European Journal of Orthodontics 32 (2010) 472–476
doi:10.1093/ejo/cjp138
Advance Access Publication 4 February 2010

Mesiodistal angulations of the mandibular canines, premolars and molars with or without the presence of third molars

Osmar Aparecido Cuoghi, Rodrigo Castellazzi Sella and Marcos Rogério de Mendonça
Department of Pediatric and Social Dentistry, Discipline of Orthodontics, School of Dentistry, São Paulo State University, UNESP, Araçatuba, São Paulo, Brazil

SUMMARY The purpose of the present research was to compare the normal average values of mesiodistal axial angulation, with the mesiodistal axial angulation of canines, premolars and mandibular molars in individuals with and without the presence of the mandibular third molars. Panoramic radiographs of 19 male and 21 female Caucasians, with a mean age of 22.35 years, who had not undergone orthodontic treatment were studied. The subjects were divided into two groups: group I, 20 radiographs of subjects without, and group II, 20 radiographs of subjects with mandibular third molars. The mean values of the groups were compared using a Student's *t*-test.

The results show that, in both groups, the mandibular premolars and molars had enhanced angulation in the mesial direction, when compared with a control group of 42 Caucasians ranging in age from 12 to 17 years with a 'normal' occlusion ($P < 0.05$), while the mesiodistal axial angulation of the mandibular canines was similar to the control group ($P < 0.05$). The two groups, when compared, exhibited similar angular values for the canines, premolars and mandibular molars ($P < 0.05$), indicating no influence of the third molars.

Introduction

Throughout history, different methods for achieving correct tooth angulation at the end of orthodontic treatment have been used. Initially, angulations were obtained through artistic bends in the wires, following the angulation of the brackets (Holdaway, 1952). These angulations were obtained by an appliance developed by Andrews (1976a,b,c) incorporating standard brackets; the necessary requirements for obtaining the 'six keys for normal occlusion'.

Appropriate dental mesiodistal angulation is necessary. Dental positioning is an important factor since stability of the stomathognathic system can be maintained through neutralization of occlusal forces and the provision of normal function (Roth, 1981, 1987).

Thus, mesial force is intimately related to well-defined contact points, dependent on correct axial angulation and the occlusal relationship of a tooth against two teeth. Therefore, the appropriate axial angulation should be included in the orthodontic treatment objectives, as accurate angulation is directly related to dental alignment. Additionally, providing correct angulation is a decisive factor for long-term stability of the treatment results (Dewel, 1949; Swessi and Stephens, 1993; Årtun *et al.*, 2005).

The panoramic radiograph constitutes an auxiliary method of diagnosis, allowing the visualization of a series of anatomical structures and relevant factors. The simplicity of acquisition and the increased amount of information obtained, combined with patient comfort and the minimal amount of exposure to radiation, make the panoramic radiograph an instrument well used in dentistry and in orthodontics (Graber, 1966; Phillips, 1967). Accurate measurement of structures on dental panoramic tomograms (DPTs) is possible, provided sufficient care is taken with head positioning (Stramotas *et al.*, 2002). These radiographs should be obtained under standardized conditions with a cephalostat, with the clinical Frankfort horizontal plane parallel to floor and the facial midline plane in a vertical position (Akcam *et al.*, 2003).

A panoramic image is made by generating an image layer or a focal trough in a standardized jaw form and size. Any deviation from this will result in some distortion of an object that is not centred in the image layer (Langland *et al.*, 2002). The reliability of the panoramic radiograph for angular measurements has been demonstrated by mathematical calculations and confirmed experimentally (Frykholm *et al.*, 1977; Phillip and Hurst, 1978; Samawi and Burke, 1984). Other researchers have developed methods for evaluation of dental mesiodistal angulations (Tavano *et al.*, 1989; Ursi *et al.*, 1990).

There are two theories concerning the influence of the third molars. The first is that these teeth are capable of causing interferences, generating certain irregularities in the positioning of adjacent teeth (Bergström and Jensen, 1961; Vego, 1962), and the second that the third molars do not have this capacity (Weinstein, 1971; Ades *et al.*, 1990), or that other factors might be involved (Richardson, 1989).

