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Differences between high- and low-angle subjects in arch form and anterior crowding from 23 to 33 years of age

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SUMMARY The aim of this study was to compare changes in arch width and length in high- and low-angle subjects. The material comprised the cephalograms and study models of 17 males and 15 females with a high-angle and 12 males and 16 low-angle females. The age of the subjects at the first examination (T1) was 22 years 10 months and 22 years 8 months in the high-angle groups, 22 years 5 months and 22 years 8 months in the low-angle subjects, respectively, for males and females. The second assessment (T2) was 10 years and 9 years 10 months later in the high-angle and, 10 years 3 months and 9 years 10 months in the low-angle groups, respectively. Statistical analysis of changes for each group during the observation period T1–T2 was undertaken using a paired *t*-test, and the differences between the groups with two-sample *t*-tests.

The findings showed a general reduction in upper and lower arch length, an increase of intermolar width, and a decrease of intercanine width in both genders. Anterior perimeter and anterior space in both angles decreased in both males and females. The mean changes were small, but with large individual differences. There were no significant differences between the genders or the high- and low-angle groups in the changes, except that the female high-angle group had a statistically significant ($P = 0.05$) greater decrease in mandibular arch length than the low-angle female group.

Introduction

Several studies concerning changes in the occlusion in adults report an increase in crowding (Bishara *et al.*, 1994; Richardson, 1995; Bondevik, 1998; Carter and McNamara, 1998; Richardson and Gormley, 1998; Henrikson *et al.*, 2001). Bishara *et al.* (1994) found a greater increase in crowding in females than in males both in upper and lower arch from 25 to 46 years of age. Bondevik (1998) also showed a greater increase in females than in males from 23 to 34 years of age, while Carter and McNamara (1998) reported no significant difference between the genders. Richardson and Gormley (1998) studied changes only in the mandibular perimeter and found greater alterations in orthodontically treated subjects than in untreated subjects, even if retention was maintained after 18 years of age. They concluded that in untreated subjects the changes in the lower dental arch perimeter were very small and clinically undetectable.

Henrikson *et al.* (2001) found a significant correlation between changes in mandibular arch form and an increase in crowding. Freeman (1994) compared post-retention mandibular incisor irregularity in Class II division 1 subjects versus untreated Class I ‘normals’ but found no differences. However, the age range in the treated group was wider than in the untreated group.

It has been argued that there is a difference in arch length and width development in subjects with anterior or posterior rotation of the mandible (Bjőrk and Palling, 1954; Bjőrk, 1975). Anterior rotation usually results in a low angle with an increase in arch length, and posterior rotation in a high angle with a decrease in arch length.

The purpose of this study was to test the hypothesis that there is a difference between high- and low-angle subjects in crowding of the incisors at 23 years of age; a difference in changes between high- and low-angle adults in arch length, width, and crowding from 23 to 33 years of age, and a difference in the changes related to gender.

Materials and methods

This study was approved by the Regional Committee for Medical Research Ethics, Southern Norway.

Cephalograms and study models were obtained of all third-year Norwegian dental students at the University of Oslo, Norway, from 1972 to 1989 (T1). Of these, 102 males and 108 females attended a recall appointment approximately 10 years later (T2) when new cephalograms and models were obtained.

The mean mandibular plane angle (NSL–ML, Figure 1) in males was 26.2 degrees [standard deviation (SD) 5.3 degrees], and in females 29.6 degrees (SD 5.6 degrees). The subjects aged between 20 and 26 years at T1 were divided into four groups high- and low-angle males and high- and low-angle females. The criteria for diagnosis of a high angle was a mean NSL–ML of +1 SD or more and for a low-angle −1 SD or more. The mean age at T1, the time period from T1 to T2, and the number of subjects in the different groups are shown in Table 1, and the mean and SD of NSL–ML

