The variation and changes of arch dimensions and area between normal girls and boys (a longitudinal study in Qazvin-Iran)*

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ABSTRACT

Purpose: Transition of dentition from late mixed dentition to early permanent stage has an impact on dental arch length, circumference also width and depth of arch. Recognition of these changes and prediction of its pattern is important in treatment planning especially because there are differences between genders that should be considered. This study was designed to evaluate the variations between Iranian (residence of Qazvin city) normal girls and boys in arch dimensions and area.

Materials & Methods: This was a longitudinal descriptive study on 26 normal occlusion adolescents with mean age of 12±1 years at the commencement and 16±1 years at the end of study (12 girls & 14 boys). The individuals had normal occlusion defined by Moyers. Study casts were taken from the sample during 1998 and 2002 respectively. The casts were trimmed according to Profitt. Two photographs were taken from the occlusal view of each with 20 cm distance and vertical to its midline. After superimposition of the two dental arches on the midline and registration on best fit of incisal edges and mesiobuccal cusp of first molar, changes of depth and width at molar and canine regions were calculated based on genders. Variations in the shape and area of the dental arch were also studied. Mean, SD and confidence interval of the landmarks in each sex was calculated and compared for differences by means of t test.

Results: The size and area of arch was always larger in boys and this difference increased by age. In maxilla and mandible, molar width increased in boys but decreased in girls. In maxilla, reduction of canine depth was seen only in boys.

Conclusion: There are significant differences between normal arch dimension and area between boys and girls that should be considered in treatment planning.

Keywords: Arch dimensions, Cast analysis, Iranian, Sex.

INTRODUCTION

The size and shape of the arches will have considerable implications in orthodontic diagnosis and treatment planning, dental aesthetics, and stability of the dentition.¹ Arch dimensions change with growth. Moorrees (1969) have pointed out that considerable individual variation in arch form will occur with normal growth.² Knott (1972), Koch (1972), Sillman (1969), Sinclair (1983) and Braun and Hnat (1998) have studied the arch...
growth in untreated cases and it seems that after the change from primary to permanent dentition the arch length will become shorter with some expansion in the intermolar region.\(^3\) One of the problems in prediction of the post-treatment and post-retention changes seen in orthodontically treated cases is that we are unable to determine whether the changes in arch shape and size are primarily a result of therapy or are part of normal developmental maturation. Documentation and review of serial records involving untreated normal cases followed through the early permanent dentition and adulthood should offer clues for evaluating the complex and intricate interaction of numerous craniofacial and dental factors predisposing to arch changes during the normal growth process.\(^8\)

Furthermore, the regular and orderly teeth are seen in people with different patterns of facial and dental arch. Some orthodontists had introduced a special arch form for correcting all malocclusions, which provide the most esthetic and functional occlusion for the patient.\(^3,7\)

Previously, computers, scanners and digital cameras were not widely used and orthodontists used gypsum casts for all analyses. The direct method only allows linear variables to be assessed and these are influenced by the examiner's error when measurement is performed by hand.\(^9\) In addition, taking photographs by means of conventional cameras was accompanied by problems which could not be corrected.\(^9\)

Today, digital cameras with different software programs are available and provide a wide range of information regarding measurement of teeth dimensions, dental arch area and circumference, comparison of the arch pattern in different people or the same person in different times.\(^9,10,11\)

It is generally believed that there is an individuality in the dental arch form and that an integrity of this form exists. Whether or not stability in arch form from the early to late permanent dentition is achievable by orthodontic treatment might be substantiated by the stability of untreated normal occlusion samples. The present longitudinal study has been designed to evaluate dental arch size and form changes in 12-16 year-old Iranian adolescents in Qazvin, as this population has not been previously studied. The changes of dental form and size were evaluated after 4 years of follow up to evaluate the differences between genders.

**MATERIALS & METHODS**

This descriptive, longitudinal study was conducted on 26 adolescents, 12 girls and 14 boys, with normal occlusion. They were randomly selected from schools of Qazvin on 1998 with the following characteristics:

- Appropriate and symmetric face
- Maximum interocclusal contact presumably all permanent teeth were fully erupted and there was no abnormality in number (agenesis, extraction or supernumeraries).
- Angle Cl I occlusion.
- Normal overbite and overjet.
- Conformity of mandibular and maxillary midlines.
- Lack of caries in interproximal surfaces.

