Correction of the transverse discrepancy-induced spontaneous mandibular protrusion in Class II Division 1 adolescent patients

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Background: A Class II malocclusion is the most frequent sagittal skeletal disharmony presenting for orthodontic treatment. A transverse interarch discrepancy (TID) may be considered as a possible functional cause of a Class II relationship.

Objective: The purpose of the present study was to determine transverse interarch width dimensions before and after orthodontic therapy and their possible relationship with increased mandibular projection following treatment.

Methods: The sample included 40 adolescent patients who were divided into two groups, one possessing and one without a transverse discrepancy. Interarch width differences (including ICWD, IPWD, IMWD, IAWD) were measured before and after treatment, and Pogonion (Pog) to Nasion (N) perpendicular was similarly measured in each group.

Results: The differences in arch and alveolar width dimensions between the two groups (including ICWD, IPWDI, IPWDII, IMWD, IAWD) before treatment were statistically significant (p < 0.05). A comparison of Pog to N perpendicular between the two groups showed that mandibular protrusion after treatment in the transverse discrepancy group was 2.6 ± 1.3 mm, while mandibular protrusion after treatment in the group without a transverse discrepancy was 0.6 ± 0.3 mm. The statistical comparison showed that the differences were significant (p < 0.01).

Conclusion: A transverse interarch discrepancy may have a functional relationship with mandible retrusion. If a transverse discrepancy is corrected via orthodontic treatment, the mandible may spontaneously protrude.


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Introduction

A Class II malocclusion is the most frequently encountered sagittal skeletal disharmony.1 Class II patients often present with a poor transverse arch relationship, which is of equal importance as the sagittal or vertical disharmony. A transverse discrepancy is generally attributed to a reduction in maxillary width.2 Staley et al.3 extensively assessed transverse maxillary deficiency and posterior crossbite tendencies in an adult Class II sample in comparison with an adult Class I group and determined that a transverse discrepancy (TID) may be a possible functional cause of distocclusion. Varrela4 reported that deficient transverse growth of the maxilla and the sagittal growth of the mandible appeared to produce a typical Class II malocclusion. As a treatment goal is to obtain the maximum number of functional occlusal contacts, the presence of an initial transverse discrepancy between the dental arches induces a retruded position of the mandible and, clinically, a Class II malocclusion is established. In addition, a Class II relationship may be due to a micrognathic mandible in the absence of a primary transverse discrepancy. In these cases, a slight exaggeration of maxillary posterior buccal overjet caused by an anteroposterior jaw discrepancy is often clinically evident.2

Staley et al.3 suggested that a more pertinent approach to evaluate a transverse discrepancy between the dental arches is to assess the differences between the maxillary and mandibular arch widths, which are considered to...
produce more consistent and interpretable results. Therefore, the purpose of the present study was to determine transverse interarch width dimensions, before and after treatment, and their relationship to increased mandibular projection following treatment in Class II division 1 adolescent patients.

**Materials and methods**

The present research was conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki. The investigation was undertaken with the understanding and written consent of each subject. The study was independently reviewed and approved by the Medical Ethical Committee of Zhejiang Stomatology Hospital.

A sample of 40 subjects (18 boys, 22 girls, mean age 12.06 ± 1.45 years, age range 11 to 14 years) was obtained from the files of the Orthodontic Department of Zhejiang University. The following criteria were used for the selection of the 40 subjects from the Class II division 1 sample:

- 11 to 14 years old.
- Bilateral Class II molar relationship in centric occlusion.
- Protrusive maxillary incisors.
- Convex soft tissue profile.
- Excessive overjet.
- No missing teeth.
- Absence of posterior crossbite (even limited to a single tooth) and palatally-positioned anterior teeth.

The sample was divided into two groups based on their transverse relationships. Assessment methods advocated by Tollaro et al.² allowed for a quick and easy evaluation of a transverse discrepancy during the clinical examination, at least at the occlusal level, by having the Class II division 1 patient posture his or her mandible forward into a Class I relationship to identify a discrepancy.

The Class II division 1 group without a transverse interarch discrepancy exhibited a normal buccal overjet without a transverse maxillary deficiency when the mandible was protruded to a Class I molar relationship.

