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Mandibular third molar space in different antero-posterior skeletal patterns

E. S. J. Abu Alhaija, H. M. AlBhairan and S. N. AlKhateeb
Department of Preventive Dentistry, Faculty of Dentistry, Jordan University of Science and Technology, Irbid, Jordan

Correspondence to: Professor E. S. J. Abu Alhaija, Department of Preventive Dentistry, Faculty of Dentistry, Jordan University of Science and Technology, PO Box 3030, Irbid, Jordan. E-mail: elham@just.edu.jo

SUMMARY Retromolar space has long been identified as a major factor in the aetiology of mandibular third molar impaction. The aims of this study were to compare mandibular third molar space between the different antero-posterior (A-P) skeletal patterns, between erupted and impacted third molars in the different A-P skeletal patterns, and to report on the status of third molar eruption/impaction among the studied subjects.

A total of 432 mandibular third molars in 270 subjects (132 females and 138 males) were investigated from dental pantomograms (DPTs) and lateral cephalograms (LC). The average age for the total sample was 20.80±2.03 years. The subjects were divided into three groups according to their ANB angle as follows: skeletal Class I (144 third molars in 90 subjects), skeletal Class II (145 third molars in 95 subjects), and skeletal Class III (143 third molars in 85 subjects). Each group was subdivided into impacted and erupted subgroups. DPT and LC were traced and the following variables were measured: retromolar space width, third molar width and angulation, β angle, second molar angulation, mandibular length, and gonial angle. Independent *t*-test, analysis of variance, and chi-square test were used for statistical analysis.

Retromolar space width in the Class III subjects was smaller than in the Class I subjects ($P<0.05$). Mandibular third molars were recorded as impacted in 26, 32, and 42 per cent of the Class I, II, and III subjects, respectively ($P<0.001$). The impacted groups had a reduced retromolar space width, increased β angle, and reduced third molar angulation in all A-P skeletal patterns. Class III subjects showed increased mandibular third molar impaction with reduced retromolar space width.

Introduction

The rate of third molar impaction is higher than for other teeth in modern populations (Bishara and Andreasen, 1983; Grover and Lorton, 1985). The mandibular third molar is by far the most frequently impacted tooth after the maxillary third molar (Bishara and Andreasen, 1983; Grover and Lorton, 1985; Alling and Alling, 1993). They account for 98 per cent of all impacted teeth (Bishara, 1999).

It has been reported that approximately 73 per cent of young adults may have at least one impacted mandibular third molar (Hugoson and Kugelberg, 1988). The prevalence of mandibular third molar impaction varies in different populations, ranging from 18 to 32 per cent (Andreasen, 1997). Most studies have reported no gender predilection in Caucasian (Brown *et al*., 1982), Negro (Kramer and Williams, 1970; Brown *et al*., 1982), Arab (Haidar and Shalhoub, 1986; Hattab *et al*., 1995), or Chinese (Montelius, 1932) populations. However, other studies reported a higher frequency in female Caucasians (Murtomaa *et al*., 1985; Hugoson and Kugelberg, 1988).

The time of eruption of third molars varies significantly between populations, ranging from 14 years in Nigerians (Odusanya and Abayomi, 1991) to 24 years in Greeks (Haralabakis, 1957), with males 3–6 months ahead of females.

Shortage of space between the second molar and the ramus has long been identified as a major factor in the aetiology of mandibular third molar impaction (Björk, 1963; Olive and Basford, 1981; Alling and Alling, 1993; Hattab and Abu Alhaija, 1999; Behbehani *et al*., 2006; Uthman, 2007). Björk *et al*. (1956) noted that in subjects with mandibular third molar impaction, the alveolar arch space behind the second molar was reduced in 90 per cent of the cases. It has been reported that the space necessary for the third molar is diminished by several factors, including backward direction of eruption of the dentition (Björk *et al*., 1956; Richardson, 1977; Capelli, 1991) and vertical direction of condylar growth, which has been associated with less resorption at the anterior aspect of the ramus (Björk, 1963). Another suggested factor that influences third molar impaction is mandibular length (Björk *et al*., 1956; Richardson, 1977; Capelli, 1991). It has been suggested that a short mandibular length predisposes to mandibular third molar impaction (Björk *et al*., 1956; Richardson, 1977; Ricketts, 1979). However, Kaplan (1975) and Dierkes (1975) did not find significant differences in mandibular length between subjects with impacted and erupted teeth.