Slight deformities such as crowding of 1-2 mm and little rotations were ignored.\(^12\) The cases had 14±1 years of age at the time of commencement of the study, and were recalled for reevaluation in 2002. Cast preparations were done according to orthodontic model standards.\(^13\)

After preparation of the maxillary posterior surface of the gypsum model, the two casts were placed with maximum contact and posterior surfaces of the mandibular cast was prepared in line with the maxillary cast.\(^13\)

**Curve Definition**

The curves passing the tips of the buccal cusps of the posterior teeth and the canine teeth, along with the incisal edges of the anterior teeth were studied. The reference points on the casts were defined as follows:

- Tips of the mesiobuccal and distobuccal cusps of maxillary and mandibular first and
second molar teeth.
   - Tips of first and second premolars buccal cusps.
   - Canine cusp tip point.
   - Midpoint of incisal edge of lateral and central teeth.

The maxillary midline was constructed using second rugae and midpoint of foveae palatine and was transferred to mandibular arch when casts were in interdigitation.

Photography
The digital camera (Samsung-Visualizer) was placed at the distance of 20cm (with the same distance from the bottom of instrument at every photograph) which was the best place for the clearness and contrast of the pictures. A cardboard sheet was placed beneath the instrument and the contact points of casts’ bases were drawn on it in order to place all the casts in the same position. An engineering ruler was placed at the bottom of the page as a scale to determine the magnification. Each cast was identified with a 4-digit number (M: Male, F: Female, the case number: 101-127, 1998 cast: 3, 2002 cast: 1, Lower jaw: L, Upper jaw: U).

The properties of the pictures were determined and approved by the computer operator and then, taken and saved on the computer hard disc and a backup CD.

The pictures were analyzed via the CATIA V5R8 (NURBS), Mechanical Desktop V 6.0 software program. A file consisting of upper and lower jaw cast pictures taken during the study was created for each subject. The pictures were marked in order to be clearly distinguishable. The midsagital line of the upper jaw, which was transferred to the lower cast by means of contact points, was determined as the y-axis. For superimposition of the two arches on each other, after midsagital line matching, the pictures were moved backward and forward so that the midpoints of incisal edges, canine cusp and tip point of the first molar mesial cusp had the least distance to the first registration. As mentioned in reviewed articles, shortening and widening of arch were considered during picture superimposition. The x-y axis was determined and the measurements were assessed using this axis after superimposition. The measurements were carried out for both lower and upper jaws in 1998 and 2002 and the figures were, rounded to 0.001mm approximation.

Statistical analysis
Mean and standard deviation (at 95% and 68% confidence intervals) of Wc, Wm, Dc, Dm dimensions and the area under the curve were calculated for maxillary and mandibular casts of 26 cases for both females and males at the 95% confidence interval. Differences between the measurements were analyzed using paired t-test for all samples, unpaired t-test was used to analyse differences between genders.

RESULTS
All maxillary measurements except upper molar distance had significant differences between boys and girls in 1998. The differences of mandibular measurements were not significant in 1998 the samples had 12 years of age at that time. In 2002 that the samples were 16 years old all differences were significant except upper canine distance between two genders. In considering the changes in the four year period, the decrease of area was higher in maxilla in girls but in mandible it was adverse. At maxilla in boys, the canine width was constant but canine and molar depth decreased. The molar width was increased. At mandible, canine width decreased a little (0.66mm), molar width increased and canine and molar depth both decreased.

In girls at maxilla canine width and depth increased a little and molar depth and width decreased.

At mandible canine depth and width and molar depth decreased but canine distance was constant.
Table 1. The effect of gender on measured variables on two times.