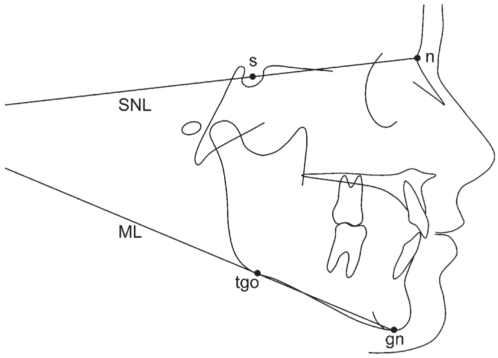

Figure 1 The mandibular plane angle expressed as the angle between the line SNL from the midpoint of sella turcica (s) to nasion (N) and the line ML from gnathion (gn) and as a tangent to gonion (tgo).

Table 1 NSL–ML values (degrees) in the high- and low-angle groups at the first observation (T1).

	High angle			Low angle		
	n	Mean	SD	*n*	Mean	SD
Males	17	34.6	2.8	12	17.8	1.3
Females	15	38.1	4.1	16	20.8	2.5

angle and the number of subjects in each of the four groups in Table 2.

The changes in arch length, width, and crowding were measured on the study models. The anterior perimeter of the upper and lower arches were measured from the distal contact points of the canine on one side to the distal contact point on the contralateral canine. These measurements, to the nearest 0.0 mm, were made using a soft ruler. The teeth were measured using an electronic digital sliding calliper (Mitutoyo Corp., Tokyo, Japan) accurate to the nearest tenth of a millimetre.

The anterior space condition at T1 is shown in Table 3 and is expressed as the anterior perimeter of the arches minus the sum of the mesio-distal width (Figure 2) of the six anterior teeth.

The measurements of width and length (Figure 3) were made with the modified Dentofacial Shorts Program (Dentofacial Software, Inc., 1990, Toronto, Canada). The points were plotted on the models and transferred to the computer where the measurements were statistically analysed. The anterior and total length of the arches were measured as the distances a–b and a–c (Figure 3) which are the distances from the contact point between the central incisors (a) to the intercanine line (d–d) and intermolar line (e–e), respectively.

The anterior widths of the arches were measured as the shortest distance between points d–d which are the most palatal or lingual points at the margin of the gingivae on the canines, and between points e–e which are the most palatal points at the gingival margin on the first molars in the maxilla and mandible, respectively.

Table 2 Anterior space condition (ASC, mm) and the probability (*P*) for significant differences between the high- (17 males and 15 females) and the low- (12 males and 16 females) angle groups at the first observation (T1). Negative mean values indicate crowding.

	High angle		Low angle		*P*
	Mean	SD	Mean	SD	
Lower ASC					
Males	0.10	3.25	0.12	4.58	0.99
Females	−0.13	0.92	−1.01	0.99	0.02*
Upper ASC					
Males	1.67	3.68	0.73	2.13	0.39
Females	−0.16	1.99	−0.06	1.19	0.86

$^*P < 0.05$.

Table 3 Changes in anterior (AL) and total arch (TL) length (mm) from 23 to 33 years of age in the high- ($n = 17$) and low- ($n = 12$) angle males and high- ($n = 15$) and low- ($n = 16$) angle females, and the probability (*P*) of significant gender differences between the two groups. Negative mean values indicate a decrease in AL and TL.

	High angle		Low angle		*P*
	Mean	SD	Mean	SD	
Lower AL					
Males	−0.03	0.28	−0.04	0.45	0.93
Females	−0.47	0.44	−0.13	0.39	0.03*
Lower TL					
Males	−0.12	0.38	−0.04	0.26	0.52
Females	−0.43	0.32	−0.09	0.38	0.01*
Upper AL					
Males	−0.12	0.38	−0.08	0.36	0.81
Females	−0.43	0.32	−0.28	0.32	0.44
Upper TL					
Males	−0.21	0.53	−0.21	0.26	0.99
Females	−0.50	0.38	−0.38	0.34	0.34

$^*P < 0.05$.

