Facial Asymmetry in Adults Following Temporomandibular Joint Disc Displacement with Onset During Growth

Annika Isberg, DDS, PhD¹/Per Erik Legrell, DDS, PhD²

Aims: The purpose of this investigation was to evaluate facial symmetry in adult patients with (1) radiographically verified, (2) unilateral, (3) nonreducing disc displacement of the temporomandibular joint, (4) with onset before the end of the growth spurt. Methods: Thirteen patients were compared with 12 volunteers, all with radiographically verified normal superior disc position bilaterally. Paired lateral and frontal cephalograms with external radiographic markers in the gonion areas were used for identification of mandibular sides in the lateral cephalogram and for correct identification of gonion in the frontal cephalogram. This allowed valid measurements of craniofacial height. Results: Craniofacial height in patients was consistently shorter on the side with disc displacement. The difference between sides was significantly greater in patients than in volunteers, \( P < 0.0005 \). The chin deviated to the disc displacement side in all but two patients. Chin deviation was observed in half the volunteers, with the direction being inconsistent. Chin deviation was significantly more pronounced in patients than in volunteers, \( P < 0.05 \). In patients, but not in volunteers, chin deviation was linked with external lower face asymmetry, \( P = 0.006 \), implying a superolateral shift of the lower face toward the disc displacement side. Conclusion: Onset of unilateral nonreducing temporomandibular joint disc displacement during growth was found to be associated with craniofacial and external facial asymmetry in adulthood. The results indicate implications involving jaw orthopaedic treatment. World J Orthod 2000;1:164–172.

In recent years, increasing interest has focused on whether the specific disease entity temporomandibular joint (TMJ) disc displacement has an impact on facial skeletal form. The question of whether there are characteristic findings from cephalometric analyses that could affect orthodontic treatment, as well as pretreatment patient education, has been raised.¹

An association between mandibular shortening and TMJ disc displacement on the ipsilateral side in patients demonstrating facial asymmetry with chin deviation has previously been found.²-⁴ When patients with radiographically verified uni- or bilateral TMJ disc displacement were compared with asymptomatic volunteers with unknown disc position, mandibular midline deviation was found to be more frequent and of a larger magnitude among the patients.⁵ The midline deviation was associated with a superior tilt of the occlusal plane on the disc displacement side that significantly exceeded that found in volunteers. Whether the asymmetry had predisposed for disc displacement, or if the displaced disc had caused the shortening of the mandible, remained obscure.

¹Professor, Department of Odontology, Oral and Maxillofacial Radiology, Umeå University, Umeå, Sweden.
²Assistant Professor, Department of Odontology, Oral and Maxillofacial Radiology, Umeå University, Sweden.

REPRINT REQUESTS/CORRESPONDENCE
Prof Annika Isberg, Department of Odontology, Oral and Maxillofacial Radiology, Umeå University, SE-901 87 Umeå, Sweden.
Tel: +46 90 785 61 70. Fax: +46 90 17 80 17.
E-Mail: Annika.Isberg@odont.umu.se
To reveal causation, the facial skeletons of adolescents presenting with clinical signs of disc displacement were longitudinally compared with those of asymptomatic controls. The patients with unilateral disc displacement developed mandibular shortening on the ipsilateral side, compared with the contralateral side. The results indicated that disc displacement in growing individuals influenced the development of mandibular form. The measurements were based on transpharyngeal radiographs that did not allow full control of projection and magnification. The significance of the finding is therefore somewhat uncertain. Furthermore, no radiographic verification of disc position was available. Support of the finding was achieved when the facial skeletons of 2 adolescents with radiographically verified disc displacement were longitudinally evaluated. Both patients developed a progressive shortening of the mandible.

Longitudinal experimental studies have revealed that surgically created, unilateral, nonreducing disc displacement induces shortening of mandibular height and length on the ipsilateral side. The shortening resulted in a deviation of the mandibular midline and developed whether or not the disc displacement was associated with osteoarthrosis.