It has been reported that subjects with third molar impaction possess larger third molars than those with erupted third molars (Richardson, 1977; Ng *et al*., 1986; Ventä *et al*., 1997; Hattab and Abu Alhaija, 1999).

In a study to investigate symmetry of third molar space and angulation in Class II subdivision malocclusions, Janson *et al*. (2007) reported significant differences in maxillary and mandibular third molar space availability and in third molar angulation between Class I and Class II molar sides.

Little research has been conducted on mandibular third molar space and the status of third molar eruption/impaction in the different antero-posterior (A-P) skeletal patterns. The aims of this study were to compare mandibular third molar space between the different A-P skeletal patterns, to compare mandibular third molar space between erupted and impacted molar teeth in the different A-P skeletal patterns, and to report on the status of third molar eruption/impaction among the studied subjects.

Materials and methods

The study was carried out on diagnostic (pre-treatment) lateral cephalometric (LC) films and dental pantomograms (DPTs) available in the archive of the Dental Teaching Center of Jordan University of Science and Technology. A total of 432 third molars in 270 Caucasian subjects (132 females and 138 males) were included in this study (Table 1). A total of 108 subjects had unilateral presence of third molars. Subjects included in this study fulfilled the following criteria: at least 18 years of age, no previous orthodontic or orthognathic surgical treatment, no missing or extracted permanent teeth, no history of medical conditions that could have altered the growth of the apical base, and average maxillomandibular planes (MM) angle 27±5 degrees. MM angle averaged 26.73±2.42 degrees.

Patients with pathological conditions related to mandibular second and third molars such as cysts or extensive caries were excluded. Those with poor quality DPTs were also excluded.

Table 1 Distribution of subjects in this study.

	Females (no. of third molars/no. of subjects)	Males (no. of third molars/no. of subjects)	Total (no. of third molars/no. of subjects)
Class I skeletal relationship	75/47	69/43	144/90
Class II skeletal relationship	76/50	69/45	145/95
Class III skeletal relationship	58/35	85/50	143/85

The age of subjects in this study ranged between 18 and 30 years. The average age for the total sample was 20.80±2.03 years. The subjects were divided into three groups according to their ANB angle as follows:

Skeletal Class I (ANB 1–5 degrees)—144 third molars in 90 subjects (47 females and 43 males). ANB angle averaged 2.62±1.16 degrees (2.60±1.13 and 2.65±1.19 in females and males, respectively).

Skeletal Class II (ANB more than 5 degrees)—145 third molars in 95 subjects (50 females and 45 males). Average ANB angle was 6.32±1.39 degrees (6.13±1.18 and 6.42±1.46 in females and males, respectively).

Skeletal Class III (ANB less than 1 degree)—143 third molars in 85 subjects (35 females and 50 males). ANB angle averaged −2.20±2.64 degrees (−1.93±1.88 and −2.36±3.04 in females and males, respectively).

LC were taken for each participant in centric occlusion with the lips in repose and the Frankfort plane horizontal, according to the natural head position, using an Orthoslice 1000 C (Trophy, Marne La Vallee Cedex 2, France) cephalostat at 64 KVp, 16 mA, and 0.64 seconds exposure. LC were used to allocate subjects to their groups based on ANB angle and to measure mandibular length (Ar–Gn, Ar–Go, and Go–Gn). A DPT was taken for each participant with the upper and lower incisors in an edge-to-edge relationship using the Orthoslice 1000 C cephalostat at 64 KVp, 16 mA. The DPTs were traced manually by the same investigator (HMA) in a darkened room on acetate tracing paper using a 0.3 mm HB mechanical pencil. Two linear and three angular measurements (Figure 1) were recorded. Measurements were performed manually using a ruler to the nearest 0.1 mm. The third molar status of eruption was recorded as erupted or impacted. For the purpose of this study, a third molar was deemed to be impacted when its normal path of eruption was impeded or blocked by an adjacent second molar (Raghoebar *et al*., 1991).

