Comparison of Skeletal and Dental Morphology in Asymptomatic Volunteers and Symptomatic Patients with Bilateral Disk Displacement with Reduction

Ioanna K. Gidarakou, DDS a; Ross H. Tallents, DDS b; Stephanos Kyrkanides, DDS, PhD c; Scott Stein, DMD b; Mark E. Moss, DDS, PhD b

Abstract: The purpose of this study was to evaluate the effect of bilateral disk displacement with reduction (BDDR) on the skeletal and dental pattern of affected individuals. There were 42 symptomatic female patients and 46 asymptomatic normal female volunteers. All study participants had bilateral high-resolution magnetic resonance scans in the sagittal (closed and open) and coronal (closed) planes for evaluation of the temporomandibular joints. Linear and angular cephalometric measurements were taken to evaluate the skeletal, denture base, and dental characteristics of the two groups. Analysis of variance was used to compare the symptomatic subjects with the control subjects. The length of both the anterior (S-Na) and posterior (S-Ba) cranial base was smaller in the BDDR group. SNA and SNB angles were also smaller in the symptomatic group. There were also significant differences in the denture pattern. The interincisal angle was larger and the upper incisor was more retroclined in the BDDR group. This study showed that alterations in skeletal morphology may be associated with disk displacement (DD). The mechanisms by which DD is produced or the mechanisms that cause that skeletal alteration are yet to be clarified. This study suggests that subjects with BDDR may manifest altered craniofacial morphology. The clinician should be aware of this possibility especially for the growing patients and the orthognathic surgery candidates. (Angle Orthod 2002;72:541–546.)

Key Words: Joint; Skeletal; Alterations; Cephalometrics

INTRODUCTION

Temporomandibular joint disorder (TMD) is a collective term embracing a number of clinical problems that involve the masticatory musculature, the temporomandibular joint (TMJ) and associated structures, or both.1 Disk displacement (DD) with reduction is frequently associated with a clicking sound, and DD without reduction is often associated with limitation of jaw opening.2 Autopsy studies in both young and mature adults show DD in 10–32% of individuals in the general population.3,4 Several studies have suggested that DD occurs in asymptomatic subjects with a prevalence ranging from 10–33%.5–11 The interesting finding of a high prevalence of DD in asymptomatic volunteers (AVs) is not unique to the TMJ. Magnetic resonance imaging (MRI) studies of asymptomatic subjects in the knee, cervical spine, and lumbar spine indicate a similar disease prevalence in asymptomatic subjects.12–17 MRI studies have also shown DD to be common in knees of asymptomatic athletes.18 These studies demonstrate that DD can be present in patients without clinical signs and symptoms. On the other hand, it has been shown that not all TMJ pain, clicking, and limited jaw motion can be related to DD within the TMJ in symptomatic patients.19 Paesani et al20 studied 115 patients having signs and symptoms of TMD. Seventy-eight percent had unilateral or bilateral DD. Twenty-two percent had bilaterally normal TMJs. Paesani et al20 also concluded that the structural difference between painful and nonpainful DD, as seen in im-
aging studies, is not yet clear. Although there was radiologic evidence of DD in a significant proportion (78%) of the patients in their series, this does not necessarily indicate that DD is the source of the pain in every patient.

DD has been suggested to affect skeletal morphology. Nebbe et al.21 have suggested that adolescent female patients presenting for orthodontic treatment with bilateral DD show numerous angular and linear cephalometric differences compared with age-matched female controls. Nebbe et al.22 also demonstrated that associations exist between DD and craniofacial morphology in a sample of adolescent female subjects. Using posteroanterior films, a recent study investigated the amount of craniofacial asymmetry in female orthodontic patients with uni- or bilateral TMJ DD compared with female controls without DD. The authors concluded that a female patient with uni- or bilateral DD may present with or develop a vertical mandibular asymmetry.23 Schellhas et al.24 and Dibbens et al.25 suggested that there are morphologic changes in children with DD and symptoms, respectively.