Taken together, these studies point to a risk for development of mandibular deficiency in growing patients with nonreducing disc displacement. Lateral cephalometry in adolescent females and males showed a correlation between increasing severity of TMJ disc displacement and reduced ramus height, reduced posterior facial height, reduced sagittal length of the mandibular corpus, and larger antero inferior inclination of the palatal plane. In adult patients with unknown onset of TMJ disc displacement, no such specific parameters associated with radiographically verified TMJ disc displacement were identified. All 3 studies lacked distinction between unilateral and bilateral TMJ affliction, and between reducing and nonreducing disc displacement. Therefore, it is quite possible that the 2 patient groups were not comparable. Another explanation for the difference in study results could be that the adults had developed disc displacement after the pubertal growth spurt, thereby avoiding the influence on facial growth. In these studies, any asymmetries in patients with unilateral disc displacement would have been obscured in the lateral cephalograms due to superimposition and difference in magnification of bilateral structures, and because the routine cephalometric evaluation is based on averaging of left- and right-side landmarks.

Frontal cephalometry has been used for evaluation of facial asymmetry. Chin deviation is readily determined in relation to the midline in the frontal projection. Measurements of facial height commonly involve the landmarks gonion and antegonion, and this constitutes a problem in frontal cephalograms because identification errors can be of an unacceptable magnitude. Any difference in height between the left and right side, not exceeding 30 mm, could be attributed to identification error. The use of other radiographic techniques, such as tomography or computed tomography, has been suggested in order to achieve higher accuracy in measurements. However, these techniques are costly, not readily available, and involve a relatively high radiation dose. Therefore, the authors developed a technique to transfer gonion, as identified in the lateral cephalogram, to a paired frontal cephalogram in order to allow valid measurement of facial height.

TMJ disc displacement in children may potentially lead to an alteration of mandibular growth and the development of mandibular deficiency. The authors hypothesized that an onset of unilateral, nonreducing disc displacement during childhood or adolescence will induce a shortening of the mandible on the ipsilateral side and a subsequent chin deviation that will remain manifest in adulthood.

The aim of this investigation was to evaluate facial symmetry in adult patients with radiographically verified, unilateral, nonreducing TMJ disc displacement with onset before the end of the growth spurt.

MATERIAL AND METHODS

Subjects

This study was based on adult patients with a history of unilateral permanent TMJ locking, resulting in significantly impaired mouth opening, with onset before the end of the growth spurt (before the age of 13 years for girls and before the age of 15 years for boys). Furthermore, unilateral, nonreducing TMJ disc displacement was radiographically verified on the symptomatic side. Consecutive patients scheduled for radiographic TMJ examinations were asked to participate in the study, which was approved by the ethics committee at Umeå University, Dnr 89/94. Thirteen patients, 12 females and 1 male, met the criteria and constituted the material.

A control group was composed of volunteers with professional knowledge regarding radiation hazards. They had no history, signs, or symptoms of temporomandibular disorders. Of the 14 subjects who volunteered, magnetic resonance imaging revealed unilateral asymptomatic disc displacement in 2 females who were discarded from the study. The remaining 12 volunteers, 4 females and 8 males, had radiographically verified normal superior disc position.
All patients and volunteers gave informed consent. Eleven patients and 11 volunteers agreed to have their photos taken.

**Cephalography and photography**

Paired lateral and frontal cephalograms of all patients and volunteers were obtained. To assist identification of mandibular sides, lead markers of different sizes were attached to the skin bilaterally over the region of the landmark gonion, as estimated by digital palpation. The smaller marker was placed on the side facing the film. In the lateral cephalogram, the difference in magnification between sides enhanced the difference in marker size, and not the reverse.

While the subject was seated in the cephalostat, an en-face photograph was taken with the camera aperture on the same level as the radiographic focal spot and with the film plane parallel to the coronal plane.