The transverse interarch discrepancy group included 22 patients (9 male, 13 female, age 12.38 ± 1.25 years, with an age range of 11 to 14 years), and the normally related, transverse interarch group comprised 18 patients (9 male, 9 female with an age of 11.95 ± 1.42 years, with a range of 11 to 13 years).

**Orthodontic treatment**

All 40 subjects were treated with a straight-wire fixed appliance (MBT, 0.022 inch slot, Forestadent, 3M Unitek, MO, USA). The first premolars in the upper and the second premolars in the lower dental arch were planned for extraction. In all subjects, no functional orthopaedic treatment was used and only light class II elastics were applied. The transverse discrepancy between the maxillary and mandibular arches was corrected by archwire expansion. The mean treatment duration was two years and one month.

**Acquisition of 3D digital model data by surface scanning**

Dental casts of the 40 subjects were taken before and after treatment. A 3D surface scanning system (SN-R700, 3Shape Co. Ltd., CPH, Denmark) was used to obtain the 3D data from the dental models. The base of the digital model was subsequently fabricated similarly to an orthodontic diagnostic model. The 3D models were measured and analysed with 3Shape OrthoViewer software. Measurements were performed at three separate time points by a single observer over a three-week period. The measurements of all subjects were repeated two weeks later to determine the measurement error (Figure 1).

The measurements undertaken were:

- Intercanine width: the distance between the cusp tips of bilateral maxillary and mandibular canines.
- First premolar width: the distance between the buccal cusp tips of bilateral maxillary and mandibular first premolars.
- Second premolar width: the distance between
the buccal cusp tips of bilateral maxillary and mandibular second premolars.

- Intermolar width: the distance between the mesiobuccal cusp tips of bilateral maxillary and mandibular first molars.
- Alveolar width: the distance between the mucogingival junctions above the mesiobuccal cusp tips of bilateral maxillary and mandibular first molars.

Maxillary and mandibular measurement differences:

- Intercanine width difference (ICWD): the mandibular intercanine width was subtracted from the maxillary intercanine width.
- Interpremolar width difference (IPWD): the mandibular premolar width was subtracted from the maxillary premolar width. (Before treatment IPWD was divided into IPWDI and IPWDII.

After treatment IPWD was defined as: The mandibular first premolar width subtracted from the maxillary second premolar width.)
- Intermolar width difference (IMWD): the mandibular intermolar width subtracted from the maxillary intermolar width.
- Interalveolar width difference (IAWD): the mandibular interalveolar width subtracted from the maxillary interalveolar width.

Cephalometric analysis

Lateral cephalograms of the 40 subjects were taken before and after treatment with the same cephalometric machine and by the same technician. All lateral cephalometric radiographs were digitised on the same computer by the same operator using Dolphin Digital Imaging software (version 11.5 Premium, Dolphin, CA, USA). The sagittal reference planes were Frankfort horizontal (FH) and the mandibular plane (MP) and the vertical reference plane was a line from hard-tissue nasion perpendicular (N-perp) to FH. The FH-MP angle and the linear distance from pog-point to N-perp plane were measured (Figure 2).

Statistical analysis

The data were analysed by using the SPSS statistical package (version 10.0; SPSS, IL, USA). Statistical comparison was performed using the independent samples’ t-test. The comparison differences were significant when $p < 0.05$ and were not significant when $p > 0.05$. 

![Figure 1. Measurement of arch width on 3D digital model.](image1)

![Figure 2. Linear measurements of Pog-N perpendicular (mm).](image2)
MANDIBULAR PROTRUSION IN CLASS II PATIENTS

Results

The anterior overjet in the transverse discrepancy group was $7.59 \pm 1.16$ mm (range 6.0 – 9.0 mm). In the normal transverse group the overjet was $7.04 \pm 1.30$ mm (range 4.5 – 9.0 mm). The statistical comparison between the two groups showed that the differences were not significant ($p > 0.05$).

In the transverse discrepancy group, ANB was $4.69 \pm 1.45$ (range 2.1 – 6.7). In the normal transverse group, ANB was $4.89 \pm 1.58$ (range 2.0 – 6.4). The statistical comparison between the two groups showed that the differences were not significant ($p > 0.05$).

