Assessment of Intercanine and Intermolar Width of Untreated Orthodontic Patients with Crowded and Uncrowded dentitions in University of Benin Teaching Hospital, Benin City, Nigeria

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ABSTRACT

Objective: To determine the intercanine (IC) and intermolar (IM) widths of orthodontic patients with crowded and uncrowded dentitions in University of Benin Teaching Hospital, Benin City, Nigeria.

Methods: This was a cross sectional study. Fifty (50) pairs of dental casts of 50 (Fifty) untreated orthodontic patients were selected and classified using Angle's method. Using a digital caliper (European Directive ROHS 2002/95/CE), lingual arch widths measurements was carried out for first permanent canines and molars of each arch (maxillary and mandibular). The arch width measurements were carried out according to the method described by McDougall et al in 1982. Data was computed and analyzed using the SPSS version 21.0 software. P values at <0.05 was set as significant.

Results: Fifty dental casts with crowded dentition and fifty dentals with uncrowded dentition were evaluated. Each participant had a maxillary and a mandibular cast. The mean age of study population was 21.72±2.52 years. The mean maxillary IC width in crowded and uncrowded dentition of female population was 27.13±1.39 mm and 29.31±4.17 mm respectively (P>0.05). The mean maxillary IM width in crowded and uncrowded dentition of female population was 37.73±2.30 mm and 38.07±4.89 mm respectively (P>0.05). The mean maxillary IC width in crowded and uncrowded dentition of male population was 26.92±3.05 mm and 27.76±2.29 mm respectively (P>0.05). The mean maxillary IM width in crowded and uncrowded dentition of male population was 37.11±4.13 mm and 38.47±1.48 mm respectively (P>0.05).
The mean mandibular IC width in crowded and uncrowded dentition of female population was 20.48±2.44 mm and 26.67±4.81 mm respectively(P<0.05). The mean mandibular IM width in the crowded and uncrowded dentition of female population was 33.35±2.57 mm and it was 36.89±4.98 mm respectively (P>0.05). The mean mandibular IC width in crowded and uncrowded dentition of male population was 21.54±2.47 mm and 26.11±5.43 mm I respectively(P<0.05). The mean mandibular IM width in crowded and uncrowded dentition of male population was 33.49±2.34 mm and 36.44±5.17 mm respectively (P>0.05).

Conclusion: This study recorded higher values of IC and IM widths in the maxillary and mandibular arch of uncrowded dentitions of male and female populations when compared to the crowded dentitions. The difference was statistically significant in the male and female IC width recorded in the mandibular arch only

Key words: Intercanine width, intermolar width, crowded, uncrowded, malocclusion

INTRODUCTION

Knowledge of dental arch widths in a population plays a key role in orthodontics. The size and shape of the arches will have considerable implications in orthodontics and treatment planning affecting space available, dental aesthetics and stability of the dentition (Lee, 1999; Aluko et al, 2009). Previous studies described the dental arches in simple geometric terms such as ellipse, parabola, and segments of circles joined to straight line or modified spheres (Andrews, 1972; Buschang et al, 1994; Al-Khateeb & Abu Alhaija, 2006). The proposed ideal arrangement of the teeth was described geometrically by Angle as the line of occlusion (Andrews, 1972; Buschang et al, 1994; Al-Khateeb & Abu Alhaija, 2006).

Dental crowding is the consequence of a tooth size-dental arch dimension discrepancy. Identifying the aetiology of malocclusion has proven to be one of the most important issues in orthodontics. Different theories have tried to explain the aetiology of dental crowding which includes hereditary and environmental factors (Proffit & Fields, 2000; Posti & Jalali, 2007). The causes of malocclusions could be classified in two major categories, either dental or skeletal. One way of distinguishing between the two is to compare tooth size and arch dimensions in Class I malocclusions with no crowding with Class I malocclusions exhibiting severe crowding. The result will reveal the dental or skeletal cause of crowding. This information will be helpful in orthodontic treatment planning (Graber & Vanarsdall, 2000).

Differences in arch widths have been reported to exist between the races (Lavelle et al, 1971) and blacks have been shown to have larger arch widths than whites with less convergent middle and posterior arch segments (Mack, 1981; Burns & Harris, 2000). Saudi and Egyptian arch widths have been reported to represent a median between Nigerian and British subjects (Younes, 1984). In addition, transverse arch measurements have been found to be larger in males than females (Dekock,1972; Raberin et al, 1993; Harris, 1997; Bishara et al, 1997).

