar axial angle was found in patients with ICR. Such a change may be affected by bone modeling at the medial and lateral poles of the condyle. A change in condylar form in these areas would change the position of the most lateral and medial points of the condyle used to measure the condylar axial angle (Table III). Bony resorption or absence of bone formation at the medial and lateral parts of the condyle would be accompanied by a reduction in condylar width, which was also found (Table III). A change in the condylar axial angle may, however, also result from condylar resorption from the superior aspect of the condyle. Investigating the mandibular anatomy, we saw that the condylar head emerges from the ramus and twists outward in a superior direction. Therefore, when bone resorption takes place at the top of the condylar head, an inward twist of the condylar head may be observed, leading to reduction of the condylar axial angle.

Park et al[29] also found a decreased condylar axial angle in their study of condylar modeling after orthognathic surgery. They reported a mean decrease in the condylar axial angle of 5.7°, which is less than we observed. However, their patient sample also had less resorption of the condyle. We found a statistically significant difference in the condylar axial angle but considered it to be of little clinical interest. Before this measurement can be applied in a daily clinical routine, reference values need to be established for the normal variations in relation to age.

Hwang et al[30,33] measured condylar neck angles in panoramic radiographs using the horizontal orientation of the radiograph to construct the midpoints of the ramus, which served to draw the ramus line. That method is sensitive to changes in head posture and is poorly transferable to CBCT scans. In a pilot study, we found the reliability of condylar neck measurements to be low (intraexaminer reliability on 10 double measurements: mean, −2.2° difference; 95% CI, −4.5°, 0.1°; smallest detectable difference, −12.1°, 7.6°) and therefore decided to categorize the condylar neck angle as either anteriorly, parallel, or posteriorly inclined, as was also done in other studies.[30,33] We more frequently found a posterior inclination of the condylar neck angle in patients with ICR than in the controls. However, since bony deformations were most often at the anterior and superior parts of the condylar head, displacement of the superior condylar point will be in a posterior direction, thereby increasing the condylar neck angle. Therefore, this measurement may be the result of ICR rather than a potentially predisposing factor for ICR. However, Hwang et al[30] found a low odds ratio of 1.12 for preoperative condylar inclination as a risk factor for condylar resorption.

There is no generally accepted grading system for evaluating ICR severity in the TMJ, but Hatcher[5] described general characteristic findings for ICR patients that we used for TMJ evaluation in this study. All bony deformations were significantly increased in the ICR group and may represent different stages of joint degeneration or abnormal development (Table II). Therefore, all characteristics were considered important when evaluating the TMJ and as possible candidates for inclusion in a severity grading system for ICR patients.

The resorption patterns are thought to be associated with compression as the main cause of events leading to disease.[14] The superior part of the condyle was involved in all joints with bony deformations; this agrees with the literature on patients with progressive condylar resorption (condylar resorption after orthognathic surgery).[14,31] The anterior part was involved in 95% of the patients with bony deformations, which corresponds to the findings of Hoppenreijs et al.[14] Kobayashi et al[31] reported anterior resorption in only 33% of the joints. We found that the posterior part of the condyle was involved in 81% of the involved joints, but about 50% of the joints were reported in progressive condylar resorption (PCR) patients.[14,31] A direct comparison with these studies is difficult because the x-ray materials analyzed and the method used to evaluate condylar resorption differed between the studies. The sample sizes were generally small, and this could easily affect the results (eg, Kobayashi et al included only 6 patients).[31]

We found that 77% of joints in the sagittal plane and 70% of the joints in the coronal plane had bony deformations in all thirds of the condyle, suggesting a systemic etiology different from PCR. Hoppenreijs et al[14] also found 58% to have condylar resorption in all 3 parts of the condyle from a sagittal perspective.

However, a subgroup with degenerative changes in the anterosuperior parts (18%) and in the lateromiddle parts (23%) of the condylar head was also found. The differences in location of bony deformations may indicate a dual or even multifactorial etiology.

Arthralgia was found in 40% of the patients with ICR. This percentage confirms the findings by Handelman and Greene[19] in patients with ICR who obtained their data from questionnaires sent to private practitioners. They found that a third of the patients (12 of 39) had TMJ pain. However, they did not differentiate between TMJ joint pain and muscular pain. A similar frequency was reported before surgery: 35% of patients with progressive condylar resorption had TMJ pain.[30]

Myalgia was found in a third of the ICR patients. TMJ muscular pain has been described in clinical case reports, but it has not previously been described thoroughly in this patient group.[4,15,19,24]

This study showed that symptoms and signs of TMJ arthralgia and myalgia are frequent in patients with ICR, although some with no signs or symptoms of TMD are also seen.