Brand et al.26 and Bosio et al.26 also suggested that there are skeletal changes associated with DD. Patients referred for orthognathic surgery have also showed a high prevalence of DD.27,28 and animal studies have suggested that there are arthrotic changes associated with surgically created DD.29-32 This study will evaluate AVs and symptomatic bilateral DD with reduction (BDDR) subjects presenting with localized jaw joint pain for skeletal and dental morphologic changes.

MATERIALS AND METHODS

Materials

There were 46 asymptomatic normal female volunteers (AVs) and 42 symptomatic age-matched females with BDDR. The mean age was 28.3 ± 6.7 years for the AVs, whereas the mean age of the symptomatic subjects was 29.9 ± 10.7 years. All study participants read and signed an informed consent before initiation of the study that was approved by the Research Subjects Review Board of the University of Rochester, School of Medicine and Dentistry.

All AVs answered a solicitation for examination and inclusion in the study. They were all examined by one investigator (RHT) and were accepted in the study after completion of:

• A TMJ subjective questionnaire documenting the absence of jaw pain, joint noise, locking, and positive history of TMD.
• A clinical TMJ and dental examination for signs and symptoms commonly associated with TMD or internal derangement. All symptomatic subjects had localized jaw joint pain and pain on movement or when eating. Vertical opening and right and left mandibular movements were measured and recorded. The masseter, anterior, middle, and posterior temporalis, and temporalis tendon area were digitally palpated. All AVs demonstrated a maximal opening of at least 40 mm. The asymptomatic and symptomatic subjects were not blinded to the examiner.
• All study participants had bilateral high-resolution MRIs in the sagittal (closed and open) and coronal (closed) planes for evaluation of the TMJs as described by Katzberg et al.33 and Westesson et al.34 Each study participant was classified as AV or symptomatic BDDR.
• All study participants had lateral cephalograms with the teeth in centric occlusion position and with the Frankfort horizontal parallel to the floor. All cephalograms were taken on the same radiographic machine at the orthodontic clinic set for standardized exposure.

Null hypothesis

There are no statistically significant differences between skeletal, denture base, and dental characteristics of symptomatic BDDR patients and those of a sample of individuals with bilateral normal asymptomatic TMJs.

Cephalometric measurements

Figure 1 shows the cephalometric points used. Tables 1 through 5 summarize the angular and linear cephalometric
BILATERAL DISK DISPLACEMENT WITH REDUCTION

TABLE 2. Profile Analysis Used in This Study

<table>
<thead>
<tr>
<th>Measurements</th>
<th>AV-N</th>
<th>BDDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>FH to Na-Pg</td>
<td>89.18</td>
<td>88.41</td>
</tr>
<tr>
<td>FH to Na-A</td>
<td>90.71</td>
<td>90.54</td>
</tr>
<tr>
<td>Na-A-Pog</td>
<td>2.99</td>
<td>4.54</td>
</tr>
</tbody>
</table>

* BDDR indicates bilateral disk displacement with reduction. AV-N = asymptomatic volunteer with normal joints.
* P ≤ .05 is considered significant.

TABLE 3. Denture Base Measurements Used in This Study

<table>
<thead>
<tr>
<th>Measurements</th>
<th>AV-N</th>
<th>BDDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANS-PNS</td>
<td>56.3</td>
<td>56.28</td>
</tr>
<tr>
<td>SNA</td>
<td>81.81</td>
<td>80.17</td>
</tr>
<tr>
<td>SNB</td>
<td>79.18</td>
<td>76.63</td>
</tr>
<tr>
<td>ANB</td>
<td>2.64</td>
<td>3.53</td>
</tr>
<tr>
<td>A-B to FP</td>
<td>-4.99</td>
<td>-6.55</td>
</tr>
</tbody>
</table>

* BDDR indicates bilateral disk displacement with reduction. AV-N = asymptomatic volunteer with normal joints.
* P ≤ .05 is considered significant.

