A Correlation between Dental and Alveolar Arch Widths and Cephalometric Characteristics of Class II Division 1 and Division 2 Malocclusion

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Abstract
Aim: This study was designed to compare differences in transverse dimensions of dental arches, alveolar widths and skeletal factors of Class II division 1, Class II division 2 malocclusion. Methods: Dentoskeletal characteristics of class II malocclusion subjects were evaluated using cephalometric radiograph and dental cast of 70 untreated patients. Sample included 37 class II Division 1 and 33 class II Division 2 malocclusion patients. Inter canine, inter premolar, inter molar, inter canine alveolar, inter premolar alveolar, inter molar alveolar widths are measured on study models. Radiographs digitized using Auto CAD program all the data compared by independent t-test. Results: Showed statistically significant difference between groups for maxillary inter premolar, inter molar, alveolar inter premolar, mandibular inter canine and inter canine alveolar. Results revealed SNB angle was responsible for skeletal sagittal difference between groups. Class II division 1 showed a retrognathic mandible. Conclusion: maxillary inter premolar, inter molar and alveolar inter premolar widths were significantly narrower in the Class II division 1. Rapid maxillary expansion rather than slow expansion may be considered. There was a significant reduction of mandibular intercanine width in division 2 subjects. Class II division 1 subject show more retrognathic mandible than class II division 2 subjects.

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1. Introduction

The size and shape of the arches have considerable implications in orthodontic diagnosis and treatment planning, affecting the space available, dental esthetics, and stability of the dentition (Lee R. T., 1999). Investigators have studied the growth of arch widths in persons with normal occlusion and compared these values with those of different malocclusion samples (Sayin M. O., Turkkahraman H., 2004). However, there is considerable controversy among the results presented in the literature. As one of the most frequently encountered orthodontic problems, Class II malocclusions have been analyzed in many cephalometric and dental model studies. (Moorrees et al., 1969) used dental study casts to compare arch dimensions of untreated Class II division 1 and division 2 groups and concluded that in Class II division 2 subjects the maxillary and mandibular intercanine distances were greater than the control-reference population, whereas intermolar distances were normal. On the other hand, in the Class II division 1 group the intercanine and intermolar distances were found to be smaller than average. (Fröhlich F. J., 1961) compared intercanine and intermolar widths of both arches from 51 children with Class II malocclusion with normal occlusion. He found that the absolute arch widths of the Class II children did not differ appreciably from those of children with normal occlusion. (Sayin, Turkkahraman, 2004) compared the arch and alveolar widths of patients with Class II division 1 malocclusion and subjects with Class I ideal occlusion in the permanent dentition. They indicated that mandibular intercanine widths were
significantly larger in the Class II division 1 group, although maxillary intermolar widths were larger in the normal occlusion sample. (Buschang et al., 1994; Walkow, Peck, 2002) indicated in their studies that division 2 subjects show a reduced intercanine width (Staley et al., 1985) stated that patients with Class II division 1 malocclusion had narrower maxillary intercanine, intermolar, and alveolar widths. Their findings revealed a posterior crossbite tendency in the Class II group. (Enlow, Hans, 1996) discussed generic Class II skeletal dental features and facial growth without differentiating Class II division 2 from Class II division 1 and reported that Class II patients have long, narrow anterior cranial bases that affect the nasomaxillary complex and result in long, narrow palates and maxillary arches. A comparison of dentoskeletal morphology in 347 class II division 1 and 156 class II division 2 malocclusion per formed by (Pancherz et al., 1997) using lateral cephalometric radiographs, the results revealed broad variations in the variables analyzed. (Pancherz et al., 1997) stated that mandibular retraction was a common characteristic not only of class II division 1 subjects but also of division 2 subjects. In a more recent investigation, the craniofacial morphology in class II division 1 children with and without deep bite was evaluated, and the results that the anterior mandibular growth rotation occurred especially in subjects with a lack of incisor support (Karlsen, 1994). Examination of these investigations revealed that no definite dental and skeletal differences appear to exist between Class II division 1 and division 2 malocclusions (Pancherz et al., 1997; Zentner et al., 2003 ; Riesmeijer et al., 2004 ). The absence of any clear-cut differences may be due to several factors such as insufficient sample size lack of homogeneity in the age groups and variation in dento-skeletal selection criteria.

2. Objective

The aim of this study was to compare the differences in transverse dimensions of the dental arches and alveolar widths and skeletal factors of Class II division 1 and Class II division 2 malocclusion groups.