Despite a large number of studies (Dewel, 1949; Holdaway, 1952; Roth, 1981, 1987; Ursi *et al.*, 1990; Swessi and Stephens, 1993) involving measurement of dental angulations, there are many uncertainties regarding appropriate treatment and whether the presence of the third molars is capable of causing alterations in the positioning of other teeth. Therefore, the purpose of this research was to compare the normal mean values of the dental mesiodistal angulation, proposed by Ursi *et al.* (1990), with the mesiodistal angulation of canines, premolars and mandibular molars in subjects with and without mandibular third molars.

Materials and methods

The sample consisted of panoramic radiographs of 19 male and 21 female Brazilian Caucasians with a mean age of 22.35 years (range 18–25 years) that had not undergone orthodontic treatment and had all teeth present, except for the third molars in 20 individuals. The radiographs were divided into two groups: group I, 20 subjects with the mandibular third molars absent due to agenesis, and group II, subjects with the presence of mandibular third molars. Individuals that presented agenesis of any tooth, except for the third molars, were excluded from the sample, as well as those with supernumerary teeth.

In group I, 12 subjects exhibited a Class I malocclusion (6 females and 6 males) and 8 a Class II malocclusion (5 females and 3 males) and in group II, 10 subjects had a Class I malocclusion (6 females and 4 males) while the other 4 females and 6 males exhibited a Class II malocclusion.

To select the group II radiographs, the third molars had to be present with a root length equal to or greater than the crown stage (F stage) according to Demirjian *et al.* (1973). This stage presents high eruption potential. According to Richardson (1979), development of lower arch crowding in late adolescence is a common orthodontic problem.

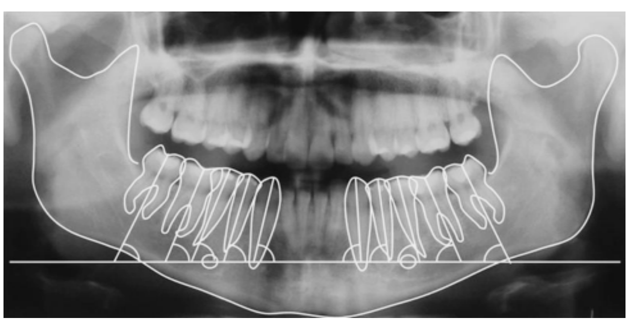

Figure 1 Superimposition of tracing on the panoramic radiograph. The angles formed by the reference line and the long axes of the teeth were: A_{33} and A_{43}—intersection of the long axes of the mandibular left and right canines; A_{34} and A_{44}—intersection of the long axes of the mandibular left and right first premolars; A_{35} and A_{45}—intersection of the long axes of the mandibular left and right second premolars; A_{36} and A_{46}—intersection of the long axes of the mandibular left and right first molars; and A_{37} and A_{47}—intersection of the long axes of the mandibular left and right second molars.

The dentoalveolar and skeletal structures drawn on the radiographs were the external profile of the mandible, the mental foramen and the contours of the canines, premolars and mandibular molars (Tavano *et al.*, 1989). A reference line was used to determine the angular measurements of the mandibular teeth. This reference line passed through the centre of the mental foramen.

To determine the long axes of single-rooted teeth (canine, first and second premolars), the image of the root canal at its longest aspect was used, while the long axes of double-rooted teeth (first and second molars) followed the average image of the mesial and distal root canals (Ursi *et al.*, 1990; Figure 1).

The tracings were digitized with a scanner (Genius Color-Page-Vivid III, Hong Kong, China) and the angle A_{43}, A_{33}, A_{44}, A_{34}, A_{45}, A_{35}, A_{46}, A_{36}, A_{47} and A_{37} (Figure 1), formed by the intersection of the long axes of the teeth with the reference line were determined using the AutoCAD 2000 software program (Autodesk Inc., San Rafael, California, USA).

The mean values of group I were compared with those of group II.

The mean values of the two groups were also compared with those of a control group (42 Caucasians ranging in age from 12 to 17 years) who presented with a normal untreated occlusion and exhibited normal mean values for mesiodistal angulations (Ursi *et al.*, 1990). This control sample, used previously by Almeida-Pedrin *et al.* (2006), was obtained from the files of the University of São Paulo Growth Study. They had a full complement of teeth (except third molars), a Class I canine and molar relationship, a maximum overbite of 3 mm, and a maximum overjet of 1 mm.