Method error

Ten radiographs were randomly selected and remeasured by the same examiner after a period of 1 week. The formula of Dahlberg (1940) was used to calculate the standard error of the method $S=\sqrt{\sum d^2/2n}$. The coefficient of reliability (Houston, 1983) was calculated for the numerical data and kappa test was used to determine intra-examiner reliability for the categorical variables. Dahlberg error ranged from 0.23 mm for third molar width, 0.54 mm for mandibular length, 0.32 degrees for second molar angulation, to 0.43 degrees for β angle. The coefficient of reliability and kappa scores were above 90 per cent for all measured variables.

Statistical analysis

Data analysis was carried out using the Statistical Package for Social Sciences (version 15.0; SPSS Inc., Chicago,

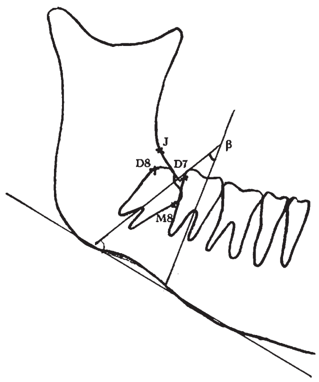

Figure 1 Points and measurements used for dental pantomograph analysis in the present study. Points—J x, a point at the junction of the body and anterior border of the mandibular ramus; D7 x, a point located at distal surface of the lower second molar; M8 x, a point located at mesial surface of the lower third molar; D8 point, a point located at the distal surface of the lower third molar. Measurements—β Angle, angle formed between the intersected long axes of the second and third molars drawn through the midpoint of the occlusal surface and the midpoint of the bifurcation; third molar mesio-distal crown width, measured as the greatest distance between the mesial (M8) and distal (D8) surfaces of the crown; retromolar space, the distance between the distal contact point and the junction of the anterior border of the ramus with the body of the mandible (point J); third molar angulation, the angle formed as a result of a line bisecting the third molar from the mid point and lower border of the mandible; second molar angulation, the angle resulting from a line bisecting the second molar from the mid point and lower border of the mandible.

Illinois, USA). An independent *t*-test was used to detect gender differences. Analysis of variance (ANOVA) was used to determine whether significant differences existed between the groups. Bonferroni multiple comparison test was applied to identify which of the groups were different. A chi-square test was applied to identify differences between groups with respect to the eruption/impaction status of third molars.

Results

The means, standard deviations, and mean differences of all measured parameters for females, males, and the total sample in each A-P skeletal pattern are shown in Table 2.

In Class I, gender differences were found for third molar width ($P<0.001$), second molar angulation ($P<0.05$), Ar–Gn ($P<0.001$), Ar–Go ($P<0.05$), and Go–Gn ($P<0.001$). In Class II, no gender differences were detected. In Class III, gender differences were observed in retromolar space width ($P<0.001$), second molar angulation ($P<0.01$), Ar–Gn ($P<0.001$), Ar–Go ($P<0.001$), and Go–Gn ($P<0.001$).

For the total sample, gender differences were found in retromolar space width ($P<0.01$), third molar width ($P<0.01$), β angle ($P<0.05$), second molar angulation ($P<0.01$), Ar–Gn ($P<0.001$), Ar–Go ($P<0.001$), Go–Gn ($P<0.001$), and gonial angle ($P<0.01$).

The status of third molar eruption/impaction in the different A-P skeletal patterns is shown in Table 3. Third molars were recorded as impacted in 26, 32, and 42 per cent of Class I, II, and III subjects, respectively. Significant differences were observed in the frequency of impaction in the different A-P skeletal patterns in the female group and in the total sample ($P<0.001$).