3. Patients and Method

A sample of 37 patients (17 male and 20 female) with Class II division 1 malocclusion and a sample of 33 patients (15 male and 18 female) with Class II division 2 malocclusion were selected from patient records. For each patient for both groups lateral cephalometric radiographs and dental casts were taken, using alginate impression and dental stone. The age of the patients range between 13 and 25 years old.

3.1 The inclusion criteria used to select Class II division I samples were (Staley et al., 1985):

1. bilateral Class II molar relationship in centric occlusion with the distobuccal cusp tip of the maxillary first molar within one mm (anterior or posterior) from the buccal groove of the mandibular first molar and protrusive maxillary incisors.
2. All teeth present except third molars.
3. No significant medical history.
4. No history of trauma, and no previous orthodontic treatment.

3.2 The criteria used to select Class II division 2 samples were (Walkow and Peck, 2002):

1. Class II molar relationship on at least one side in centric occlusion.
2. Class II permanent canine relationship and retroclination of two or more maxillary incisors.
3. All teeth present except third molars.
4. No significant medical history.
5. No history of trauma, and no previous orthodontic treatment.

3.3 Data collection:

For dental casts measurements a caliper was used to measure the transverse widths of the upper and lower dental casts, the following distances were measured:

1. Maxillary inter canine width (UC-C): The distance between the cusp tips of the right and left canines.
2. Maxillary inter premolar width (UP-P): The distance between the cusp tips of the right and left first premolar.
3. Maxillary inter molar width (UM-M): The distance between the mesiobuccal cusp tips of the right and left first molar.
4. Mandibular inter canine width (LC-C): The distance between the cusp tips of the right and left mandibular canines.
5. Mandibular inter premolar width (LP-P): The distance between the cusp tips of the right and left mandibular canines.
6. Mandibular inter molar width (LM-M): The distance between the most gingival extensions of the buccal grooves on the first mandibular molars.
7. Maxillary canine alveolar width (UAC-C): The distance between two points at the mucogingival junctions above the cusp tips of the right and left canines.
**Table 1:** Age range in years and gender distribution of the study groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Mean age/Y</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class II division 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>20</td>
<td>16.31</td>
<td>2.13</td>
<td>13.4</td>
<td>24.6</td>
</tr>
<tr>
<td>Male</td>
<td>17</td>
<td>15.83</td>
<td>1.49</td>
<td>14.1</td>
<td>22.7</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>15.56</td>
<td>2.13</td>
<td>13.5</td>
<td>23.5</td>
</tr>
<tr>
<td>Class II division 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>18</td>
<td>16.41</td>
<td>2.06</td>
<td>13.1</td>
<td>25.2</td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>17.23</td>
<td>1.76</td>
<td>13.9</td>
<td>23.8</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>16.32</td>
<td>2.30</td>
<td>13.4</td>
<td>24.5</td>
</tr>
</tbody>
</table>

SD indicate Standard deviation; Min: minimum; and Max: maximum

**Table 2:** Descriptive statistics and statistical comparisons of dental and alveolar widths of class II division 1 and Class II division 2 malocclusion samples

<table>
<thead>
<tr>
<th></th>
<th>Class II Division 1</th>
<th>Class II division 2</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Dental arch widths</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UC-C</td>
<td>33.93</td>
<td>1.22</td>
<td>34.06</td>
</tr>
<tr>
<td>UP-P</td>
<td>38.21</td>
<td>2.13</td>
<td>40.06</td>
</tr>
<tr>
<td>UM-M</td>
<td>49.33</td>
<td>1.48</td>
<td>51.82</td>
</tr>
<tr>
<td>LC-C</td>
<td>27.92</td>
<td>2.18</td>
<td>26.01</td>
</tr>
<tr>
<td>LP-P</td>
<td>35.21</td>
<td>2.14</td>
<td>35.11</td>
</tr>
<tr>
<td>LM-M</td>
<td>45.61</td>
<td>2.51</td>
<td>45.43</td>
</tr>
<tr>
<td>Alveolar arch widths</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UAC-C</td>
<td>36.84</td>
<td>2.71</td>
<td>36.51</td>
</tr>
<tr>
<td>UAP-P</td>
<td>48.31</td>
<td>2.16</td>
<td>50.06</td>
</tr>
<tr>
<td>UAM-M</td>
<td>58.41</td>
<td>2.42</td>
<td>59.02</td>
</tr>
<tr>
<td>LAC-C</td>
<td>28.06</td>
<td>1.65</td>
<td>26.43</td>
</tr>
<tr>
<td>LAP-P</td>
<td>39.91</td>
<td>2.18</td>
<td>41.08</td>
</tr>
<tr>
<td>LAM-M</td>
<td>55.62</td>
<td>2.38</td>
<td>55.32</td>
</tr>
</tbody>
</table>

SD Standard deviation; NS not significant; * p < 0.05; ** p < 0.01; *** p < 0.001.

