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ORIGINAL ARTICLE

Mandibular cephalometric characteristics of a Saudi sample of patients having impacted third molars

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KEYWORDS

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Impaction;
Etiology;
Mandibular geometry;
Cephalometrics;
Saudi

Abstract *Objective:* To evaluate the cephalometric characteristics of mandibles of Saudi patients having impacted third molars and to compare them to those of patients having normally erupted third molars.

Material and methods: One hundred and twenty-one Saudi adult subjects (59 females and 62 males; age: 20–40 years) were divided into two groups based on the status of the mandibular third molars: (1) impaction group and (2) normal group. Means and standard deviations of 21 cephalometric measurements related to mandibular geometry were measured and compared between the two groups using the unpaired *t*-test. Males and females in the impaction group were also compared with their equivalent subgroups in the normal group using the unpaired *t*-test.

Results: Anteroposteriorly, space distal to second molar, ramal width and mandibular body length were significantly less in the impaction group than in the control group. In addition, posterior teeth were more upright in the impaction group. Vertically, posterior alveolar height was significantly less in the impaction group. The *Y*-axis was significantly increased in the impaction group.

The significance of these measurements was variable between males and females.

Conclusions: Third-molar impactions in the Saudis living in the Western region of Saudi Arabia were more likely to occur when inadequate retromolar space is present. This can be attributed to certain

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mandibular skeletal and dental features, among which the increased width of mandibular ramus and backward inclination of posterior teeth seem to be the most influencing factors in both sexes.

1. Introduction

Third molar is the most frequently impacted tooth (Andreasen, 1997). The registered frequency of its impaction was highly variable among the different populations with the highest registered in a Singapore Chinese population at 68.6% (Quek et al., 2003). In a Saudi population living in the central region, the prevalence was reported to be 32.2% (Haidar and Shalhoub, 1986). In the Western region of Saudi Arabia, however, a higher frequency was reported at 40.5% (Hassan, 2010). Interestingly, impaction was significantly more common in the mandibles than in the maxillae (Hassan, 2010).

Many international studies were conducted to determine the etiology of third-molar impaction. Lack of space between the distal surface of the second molar and the ramus (retromolar space) was found by many investigators to be a significant etiological factor for mandibular third-molar impaction (Björk et al., 1956; Ricketts, 1972; Schulhof, 1976; Forsberg et al., 1989). Several other skeletal and dental factors were also blamed to contribute to the impaction of third molars. These include, the size, the growth amount and direction of the mandible (Broadbent, 1943; Björk et al., 1956; Björk, 1963; Richardson, 1977), the remodeling and the width of the ramus, the rate of maturation of third molars, the inclination of posterior dentition and the size of dentition relative to the jaws (Begg, 1954; Björk et al., 1956; Björk, 1963; Ricketts, 1972; Richardson, 1977; Forsberg, 1988).

Björk (1963) in a longitudinal cephalometric study found that the space distal to the second molar was considerably reduced in most of the mandibular third-molar impaction cases. This agrees with the findings of (Ricketts, 1972; Schulhof, 1976; Forsberg et al., 1989). Björk (1963) identified two skeletal and two dental factors that may cause third-molar impaction: vertical direction of condylar growth, a small total mandibular length as the distance from the chin point to the condylar head, backward directed eruption of the dentition and retarded maturation of third molars. However, Broadbent (1943) found that the inability of the mandible to achieve its full growth potential may contribute to the impaction of third molar. Capelli (1991) suggested that third-molar impaction is more likely to occur in vertically growing mandibles. A long ascending ramus, short mandibular length, and greater mesial crown inclinations of the third molars seem to be indicative of third-molar impaction. Breik and Grubor (2008) concluded that subjects with brachyfacial facial growth pattern demonstrated two times lower incidence of third-molar impaction than subjects with dolichofacial growth pattern.

Ricketts (1972) believed that the direction of tooth eruption plays a critical rule for third molar. This agrees with the findings of Björk (1963) and Björk et al. (1956) who stated that distal direction of eruption is associated with lack of space for third molar. It also agrees with the observations of Begg (1954) who attributed impaction to insufficient forward movement of the teeth of modern man due to the lack of interproximal attrition that was observed in ancient skulls. Richardson (1977) concluded that the space distal to the mandibular second molar increases over the five years following full transition form the primary to permanent dentition and this increase is due to equal but highly variable contribution from the remolding resorption of the anterior border of the ramus and the mesial movement of the first molar.