Factors reported to affect arch width include, genetics (Cassidy & Tolley, 1998), environment (Gross et al, 1994; Ogaard et al, 1994), and nutrition (Beecher & Corrucini, 1981). In addition, a secular trend towards a reduction in arch width has been shown in a number of studies (Harper, 1994; Welland et al, 1997).

Longitudinal studies in arch growth have shown an increase in arch width up to the age of 13 years with very little significant growth after this period (Sillman, 1964; Bishara et al, 1997). However, some studies noted a slight decrease in arch size (Sillman, 1964; Bishara et al, 1997).

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Tooth size in Nigerians have been observed to be significantly larger than those of Caucasians (Mack, 1981; Otuyemi & Noar, 1996; Adeyemi, 1999). However, studies on malocclusion in the Nigerian population showed a high prevalence of spacing when compared with findings in Caucasians (DaCosta, 1999; Otuyemi et al, 1999; Onyeaso, 2004).

In a previous study (Poosti and Jalali, 2007), two groups of dental casts were selected and each group consisted of 30 pairs of dental casts including class I malocclusions without crowding or spacing, while the second group exhibited class I malocclusions with severe dental crowding (less than a 5 mm space deficiency), intercanine and intermolar arch widths were determined. Statistically significant differences in intercanine and intermolar arch widths were found between the two groups. The crowded group was found to have a significantly smaller maxillary arch width when compared with the uncrowded group. In a previous study by Rasheed et al (Rasheed et al, 2018), 52 pairs of study models selected from the patients and students of the orthodontic and dentofacial orthopaedics Department of Dhaka Dental College and Hospitals were divided into 2 groups, 27 pairs of dental casts with normal occlusion, 25 pairs of dental casts with class I crowded malocclusion including equal male and female samples. Results showed that in the maxilla and mandible, no significant differences were found in intercanine arch width of the two groups. The intermolar arch width in class I crowded group were significantly smaller than that of class I normal occlusion. In the mandible, it was found that intermolar arch width was smaller in class I crowded group than in those with normal occlusion. Males had a significantly larger intermolar arch widths than females in the two groups. Previous studies (Sillman, 1964; Randzic, 1988) compared the arch width of class I normal subjects with subjects having gross dental crowding (no Angle's classification were given). Maxillary and mandibular intercanine and

intermolar widths were significantly larger in the class I normal occlusion in both genders. Saheed and Mageet in a study among a Sudanese population showed that maxillary intercanine and intermolar widths were significantly higher in males than females. Findings were similar in the mandibular arch (Saheed & Mageet, 2018). Previous study (Waheed & Imran Rahbar, 2005) assessed 80 patients, 20 males, 20 females in crowded and uncrowded group comprising 40 patients each, with an age range of 14-18 years reporting to the orthodontic unit in a Pakistani hospital. Statistically significant difference was observed when intermolar lingual arch width of crowded and uncrowded groups were measured. No statistically significant difference was found between the males and females, although females showed smaller values when compared to males. No significant association was found between crowded and uncrowded arches in intercanine width (P>0.05). In a previous Nigerian study (Aluko et al, 2009), study population consisted of two groups 150 subjects. Group 1 consisted of 75 males and 75 females aged 10-13 years, while Group 2 consisted of 75 males and 75 females aged 18-25 years. Measurements taken included maxillary and mandibular intercanine and intermolar widths for both groups. Results showed that all findings were significantly greater in males in maxillary and mandibular arch, but there was no significant difference between males and females in the mandibular arch though values among the males were slightly higher.

The objective of this study was to determine the intercanine and intermolar widths of orthodontic patients with crowded and uncrowded dentitions in University of Benin Teaching Hospital, Benin City, Nigeria.

MATERIALS AND METHODS

This cross-sectional study was carried out on study casts of untreated orthodontic patients of the University of Benin Teaching Hospital, Benin City, after obtaining clearance from the Ethical Committee of the College of Medical Science, University of Benin, Benin City. Fifty pairs of dental casts of 50 untreated orthodontic patients (of the Orthodontic Unit) of the University of Benin Teaching Hospital, Benin City were evaluated. Privacy and confidentiality of the information from the dental casts were maintained throughout the duration of the study.