**Table 3:** Comparisons of cephalometric measurements of the study groups

<table>
<thead>
<tr>
<th></th>
<th>Class II Division I</th>
<th>Class II Division II</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Skeletal measurements</td>
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<td></td>
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<tr>
<td>SNA°</td>
<td>80.34</td>
<td>1.32</td>
<td>81.46</td>
</tr>
<tr>
<td>SNB°</td>
<td>73.28</td>
<td>1.61</td>
<td>76.51</td>
</tr>
<tr>
<td>ANB°</td>
<td>6.61</td>
<td>1.17</td>
<td>5.20</td>
</tr>
<tr>
<td>Jarabak ratio%</td>
<td>64.31</td>
<td>1.80</td>
<td>67.28</td>
</tr>
<tr>
<td>SN–MP°</td>
<td>35.76</td>
<td>2.62</td>
<td>30.82</td>
</tr>
<tr>
<td>N-S-Gn° (y Axis)</td>
<td>61.65</td>
<td>1.48</td>
<td>59.32</td>
</tr>
<tr>
<td>Dental measurements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1–SN°</td>
<td>104.32</td>
<td>1.51</td>
<td>87.56</td>
</tr>
<tr>
<td>IMPA °</td>
<td>93.12</td>
<td>2.18</td>
<td>86.52</td>
</tr>
<tr>
<td>Overjet (mm)</td>
<td>7.21</td>
<td>0.99</td>
<td>3.02</td>
</tr>
<tr>
<td>Overbite (mm)(</td>
<td>3.56</td>
<td>1.08</td>
<td>5.50</td>
</tr>
<tr>
<td>Soft tissue measurements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convexity angle °</td>
<td>167.81</td>
<td>1.20</td>
<td>172.34</td>
</tr>
<tr>
<td>° H angle</td>
<td>22.41</td>
<td>0.42</td>
<td>17.94</td>
</tr>
</tbody>
</table>

SD Standard deviation; NS not significant; * p < 0.05; ** p < 0.01; *** p < 0.001.

(8) maxillary premolar alveolar width(UAP-P): the distance between two points at the mucogingival junctions above the interdental contact point of the maxillary first and second premolars.

(9) maxillary molar alveolar width(UAM-M): the distance between two points at the mucogingival junctions above the mesiobuccal cusp tips of the maxillary first molars.
(10) mandibular canine alveolar width (LAC-C): the projection of UAC-C point in the lower jaw
(11) mandibular premolar alveolar width (LAP-P): the projection of UAP-P point in the lower jaw
(12) mandibular molar alveolar width (LAM-M): the projection of UAM-M point in the lower jaw.

For the cephalometric measurements:

Every lateral cephalometric radiograph was analyzed using Auto CAD program to calculate the angular and linear measurements. All the scanned images of the radiographs were then digitized and processed by one investigator. The measurements were obtained for six skeletal, four dental and two soft tissue parameters. The related landmarks are shown in Figure 3.
4. Experimental Procedure

Independent-samples t-test was applied for comparison of the groups. All statistical analyses were performed using the Statistical Package for Social Sciences for Windows (SPSS) version15 (2006) computer program.

5. Result

No statistically significant differences were found between gender groups, therefore the samples were pooled. Descriptive statistics (mean, standard deviation,) and statistical comparisons of dental and alveolar width measurements for dental casts in the groups (Class II division 1, and Class II division 2) are shown in table 2. According to the independent-samples t-test, statistically significant differences were found in maxillary and mandibular dental arch and alveolar width dimensions among Class II division 1, Class II division 2 samples. Statistically significant differences were found only in five of the 12 transverse measurements ($p < .05$) (table 2). Class II division 1 malocclusion had statistically significant narrower upper inter premolar, premolar alveolar and inter molar widths ($p < .001$) than did the subjects with Class II division 2 malocclusion. The mandibular intercanine and inter canine alveolar width measurements were narrower in the Class II division 2 subjects when compared with the Class II division 1 subjects. Skeletal angular cephalometric comparison of class II division 1 and class II division 2 malocclusion samples are presented in table 3. SNA value for class II division 1 is smaller than the class II division 2 without any significant difference. The cephalometric results revealed that SNB angle was responsible for the skeletal sagittal difference between the two groups. SNB value for class II division 2 malocclusion is larger than division 1 with statically significant difference($P < .01$) . Jarabak ratio, SN-MP angle and y axis all showed that the division 1 group had higher vertical proportion. Convexity angle, H angle indicated that the class II division 2 group present amore concave profile.