Statistical analysis

Analysis of changes from T1 to T2 for each group was undertaken using paired *t*-tests and the differences in the changes between the groups with two-sample *t*-tests.

Results

Changes in arch length

For both genders, all groups showed a decrease of anterior and total upper and lower arch length (Table 4). This was greater in the upper than in the lower arch for all groups except for the high-angle males where there was a greater decrease in lower than in upper anterior length. The differences between the changes in the mandibular and maxillary arches were, however, small and not significant.

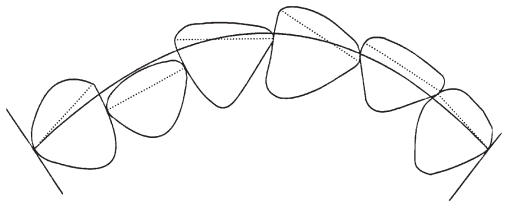

Figure 2 Measurements of the anterior perimeter (solid line) and of the mesio-distal width of the teeth (broken line).

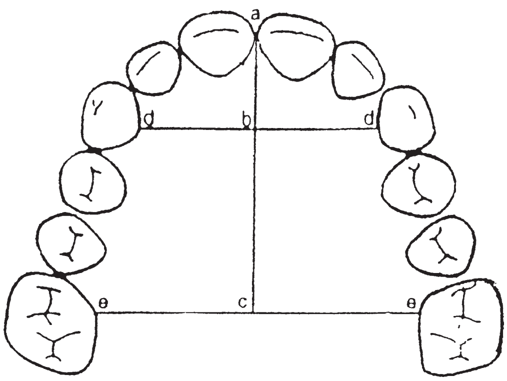

Figure 3 Measurements of the arch width and length; d and e are, respectively, the most palatal and lingual points on the gingival margin of the canines and molars; a is the contact point between the central incisors; b the intersection between the sagittal midline and line d–d and c the intersection between line e–e and the sagittal midline.

The widest variation was seen in the high-angle females where the changes in upper anterior arch length varied from −2.0 to +0.5 mm. Although the changes from T1 to T2 were small, there were significant differences between the high- and low-angle female groups regarding the decrease in both anterior and total mandibular arch length, with a greater decrease in the high-angle group. There were no significant differences for the upper arch or for males (Table 3).

Changes in arch width

Arch width changes showed a different pattern from those of arch length. While upper and lower anterior and total arch length decreased, posterior width increased and the anterior width decreased in all groups (Table 4). The greatest change from T1 to T2 was in canine width in high-angle males, which decreased by almost 0.4 mm. None of the changes in width from T1 to T2 were statistically significant, nor were there any statistically significant differences between the high- and low-angle male or female groups.

Changes in perimeter and anterior space conditions

Both upper and lower anterior perimeters decreased in all groups (Table 5). For both genders, the mean perimeter reduction was larger in the high- than in the low-angle groups, but the differences were small and not statistically significant.

Table 4 Changes in width (mm) between the canines and molars from 23 to 33 years of age in the high- (n = 17) and low-angle (n = 12) males and in the high- (n = 15) and low- (n = 16) angle females, and the probability (P) of significant gender differences between the two groups. Negative mean values indicate a decrease in width.

	High angle		Low angle		*P*
	Mean	SD	Mean	SD	
Lower canines					
Males	−0.38	0.34	−0.24	0.24	0.22
Females	−0.19	0.29	−0.20	0.31	0.95
Lower molars					
Males	0.29	0.44	0.28	0.56	0.98
Females	0.25	0.29	0.20	0.34	0.64
Upper canines					
Males	−0.10	0.30	−0.06	0.32	0.73
Females	−0.08	0.24	−0.14	0.36	0.57
Upper molars					
Males	0.28	0.43	0.25	0.39	0.83
Females	0.26	0.44	0.23	0.30	0.83

Table 5 Changes (mm) in anterior perimeter (AP) and anterior space condition (ASC) from T1 to T2 in the high- (n = 17) and low- (n = 12) angle males and in the high- (n = 15) and low- (n = 16) angle females, and the probability (P) of significant gender differences between the two groups. Negative mean values indicate a decrease.