TABLE 4. Denture Pattern Used in This Study

<table>
<thead>
<tr>
<th>Measurements</th>
<th>AV-N</th>
<th>BDDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>FH to OP</td>
<td>5.14</td>
<td>5.37</td>
</tr>
<tr>
<td>U1 to L1</td>
<td>128.2</td>
<td>137.1</td>
</tr>
<tr>
<td>U1 to OP</td>
<td>109.2</td>
<td>104.7</td>
</tr>
<tr>
<td>U1 to FH</td>
<td>110.7</td>
<td>105.9</td>
</tr>
<tr>
<td>U1 to S-Na</td>
<td>101.8</td>
<td>95.38</td>
</tr>
<tr>
<td>U1 to A-Pog</td>
<td>23.3</td>
<td>19.60</td>
</tr>
<tr>
<td>L1 perpendicular to A-Pog</td>
<td>7.38</td>
<td>6.35</td>
</tr>
<tr>
<td>L1 to MP</td>
<td>5.89</td>
<td>2.07</td>
</tr>
<tr>
<td>L1 to OP</td>
<td>25.1</td>
<td>21.71</td>
</tr>
<tr>
<td>L1 to A-Pg</td>
<td>27.7</td>
<td>23.12</td>
</tr>
<tr>
<td>L1 perpendicular to A-Pog</td>
<td>4.14</td>
<td>2.72</td>
</tr>
<tr>
<td>Overbite (perpendicular to FH)</td>
<td>2.88</td>
<td>3.59</td>
</tr>
<tr>
<td>Overjet (parallel to FH)</td>
<td>3.07</td>
<td>3.49</td>
</tr>
</tbody>
</table>

* BDDR indicates bilateral disk displacement with reduction. AV-N = asymptomatic volunteer with normal joints.
* P ≤ .05 is considered significant.

TABLE 5. Vertical Relationships Used in This Study

<table>
<thead>
<tr>
<th>Measurements</th>
<th>AV-N</th>
<th>BDDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP to FH</td>
<td>24.36</td>
<td>25.09</td>
</tr>
<tr>
<td>S-Gn to FH</td>
<td>58.02</td>
<td>58.97</td>
</tr>
<tr>
<td>Na-ANS (UFH)</td>
<td>53.8</td>
<td>54.24</td>
</tr>
<tr>
<td>ANS-Me (LFH)</td>
<td>65.99</td>
<td>64.96</td>
</tr>
<tr>
<td>Na-Me (TFH)</td>
<td>119.8</td>
<td>119.2</td>
</tr>
<tr>
<td>U6 perpindicular to PP</td>
<td>23.45</td>
<td>24</td>
</tr>
<tr>
<td>U1 perpindicular to PP</td>
<td>29.23</td>
<td>29.44</td>
</tr>
<tr>
<td>L6 perpindicular to MP</td>
<td>32.37</td>
<td>31.8</td>
</tr>
<tr>
<td>L1 perpindicular to MP</td>
<td>41.97</td>
<td>40.89</td>
</tr>
<tr>
<td>PP to OP</td>
<td>6.65</td>
<td>6.54</td>
</tr>
<tr>
<td>PP to MP</td>
<td>25.86</td>
<td>26.18</td>
</tr>
<tr>
<td>PP to FH</td>
<td>-1.09</td>
<td>-1.03</td>
</tr>
<tr>
<td>Ar-Go-Gn</td>
<td>126.5</td>
<td>126.3</td>
</tr>
<tr>
<td>Antegonial notch</td>
<td>171.7</td>
<td>173.2</td>
</tr>
</tbody>
</table>

* BDDR indicates bilateral disk displacement with reduction. AV-N = asymptomatic volunteer with normal joints.
* P ≤ .05 is considered significant.

Error of measurement

Retracing 20 cephalograms in the experimental and control groups evaluated errors in landmark localization during tracing. The reliability of tracing, landmark identification, and analytical measurements had an intra-class correlation coefficient greater than 0.92.