6. Discussion

This investigation studied the dento-skeletal characteristics of Class II patients using lateral cephalometric radiographs and dental casts. The sample consisted of subjects in the permanent dentition to ensure minimal changes in arch widths due to growth (Bishara et al., 1997). Investigators who studied growth changes in the transverse arch width found that molar and canine arch widths did not change after age 13 in female subjects and age 16 in male subjects (DeKock, 1972; Sillman, 1964). The minimum ages of the subjects measured in this study were chosen on the basis of these previous studies. Therefore, we assumed that the arch widths of the subjects studied were fully developed. Clinicians have speculated that nasal obstruction, finger habits, tongue thrusting, low tongue position, and abnormal swallowing and sucking behaviors were reasons for narrower maxillary dental arch widths in Class II division 1 malocclusions compared with a normal occlusion sample. (Staley et al., 1985) stated that the maxillary dental arch as a whole is narrower in adults with Class II division 1 malocclusion than it is in adults with normal occlusion. When we compare the dental and alveolar arch widths of Class II division 1 malocclusion samples with Class II division 2 malocclusion samples, statistically significant different values were found in the maxillary inter premolar inter molar, alveolar inter premolar, mandibular inter canine ,alveolar inter canine widths. According to the result had been reported by (Jyoti, 2011) for maxillary arch ;the statistically significant differences among the groups were found for the Maxillary inter- premolar, inter-premolar alveolar width. But the different result in molar width between class II division 1 and division 2 had been noted. Maxillary inter premolar width ,all maxillary alveolar widths mandibular premolar width and molar alveolar widths were significantly narrower in class II division 1 group when compared to normal occlusion sample reported by (Uysal et al., 2005; Staley et al., 1985; Turkkahraman, 2004) and (Jamal et al., 2011) suggested that the narrow widths of the dental arch in Class II division 1 patients appeared to be caused by palatally tipped teeth and also by narrower bony bases of the dental arch. Their results showed that transverse discrepancy in Class II division 1 patients originated from upper posterior teeth and not from the maxillary alveolar base .The present study revealed a significant constriction in the mandibular inter canine and canine alveolar width in class II division 2 samples. (Buschang et al., 1994) have a similar finding, regarding the constriction of mandibular inter canine width in division 2 subjects. (Walkow, Peck, 2002) suggested that class II division 2 malocclusion is characterized by normal transverse dimensions in the maxillary and mandibular posterior segments, but reduce inter canine arch dimension in the mandible, decrease in mandibular anterior arch width is a result of severe bite that inhibits forward mandibular dentoalveolar growth but not the strong basal and symphyseal growth in the class II division 2 mandible (Peck, 1998). The result showed that the SNA angle which indicates maxillary sagittal position are similar while comparing class II Division 1 and Division 2 malocclusion ,which are in agreement with
previously published studies, SNB angle in the division 1 and 2 groups was 73.28± 1.61 and 76.51± 2.43 degrees, respectively. When compared with normative data (Riolo et al., 1974) only the values for the Class II division 1 subjects suggested a retrognathic mandible. This finding is in agreement with (Demisch et al., 1992; Peck et al., 1998) who stated that in Class II division 2 cases, the mandible is not posteriorly displaced. On the contrary, in a study by (Pancherz et al., 1997) SNB angle in both the division 1 and 2 groups was found to be smaller than the reference data. A reason for the dissimilar results for mandibular position may be explained by the age difference between the samples. (Pancherz et al., 1997) who found that the division 2 group presented a smaller SNB angle than the division 1 group, concluded that this trend resulted from the constriction of the retroclined anterior maxillary dentition on the mandibular structures. The vertical parameters in the present study demonstrate that Class II division 2 subjects have a more hypodivergent skeletofacial pattern than division 1 cases. Similar findings of a definite hypodivergent facial pattern with a flat mandibular plane angle have also been found (Houston, 1967; Pancherz et al., 1997; Peck et al., 1998). According to the Jaraback ratio in this study there was a significant difference in the value of this ratio between class II division 1 group and division 2 group. The mean value of this ratio for class II division 2 group is 67.4% means relatively greater posterior face height and horizontal growth, this agreed with (Bjok, 1972; Karlsen, 1994). The angle determine the position of the mandible relative to the cranial base is the N-S-Gn (y Axis) angle its normal value according to (Racosi T., 1982) is 66°, in this study both class II division 1 and 2 showed less than normal value (61.65°, 59.32°) respectively, so the mandible is in an anterior position relative to the cranial base and growth predominantly anterior. The value of y axis for class II division 2 is less than class II division 1, so the class II division 2 patients show more anterior position of the mandible relative to the cranial base. The skeletal convexity decrease with age, in this study there was high significant difference in the angle of convexity between class II division 1 and class II division 2, class II division 2 group have more concave profile this find in agreement with (Karlsen A.T., 1994). On the other hand not agreed with (Houston, 1967; Kerr et al., 1994). The inclination of the mandible to the anterior cranial base is determined by the SN-Mp angle, in our study there was significant difference in the amount of this angle between class II division 1 group and division 2 the value of this angle for class II division 1 is more than class II division 2 in this study, so the inclination of the mandible for the class II division 1 group is posterior. While, for the class II division 2 patient the inclination of the mandible is anterior. So the class II division 2 subjects have a more hypo divergent skeleton facial pattern than division 1 cases. Similar findings of a definite hypo divergent facial pattern with a flat mandibular plan angle have also been found, (Houston, 1967; Pancherz et al., 1997; Peck et al., 1998; Shahba’a, 2012). There was a high significant difference between class II division 1 and 2 malocclusion in the mean value of the H-angle this difference may be due to the difference in the amount of ANB angle, this finding indicated amore concave profile for class II division 2 subjects. According to (Lapatki et al., 2002) the result of the lower lip exerting an excessive pressure on the anterior teeth, which made division 2 treatment more prone to relapse (Isik et al., 2006; Lapatki et al., 2002; Baccetti et al., 1997) In this study the mean value of the over jet for the class II division 1 was 7.21, while its mean value for the class II division 2 was 3.02, this is due to the retroclination of the anterior teeth in class II division 2 cases, this agree with other studies (Baccetti et al., 1997). The bite indicating a deep bite condition for the class II division 2 cases more than class II division 1 this in agreement with (Isik et al., 2006).