For valid measurements of facial height, the landmark gonion, as identified in the lateral cephalogram, was transferred from the lateral to the paired frontal cephalogram as follows: Gonion was identified for each side in the lateral cephalogram according to the standard definition.\(^\text{18}\) Mandibular left side versus right side was identified based on calculations of the inclination of the x-ray beam through the mandibular base on each side and through each marker. The relative movement of markers and inferior mandibular outlines between cephalographic projections was related to projection geometry. This procedure is described in detail elsewhere, and has been evaluated and found valid.\(^\text{17}\) The magnification for each gonion area was individually calculated in all lateral cephalograms. The vertical vector of the distance between gonion and the ipsilateral marker was measured (Fig 1) and transferred to the frontal cephalogram, after compensation for the individual enlargement factor. Gonion was thereby identified bilaterally in the frontal cephalogram.

Craniofacial height was determined bilaterally in the frontal cephalogram. The height was defined as the distance from gonion perpendicular to a reference line running through the supraorbital rims (Fig 2). In patients, the disc displacement side was compared with the contralateral side. In volunteers, the left side was compared with the right side. Any difference between sides in the reference group was given a positive value.
The occlusal plane was defined in the frontal cephalogram as a line connecting the tip of the most buccally projected cusp of the second maxillary molar of the left and the right sides (Fig 2). A line parallel to the reference line was drawn through the tip of the molar cusp on the left side, forming another reference line. In the following sections, this line is referred to as the occlusal reference line. The perpendicular distance between the occlusal reference line and the tip of the corresponding cusp of the contralateral molar was measured.

The midpoint of the chin was determined, relative to the skeletal facial midline, in the frontal cephalogram. The skeletal facial midline was defined as perpendicular to the reference line, through the midpoint between the medial border of the orbital cavities (Fig 2).

The external symmetry of the lower part of the face was measured in the photographs on a level halfway between the rim of the lower lip and the point of the chin (Fig 3). Symmetry was determined by comparing the width of the left and the right sides of the face, expressed as the perpendicular distance from the external facial midline to the lateral facial contour. The external facial midline was defined as the midpoint perpendicular to a line through the pupils in the photograph.

**Temporomandibular joint radiography**

The disc position was determined bilaterally by single contrast, dual space arthrotomography or in T1-weighted and proton density magnetic resonance images, at mouth closure and in the open mouth position. The angle between the long axis of the condyle and the coronal plane was measured in axial images. Condyle form and condyle position in the articulating fossa were determined in corrected sagittal tomograms or magnetic resonance images.

After determination of disc position, the magnetic resonance images of 1 patient became unavailable for determination of condyle form and position.

**Statistics**

Differences between the patient group and the reference group within the above mentioned parameters were evaluated with Mann-Whitney's U test for independent samples. Differences with a value of $P < 0.05$ were regarded as significant.

Any difference between the disc displacement side and contralateral side was determined in the patient group. In the reference group, any difference between the left and the right sides was calculated and given a positive value in the subsequent analyses.

**RESULTS**

**Cephalography and photography**

**Craniofacial height.** In the patients, the craniofacial height of the disc displacement side was consistently shorter than the contralateral side. The difference ranged from 1 to 8 mm, with a mean of 4.5 mm (Fig 4). Two volunteers were symmetric; 10 were asymmetric, with 2 shorter on the left side and 8 shorter on the right side. The difference ranged from 0 to 1.5 mm with a positive mean value of 0.8 mm. The difference between patients and volunteers was statistically significant, $P < 0.0005$.

**Occlusal plane.** The occlusal plane tilted superiorly on the disc displacement side in all but 1 patient. This patient demonstrated a tilt in the reverse direction. In the patients, the distance between the occlusal plane and the occlusal reference line ranged from −1 to 4 mm with a mean of 1.5 mm. The occlusal plane was parallel with the occlusal reference line in 2 volunteers, and tilted superiorly on the left side in 5 and on the right side in 5, ranging from −1.5 to 1.5 mm with a positive mean value of 1.0 mm. There was no statistically significant difference between the 2 study groups, $P = 0.27$.