Method error assessment

The method error was determined through random selection of 10 panoramic radiographs from each of the two groups

Table 1 Means and standard deviations (SDs) of the differences, 't' values (systematic error), P levels and Dahlberg values (casual error) in group I n = 20 (with the mandibular third molars absent).

Angle	Mean	SD	t	P	Dahlberg
A_{47}	0.87	0.48	−4.02	0.99	0.98
A_{46}	1.05	0.59	−2.34	0.98	1.43
A_{45}	0.88	0.76	−2.53	0.98	1.31
A_{44}	1.13	0.39	−2.93	0.99	1.42
A_{43}	0.92	0.47	−3.83	0.99	1.05
A_{33}	1.03	0.55	−2.64	0.99	1.34
A_{34}	1.06	0.49	−2.75	0.99	1.36
A_{35}	1.03	0.60	−2.45	0.98	1.39
A_{36}	1.05	0.56	−2.52	0.98	1.38
A_{37}	0.95	0.34	−5.03	0.99	1.01

that were traced and measured twice by the same author (RCS), with an interval of 30 days (Houston, 1983).

The random error was determined using the formula proposed by Dahlberg (1940): $S_e^2 = \sum d^2 / 2n$, where S_e is the standard error of the method, d is the difference between repeated measurements of a variable and n is the number of repeated measurements. Systematic errors were determined using a Student's t-test.

Dahlberg values are recognized as significant when above 1.5 degrees (Sandler, 1988; Liu and Gravely, 1991).

Table 2 Means and standard deviations (SDs) of the differences, 't' values (systematic error), P levels and Dahlberg values (casual error) in group II, $n = 20$ (with the presence of the mandibular third molars).

Angle	Mean group	SD	t	P	Dahlberg
A_{47}	0.95	0.34	−5.03	0.99	1.01
A_{46}	0.93	0.62	−2.84	0.99	1.23
A_{45}	1.05	0.56	−2.52	0.98	1.38
A_{44}	1.06	0.49	−2.75	0.99	1.36
A_{43}	1.05	0.59	−2.34	0.98	1.43
A_{33}	1.13	0.39	−2.93	0.99	1.42
A_{34}	0.88	0.76	−2.53	0.98	1.31
A_{35}	1.03	0.60	−2.45	0.98	1.39
A_{36}	0.92	0.47	−3.83	0.99	1.05
A_{37}	0.87	0.48	−4.02	0.99	0.98

Table 3 Means and standard deviations (SDs) of the mesiodistal angulations of the canines, premolar and mandibular molars in groups I (third molars present), II (third molars absent) and the controls.

Angle	Mean group I ($n = 20$)	SD	Mean group II ($n = 20$)	SD	Control group mean ($n = 42$)	SD
A_{47}	58.72	5.15	61.63	7.45	74.92	5.13
A_{46}	65.36	5.50	68.06	6.09	82.64	4.35
A_{45}	75.73	4.11	73.89	5.33	88.47	5.94
A_{44}	82.14	4.65	81.67	3.49	86.42	4.13
A_{43}	87.96	5.69	85.76	3.44	88.02	3.55
A_{33}	84.60	5.77	84.84	5.70	86.11	4.23
A_{34}	82.28	4.19	82.14	4.66	85.57	4.09
A_{35}	73.58	4.26	73.49	5.85	88.69	5.38
A_{36}	67.24	4.93	68.97	6.61	85.50	4.48
A_{37}	60.93	5.70	62.79	7.93	76.92	5.70

Results

The method error was within acceptable parameters and did not compromise the reliability of the conclusions (Tables 1 and 2).

The mean values and standard deviations for the canines, premolars and molars in groups I and II and the control are shown in Table 3, and comparisons of angular mean values between the groups in Table 4. A value of $P < 0.05$ was considered as being statistically significant.

Discussion

The panoramic radiographs were obtained in the same DPT (Rotograph Plus, Milano, Italy) and all the subjects positioned in the DPT fitted the universal focal trough and did not compromise the fidelity of the angular measurements values extracted from the radiograph.

The values for groups I and II were compared individually with the normal mean values of the control group (Ursi *et al.,* 1990). Additionally, in accordance with the methodology used, smaller angular values than those shown by the control group represented a situation of accentuated crown angulation in a mesial direction.