RESULTS

Tables 1 through 5 summarize the findings of the measurements. Table 1 demonstrates that there are cranial base differences between the two groups. The anterior (S-Na) and posterior (S-Ba) cranial base lengths were smaller for the BDDR group. The denture base measurements showed smaller values of the SNA and SNB angles (Table 3).

The dental characteristics demonstrated that the interincisal angle was larger, the upper incisor was more retroclined, and the lower incisor was more retruded (L1 perpendicular to A-Pog) in the BDDR sample (Table 4). No significant differences were found in the profile analysis (Table 2) or in the vertical pattern (Table 5). The significant measurements are shown in Figures 2 and 3.

DISCUSSION

DD is quite prevalent in the asymptomatic population. Using TMJ arthrography, Westesson et al5 found that 15% of their AVs had unilateral DD. Tallents et al,6 in a study of evaluation of TMJ sounds in AVs, found that 24% had one or two joints with DD as diagnosed by MRI. Ribeiro et al7 found that the prevalence of DD in asymptomatic children and young adults was 34%, whereas the prevalence of DD was 86% in symptomatic TMD patients. Their re-
Results showed that 13.8% had bilateral symptomatic but normal joints, 28% had unilateral DD, and 58% had bilateral DD. They suggested that DD is relatively common in AVs. Similar results (32%) in AVs were found by Kircos et al.11 The interesting finding of a high prevalence of DD in AVs is not unique to the TMJ. MRI studies of the knee, cervical spine, and lumbar spine in asymptomatic subjects indicate a similar disease prevalence in those body parts as well.12-17 Brunner et al18 showed that half of the asymptomatic athletes included in the study had significant baseline knee MRI scan abnormalities. Oberg et al19 macroscopically examined the shape, size, and appearance of the joint surfaces in the right TMJs of 155 cadavers of different ages. They found, among other things, that below the age of 20 years, all TMJs appeared normal, but with increasing age, the number of joints with local changes in the shape, remodeling, or arthritic changes of the articular surfaces increased. The arthritic changes were significantly more prevalent in women. DD has been suggested to cause facial asymmetry.22-24,27

In this study we evaluated the effect of BDDR on the skeletal and dental pattern of the affected individuals. Both anterior (S-Na) and posterior (S-Ba) cranial base measurements were smaller in the BDDR group. This finding agrees with that of Nebbe et al.22 They also found a more acute cranial base angle, which was not significantly different in our group, but did not clarify whether their subjects had DD with or without reduction. Both SNA and SNB angles were smaller in our symptomatic group. This can be attributed to the smaller linear measurement of the anterior cranial base, which positions point Nasion more posteriorly. Bosio et al26 also found a smaller mean SNB angle in patients with bilateral DD than in AVs. The SNB angle determines the mandibular position in relation to the anterior cranial base. The mean SNB angle is smaller in subjects with DD; thus, one could speculate that the mandible is retropositioned as a result of anterior displacement of the articular disk. Bosio et al26 did not find any significant differences among the three groups in the facial plane angle, which also shows the position of the mandible. Our profile analysis (Table 2) also showed no difference in the facial plane angle. This suggests that the smaller SNB angle can be attributed to the shorter anterior cranial base rather than to a retropositioned mandible.

There were significant differences in the denture pattern. The interincisal angle was larger. The inclination of the lower incisor was within the normal range, but the upper incisor was retroclined. This suggests that the larger value of the interincisal angle in the symptomatic group can be attributed to the altered upper-incisor inclination. The clinical significance of this finding is unknown.

