The role of occlusal curvatures and maxillary arch dimensions in patients with signs and symptoms of temporomandibular disorders

Georgios Kanavakis\textsuperscript{a}; Noshir Mehta\textsuperscript{b}

**ABSTRACT**

**Objective:** To identify differences in occlusal curvatures and maxillary arch dimensions between subjects with signs and symptoms of temporomandibular disorders (TMDs) and asymptomatic subjects.

**Materials and Methods:** One hundred subjects (78 female and 22 male) who consented to participate in this research were examined for signs and symptoms of TMDs according to the guidelines of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC-TMD). In addition, occlusal measurements were performed for all subjects on plaster models. All statistical analyses were performed with SPSS (version 19).

**Results:** Significant associations were revealed between the depth of the curve of Spee (COS) and temporomandibular joint (TMJ) sounds. Furthermore, maxillary arch width was negatively correlated to the steepness of the curve of Wilson. No differences were found between subjects with and without a history of orthodontic treatment.

**Conclusions:** Subjects with TMJ sounds tend to have a flatter COS compared to subjects without TMJ sounds. (Angle Orthod. 2014;84:96–101.)

**KEY WORDS:** Temporomandibular disorders; Occlusal curvatures; TMJ; Curve of Spee; Curve of Wilson

**INTRODUCTION**

The role of occlusion in the development of temporomandibular disorders (TMDs) has been well studied and has created controversy in orthodontics. Although there is a consensus that orthodontic treatment does not cause or treat temporomandibular disorders,\textsuperscript{1} studies have revealed associations between occlusal characteristics and signs and symptoms of TMDs. Missing posterior teeth has been identified as a factor that increases the incidence of temporomandibular joint (TMJ) pathology.\textsuperscript{2,3} In addition, reports in the literature have associated anterior open bite, excessive overjet, posterior crossbites, and lateral occlusal shifts to temporomandibular disorders.\textsuperscript{4–6} Uncorrected posterior crossbite has been accused for leading to the persistence of TMDs over time.\textsuperscript{2} Furthermore, it has been claimed that individuals with maxillary prognathism more frequently present clicking in the TMJs and that patients with narrow mandibular arches have higher levels of pain in the masticatory muscles.\textsuperscript{10}

However, various studies have not demonstrated any significant associations between occlusion and TMDs. In two population-based studies by Gesch et al.,\textsuperscript{11,12} it was revealed that only posterior open bite is weakly associated with a higher incidence of temporomandibular disorders. Others have also found no associations or very weak associations between temporomandibular disorders and malocclusion traits.\textsuperscript{13–16}

There are only a few reports in the literature regarding the association between occlusal curvatures and the incidence of TMDs. The curves of Spee and Wilson are both of high significance in the establishment of a balanced and functional occlusion,\textsuperscript{17,18} which provides bilateral, simultaneous, and equal contacts.\textsuperscript{19} They primarily serve to enhance freedom of movement during functional excursions of the mandible. In
addition, occlusal curvatures are associated with esthetics of the face and are contributing to an esthetically satisfying smile. Since curvatures are formed by the positioning of the teeth in the dental arches, the positioning should be such to efficiently absorb occlusal forces during maxillomandibular function. It has been indicated that as the curve of Spee (COS) deepens, overbite and overjet increase. It has also been reported that patients with temporomandibular disorders present greater sagittal and lateral occlusal curvatures.

The primary objective of the present study was to investigate whether there is an association between occlusal curvatures, maxillary arch dimensions, and temporomandibular disorders. In addition, differences between subjects that had orthodontic treatment and without a history of orthodontic treatment were also evaluated.

MATERIALS AND METHODS

Subject Selection

According to a sample size calculation, it was determined that a 95% power could be reached if 100 subjects were recruited for this study. All 100 subjects (78 female and 22 male) were patients or volunteers who responded to an advertisement at the Craniofacial Pain, Headache and Sleep Center at Tufts University School of Dental Medicine. The study was reviewed and approved by the Institutional Review Board at Tufts Medical Center.

In order to participate in the study, subjects had to be over 18 years old and have at least one molar, one premolar, canine, and two incisors in each quadrant. Subjects with a history of trauma involving the head, face, and neck region or with a history of systemic TMJ disease were excluded. In addition, subjects that had had treatment for temporomandibular disorders were also not included in the study.