**Conclusion**

Knowledge of dento-skeletal characteristics together with arch-width features of different types of Class II malocclusion would be helpful in determining treatment goals and successful treatment outcomes. Maxillary inter premolar, inter molar and alveolar inter premolar widths were significantly narrower in the Class II division 1 group when compared with the class II division 2 sample. For that reason, rapid maxillary expansion rather than slow expansion may be considered before or during the treatment of a Class II division 1 patient. There was a significant reduction of mandibular intercanine width in the division 2 subjects, this may be due to the deep bite retrusive maxillary incisore and excessive lip pressure which are the main keys to the frequently encountered problem of relapse in these patients. The class II division 1 subject show more retrognathic mandible than do class II division 2 subjects. The inclination of the mandible for the class II division 2 subject is interiorly, and for the class II division 1 is posteriorly. Class II division 2 subjects have more concave profile and a greater posterior face height with a horizontal growth.

**Justification of Research**

As one of the most frequently encountered orthodontic problems, Class II malocclusions. It is essential to know the descriptive characteristics of this type of malocclusions and their dental and skeletal structures in order to produce an
appropriate treatment plan with suitable treatment mechanics and retention regime. Investigators have studied the growth of arch widths in persons with normal occlusion and compared these values with those of different malocclusion samples since the size and shape of the arches have considerable implications in orthodontic diagnosis and treatment planning, affecting the space available, dental esthetics, and stability of the dentition.

Research Highlights

The data suggest that knowledge of the craniofacial growth process particularly skeletal and dentoalveolar growth pattern in Class II malocclusion patients orthodontic and orthopedic therapies may be a clinical usefulness procedure leading to proper choice of treatment time, modality to improve and to shorten the period of treatment, avoiding adverse consequences.

Limitations

The limitation of the study lies in the fact that the database collected from the cephalometric x-ray of untreated patients with class II malocclusion which is a two dimensional view instead of using a digital computerized tomography scan (3D) view so that the dimensions can be measured in a 3 axis of lines.

Author Contribution and competing Interests

The research was conducted by the Author at the University of Babylon, Iraq. The author has given their contribution to this paper in relation to her competing interests.

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