The Inclusion criteria include

i. Dental casts of patients 10 years old and beyond.
ii. Dental casts of patients with permanent dentition only.
iii. Dental casts with Angle's class I molar relationship.
iv. Dental casts which were properly prepared, based and unbroken.

Exclusion criteria include:

i. Dental casts of patients with mixed dentition.
ii. Dental casts of patients with primary dentition.
iii. Poor quality casts.
iv. Dental casts without first permanent molars.
v. Dental casts with permanent canine missing.
vi. Dental casts of patients in cross bite (anterior and posterior).
vii. Dental casts without an opposing jaw.

Figure 1: Measurement of IC width using a Digital Caliper (European Directive ROHS 2002/95/CE).

Figure 2: Measurement of IM width using a Digital Caliper (European Directive ROHS 2002/95/CE)

The molar relationship was assessed according to Angle's system (Angle, 1899). In this system (Angle, 1899), for Class I molar relationship, the mesio-buccal cusp of maxillary first permanent molar occludes in the buccal groove of the mandibular first permanent molar. The disto-buccal cusp of the maxillary first permanent molar occludes in the buccal groove of the mandibular first permanent molar in Angle's Class II, in Angle's Class III molar relationship, the mesio-buccal cusp of the maxillary first permanent molar occludes in the interdental space between the mandibular first and second permanent molars. In this study, only dental casts with Angle's Class I molar relationship were evaluated. Crowding and spacing of the mandibular and maxillary dental casts was classified using the brass wire/caliper method described by Carey (Carey, 1958) and Huckaba (Huckaba, 1964). A brass wire of about 0.5 mm was contoured to lie over the incisal edges of the anterior teeth and the centres of the contact areas of the teeth in the buccal segments. The site where the wire crossed the distal contact point of the first permanent molars was marked. The arch perimeter was then measured between these marks. The individual mesio-distal widths of the teeth (first permanent molar to first permanent molar was measured between the mesial and distal contact points using a digital caliper (European Directive ROHS 2002/95/CE). From the sum of the tooth widths in each arch and the recorded arch perimeter, the arch length discrepancy was calculated.

Arch Length Discrepancy = Arch Perimeter – Sum of mesio-distal widths first permanent molar to first permanent molar.

The arch width measurement was carried out according to the method described by McDougall et al (McDougall et al, 1982). Using a digital caliper (European Directive ROHS 2002/95/CE), lingual arch width measurements was carried out and all measurements recorded for first permanent canines and molar regions of each arch (maxillary and mandibular). Lingual arch width was measured at the cervical region of each designated mesio-distal tooth from the midpoint of the lingual surface of the tooth to a corresponding point on the opposite side (McDougall et al, 1982). Each measurement was carried out twice and the mean recorded to ensure intra-examiner repeatability. Five pairs of dental casts (ten in total) were evaluated two weeks apart by the same researcher (UDJ-first author) and using t-test, intra-examiner reliability (of the measurements) of 0.8 was obtained (0.6 and above are acceptable reliability). Data was computed and analyzed using IBM SPSS version 21.0 software. Data generated were subjected to statistical analysis to determine the variables (frequencies, percentages and means). Differences between variables were evaluated with Chi-square test. P values at <0.05 were set as significant.

RESULTS

Fifty pairs of dental casts of fifty untreated orthodontic patients were evaluated, 50 crowded (25 pairs) and fifty uncrowded (25 pairs). Each pair of dental casts consisted of a maxillary and a mandibular cast.

Study population consists of 50 pairs of dental cast of 22 (44.0%) males and 28 (56.0%) females. The mean age of patients whose dental casts were used was 21.72±2.52years and those aged 20-24 years constituted 68.0% (Table 1).