Our study agrees with previous studies, which have suggested that DD can affect skeletal morphology and symmetry. Link and Nickerson27 and Schellhas et al24 have suggested that there is a cause-and-effect relationship between DD and facial growth. Nebbe et al22 have suggested that adolescent female patients presenting for orthodontic treatment with bilateral DD show numerous angular and linear cephalometric differences compared with age-matched female controls. There was an increased mandibular and palatal plane relative to Sella-Nasion, posterior rotation of the mandible, a decrease in Ricketts' facial axis, reduced posterior facial height and ramal height, as well as a slight increase in middle anterior facial height and a decreased posterior cranial base height.22

Schellhas et al24 in their study of children 14 years of age or younger concluded that TMJ derangements are common in children and may contribute to the development of retrognathia, with or without asymmetry. Ninety-three percent of the retrognathic subjects were found to have DD, generally bilateral. In cases of lower-face asymmetry, the chin was uniformly deviated toward the smaller or more degenerated TMJ. They proposed that in the growing facial...
skeleton, DD either retards or arrests condylar growth, which results in decreased vertical dimension in the pro-
imal mandibular segment(s), ultimately causing mandibular
deficiency or asymmetry. Dibbets et al. performed mor-
phometric analyses on children with TMJ symptoms and
considered the different symptoms of TMJ dysfunction as
indicators of specific growth patterns. They showed that
children with symptoms of dysfunction formed a morpho-
logically clearly recognizable group. These children had a
profile close to that for Class II and had a shorter corpus
and a ramus with decreased posterior facial height. Dibbets
et al. concluded that TMJ dysfunction might be associated
with the growth of the mandible. Brand et al. indicated that patients with DD had significantly shorter maxillary
and mandibular lengths, compared with those of asymptomatic
normal individuals with normal TMJs. Their investigation
did not distinguish between unilateral and bilateral DD
and could not account for any asymmetries because the
right and left landmarks in the cephalometric radiograph
were averaged. Bosio et al. suggested that symptomatic
TMD patients with bilateral DD had a retropositioned man-
dible indicated by a smaller mean SNB angle compared
with AVs and symptomatic patients with no DD. Using
posteroanterior films, another study investigated the amount
of craniofacial asymmetry in female orthodontic patients with uni- or bilateral TMJ DD compared with normal con-
trasts without DD. Females with bilateral DD had significa-
cantly greater asymmetry in the vertical position of the
anteogonion. If the DD was more advanced on one side, then
the ipsilateral ramus was shorter, resulting in significant asymmetry of the mandible. The authors concluded that a
female patient with uni- or bilateral DD might present with
or develop a vertical mandibular deficiency.

Increased prevalence of DD has been found in patients
with mandibular retrognathia presenting for orthognathic
surgery. Link and Nickerson studied 39 patients referred
for orthognathic surgery, 38 of whom were found to have
DD before surgery. All their open bite patients and 88% of
the patients with Class II malocclusion had bilateral DD.
They suggested that DD may be a contributing factor in
the development of dentofacial deformities and that new
loading of deranged joints after orthognathic surgery may
be a cause of a new arthrosis and skeletal relapse suggesting
a progression of TMJ pathology. They suggested that DD
should be suspected in individuals with sagittal mandibular
deficiency, vertical ramus deficiency, or a unilateral sagittal
deficiency. The high degree of association of DD with man-
dibular deficiency suggests that DD may have a role in
causing these deformities; ie, loss of condylar height or
growth (or both) secondary to the DD caused or worsened
the horizontal or vertical ramus mandibular deficiency. Schellhas et al. in their retrospective study of 100 con-
secutive orthognathic surgery candidates, found that DD
was prevalent especially in patients who exhibited change
in their facial contour in the year before the evaluation. The
degree of joint degeneration directly paralleled the severity
of retrognathia. They concluded that TMJ DD is common
in cases of mandibular retrusion and that it leads to alter-
ations in the facial structure in a high percentage of pa-

tients.

CONCLUSIONS

The results of this study show that alterations in skeletal
morphology may be associated with DD. The severity of
these alterations does not seem to be as extensive as the
ones demonstrated by Nebbe et al. and Schellhas et al. who evaluated patients with severe degenerative joint dis-
ease. Longitudinal studies will shed some light on that as-
pect. The mechanisms by which DD is produced, or the
mechanisms that cause that skeletal alteration, are yet to be
clarified. This study and the studies mentioned suggest that
DD may affect skeletal morphology and growth pattern.
The clinician should be aware of these possibilities espe-
cially for the growing patient and the orthognathic surgery
candidate.

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