Comparison of the angular values of groups I and II with the controls demonstrated a statistically significant difference ($P < 0.05$) for the premolars and molars (Figure 2).

In both groups I and II, the angles were smaller than those in the control group. Thus, it can be inferred that in Class I and Class II malocclusion subjects with or without third molars, the crowns of the premolars and molars are more

Table 4 Comparisons of the mean angular values between the control and group I (third molars present), control and group II (third molars absent), and groups I and II .

Angle	Control group	Group I	P	Control group	Group II	P	Group I	Group II	P
A_{47}	74.92	58.72	*	74.92	61.63	*	58.72	61.63	0.15
A_{46}	82.64	65.36	*	82.64	68.06	*	65.36	68.06	0.14
A_{45}	88.47	75.73	*	88.47	73.89	*	75.73	73.89	0.22
A_{44}	86.42	82.14	*	86.42	81.67	*	82.14	81.67	0.89
A_{43}	88.02	87.96	0.95	88.02	85.76	0.02	87.96	85.76	0.14
A_{33}	86.11	84.60	0.25	86.11	84.84	0.32	84.60	84.84	0.89
A_{34}	85.57	82.28	*	85.57	82.14	*	82.28	82.14	0.92
A_{35}	88.69	73.58	*	88.69	73.49	*	73.58	73.49	0.95
A_{36}	85.50	67.24	*	85.50	68.97	*	67.24	68.97	0.35
A_{37}	76.92	60.93	*	76.92	62.79	*	60.93	62.79	0.40

*$P < 0.05$.

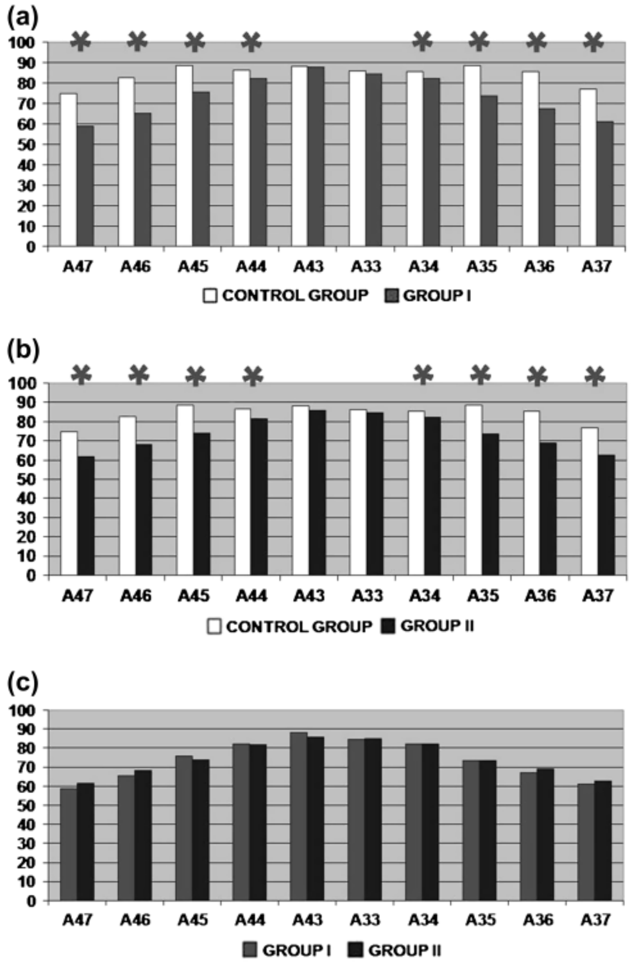

Figure 2 Comparisons of angular mean values of the control and group I (**a**), control and group II (**b**) and groups I and II (**c**). *$P < 0.05$.

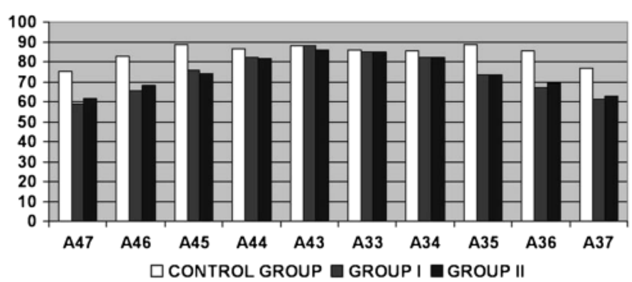

Figure 3 Mean of angular values for the control and groups I and II.

angulated in a mesial direction when compared with subjects with a normal occlusion.