In the transverse discrepancy group, FH-MP was $27.1 \pm 3.9$ (range 21.2 to 31.2). In the normal transverse group, FH-MP was $27.9 \pm 4.3$ (range 21.1 to 34.9). Statistical comparison between the two groups showed that the differences were not significant ($p > 0.05$).

A comparison of the interarch width differences between the two groups before treatment is shown in Table I. The statistical comparison showed that the differences between the two groups for arch and alveolar width difference (including ICWD, IPWDI, IPWDII, IMWD, IAWD) were significant ($p < 0.05$), especially ICWD, IPWDI and IPWDII.

A comparison of the interarch width difference between the two groups after treatment is shown in Table II. Statistical comparison revealed that the differences between the two groups for arch and alveolar width difference (including ICWD, IPWD, IMWD, IAWD) were not significant ($p > 0.05$).

A statistical comparison of interarch width difference before and after treatment in the transverse discrepancy group was performed with a paired $t$-test. The comparison showed that the differences before and after treatment were not significant ($p > 0.05$).

Table I. Comparison of interarch width difference between the two groups before treatment.

<table>
<thead>
<tr>
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<th>Discrepancy group</th>
<th>Without discrepancy group</th>
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<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>ICWD</td>
<td>6.3</td>
<td>1.1</td>
<td>8.0</td>
</tr>
<tr>
<td>IPWDI</td>
<td>5.1</td>
<td>1.6</td>
<td>7.6</td>
</tr>
<tr>
<td>IPWDII</td>
<td>4.5</td>
<td>1.5</td>
<td>7.1</td>
</tr>
<tr>
<td>IMWD</td>
<td>5.3</td>
<td>1.6</td>
<td>6.3</td>
</tr>
<tr>
<td>IAWD</td>
<td>5.4</td>
<td>2.3</td>
<td>7.6</td>
</tr>
</tbody>
</table>

ICWD: Intercanine width difference.
IPWDI: Intermolar width difference.
IMWD: Interpremolar width difference.
IAWD: Interalveolar width difference.
$p < 0.05$ significant, $p > 0.05$ not significant.

Table II. Comparison of interarch width difference between the two groups after treatment.

<table>
<thead>
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<th>Discrepancy group</th>
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<tr>
<td></td>
<td>Mean</td>
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<tr>
<td>ICWD</td>
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</tr>
<tr>
<td>IAWD</td>
<td>7.6</td>
<td>1.8</td>
<td>8.2</td>
</tr>
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ICWD: Intercanine width difference.
IPWD: Intermolar width difference.
IMWD: Interpremolar width difference.
IAWD: Interalveolar width difference.
$p < 0.05$ significant, $p > 0.05$ not significant.
after treatment for arch and alveolar width difference (including ICWD, IPWDI, IPWDII, IMWD, IAWD) were significant \((p < 0.05)\). Especially ICWD, IPWDI and IPWDII increased significantly after treatment \((p < 0.01)\).

A comparison of Pog-N perpendicular before and after treatment in the two groups is shown in Figure 3. Mandibular protrusion after treatment in the transverse discrepancy group was 2.6 ± 1.3 mm, while mandibular protrusion after treatment in the normal transverse group was 0.6 ± 0.3 mm. A statistical comparison between the two groups showed that the differences were significant \((p < 0.05)\). The lateral cephalometric radiographs and the tracing superimpositions before and after treatment of one patient from the transverse discrepancy group are shown in Figure 4.

**Discussion**

Although a transverse discrepancy associated with a Class II malocclusion has been intensively investigated, the relationship remains controversial.\(^5\) Previous studies have shown that the maxillary arch may be narrow at varying posterior tooth sites. Fröhlich found that Class II division 1 malocclusions may have a narrower maxillary intercanine width, but all had a narrower intermolar width.\(^6,7\) However, Staley et al.\(^3\) observed no differences in intercanine width but narrower maxillary molar arch widths in the Class II group. The research of Uysal et al.\(^8\) demonstrated a narrower intermolar width but greater maxillary intermolar width in Class II division 1 patients, while Sayin and Turkkahraman’s study\(^9\) reported the opposite. It was found that a Class II division 1 group had a narrower maxillary intermolar width but acceptable intermolar width.