Maxillary dental cast for females was 28 (twenty-eight), crowded group was 10 (35.7%), while

uncrowded group was 18 (64.3%). Maxillary dental cast for males was 22 (twenty-two), crowded group was 10 (45.5%) while uncrowded group was 12 (54.5%). Mandibular dental cast for females was 28 (twenty-eight), crowded group was 17 (60.7%), while uncrowded group was 11 (39.3%). Mandibular dental cast for males was 22 (twenty-two), crowded group was 13 (59.1%), while uncrowded group was 9 (40.9%) (Table 2)

The mean maxillary intercanine width in crowded female population was 27.13±1.39 mm, and it was 29.31±4.17 mm in the uncrowded group. The difference was not statistically significant (P>0.05). The mean maxillary intermolar width in crowded female population was 37.73±2.30 mm and it was 38.07±4.89 mm in the uncrowded group. The difference was not statistically significant (P>0.05) (Table 3).

The mean maxillary intercanine width in crowded male population was 26.92±3.05 mm and it was 27.76±2.29 mm in the uncrowded group. The difference was not statistically significant (P>0.05). The mean maxillary intermolar width in crowded male population was 37.11±4.13 mm and it was 38.47±1.48 mm in the uncrowded group. The difference was however not statistically significant (P>0.05) (Table 4).

The mandibular intercanine width in crowded female population was 20.48±2.44 mm and it was 26.67±4.81 mm in the uncrowded group. The difference was statistically significant (P<0.05). The mean mandibular intermolar width in crowded female population was 33.35±2.57 mm and it was 36.89±4.98 mm in the uncrowded group. The difference was not statistically significant (P>0.05) (Table 5).

The mean mandibular intercanine width in crowded male population was 21.54±2.47 mm and it was 26.11±5.43 mm in the uncrowded group. The difference was statistically significant (P<0.05). The mandibular intermolar width in crowded male population was 33.49±2.34 mm and it was 36.44±5.17 mm in the uncrowded group. The difference was not statistically significant (P>0.05) (Table 6).

Table 1: Sociodemographic Characteristics of the Study Population

Variables	Frequency (n)	Percent (%)
Sex		
Male	22	44.0
Female	28	56.0
Age (years)		
15 – 19	9	18.0
20 – 24	34	64.0
25 – 29	7	14.0
Mean age + SD (21.72 + 2.52)		

Table 2: Distribution of Dental Casts of Study Population

Arch	Crowded n (%)	Uncrowded n (%)
Maxillary		
Male (n=22)	10 (45.5)	12(54.5)
Female (n=28)	10 (35.7)	18 (64.3)
Mandibular		
Male (n=22)	13(59.1)	9 (40.9)
Female (n=28)	17 (60.7)	11(39.3)

Table 3: Maxillary Intercanine and Intermolar width in Crowded and Uncrowded Female Population

Maxilla Arch width	Crowded (n = 10) Mean±SD (mm)	Uncrowded (n=18) Mean±SD (mm)	P Value
Intercanine	27.13±1.39	29.31±4.17	0.06
Intermolar	37.73±2.30	38.07±4.89	0.807

Table 4: Maxillary Intercanine and Intermolar width in Crowded and Uncrowded Male Population

Maxilla Arch width	Crowded (n = 10) Mean±SD (mm)	Uncrowded (n=12) Mean±SD (mm)	P Value
Intercanine	26.92±3.05	27.76±2.29	0.479
Intermolar	37.11±4.13	38.47±1.48	0.305

Table 5: Mandibular Intercanine and Intermolar width in Crowded and Uncrowded Female Population

Mandibular Arch width	Crowded (n = 17) Mean±SD (mm)	Uncrowded (n=11) Mean ±SD (mm)	P Value
Intercanine	20.48±244	26.67±4.81	0.002
Intermolar	33.35±2.57	36.89±4.98	0.44

Table 6: Mandibular Intercanine and Intermolar width in Crowded and Uncrowded Male Population

Mandibular Arch width	Crowded (n = 13) Mean±SD (mm)	Uncrowded (n=9) Mean±SD (mm)	P Value
Intercanine	21.54±2.47	26.11±5.43	0.014
Intermolar	33.49±2.34	36.44±5.17	0.138

DISCUSSION

Knowledge of dental arch widths in a population plays a key role in orthodontics. The size and shape of the arches will have considerable implications in orthodontics and treatment planning affecting space available, dental aesthetics and stability of the dentition (Lee, 1999; Aluko et al, 2009).