<table>
<thead>
<tr>
<th>Gender Variable-year</th>
<th>Male</th>
<th></th>
<th></th>
<th>Female</th>
<th></th>
<th></th>
<th>P-value</th>
</tr>
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<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>SE</td>
<td>Mean</td>
<td>SD</td>
<td>SE</td>
<td></td>
</tr>
<tr>
<td>WCU 1998</td>
<td>37.72</td>
<td>0.61</td>
<td>1.92</td>
<td>34.81</td>
<td>0.61</td>
<td>2.67</td>
<td>0.003 S</td>
</tr>
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<td>2002</td>
<td>37.42</td>
<td>0.59</td>
<td>2.15</td>
<td>35.22</td>
<td>0.59</td>
<td>1.98</td>
<td>0.000 S</td>
</tr>
<tr>
<td>WMU 1998</td>
<td>58.16</td>
<td>0.80</td>
<td>2.79</td>
<td>53.50</td>
<td>0.80</td>
<td>2.70</td>
<td>0.000 S</td>
</tr>
<tr>
<td>2002</td>
<td>56.80</td>
<td>0.77</td>
<td>2.12</td>
<td>54.49</td>
<td>0.77</td>
<td>2.76</td>
<td>0.003 S</td>
</tr>
<tr>
<td>DCU 1998</td>
<td>11.95</td>
<td>0.35</td>
<td>1.42</td>
<td>11.73</td>
<td>0.35</td>
<td>1.1</td>
<td>0.074 S</td>
</tr>
<tr>
<td>2002</td>
<td>13.27</td>
<td>0.42</td>
<td>1.69</td>
<td>11.71</td>
<td>0.42</td>
<td>1.27</td>
<td>0.000 S</td>
</tr>
<tr>
<td>DMU 1998</td>
<td>35.69</td>
<td>0.76</td>
<td>3.09</td>
<td>34.28</td>
<td>0.76</td>
<td>1.93</td>
<td>0.161 NS</td>
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<tr>
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<td>0.58</td>
<td>2.61</td>
<td>32.79</td>
<td>0.58</td>
<td>2.53</td>
<td>0.000 NS</td>
</tr>
<tr>
<td>AREAU 1998</td>
<td>2043.16</td>
<td>67.23</td>
<td>236.5</td>
<td>1802.90</td>
<td>67.23</td>
<td>239.42</td>
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<tr>
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<td>2073.5</td>
<td>57.65</td>
<td>226.31</td>
<td>1890.63</td>
<td>57.65</td>
<td>185.01</td>
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<td>WCL 1998</td>
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<td>0.52</td>
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<tr>
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<td>0.83</td>
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</tr>
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<td>47.46</td>
<td>0.77</td>
<td>2.58</td>
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</tr>
<tr>
<td>DCL 1998</td>
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<td>0.24</td>
<td>1.0</td>
<td>7.27</td>
<td>0.24</td>
<td>1.0</td>
<td>0.000 S</td>
</tr>
<tr>
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<td>0.19</td>
<td>0.7</td>
<td>7.57</td>
<td>0.19</td>
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<td>0.76</td>
<td>2.82</td>
<td>34.28</td>
<td>0.76</td>
<td>2.74</td>
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</tr>
<tr>
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<td>33.80</td>
<td>0.58</td>
<td>2.40</td>
<td>32.79</td>
<td>0.58</td>
<td>1.92</td>
<td>0.000 S</td>
</tr>
<tr>
<td>AREAL 1998</td>
<td>1516.07</td>
<td>36.89</td>
<td>132.68</td>
<td>1431.64</td>
<td>36.89</td>
<td>131.80</td>
<td>0.000 S</td>
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<tr>
<td>2002</td>
<td>1598.86</td>
<td>47.64</td>
<td>157.86</td>
<td>1479.24</td>
<td>47.64</td>
<td>181.62</td>
<td>0.084 NS</td>
</tr>
</tbody>
</table>

Fig 1. Differences of measurements between genders in year 1998.

Fig 2. Differences of measurements between genders in year 2002.
DISCUSSION

The study of normal changes which occur in the dental and facial complexes helps the dentist to diagnose all occlusal abnormalities to reach the ideal orthodontic treatment for the patient. Awareness of these changes, the place and time of changes and difference between the sexes is necessary. Considering the measurements of this study these changes will be discussed below according to gender differences.

Inter canine width decreased in males, while it increased in female cases but no significant statistical difference was seen between them. No significant change was observed in this measurement through the years of study and the males’ mean average of inter canine width was higher. In the mandible, inter-canine width was decreased. The difference between male and female in inter-canine width measured in 2002 was statistically significant (P<0.000). Ross–Powell and Harris (2000) stated that female inter-canine width increases between 9–11 years of age in the maxilla, while the peak of this change is seen in 14 – years olds. However the changes after this period are not statistically significant. No distinguishable change occurs in the inter-canine width after 11 years of age in the mandible (P<0.95). (14) Bishara (2001) reported an increase of 1.7 mm in inter-canine width between 13–45 years of age in maxilla and a 1.2mm decrease in the mandible. (15)

According to Moyers (1988), this occurs because of divergence of alveolar processes and conformity of alveolar width increase, with vertical growth periods in maxilla. (12) But, in mandible alveolar process has parallel and vertical growth making the intercanine width decrease. A remarkable gender difference was observed in two canines’ distance in maxilla which was not seen in mandible.