**Mandibular midline.** Twelve patients demonstrated chin deviation; 11 deviated to the disc displacement side and 1 to the contralateral side (Fig 5). The deviation from the midline ranged from −7.5 to 8 mm, with a mean value of 2.5 mm. Six of the volunteers had no deviation of the chin. The remaining 6 had deviation but with inconsistency in direction, 3 deviating to the left side and 3 to the right. Any deviation from the midline was given a positive value resulting in a range from 0 to 4 mm with a positive mean value of 0.9 mm. The difference between the patient group and the reference group was statistically significant, $P < 0.05$.
Fig 4  Craniofacial height: Diagram of intraindividual side difference in mm. The direction of column points to the shorter side. Difference between the 2 study groups is statistically significant, \( P < 0.0005 \).

Fig 5  Mandibular midline: Diagram of deviation of midpoint of chin in mm. Difference between the 2 study groups is statistically significant, \( P < 0.05 \).
The combination of unilateral lower craniofacial height and chin deviation observed in the patient group resulted in a superolateral shift of the lower face to the disc displacement side (Fig 6).

**External facial width.** With 2 exceptions, all patients photographed were asymmetric. The face was broader on the disc displacement side in 8 patients and broader on the contralateral side in 1. The disc displacement side was 10% broader as a mean, ranging from -30% to 40%. Eight volunteers were externally symmetric and 3 were asymmetric, 2 with a broader left facial side and 1 with a broader right side. The right side was 1.3% broader as a mean, ranging from 2% broader on the left side to 10% broader on the right side (Fig 7). The difference between groups was statistically significant, \( P = 0.006 \).

**Temporomandibular joint radiography**

The condyle inclination ranged from 10 degrees to 45 degrees, with the lateral pole most anterior. An intraindividual side difference not exceeding 10 degrees was seen in 3 patients and in 5 volunteers. There was no significant difference between groups. Seven condyles in disc displacement joints were rounded, 4 were rounded-blunted,\(^1\) and 1 condyle had an anterior osteophyte and sclerosis. On the contralateral side in the patients, 10 condyles were rounded and 2 were rounded-blunted. Nine volunteers had rounded condyles bilaterally, 2 rounded-blunted condyles bilaterally, and 1 volunteer had 1 rounded and 1 rounded-blunted condyle. There was no difference between groups regarding condyle shape. No hard tissue changes or deviation in shape of the temporal joint components was observed.

Four condyles in 3 patients were positioned slightly posteriorly in the fossa. In 1 of these patients, posterior condyle position was observed both in the disc displacement joint and in the contralateral joint. In the 2 remaining patients, only the disc displacement joint showed this feature. Posterior condyle position was also seen in 2 volunteers, 1 unilaterally and 1 bilaterally. The joint space superior to the condyle was symmetric and within normal limits in all subjects.

When displaced, the discs were observed anterolateral, anterior, or anteromedial to the condyle. No disc was displaced sideways.

**DISCUSSION**

The hypothesis that temporomandibular joint disc displacement with an onset before the end of the growth spurt is associated with facial asymmetry in adulthood was verified. In all but 2 patients, the craniofacial height was consistently lower on the disc displacement side and was linked with a deviation of the chin to the ipsilateral side. The combination of height reduction and chin deviation resulted in a laterosuperior shift of the lower face toward the disc displacement side, causing an external facial asymmetry that was not observed in the volunteers. Although some volunteers showed a difference between sides in skeletal facial height or chin symmetry, the difference was random regarding side and of a significantly lesser degree than that observed in the patients. Therefore, there was never resultant external facial asymmetry. An original photograph, with the facial midline indicated, and 2 computer reconstructions of 1 patient and 1 volunteer are shown in Fig 8. On either side of the original photograph is a reconstruction: one combining 2 right facial halves and the other combining 2 left halves. It is obvious that the skeletal asymmetry results in a broader lower face, with the disc displacement side carrying a larger portion of the mouth. Depending on the degree of chin deviation, the disc displacement side can also be longer. Obesity could camouflage the skeletal asymmetry, as observed in 1 patient with a face perceived as symmetric in spite of pronounced asymmetry of the facial skeleton.

One patient differed from the others in that the mandibular ramus was lower on the disc displacement side, but the length of the mandibular body
 exceeded that of the side with the healthy joint. Hence, the chin deviated to the opposite side, which was the wider side of the asymmetric face and also the side where the superior tilt of the occlusal plane was observed. Neither patient history nor clinical or radiographic examinations revealed any explanation for this excessive growth of the mandibular body. A plausible explanation could be early trauma or some other extrinsic factor causing stimulation of growth.