An unfavorable path of eruption might also be blamed for mandibular third-molar impaction. Richardson (1977) found that the developmental initial mesial angulation of third molars to the mandibular plane was observed more in subjects with impacted third molars than in those with normally erupted third molars.

Extraction of permanent second molars (Cavanaugh, 1985; Gooris et al., 1990), first molars (Bayram et al., 2009), or premolars (Kim et al., 2003) was found to reduce the frequency of third-molar impaction due to the increased eruption space accompanying the mesial movement of the molars during space closure.

These findings point out that mandibular third-molar impaction is associated with certain dental and skeletal mandibular features that are controversial and different among the different populations. This is beside the fact that different samples and methods of analyses were used in the supporting studies. In Saudi Arabia, the etiology of the relatively high frequency of mandibular third-molar impaction remains a mystery. Therefore, it seems important to investigate the etiology of third-molar impaction in Saudis using thorough cephalometric analysis.

The objective of this study was to evaluate the cephalometric characteristics of mandibles having impacted third molars in a sample of Saudi patients living in the western region of Saudi Arabia, and to compare them with those of patients having normally erupted third molars.

2. Material and methods

This study was approved by the Ethical Research Committee at King Abdulaziz University, Faculty of Dentistry (KAU-FD). Records of patients, registered for the treatment at the Faculty of Dentistry, King Abdulaziz University, during 2003–2004 were reviewed, from which 121 patients (59 females and 62 males; age: 20–40 years with a mean age of 23.89 years) were selected. The inclusion criteria were: (1) non-syndromic patients, (2) no history of orthodontic treatment, (3) presence of initial orthopantomogram (OPG) and lateral cephalometric radiograph (LC), (4) presence of complete normal mandibular dentition, and (5) presence of mandibular third molars which have complete root formation and either fully erupted or impacted.

Subjects were divided into two groups based on the status of the mandibular third molars: (1) impaction group (IG), which included patients having one or two of incompletely erupted mandibular third molar with radiographic evidence of apical closure or near closure ($n = 71$) and (2) normal group (NG), which included patients having normally erupted third

Table 1 Cephalometric landmarks used to evaluate mandibular geometry.

Anatomical landmarks	Description
N, nasion	Most anterior point of the frontonasal suture in the midsagittal plane
S, sella	Center of the pituitary fossa of the sphenoid bone
Por, porion	Most superior point on the external auditory meatus
Or, orbitale	Lowest point in the inferior margin of the orbit
ANS	Tip of the anterior nasal spine
A, Point A	Most posterior point in the concavity between ANS and the dental alveolus
B, Point B	Most posterior point in the concavity along the anterior border of the symphysis
Pm, suprapogonion	Mid-point of the curve between B and Pog
Pog, pogonion	Most anterior point on the mid-sagital symphysis
Co, condylion	Most superior posterior point on the condyle of the mandible
Go, gonion	A point on the curvature of the angle of the mandible located by bisecting the angle formed by lines tangent to the posterior ramus and inferior border of the mandible
Gn, gnathion	A point located by taking the mid-point between the anterior (pogonion) and inferior (menton) points of the bony chin
Dc	The center of the neck of the condyle
Xi	The geometric center of the mandibular ramus

mandibular third molars ($n = 50$). Groups were further divided into male and female groups: male impaction group (MIG) ($n = 41$), male normal group (MNG) ($n = 21$), female impaction group (FIG) ($n = 30$) and female normal group (FNG) ($n = 29$).

All cephalometric radiographs were traced and analyzed manually. Fourteen landmarks and 21 linear and angular measurements related to mandibular geometry were identified (Tables 1 and 2, Figs. 1 and 2).

To assess the intra-examiner reliability, 15 randomly selected lateral cephalograms were re-traced and re-analyzed, two weeks after the first measurements. The method error was calculated using Dahlberg's double determination formula (Dahlberg, 1940).

Statistical analysis was performed using SPSS software package (SPSS for Windows 98, version 16.0, SPSS Inc, Chicago, IL, USA). Means and standard deviations of all the variables were calculated. An unpaired *t*-test was used for the statistical analysis at a significance level of $P < 0.05$ to compare variables between the two groups; IG and NG. Males and females in the impaction group were also compared to their equivalent subgroups in the NG using unpaired *t*-test ($P < 0.05$).