Clinical Examination

The examination of all participants in the study was performed by a single calibrated examiner according to the guidelines of Axis I of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC-TMD). To ensure intraexaminer reliability, the operator performed three palpations on each palpation site, and the most repeated score was reported.

For the purpose of this study, some variables in Axis I of the RDC-TMD were modified and utilized.

Study Cast Analysis

Measurements on plaster models were performed with the use of a digital caliper (Mitutoyo Digimatic caliper CD-10CX, Mitutoyo Corporation, Kawasaki-shi, Japan) with a resolution of 0.01 mm and accuracy of 0.02 mm.

The depth of the curve of Spee was measured at the most distal premolar and at the molar level. The highest value on each side was recorded.

The curve of Wilson (COW) on each side was measured as the angle between the frontal projected buccal-lingual plane of the cusp tips on the first mandibular molars, according to Ali et al. The angle was positive when the molars were inclined lingually.

Reliability/Error of the Method

The examiner was blinded when he performed the measurements on the study models. After the completion of all procedures, the data were decoded. To test interexaminer reliability, a second examiner, who was not part of any other procedure of the study, repeated the measurements on 20 random study models. The difference in measurements between the two examiners was not significant at the .01 level of significance (P = .97).

Statistical Analysis

To compare subjects with different pain scores on palpation one-way analysis of variance (ANOVA) was used. The association between occlusal characteristics and the presence of TMJ sounds was tested with the Student’s t-test for independent samples. To test for associations between different occlusal characteristics, linear regression was used.

The level of significance (α) was .05, hence any P value smaller than or .05 was considered to be
significant \( (P \leq .05) \). All statistical analyses were performed with SPSS (version 19).

**RESULTS**

In the present study, 78 women and 22 men were recruited. All subjects were adults 23 to 66 years old \((\mu = 35.22 \text{ years, } SD = 11.24)\). The history of previous orthodontic treatment among our sample population is demonstrated in Table 1.

In the present study population, subjects with pain on palpation of the head, face, and neck musculature did not appear to have a deeper curve of Spee or a steeper curve of Wilson than subjects without pain.

However, when TMJ sounds on lateral excursions were associated with occlusal curvatures, subjects with a flatter (less deep) curve of Spee presented a higher incidence of TMJ sounds on lateral excursions toward the ipsilateral side (Table 2). This finding was consistent on both sides, so it can be concluded that people with a flatter curve of Spee present a higher incidence of joint sounds during lateral excursions.

Furthermore, the curve of Wilson was positively correlated to intercanine, inter premolar, and intermolar distances (Figures 1 through 3 and 4 through 6). This means that as the curve of Wilson became steeper, these distances became smaller.

When we compared subjects without a history of orthodontic treatment to subjects that had received orthodontic treatment in the past, there was no difference between the two groups regarding the presence of pain on palpation or other signs or symptoms of temporomandibular disorders.

**DISCUSSION**

The primary objective of the present study was to investigate the relationship between signs and symptoms of TMDs, maxillary arch dimensions, and occlusal curvatures.

There is a lot of discussion and criticism on the design of studies that have addressed the association between TMD and occlusion.\textsuperscript{11,12,27} In this study, the RDC-TMD was used, which is both validated and easily reproducible for history-taking and examination procedures.\textsuperscript{28–32} In addition, the examiner who performed all measurements on the dental models was blinded regarding the results of the clinical examination, which decreased bias in our results.

Data were gathered separately for the left and right sides according to the RDC-TMD, and the unilaterality of the findings was maintained throughout the analysis of the data. To our knowledge, there are only few other studies that have performed unilateral comparisons, taking into consideration the unilaterality of TMDs.

In the present study, neither the depth of the COS nor the steepness of the COW were associated with the level of pain on palpation of the masticatory and neck muscles.