The frontal occlusal plane tilted superiorly on the disc displacement side in all but the above-mentioned patient. This finding is in accordance with a previous study reporting an association between midline deviation and a superior tilt of the occlusal plane on the disc displacement side. The degree of tilting was reported to significantly exceed that found in volunteers. Random tilting of the occlusal plane, regarding side, was also observed in the study volunteers. However, contrary to the previous report, no statistically significant difference was found between patients and volunteers in the magnitude of tilting. There was a difference in design between studies, in that the onset of disc displacement was unknown in the previous study, while all patients in this study had the joint condition before the end of the growth spurt. A probable explanation for the difference in results is a compensatory growth of the alveolar process in growing individuals that would not occur in adults. If the random tilting of the occlusal plane observed in the volunteers is regarded as a congenital baseline, the occlusal plane should have tilted inferiorly instead of superiorly on the disc displacement side in every other patient. If so, compensatory growth accounted for an even larger discrepancy between sides.

Shortening of mandibular height following unilateral TMJ disc displacement has previously been ascribed to osteoarthritis. A shift of the mandibular midline may also be a result of posterior displacement of the condyle in the articular fossa. However, these explanations do not apply to the present results because all but 1 condyle in the radiographically imaged joints with disc displacement were rounded or rounded-blunted, and that was not perceived to influ-
ence condyle height. Furthermore, posterior condyle position was not associated with facial asymmetry, but occurred both in joints with disc displacement and in joints with normal superior disc position in accordance with previous findings.\textsuperscript{10-12} The plausible explanation is that the asymmetry in the patients developed in line with the growth changes observed experimentally in growing rabbits, secondary to nonreducing unilateral disc displacement.\textsuperscript{10-12}

A prerequisite for evaluation of an association between TMJ disc displacement and asymmetry of facial form is that the joint affliction is unilateral, as in the present study. In a longitudinal study starting during the growth period, TMJ disc displacement involved both joints in 71% of the patients.\textsuperscript{6} Hence, the majority of the adolescents with unilateral disc displacement develop bilateral affliction during the time lapse between the growth spurt and adulthood. This explains why 6 years of collecting material using the strict inclusion criteria of this study resulted in no more than 13 patients. The material is uniform compared with previous studies.\textsuperscript{1-6} When reference groups have been involved in previous studies of facial asymmetry, the TMJs have been asymptomatic but disc position has not been radiographically verified.\textsuperscript{5,6} The volunteers included in the present study had radiographically verified, bilateral, normal superior disc position. The observed differences between patients and volunteers are therefore believed to better reflect the influence of disc displacement on facial growth than those observed in earlier studies. Based on the results of this study, it is reasonable to assume that bilateral disc displacement with an onset before the end of the growth spurt will result in bilateral mandibular shortening and mandibular retrognathia. This possible cause-effect is important to evaluate.

This study has shown that there are characteristic findings from cephalometric analysis of frontal cephalograms that may have implications for TMJ treatment and pretreatment patient education. Lateral cephalometry was not included in this evaluation. With the use of radiographic markers, the difficulty in identifying mandibular sides due to superimposition can be overcome.\textsuperscript{17} However, linear measurements
between landmarks at different object depth are not reliable in lateral cephalograms, since even a small, sideways change of head inclination will dramatically change the length of the projected distance. If craniofacial asymmetry places a bilateral landmark at different distances from the median plane, it will have the same effect on linear measurements as a sideways change in head inclination. The routine cephalometric evaluation is based on averaging between landmarks, which cannot be used when asymmetry is to be studied.\textsuperscript{1,13}

There is a peak in incidence of symptomatic TMJ disc displacement in the second decade of life.\textsuperscript{22} This study has shown that an onset of disc displacement at that age is likely to cause deficiency of facial form. The results strongly suggest the need of jaw orthopedic treatment.

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REFERENCES