3. Results

The range of the method errors was between 0.2 and .95° for the angular measurements and between 0.25 and 1 mm for the linear measurements. (Table 3).

Means and standard deviations of the measured variables are presented in Table 4.

Table 2 The linear and angular cephalometric measurement used to evaluate mandibular geometry.

Measurement	Abbreviation	Description
Retromolar space	M2–Xi	The distance from Xi point to the distal of the mandibular second molar crown along the occlusal plane
SNA angle	SNA	Angle formed between SN and NA
SNB angle	SNB	Angle formed between SN and NB
ANB angle	ANB	Angle formed between NA and NB
FH–SN angle	FH–SN	Angle between SN plane and Frankfort horizontal plane
Ramal length	Co–Go	Distance between Condylion and Gonion
Mandibular Body length	Go–Gn	Distance between Gonion and Gnathion
Effective mandibular length	Co–Gn	Mandibular length as measured between Condylion and Gnathion.
Corpus length	Xi–Pm	The length of the corpus between Xi point and Pm point
Ramal width	Ramal width at Xi	Ramal width: the distance from anterior to posterior ramal wall at the level of the mid-point.
Lower anterior face height	ANS–Gn	The distance between ANS and Gn
Condylar axis	Dc–Xi	The length of Condylar axis between Dc and Xi points
Mandible Arc	(Dc–Xi)–(Pm–Xi)	Mandible Arc: the angular relationship of the ramus to the mandible
Lower anterior facial height angle	ANS–Xi–Pog	Angle formed by Xi–ANS plane and Xi–Pog plane
Gonial angle	Co–Go–Gn	Gonial angle
Occlusal plane	SN–OP	Angle between the functional occlusal plane and SN line
Mandibular plane	MP–SN	Angle between mandibular plane and SN line
Y-axis to SN	*Y*-axis to SN	The angle formed between S and Gn line and SN plane
Y-axis to FH	*Y*-axis to FH	The angle formed between of FH and S–Gn
Inclination of lower posterior teeth	L6–MP (angle)	The distal angle formed between the long axis of the first molar and the mandibular plane
Posterior alveolar height	L6–MP (distance)	Perpendicular distance from mandibular plane to the mesio-buccal cusp of the lower first molar

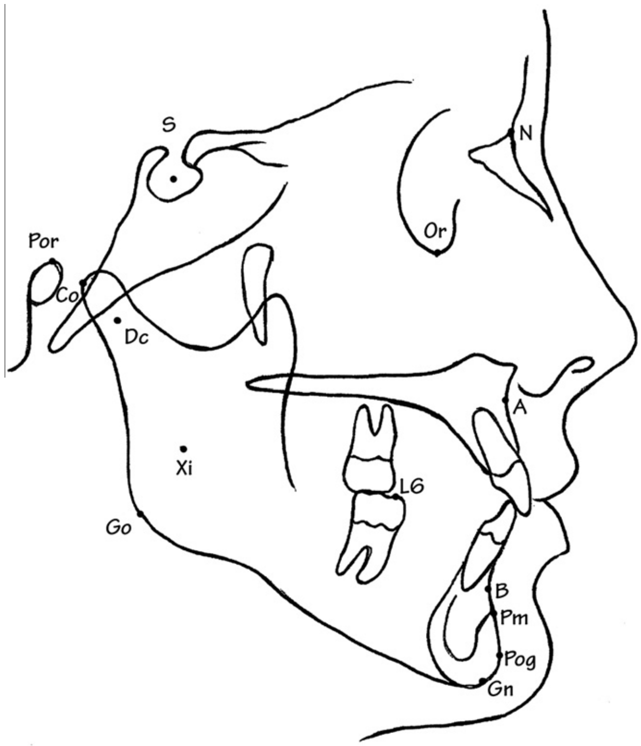

Figure 1 Cephalometric points used in the study.