### Table 1. Comparisons Between Subjects With and Without a History of Orthodontic Treatment

<table>
<thead>
<tr>
<th>Previous Orthodontic Treatment</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premolar Extractions (n = 19)</td>
<td>5</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>No Premolar Extractions (n = 36)</td>
<td>14</td>
<td>28</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>45</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 2. Presence of Temporomandibular Joint (TMJ) Sounds on Lateral Excursions

<table>
<thead>
<tr>
<th>Right TMJ</th>
<th>Left TMJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>No TMJ Sounds</td>
<td>Presence of TMJ Sounds</td>
</tr>
<tr>
<td>N</td>
<td>( \mu )</td>
</tr>
<tr>
<td>Left curve of Spee, mm</td>
<td>53</td>
</tr>
<tr>
<td>Right curve of Spee, mm</td>
<td>53</td>
</tr>
<tr>
<td>Inter canine distance, mm</td>
<td>55</td>
</tr>
<tr>
<td>Inter premolar distance, mm</td>
<td>55</td>
</tr>
<tr>
<td>Intermolar distance, mm</td>
<td>55</td>
</tr>
</tbody>
</table>

Figure 1. Correlation between intercanine distance and the COW on the left.
Research has revealed that the COS is closely related to the amount and direction of crushing forces during mastication. According to those reports, one could assume that people with a deeper COS generate more force during mandibular function and therefore would be more prone to developing hyperactivity of the masseter muscle. If this were true, bruxers with deeper COS would be expected to have more muscle pain on palpation. However, the present results did not reveal any significant association, and this is in agreement with evidence showing that increased muscle activity may be disconnected from muscle pain. Intra-articular structural changes can clinically lead to the development of TMJ sounds, which are usually expressed as clicking and/or crepitation within the joint. This study tested the association between the presence of TMJ sounds and occlusal variables. The depth of the COS was significantly associated with the presence of TMJ sounds during lateral excursions. In addition, it was observed that the COS was less deep among subjects with joint sounds on all mandibular movements, although this association did not reach the level of significance. In a study by Osborn, the COS was biomechanically associated with the relative position of the condyle inside the mandibular fossa. According to that model, a flatter COS would be in coordination with a more posteriorly positioned condyle, and a steeper COS would be found in people with more anteriorly positioned condyles. It has been reported that a more posterior relative position of the condyle in the mandibular fossa could be one of the reasons for anterior displacement of the articular disc which frequently results in TMJ sounds. Thus, it can be concluded that a flatter COS could possibly be a predisposing factor for the development of TMJ sounds or could be the result of the positioning of the condyle more posteriorly during growth and development. In addition, one could...
assume that people with flatter COS would present less disocclusion of the posterior teeth and consequently would be more likely to have more molar contacts during normal excursions of the mandible.\textsuperscript{20} This would increase the forces applied to the temporomandibular joints during normal function and could be the cause of more sounds in the joints. However, this assumption has not been confirmed in the literature, and studies have shown that patients with disc displacement and clicking sounds have actually fewer contacts on the balancing side during lateral excursions.\textsuperscript{19}

This study also investigated the association between the COW and other occlusal characteristics and found a statistically significant negative correlation between the COW on both sides and the intercanine, inter-precancelar, and intermolar distances. It can be safely concluded that subjects with a steeper COW presented narrower maxillary arches.

This finding is in agreement with the “fencing theory” by Mehta et al.,\textsuperscript{18} which supports that the maxilla defines the boundaries of function for the mandible and serves as a “fence” that either restricts or allows the mandible to function without any interferences. In patients with a narrower maxilla, the mandibular posterior teeth would have to be positioned more lingually to occlude with the maxillary posterior teeth, which would produce a steeper COW. However, in patients with excessive mandibular growth (ie, skeletal Class III) or very deficient maxillary arches, this would not apply; instead, a posterior crossbite relationship would develop.\textsuperscript{19}

Regarding the effect of orthodontic treatment on signs and symptoms of TMDs, the present study did not reveal any significant results supporting this association. This is in agreement with the general consensus that orthodontic treatment (with or without premolar extractions) neither causes, worsens, or treats temporomandibular disorders\textsuperscript{1,40–44}

**CONCLUSIONS**

- Subjects with TMJ sounds present a flatter COS.
- Deep occlusal curvatures are not associated with TMJ pain or pain of muscular origin.
- History of previous orthodontic treatment was not associated with the presence of TMDs.

**REFERENCES**