When impacted lower third molars were compared with erupted third molars (Table 4), retromolar space was reduced ($P<0.001$), β angle was increased ($P<0.001$), and third molar angulation was reduced ($P<0.001$) in all A-P skeletal patterns. Gonial angle was increased in the impacted Class I third molar group. Second molar angulation was reduced in the Class II impacted third molar group ($P<0.05$).

Comparisons between A-P skeletal patterns

F values for ANOVA test, mean differences, and the level of significance of the differences between radiographic variables in the different A-P skeletal patterns are shown in Table 5.

Total sample

Retromolar space width was smaller compared with Class I ($P<0.05$) subjects. Mandibular length in subjects with a Class III skeletal pattern was significantly longer than in the Class I and Class II subjects ($P<0.001$).

Females

Overall, retromolar space width was smaller in Class III females compared with Class I and Class II females ($P<0.05$). In Class III females, overall mandibular length (Ar–Gn) and mandibular body length (Go–Gn) were significantly longer than those of Class I and Class II subjects ($P<0.001$ and $P<0.01$, respectively).

Males

The only significant difference between the different groups of males was mandibular length. In Class III males, Ar–Gn, Ar–Go, and Go–Gn lengths were significantly longer than those of Class I ($P<0.001$) and Class II ($P<0.001$) subjects.

Discussion

In this research, retromolar space width and other related mandibular third molar variables were evaluated using DPT and LC. It has been demonstrated that panoramic radiography can provide measurements as reliable as those of LC (Mattilla *et al*., 1977; Abu Alhaija, 2005). Of the radiographic techniques used to assess lower third molar space and mandibular linear dimensions and angles, it has been reported that panoramic radiography yielded accurate estimates (Kaplan, 1975; Olive and Basford, 1981). The

Table 2 Means, standard deviations (SDs), mean differences, and the level of significance for the mandibular radiographic variables in all groups.

Variable	Females (F), mean±SD	Males (M), mean±SD	Total, mean±SD	Mean difference (F and M)	Significance
Skeletal Class I					
Retromolar space (mm)	13.19±3.82	14.36±3.93	13.75±3.90	−1.17	NS
Third molar width (mm)	12.29±1.68	13.14±1.14	12.70±1.50	−0.85	***
β angle	11.61±13.49	14.46±17.11	12.98±15.34	−1.12	NS
Third molar angulation	76.96±16.02	73.87±18.70	75.48±17.36	3.09	NS
Second molar angulation	88.79±6.09	91.16±7.35	89.92±6.80	−2.37	*
Ar–Gn (mm)	109.19±6.16	115.90±5.78	112.27±6.85	−7.99	***
Ar–Go (mm)	44.85±4.04	46.54±5.91	45.64±5.06	−1.69	*
Go–Gn (mm)	71.70±7.95	74.87±4.86	73.18±6.86	−3.17	***
Gonial angle	125.22±7.39	123.23±8.16	124.30±7.80	1.90	NS
Skeletal Class II					
Retromolar space (mm)	13.27±3.01	13.64±3.77	13.45±3.39	−0.38	NS
Third molar width (mm)	12.72±1.00	13.34±4.86	13.02±3.43	−0.62	NS
β angle	13.93±15.44	18.87±17.80	16.28±16.73	−4.94	NS
Third molar angulation	72.47±20.34	69.64±17.24	71.12±18.92	2.84	NS
Second molar angulation	88.50±7.43	90.48±6.51	89.44±7.05	−1.98	NS
Ar–Gn (mm)	109.19±11.22	111.57±6.27	110.32±9.27	−2.31	NS
Ar–Go (mm)	45.23±3.88	45.24±4.30	72.94±4.66	−0.17	NS
Go–Gn (mm)	73.25±4.74	72.62±4.58	45.23±4.09	0.63	NS
Gonial angle	124.91±6.99	123.02±8.09	123.99±7.59	1.96	NS
Skeletal Class III					
Retromolar space (mm)	11.59±3.25	13.36±3.03	12.65±3.23	−1.77	***
Third molar width (mm)	12.26±1.43	12.72±1.39	12.53±1.42	−0.47	NS
β angle	13.95±12.67	15.69±18.58	14.99±16.42	−1.75	NS
Third molar angulation	74.64±13.59	74.59±24.48	74.61±20.70	0.05	NS
Second molar angulation	88.72±6.99	92.31±7.91	90.84±7.73	−3.59	**
Ar–Gn (mm)	116.24±6.72	120.86±5.98	118.36±6.77	−6.15	***
Ar–Go (mm)	44.70±3.24	49.13±5.16	47.37±4.98	−4.43	***
Go–Gn (mm)	77.02±4.37	79.12±3.76	78.28±4.13	−2.11	***
Gonial angle	125.21±6.71	123.99±7.38	124.47±7.12	−0.21	NS
Total sample					
Retromolar space (mm)	12.78±3.45	13.78±3.57	13.29±3.55	−1.02	**
Third molar width (mm)	12.44±1.41	13.05±2.90	12.76±2.32	−0.61	**
β angle	13.11±14.00	16.22±17.90	14.72±16.19	−3.12	*
Third molar angulation	74.68±17.17	72.92±20.71	73.77±19.08	1.77	NS
Second molar angulation	88.67±6.82	91.35±7.32	90.05±7.20	−2.69	**
Ar–Gn (mm)	110.86±8.93	115.44±6.94	112.99±8.39	−6.06	***
Ar–Go (mm)	44.95±3.80	46.97±5.39	45.99±4.79	−2.02	***
Go–Gn (mm)	73.51±6.48	75.54±5.16	74.56±5.93	−2.03	***
Gonial angle	125.10±7.06	123.43±7.85	124.24±7.52	1.68	**