Considering that the aim of orthodontic treatment is to provide the same mesiodistal angulation as in a normal occlusion (Ursi *et al.,* 1990), the axial mesiodistal angulation of the mandibular premolars and molars should receive special attention at the end of treatment. While, the angular values in subjects with malocclusions were smaller in relation to those with a normal occlusion (Figure 2), when the means of the mesiodistal angulation of the canines, premolars and mandibular molars in groups I and II were compared (Figure 2), there was no difference between the groups. The values between the groups and the difference in these values compared with the subjects with a normal occlusion (Figure 3) were similar.

Individuals with a malocclusion who had not undergone orthodontic treatment had mandibular premolars and molars with an increased mesiodistal angulation, independent of the presence of mandibular third molars. Correction of premolar and molar angulation during orthodontic treatment should be established as one of the requirements for the correction of malocclusion, independent of the presence of third molars.

The reduced angular values, corresponding to an accentuated mesial crown angulation in groups I and II, can be related to other factors inherent in malocclusions. These include a deep curve of Spee, influence of the anterior component of force by functional vectors and dental wear. The findings of the present study demonstrate that the third molars exercise little or no influence in the mesiodistal angular positioning of the canines, premolars and mandibular molars.

Considering the two theories on the development of the third molars, the results of the present research are in agreement with those of Weinstein (1971) and Ades *et al.* (1990) that third molars have a negative effect contrary to the older theory of Bergström and Jensen (1961) and Vego (1962). This more current theory considers that the aetiology of these alterations is multifactorial (Richardson, 1989), involving the dynamics of the stomathognathic system, such as the anterior component of force and the presence of correct interdental contacts (Weinstein, 1971).

Individuals with Class I and II malocclusions did not exhibit angulations of the premolars and molars, similar to subjects with a normal occlusion (Ursi *et al.,* 1990). These teeth presented smaller values; in other words, they exhibited crowns more angulated in the mesial direction when compared with the normal pattern.

The canines did not show an influence on the malocclusion from the third molars. Therefore, according to the findings of the study, the canines have mean values similar to the normal pattern.

This investigation did not consider bone architecture, but it is a significant factor that can influence tooth movement (Oppenheim, 1911). There are also racial differences in craniofacial morphology among populations (Ishii *et al.,* 2002) and the condition of subjects in whom third molars have been extracted should be considered. Thus, for precise information about how these factors can influence mesiodistal angulations, future investigations are necessary.

Conclusions

Individuals with and without the presence of the mandibular third molars and with a malocclusion who had not undergone orthodontic treatment, when compared with a control group of normal occlusion subjects, exhibited:

1. Mandibular premolars and molars more angulated in the mesial direction.
2. Mandibular canines with similar mesiodistal angulations.

The two groups investigated presented similar values for mesiodistal angulations for the canines, premolars and mandibular molars so that:

1. The presence of the third molars did not influence these dental angulations.
2. The largest mesiodistal angulation was found for the premolars and mandibular molars in both groups, suggesting that this is a characteristic related to factors inherent in malocclusions with little influence of the third molars.

Address for correspondence

Professor Osmar Aparecido Cuoghi
Rua Jose Bonifácio 1193
CEP: 16015-050—Araçatuba
SP
Brazil
E-mail: osmar@foa.unesp.br

References

Ades A G, Joondeph D R, Little R M, Chapko M K 1990 A long-term study of the relationship of third molars to changes in the mandibular dental arch. American Journal of Orthodontics and Dentofacial Orthopedics 97: 323–335

Akcam M O, Altiok T, Ozdiler E 2003 Panoramic radiographs: a tool for investigating skeletal pattern. American Journal of Orthodontics and Dentofacial Orthopedics 123: 175–181

Almeida-Pedrin R R, Pinzan A, Almeida R R, Ursi W, Almeida M R 2006 Panoramic evaluation of mesiodistal axial inclinations of maxillary anterior teeth in orthodontically treated subjects. American Journal of Orthodontics and Dentofacial Orthopedics 130: 56–60