In this study, the mean maxillary IC (intercanine) and IM (intermolar) in uncrowded female population was higher than the values obtained in the crowded group, though the difference was not statistically significant. This finding varied with previous studies (Waheed & Imran Rahbar, 2005; Poosti & Jalali, 2007; Rasheed et al., 2018) which recorded statistically significant difference between crowded and uncrowded subjects. However, in a previous study (Waheed & Imran Rahbar, 2005) there was significant difference in IM width between crowded and uncrowded subjects while there was no significant difference in IC width between crowded and uncrowded subjects. This finding in IC width between crowded and uncrowded subjects by Waheed & Imran Rahbar (2005) was similar to findings on maxillary IC width in crowded and uncrowded female population in this study. This study recorded higher values in maxillary IC and IM width in uncrowded male population when compared to the crowded group, though the difference was not statistically significant. This finding was at variance with previous studies (Poosti & Jalali, 2007; Rasheed et al, 2018) which recorded significant difference in maxillary IC and IM width between uncrowded and crowded subjects. Findings from this study also varied with that of previous study on IM width (Waheed & Imran Rahbar, 2005) between uncrowded and crowded population which was significantly different. This study recorded no

significant difference in maxillary IC width in males between uncrowded and crowded population which was similar to finding from previous study (Waheed & Imran Rahbar, 2005).

In this study, the mandibular IC width in uncrowded female population was higher than the values recorded in the crowded group, which was significant. This was similar to findings in previous studies (Poosti & Jalali, 2007; Rasheed et al, 2018). Sillman (1964) and Randzic (1988) recorded statistically significant difference between uncrowded and crowded population in maxillary and mandibular IC and IM width, which is at variance to findings on mandibular IM width in uncrowded and crowded females in this study where there was no significant difference.

This study recorded higher mandibular IC width in uncrowded male population when compared to the crowded group which was statistically significant. This was similar to findings from previous studies (Sillman, 1964; Randzic, 1988; Poosti & Jalali, 2007; Rasheed et al, 2018). The mandibular IM width in the male population in this study was higher in the uncrowded group when compared to the crowded group, which was not statistically significant. This is at variance with findings in previous studies (Sillman, 1964; Randzic, 1988; Poosti & Jalali, 2007; Rasheed et al, 2018).

This study recorded higher mean values for IC and IM widths in males when compared to the female group except in the maxillary IC width (uncrowded), maxillary IM width (crowded) and mandibular IC width (uncrowded) where males recorded lower values when compared to females. This is at variance with previous studies (Sillman, 1964; Randzic, 1988; Poosti & Jalali, 2007; Rasheed et al, 2018; Saheed & Mageet, 2018) which recorded significantly higher mean values for maxillary and mandibular IC and IM widths in males when compared to females. Aluko et al (Aluko et al, 2009) recorded no significant difference between male and female mandibular IC and IM widths though the male values were slightly higher.

CONCLUSION

This study recorded higher values of IC and IM widths in the maxillary and mandibular arches of uncrowded male and female population when compared to the crowded group, though the difference was not statistically significant except in the female and male IC width recorded in the mandibular arch which was statistically significant. Higher mean values of IC and IM widths was recorded in males except in the maxillary IC width (uncrowded), maxillary IM width (crowded) and mandibular IC width (uncrowded) where males recorded lower values compared to females.

RECOMMENDATIONS

1. All patients seeking orthodontic treatment should have study models made as part of their records.
2. IC (intercanine) and IM (intermolar) widths should be assessed on all dental casts of pre-treatment orthodontic patients because it is necessary for diagnosis and treatment planning.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

REFERENCES

Adeyemi TA (1999). Mesiodistal crown dimensions of permanent teeth in a Nigerian population. FWACS Thesis.

Al-Khateeb SN, Abu-Alhaija ESJ (2006). Tooth size discrepancies and arch parameters among different malocclusions in a Jordanian sample. Angle Orthod; 76:459-465.

Aluko IA, da Costa OO, Isiekwe MC (2009). Dental arch widths in the early and late permanent dentitions in a Nigerian population. Nig Dent J; 17:7-11.

Andrews LF (1972). The six keys to normal occlusion. Am J Orthod:63-296.

Angle EH (1899). Classification of malocclusion. Dent Cosmos; 41:248-264.

Beecher RM, Corucini RS (1981). The effects of dietary consistency on craniofacial and occlusal development in the rat. Angle Orthod:61-69.