NS, not significant. *$P<0.05$, **$P<0.01$, ***$P<0.001$.

right and left sides can be measured separately without any superimposition (Uthman, 2007).

Although Behbehani *et al*. (2006) considered that retromolar space width is more accurately determined when the Xi point (Ricketts, 1979) is used as the posterior point, in the present study, retromolar space was measured as the distance between the distal contact point of the second molar and the junction of the anterior border of the ramus with the body of the mandible (Legović *et al*., 2008) to enable measurement of the right and left sides separately using DPT.

Retromolar space width was reduced in all impacted groups in the different A-P skeletal patterns. This confirms previous reports that a shortage of retromolar space is a major factor in the aetiology of mandibular third molar impaction (Björk, 1963; Olive and Basford, 1981; Alling and Alling, 1993; Hattab and Abu Alhaija, 1999; Behbehani *et al*., 2006; Uthman, 2007). However, when retromolar space width was compared in the different A-P skeletal patterns, it was reduced in Class III subjects.

Richardson (1977) suggested that a short mandibular length predisposed to mandibular third molar impaction. In this study, no significant differences were detected between the erupted and impacted groups for any mandibular length measurement (Ar–Gn, Ar–Go, and Go–Gn) in the different A-P skeletal patterns. This is in agreement with Kaplan (1975) and Dierkes (1975) who suggested that there was no

Table 3 Status of third molar eruption in the different antero-posterior skeletal patterns.

	Third molar status	Females	Males	Total
Skeletal Class I	Erupted	47 (62.7%)	44 (63.8%)	91 (63.2%)
	Impacted	28 (37.3%)	25 (36.2%)	53 (36.8%)
Skeletal Class II	Erupted	42 (55.3%)	38 (54.4%)	80 (54.9%)
	Impacted	34 (44.7%)	31 (45.6%)	65 (45.1%)
Skeletal Class III	Erupted	18 (31.0%)	38 (44.7%)	56 (39.2%)
	Impacted	40 (69.0%)	47 (55.3%)	87 (60.8%)
Pearson's chi-square test		13.89***	5.59	17.13***

***$P<0.001$.

difference in mandibular length between subjects with impacted compared with those with erupted teeth. On the other hand, Behbehani *et al*. (2006) found that a deficiency in mandibular length was marginally associated with an increased risk of impaction. However, the use of gnathion point in the present research to indicate the anterior limit of the mandible instead of pogonion used in the above studies may explain these differences.