Andrews L F 1976a The diagnostic system: occlusal analysis. Dental Clinics of North America 20: 671–690

Andrews L F 1976b The straight-wire appliance, origin, controversy, commentary. Journal of Clinical Orthodontics 10: 99–114

Andrews L F 1976c The straight-wire appliance. Explained and compared. Journal of Clinical Orthodontics 10: 174–195

Årtun J, Thalib L, Little R M 2005 Third molar angulation during and after treatment of adolescent orthodontic patients. European Journal of Orthodontics 27: 590–596

Bergström K, Jensen R 1961 Responsibility of the third molar for secondary crowding. Svensk Tandläkare Tidskrift 54: 111–124

Dahlberg G 1940 Statistical methods for medical and biological students. George Allen and Unwin Ltd, London

Demirjian A, Goldstein H, Tanner J M 1973 A new system of dental age assessment. Human Biology 45: 211–227

Dewel B F 1949 Clinical observations on the axial inclination of teeth. American Journal of Orthodontics 35: 98–105

Frykholm A, Malmgren O, Sämfors K A, Welander U 1977 Angular measurements in orthopantomography. Dentomaxillofacial Radiology 6: 77–81

Graber T M 1966 Panoramic radiography. Angle Orthodontist 36: 293–311

Holdaway R A 1952 Bracket angulation as applied to the edgewise appliance. Angle Orthodontist 22: 227–236

Houston W J B 1983 The analysis of errors in orthodontic measurements. American Journal of Orthodontics 83: 382–390

Ishii N, Deguchi T, Hunt N P 2002 Craniofacial differences between Japanese and British Caucasian females with a skeletal Class III malocclusion. European Journal of Orthodontics 24: 493–499

Langland O E, Langlais R P, Preece J W 2002 Principles of dental imaging. Lippincott Williams & Wilkins, Baltimore

Liu Y T, Gravely J F 1991 The reliability of the 'Ortho Grid' in cephalometric assessment. British Journal of Orthodontics 18: 21–27

Oppenheim A 1911 Tissue changes, particularly of the bone, incident to tooth movement. Transactions of the European Orthodonstic Society pp. 303–359

Phillip R G, Hurst R V 1978 The cant of the occlusal plane and distortion in the panoramic radiograph. Angle Orthodontist 48: 317–323

Phillips J E 1967 Principles and function of the orthopantomograph. Oral Surgery, Oral Medicine, Oral Pathology 24: 41–49

Richardson M E 1979 Late lower arch crowding: facial growth or forward drift? European Journal of Orthodontics 1: 219–225

Richardson M E 1989 The role of the third molar in the cause of late lower arch crowding: a review. American Journal of Orthodontics and Dentofacial Orthopedics 95: 79–83

Roth R H 1981 Functional occlusion for the orthodontist. Part III. Journal of Clinical Orthodontics 15: 174–198

Roth R H 1987 The straight-wire appliance 17 years later. Journal of Clinical Orthodontics 21: 632–642

Samawi S S, Burke P H 1984 Angular distortion in the orthopantomogram. British Journal of Orthodontics 11: 100–107

Sandler P J 1988 Reproducibility of cephalometric measurements. British Journal of Orthodontics 15: 105–110

Stramotas S, Geenty J P, Petocz P, Darendeliler M A 2002 Accuracy of linear and angular measurement on panoramic radiographs taken at various positions *in vitro*. European Journal of Orthodontics 24: 43–52

Swessi D M, Stephens C D 1993 The spontaneous effects of lower first premolar extraction on the mesio-distal angulation of adjacent teeth and the relationship of this to extraction space closure in the long term. European Journal of Orthodontics 15: 503–511

Tavano O, Ursi W J S, Almeida R R, Henriques J F C 1989 Determinação de linhas de referência para medições angulares em radiografias ortopantomográficas. Odontólogo Moderno 16: 22–25

Ursi W J S, Almeida R R, Tavano O, Henriques J F 1990 Assessment of mesiodistal axial inclination through panoramic radiography. Journal of Clinical Orthodontics 24: 166–173

Vego L 1962 A longitudinal study of mandibular arch perimeter. Angle Orthodontist 32: 187–192

Weinstein S 1971 Third molar implications in orthodontics. Journal of the American Dental Association 82: 819–823