Bishara SE, Jacobson JR, Treder J, Nowak A (1997). Arch width changes from 6 weeks to 45 years of age. Am J Orthod Dentofac Orthop; 111:401-409.

Burns BG, Harris E (2000). Maxillary arch size and shape in American blacks and whites. Angle Orthod; 70:297-302.

Buschang PH, Stroud J, Alexander RG (1994). Differences in dental arch morphology among adult females with untreated Class-I and Class-II malocclusions. Eur J Orthod; 16:47-52.

Carey CW (1958). Treatment planning and the technical program in the four fundamental treatment forms. Am j Orthod; 44:887-898.

Cassidy KM, Tolley EA (1998). Genetic influence on dental arch form in orthodontic patients. Angle Orthod; 68:445-454.

daCosta OO (1999). The prevalence of malocclusion among a population of northern Nigerian school children. West Afr J Med; 18:91-96.

Dekock WH (1972). Dental arch depth and width studied longitudinally from 12 years of age to adulthood. Am J Orthod; 62:56-66.

Graber TM, Vanarsdall IR (2000). Orthodontics, Current Principles and Techniques. 3rd ed St Louis: Mosby; P.395-397, 408.

Gross AM, Kellin GD, Franz D, Michas K, Walker M, Foster M et al (1994). A longitudinal evaluation of open mouth posture and maxillary arch width in children. Angle Orthod; 64:419-424.

Harper C (1994). A comparison of medieval and modern dentitions. Eur J Orthod; 16:163-173.

Harris EF (1997). A longitudinal study of arch size and form in untreated adults. Am J Orthod Dentofac Orthop; 111:419-427.

Huckaba GW (1964). Arch size analysis and tooth size prediction. Dent Clin N Am:431-440.

Lee RT (1999). Arch and form: A review. Am J Orthod Dentofac Orthop; 115:305-315.

Mack PJ (1981). Maxillary arch and central incisor dimensions in a Nigerian and British population sample. J Dent; 9:67-70.

McDougall PD, McNamara JA jr, Dierkes JM (1982). Arch width development in class II patients treated with the Frankel appliance. Am J Orthod; 82:10-22.

Ogaard B, Larsson E, Lindsten R (1994). The effect of sucking habit, cohort gender, intercanine width and breast or bottle feeding on posterior crossbite in Norwegian and Swedish 3 year old children. Am J Orthod Dentofac Orthop; 106:161-166.

Onyeaso CO (2004). Prevalence of malocclusion among adolescents in Ibadan Nigeria. Am J Orthod Dentofac Orthop; 126:604-607.

Otuyemi OD, Noar JH (1996). A comparison of crown size dimensions of a Nigerian and British population. Eur J Orthod; 18:623-628.

Otuyemi OD, Ogunyinka A, Dosunmu O, Cons NC, Jenny J (1999). Malocclusion and orthodontic treatment need of secondary schools in Nigeria according to the dental aesthetic index (DAI). Int Dent J; 49:203-210.

Poosti M, Jalali T (2007). Tooth size and arch dimensions in uncrowded versus class I malocclusions. J Contemp Dent Pract; 8:1-8.

Proffit WR, Fields HW (2000). Contemporary Orthodontics. 3rd ed St. Louis: Mosby. P. 108-110.

Raberin M, Laumon B, Martin J, Brunner F (1993). Dimensions and form of dental arches in subjects with normal occlusion. Am J Orthod Dentofac Orthop; 104:67-72.

Randzic D (1988). Dental crowding and relationship to mesiodistal crown diameters and arch dimension. Am J Orthod Dentofac Orthop; 94:50-56.

Saeed HK, Mageet AO (2018). Dental arch dimensions and form in a Sudanese sample. J Contemp Dent Pract; 19:1235-1241.

Sillman JH (1964). Dimensional changes of dental arches. Longitudinal study from birth to 25 years. Am J Orthod; 50:824-831.

Waheed UH, Imran Rahbar M (2005). Dental crowding and its relationship to tooth size and arch dimensions. Pakistan Oral & Dent J; 25:47-52.

Welland FJ, Jonke E, Banteleon HP (1997). Secular trends in malocclusion in Australian men. Eur J Orthod; 50:824-831.

Younes SA (1984). Maxillary dimensions in Saudi and Egyptian population sample. Am J Orthod; 85:83-88.