In the current research, although Class III subjects had a larger mandible than Class I and Class II subjects, more impacted third molars were recorded in the Class III subjects. This is contrary to the findings of Richardson (1977) who suggested that a skeletal Class II dental base relationship with a shorter mandible was found in association with

Table 4 Means, standard deviations (SDs), mean differences, and *P* values for the mandibular radiographic variables in all groups according to status of eruption.

Variable	Erupted (E), mean±SD	Impacted (I), mean±SD	Mean difference (E and I)	Significance
Skeletal Class I				
Retromolar space (mm)	15.14±3.63	11.35±3.14	3.79	***
Third molar width (mm)	12.84±1.30	12.45±1.79	0.39	NS
β Angle	5.37±10.73	26.04±13.15	−20.66	***
Third molar angulation	82.11±15.01	64.09±15.16	18.02	***
Second molar angulation	89.11±7.19	91.32±5.88	−2.21	NS
Ar–Gn (mm)	112.39±7.17	112.23±7.09	0.16	NS
Ar–Go (mm)	45.55±4.82	47.00±5.22	−1.45	NS
Go–Gn (mm)	73.10±8.10	73.23±5.64	−0.13	NS
Gonial angle	122.35±8.07	125.79±7.00	−3.44	**
Skeletal Class II				
Retromolar space (mm)	15.01±3.00	11.57±2.86	3.44	***
Third molar width (mm)	13.16±4.44	12.87±1.54	0.30	NS
β Angle	6.11±10.54	28.63±14.56	−22.52	***
Third molar angulation	81.92±12.60	57.86±16.97	24.06	***
Second molar angulation	90.59±6.76	87.95±7.20	2.64	*
Ar–Gn (mm)	109.88±13.18	110.33±5.67	−0.45	NS
Ar–Go (mm)	46.01±4.03	45.27±3.82	0.75	NS
Go–Gn (mm)	73.44±5.10	72.76±4.18	0.69	NS
Gonial angle	125.01±7.66	123.13±8.20	1.88	NS
Skeletal Class III				
Retromolar space (mm)	14.44±2.65	11.49±3.05	2.94	***
Third molar width (mm)	12.35±1.22	12.66±1.54	−0.31	NS
β Angle	1.86±7.27	23.44±15.05	−21.58	***
Third molar angulation	88.96±17.15	65.37±16.29	23.60	***
Second molar angulation	92.23±8.23	89.92±7.28	2.31	NS
Ar–Gn (mm)	117.48±6.85	119.42±6.03	−1.94	NS
Ar–Go (mm)	47.92±5.44	48.50±5.02	−0.58	NS
Go–Gn (mm)	78.94±4.20	78.01±3.98	0.92	NS
Gonial angle	123.49±7.07	125.38±8.41	−1.89	NS
Total sample				
Retromolar space (mm)	14.94±3.19	11.48±3.00	3.46	***
Third molar width (mm)	12.84±2.82	12.67±1.60	0.17	NS
β Angle	4.74±10.74	25.76±14.53	−21.02	***
Third molar angulation	83.78±15.01	62.66±16.91	20.12	***
Second molar angulation	90.38±7.38	89.66±7.00	0.72	NS
Ar–Gn (mm)	112.72±9.87	113.08±7.16	−0.36	NS
Ar–Go (mm)	46.37±4.87	46.66±4.79	−0.29	NS
Go–Gn (mm)	74.87±6.78	74.22±5.14	0.65	NS
Gonial angle	123.51±7.72	124.63±7.88	−1.12	NS

NS, not significant. *$P<0.05$, **$P<0.01$, ***$P<0.001$.

Table 5 *F* values, mean differences (MD), and level of significance for the mandibular radiographic variables in the different antero-posterior skeletal patterns.