	High angle		Low angle		*P*
	Mean	SD	Mean	SD	
Lower AP					
Males	−0.35	0.42	−0.25	0.62	0.62
Females	−0.43	0.26	−0.24	0.35	0.10
Upper AP					
Males	−0.24	0.40	−0.21	0.45	0.87
Females	−0.50	0.68	−0.34	0.40	0.45
Lower ASC					
Males	−0.36	0.41	−0.25	0.62	0.60
Females	−0.38	0.34	−0.24	0.36	0.27
Upper ASC					
Males	−0.17	0.46	−0.13	0.48	0.80
Females	−0.50	0.68	−0.38	0.46	0.58

All four groups showed a decrease in anterior space both in the upper and lower anterior segment, which was greater in the high- than in the low-angle groups (Table 5). For both genders, the mean decrease in anterior space was larger in the mandibular than in the maxillary arch, but the changes were not statistically significant. Neither was there any statistically significant difference between the high- and low-angle male or female groups.

Discussion

Both orthodontically treated and untreated subjects were included in the investigation and, as all except two of the treated patients had been out of retention for more than 5 years, changes due to treatment would have occurred before T1 and those subsequently observed were due to ageing.

The error of the method has been tested previously (Bondevik, 1998) and as no systematic errors were found between the duplicate measurements, the results should be valid.

The reason why females but not the males showed a significant difference between the high- and low-angle groups in mandibular arch length from 23 to 33 years of age may be a result of the high-angle female group having more posterior rotation than the high-angle male group, which may have caused shortening of the arch in the females. In the upper arch there was no such rotation.

The general tendency for both genders in the high-angle groups to have a greater arch length reduction compared with the low-angle groups is in accordance with the cephalometric findings of Bjőrk and Palling (1954) and Bjőrk (1975) and with measurements on study models (Bondevik, 1998; Henrikson *et al.*, 2001). Nielsen (1993) was also of the opinion that mandibular posterior rotation resulted in a decrease in mandibular arch length, and subsequently in lower anterior space.

Although the changes in the present study were small and most were not significant, probably because the SDs were large, all changes indicate a decrease in intercanine width and an increase in intermolar width. Together with shortening of arch length in both genders, it reflects a change in the form of the arches from 23 to 33 years of age. In that period, the arches will become shorter both totally and anteriorly, wider in the molar region, and narrower in the canine region. These results, together with the reduction in anterior perimeter, may explain the decrease in anterior space in the upper and lower arches, although these findings were not significant.

No gender differences were found, and there was no statistically significant difference between the high- and low-angle subjects except for the change in lower arch length in females. The reason for this may be that the mean changes were small and there were large individual variations.

Regarding the differences in mean anterior space conditions between the groups at T1, only the lower arch in females showed a significant difference between the high- and low-angle groups. The reason may be that the high-angle females had more posterior rotation of the mandible than the males before 23 years of age. In the upper arch in the females, and in both arches in males, the mean differences between the high- and the low-angle groups were smaller and therefore significant differences would not be expected, especially as the SDs were larger in these groups.

There was no significant difference between high- and low-angle subjects except for lower arch length in the females, which means that it is not necessary to differentiate between low- and high-angle males concerning the length of the retention period if treated orthodontically between 23 and 33 years of age. For females, there is a greater necessity for retention in high-angle subjects, if there is a risk of crowding.

While the changes observed were small, if this is an ongoing process which continues into the next decades, the decrease in anterior space may result in an increase in crowding with age.

Conclusion

There is an ongoing change in upper and lower arch form from 23 to 33 years of age. For both genders, there is a reduction in arch length, a decrease in width in the canine area, and an increase in the molar area in both arches, a decrease of the anterior perimeters and a decrease of the anterior space condition.

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