Male samples had significant increase in the inter-molar width during the follow up time, while the female samples showed decrease of it (1.59mm) which was not significant. The inter-molar distance difference between males and females during the years 1998-2002 was statistically significant (P<0.003). In the mandible, the increase of inter-molar width occurred in females and males, furthermore, the difference between two sexes was
significant during the years 1998–2000 (P<0.022).

Bishara’s (2001) results showed a 2.2mm and 1mm increase of inter-molar width in 8-18 year-old samples in the maxilla and mandible respectively. This occurred because of development of alveolar sockets during the age of 8-13 years and consequent outward divergence of its processes in the following years. In the mandible, the slight increase of inter-molar width was believed to be due to conformity of molars to occlusion and slight bone deposition on the outer surfaces of the mandible’s body.\(^{(15)}\) No difference between the two sexes in inter-molar width increase was mentioned in Bishara’s (2001) study,\(^{(15)}\) but Henrikson and Person (2000) in a study carried out on 13-31 year-olds observed a significant difference in inter-molar change between females and males (P<0.003).\(^{(13)}\) An increase of inter-molar width was observed during these years in males, while this was not so in females.\(^{(16)}\) His finding was similar to ours. Sinclair (1983) also reported a slight inter-molar width increase during the period of 9–11 to 17-18 years in males, while in females, it was decreased significantly (P<0.001) during 12-13 and 17-18 years of age.\(^{(6)}\)

Canine depth in the maxilla showed significant decrease of (P<0.025) about 1.32 mm in males, while no change was observed in females. The difference between the two sexes was significant. The difference between females and males in canine depth was significant in 1998, while this was not so in 2002. In the mandible, canine depth was significantly decreased in females and males. The observed decrease may be due to vertical growth of incisors as well as decrease of inter-canine width which causes teeth to be placed on a smaller arch and canine depth to decrease consequently. Ross–Powell and Harris (2000) reported similar results in a study conducted on 12-18-year-old cases. They observed a progressive and slow decrease in maxillary canine depth of about 1.5 mm. In the mandible, anterior arch depth changes were amount to half of maxilla’s. Anterior depth moves slightly backward after the age of 10.\(^{(14)}\)

Males showed a significant decrease of 1.69 mm in the arch depth (P<0.001), while the decrease of 1.48mm reported in females was not statistically significant. The changes significantly differed in males and females in 2002. In the mandible, there was an overall decrease of 1.9 mm for males and 1.49 mm for females. It is obvious that arch depth decreased in females and males equally both in maxilla and mandible as a result of occlusion conformity of maxillary and mandibular molars. Bishara (2001) reported a slight decrease of arch length during the period of 8-18 years in both the maxilla and mandible.\(^{(15)}\) The results of the Henrikson and Person (2000) study were similar to this; i.e. jaw depth decreases significantly in the mandible and in males from 13-31 years-old (P<0.01). This may be due to mesial migration of posterior teeth during lifetime, less inter-dental abrasion, lingual position of incisors as a result of differential growths of the maxilla and mandible, and natural torque of molars and incisors.\(^{(13)}\) Canine depth change was unidirectional and decreasing, shortening the curve of arch during this period.\(^{(16,17)}\)

In males, the mean area under the maxillary curve was decreased up to 30.34mm\(^2\) from 1998 to 2002 which was not statistically significant. Female cases showed a decrease of 87.73mm\(^2\) in the area under the curve with the primary area of 1802.90mm\(^2\) in 2002 and significant change. The difference in the area under the curve between males and females was significant in 2002 (P<0.000). In the mandible, males with mean area of 1697.19 mm\(^2\), and females with that of 1431.64mm\(^2\) showed a decrease of 82.79mm\(^2\) and 47.06mm\(^2\), respectively. The decrease was mainly due to decrease in arch length. Burris and Harris (2000) reported the area under the curve of 1673.5mm\(^2\) and 1827.8mm\(^2\) for female and male cases in the maxilla in a study conducted on white adult patients with normal occlusion. Their reported values are less than ours. The study found a significant difference in the area under the curve between black and
white patients. So, this could be due to racial differences with possible influences on dental arch form and shape affecting dental arch as a result.\(^{(17)}\)

**CONCLUSION**

- Maxillary arch dimensions are larger in boys and as the age increases this difference becomes more significant.
- In 12 year normal Iranian girls and boys the mandibular arch dimensions were the same but at 16 years they were larger in boys.
- Arch depth decreases both in the maxilla and mandible in boys but in girls it is constant in canine region in both jaws and decreases in molar region.

**REFERENCES**