Variables	ANOVA, *F* value	MD, Class I and Class II	MD, Class I and Class III	MD, Class II and Class III
Females				
Retromolar space (mm)	4.89**	−0.08	1.59*	1.68*
Third molar width (mm)	2.45	−0.43	0.03	0.46
β angle	0.66	−2.32	−2.34	−0.01
Third molar angulation	1.29	4.49	2.32	−2.16
Second molar angulation	0.04	0.29	0.06	−0.22
Ar–Gn (mm)	17.57***	0.00	−7.05***	−7.05***
Ar–Go (mm)	0.45	−0.38	0.15	0.53
Go–Gn (mm)	15.61***	−1.55	−5.32**	−3.77**
Gonial angle	0.06	0.32	0.02	−0.30
Males				
Retromolar space (mm)	1.52	0.71	0.99	0.28
Third molar width (mm)	0.91	−0.20	0.41	0.62
β angle	1.12	−4.41	−1.23	3.18
Third molar angulation	1.21	4.23	−3.51	−4.95
Second molar angulation	1.23	0.68	−1.15	−1.84
Ar–Gn (mm)	41.66***	4.33***	−4.96***	−9.29***
Ar–Go (mm)	14.63***	1.30	−2.59***	−3.89***
Go–Gn (mm)	55.60***	2.25***	−4.25***	−6.50***
Gonial angle	0.67	0.21	−0.76	−0.97
Total sample				
Retromolar space (mm)	3.74*	0.30	1.10*	0.80
Third molar width (mm)	1.61	−0.32	0.16	0.48
β angle	1.53	−3.30	−2.01	1.30
Third molar angulation	2.12	4.36	0.87	−3.48
Second molar angulation	1.38	0.48	−0.91	−1.40
Ar–Gn (mm)	40.92***	1.95*	−6.09***	−8.05***
Ar–Go (mm)	10.23***	0.40	−1.73***	−2.13***
Go–Gn (mm)	54.61***	0.24	−5.11***	−5.34***
Gonial angle	0.19	0.31	−0.17	−0.48

*$P<0.05$, **$P<0.01$, ***$P<0.001$.

impacted third molars. The reduced retromolar space width found in Class III subjects may explain the high impaction rate reported in research those subjects. Behbehani *et al*. (2006) suggested an association between mandibular size and retromolar space, with the latter being the most important.

Second and third molar angulations did not differ between the different A-P skeletal patterns. However, they were reduced in all impacted groups. This was in agreement with Behbehani *et al*. (2006) who suggested that increased mesial angulation of the third molar bud increased the risk of impaction.

In this study, third molar width did not differ between subjects with impacted and erupted third molars. In addition, no differences were observed among the different A-P skeletal patterns. This is in contrary to Ventä *et al*. (1997), who reported that subjects with third molar impaction possess larger third molars than those in which the third molars are erupted. β angle did not differ between the different A-P skeletal patterns. However, when the erupted and impacted third molar groups were compared, β angle was increased in all impacted groups. This was in agreement with Uthman (2007) who suggested that β angle showed a marked increase in the marginal eruption group compared with the full eruption group.

Third molar angulation did not differ between the different A-P skeletal patterns. Comparisons of the angulation of the impacted and erupted mandibular third molars in the different A-P skeletal patterns revealed that third molar angulation was reduced in all groups. However, third molar angulation in Class II subjects was the most reduced. This may be explained by the small mandibular length in these subjects that may have limited the uprighting of third molars during development (Richardson, 1977). That author suggested that a more acute angle was more common among subjects with impacted third molars. In this study, gonial angle was increased in the impacted group of Class I subjects while it showed no differences between the impacted and erupted groups of Class II and Class III subjects. This is contrary to the findings of Behbehani *et al*. (2006) that a small gonial angle is associated with an increased risk of impaction. However, the selection criteria in this study included subjects with average vertical skeletal patterns (average maxillary/mandibular planes angle), which renders this variable difficult to evaluate.

One limitation of the present study is that the subjects were allocated to their groups based on ANB angle. This classification does not identify the aetiology of Class III or Class II skeletal problems and may have masked the effect of the A-P relationship on impaction of lower third molars.

Conclusions

1. Retromolar space width was reduced in Class III subjects compared with Class I and Class II subjects.
2. Impaction of the lower third molar was associated with reduced retromolar space width, increased β angle, and reduced third molar angulation in all A-P skeletal patterns.
3. A higher incidence of lower third molar impaction was found in subjects with a Class III skeletal pattern.

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