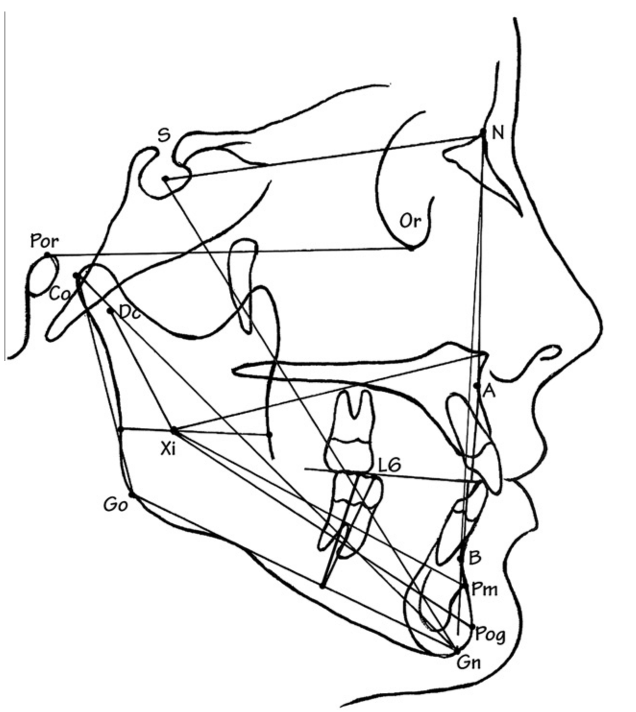

Figure 2 Illustrating the measurements made on the radiograph.

Comparing the anteroposterior dimensions of the mandibles (MAPD) between the IG and NG has shown the following: the retromolar space (Xi–M2) was significantly decreased in the IG as compared to NG and it was in the range of 21.28 ± 3.06 ($P < 0.001$). Skeletal pattern was Class I in both groups, although A and B points were significantly retruded in the IG as compared to the NG ($P < .05$). SN inclination angle relative to FH was significantly increased in the IG than in the NG ($P < 0.05$). Mandibular body length was significantly smaller in the IG than in the NG ($P < 0.05$). Ramal width was also significantly increased in the impaction group as compared to NG ($P < 0.05$).

Table 3 Method error measurement.

The variable	Method error
M2–Xi (mm)	0.91
SNA (°)	0.95
SNB (°)	0.2
ANB (°)	0.41
FH–SN (°)	0.79
Co–Go (mm)	0.91
Go–Gn (mm)	0.30
Co–Gn (mm)	1.00
Xi–Pm (mm)	0.31
Ramal width at Xi (mm)	0.79
ANS–Gn (mm)	0.32
Dc–Xi (mm)	0.25
(Dc–Xi)–(Pm–Xi)	0.42
ANS–Xi–Pog (°)	0.52
Co–Go–Gn (°)	0.22
SN–OP (°)	0.51
MP–SN (°)	0.31
Y-axis to SN (°)	0.29
Y-axis to FH(°)	0.82
L6–MP (angle) (°)	0.56
L6–MP (distance) (mm)	0.38

Comparing the vertical dimensions of the mandibles (MVD) has shown the following: Condylar axis length (Dc–Xi) was not significantly different between the two groups. ($P > 0.05$) Y-axis was also significantly increased in the IG than in the NG ($P > 0.05$). Posterior alveolar height of the mandible was significantly increased in the IG ($P > 0.05$). Mandibular first molar was significantly more upright in the IG than in the NG ($P > 0.001$).

Effective mandibular length (Co–Gn), ramal length (Co–Gn), and condylar axis length were all insignificantly different between the two groups. In addition, lower face height and angle, mandibular arc angle, and mandibular plane angle were also insignificantly different between the two groups.

In the FIG, only four mandibular measurements were significantly different than the FNG; retromolar space, ramal width, posterior alveolar height and inclination of mandibular first molar (Table 5).

In the MIG, retromolar space, A and B projection, effective mandibular length, mandibular body length, corpus length, condylar axis length, Y-axis, and ramal width were significantly different than in the MNG (Table 6).

4. Discussion

Knowing the development of third molar, its prognosis, its eruption pattern, its possible effect on the dentition during and after orthodontic treatment as well as the effect of orthodontic treatment on the third molar eruption is an important

Table 4 Comparison between the IG and NG.