The present study determined that in adolescent patients (from 11 to 14 years of age) a proportion of Class II division 1 malocclusions were accompanied by a transverse discrepancy, but others presented a normal transverse relationship. A comparison of interarch width before treatment revealed that differences between the two groups (including ICWD, IPWDI, IPWDII, IMWD, IAWD) were significant, \((p < 0.05)\), especially ICWD, IPWDI and IPWDII, which supported Fröhlich’s findings.
Clinicians have provided possible reasons in an attempt to explain the transverse discrepancy seen in Class II division 1 malocclusion cases. In a Class I normal occlusion, the maxillary and mandibular posterior teeth occlude in a buccal position to create a normal buccal overjet. When the mandible is related into a Class II relationship, the posterior overjet would invariably increase and produce a scissor bite. However, the maxillary teeth would be more palatally positioned and the mandibular teeth would be more buccally positioned as a result of compensatory eruption in order to maintain a positive buccal overjet and produce an interdigitated occlusion. Therefore, the lingual inclination of the maxillary posterior teeth has assumed a greater compensatory role. The relationship between the transverse and the anteroposterior dimensions has been previously reported by Tollaro et al., who emphasised that the presence of a primary transverse discrepancy between the dental arches induced a posterior position of the mandible. It was indicated that in Class II cases, a spontaneous repositioning of the mandible may occur after a preliminary expansion of the maxillary arch and that mandibular growth could possibly be stimulated by means of a functional forward mandibular shift. Therefore, a Class II division 1 malocclusion often requires expansion of the maxillary arch to correct a transverse discrepancy. Previous research has suggested that it is appropriate to use slow maxillary expansion (SME) to correct the discrepancy because the appliance induces more change in posterior tooth inclination which could be retained more stably.

In the present study, the transverse difference in the discrepancy group was successfully corrected by archwire expansion, which produced very effective tipping. Transverse dimension has been a topic of interest in the diagnosis and treatment of skeletal Class II patients. McNamara and others emphasised the importance of expanding the maxillary arch to obtain a permanent orthopaedic effect in Class II treatment. It is possible to remove functional interferences caused by maxillary constriction by widening the maxillary arch and apical base through palatal expansion, which allows the mandible to move to a more comfortable anterior position and facilitate Class II correction. It has been found that an RME induced positive changes in the molar relationship in 81% of Class II patients and 69% of molar end-to-end patients. A significant positive change of 2 mm or more was observed in 49% and 23% of Class II and end-to-end patients, respectively. Timmons reported that 70% showed an ‘induced change’ (Class II improvement) of at least a quarter of a cusp using archwire expansion. Thirty-eight percent continued to change and had up to a half cusp correction, while 6% had a three-fourths cusp change to complete correction. Volk et al. reported that only half experienced spontaneous Class II correction but, in others, a Class II situation worsened. It was considered that there was improvement in Class II malocclusions in 50% of patients, which suggested that maxillary expansion had the ability to assist Class II correction in some but was unpredictable in determining which patients would benefit. Guest et al. found that an RME induced a significant increase in the measurement of pogonion to nasion perpendicular of 1.9 mm in a Class II treated group, compared with 0.8 mm in a control group. In the present research, a comparison of Pog-N perpendicular before and after treatment between the two groups showed that mandibular protrusion after treatment in the transverse discrepancy group was 2.6 ± 1.3 mm, mandibular protrusion after treatment and in the normal transverse group was 0.6 ± 0.3 mm. The comparison showed that the differences were significant (p < 0.05). It may be speculated that a Class II division 1 patient with a transverse deficiency is more likely to experience spontaneous mandibular repositioning after a transverse deficiency is corrected. A repeated study with a larger sample size and over a longer time period is needed to more definitely confirm the issue.

**Conclusion**

1. In adolescent Class II division 1 malocclusion cases (from 11 to 14 years of age) only a percentage of the patients presented with a transverse discrepancy.
2. A transverse discrepancy was successfully corrected by archwire expansion in the transverse discrepancy group. ICWD and IPWD increased significantly (p < 0.01).
3. Class II division 1 malocclusion cases with a transverse deficiency were more likely to produce a spontaneous mandibular repositioning after the transverse deficiency was corrected.
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