TMJ sounds were reported by about half of the patients with ICR, and crepitation was twice as common as clicking (Table VII). No cross-sectional study has previously described the prevalence of TMJ sounds in this patient group. Studies in patients with progressive condylar resorption reported TMJ sounds in 38% to 76% of the patients before surgery.[10,14,30]

The difference between the self-reported and the objective findings may be explained by clicking gradually changing into crepitation, and the number of patients with clicking therefore declines during the disease course. Hence, when asked, patients confirmed occasional or historical clicking. A simple difference in the perception of click and crepitation between patient and examiner could be the reason for the inconsistency.

Our study shows that symptoms and signs of TMJ sounds are a frequent finding. TMJ disorders might be part of the etiology, but our material does not allow for such conclusions. Clinically, the high frequency of crepitation is important, since crepitation is rarely found in healthy joints and indicates bony deformations also in rheumatoid patients.[34]

A displaced disc is often found in patients with ICR.[4,5,19,35] One study using magnetic resonance imaging and computed tomography found an association between disc displacement without reduction and bony deformations in the TMJ.[36,37] However, the causal relationship between TMJ disc displacement and bony degenerative disorders is considered controversial.[38] It has been demonstrated that there may be degenerative changes of the articular surface in joints with a normal disc position.[2,39] This suggests that factors other than a displaced disc are involved in the bony deformations of the TMJ.

TMJ locking was reported in 28% of the ICR patients; this is comparable with the 22% frequency reported before surgery in PCR patients.[10]

Symptoms and signs of TMD were frequently found in patients with ICR. It was, however, equally interesting that 5 of the 25 patients (20%) with ICR had no TMJ arthralgia, myalgia, or TMJ sounds. Similarly, Wolford and Cardenas[18] reported that 25% of ICR patients had no signs or symptoms of TMD. This study thus confirms that symptoms and signs of TMD may be absent despite gross bony deformations.

We found a decreased mouth-opening capacity in patients with ICR compared with the controls. No other study has reported a change in mouth-opening capacity of ICR patients. Hoppenreijs et al[14] studied patients with

PCR but found no correlation between maximal incisor opening (MIO) and condylar changes. Using the same protocol for MIO measurements as our study, the mean value for 16-year-old girls was 53.7 mm (lower fifth percentile, 41.5 mm).[20] The mean value of 52.4 mm of MIO in our control group is comparable with both of these findings, and the ICR group would on average be in the lower fifth percentile.[20]

The diagnostic criteria for ICR are not uniform, but ICR is often a diagnosis used when other potential causes of condylar resorption or deformities have been ruled out (history of arthritis or other immune disease, congenital syndrome, craniofacial trauma, or previous orthognathic surgery). All of the following may aid in the correct diagnosis of ICR: epidemiologic characteristics (young female, bilateral joint involvement), clinical findings of TMD, TMJ imaging findings (resorption, cavitation, and so on), reduced mouth-opening capacity, facial characteristics (mandibular retrognathism, posterior rotation of the mandible, decreased posterior-to-anterior facial height ratio), and abnormal mandibular growth.

Today, we cannot distinguish isolated TMJ arthritis from ICR, although the etiologies of the 2 conditions may be completely different. Determining the presence and the levels of proinflammatory cytokines or other mediators found in TMJ synovial fluid may allow us to discriminate between these conditions.[40] However, both proinflammatory and anti-inflammatory cytokines may be present in homeostasis also in clinically healthy joints.[41] Future research on synovial fluid therefore must show whether ICR should still be classified as a low-inflammatory arthritic disorder.

We support the notion that ICR should be considered a syndrome of multifactorial etiology and believe that young age and female sex are primary characteristics of ICR. The pathologic process may begin with puberty in girls and may be spurred by internal TMJ derangement supported by hypermobility or hyperactivity causing changes in the biologic intra-articular homeostasis and affecting the normal TMJ growth and development of the condyle and the fossa-tuberculum.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.ajodo.2016.12.020.

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