Measurements	Impaction G		Normal G		t-Test	P-Value
	Mean	Standard Dev.	Mean	Standard Dev.		
M2–Xi (mm)	21.29	3.06	27.66	3.10	11.197	.000**
SNA (°)	77.35	9.59	81.7	3.68	3.047	.003*
SNB (°)	77	4.8	79.16	3.12	2.790	.006*
ANB (°)	2.30	2.87	2.22	3.31	−.159	.874
SN–FH (°)	7.8	2.6	6.5	2.4	2.525	.013*
Ramal width at Xi	35.12	2.68	31.68	2.78	−6.847	.000**
Co–Go (mm)	59.76	6.13	59.84	5.98	.071	.944
Go–Gn (mm)	79.28	5.23	82.40	5.29	3.213	.002*
Co–Gn (mm)	123	8.22	126	8.32	1.941	.056
Co–Go–Gn (°)	124	6.67	125	4.80	1.192	.236
Xi–Pm (mm)	72.67	5.32	75.20	8.98	1.935	.055
Co–Go (mm)	59.76	6.13	59.84	5.98	.071	.944
Dc–Xi (mm)	33.74	2.98	34.1	3.59	.656	0.51
(Dc–Xi)–(Pm–Xi) (°)	141	12.6	146	5.47776	.177	.860
ANS–Xi–Pog (°)	50.56	5.71	50.04	3.77	−.566	.572
Y-axis to SN	69.77	4.84	67.44	4.20	−2.754	.007*
Y-axis to FH	62.22	5.12	60.88	5.78	−1.348	.180
ANS–Gn (mm)	71.98	7.52	73.40	6.27	1.088	.279
MP–SN	34.66	7.99	34.20	4.92	−.363	.718
L6–MP (mm)	32.29	2.85	33.42	3.26	1.963	.047*
L6–MPL (°)	76.94	5.63	83.58	5.86	6.276	.000**

* $P < 0.05$.
** $P < 0.001$.

Table 5 Comparison between the female IG and NG.

Measurements	Impaction G		Normal G		t-Test	P-Value
	Mean	Standard Dev.	Mean	Standard Dev.		
M2–Xi (mm)	20.46	2.72	26.65	3.11	8.122	.000**
SNA (°)	80.8	3.38	81.96	4.2	1.169	.247
SNB (°)	77.8	4.02	79.06	3.16	1.343	.185
ANB (°)	3.03	2.47	2.89	2.67	−.204	.839
Ramus width at Xi	34.50	2.72	30.65	2.88	5.266	.000**
Go–Gn (mm)	77.16	4.42	79.06	3.27	1.872	.066
Xi–Pm (mm)	70.26	4.98	71.133	9.74	.434	.666
Co–Gn (mm)	117.8	6.95	120.5	5.38	1.632	.108
Co–Go (mm)	56.67	5.50	56.79	5.77	.086	.932
Dc–Xi (mm)	32.06	3.76	35.68	10.38	1.793	.078
MP–SN (°)	33.53	6.50	34.27	5.53	.471	.639
Co–Go–Gn (°)	123.2	7.20	125.6	5.47	1.430	.158
(Dc–Xi)–(Pm–Xi)	33.26	5.51	34.31	4.97	.763	.449
ANS–Xi–Pog (°)	48.56	4.55	49.58	4.15	.898	.373
OP–SN (°)	17.2	4.17	17.8	3.77	.638	.526
Y-axis to SN (°)	69.13	4.64	68.37	3.79	−.682	.498
Y-axis to FH (°)	61.30	4.42	61.93	7.13	.410	.684
ANS–Gn	67.20	6.05	69.72	4.68	1.786	.079
L6–MP (mm)	30.66	2.63	32.37	2.25	2.679	.010*
L6–MP (°)	77.90	5.92	83.89	5.42	4.054	.000**

* $P < 0.05$.
** $P < 0.001$.

issue for orthodontists to formulate a successful long term treatment plan.

The etiology of mandibular third-molar impaction was investigated by many investigators and several dental and skeletal factors were blamed. Lack of space in the retromolar region seems to be the main factor, which can be attributed to either the failure of the mandible to attain its adequate size or the tooth size-jaw size discrepancy. In addition, narrow alveolar arch can be a retarding factor for the eruption of third molar. Finally, late third molar maturation combined with early physical maturation can also be a contributing factor (Svendsen and Maertens, 1997). These etiological factors seem

Table 6 Comparison between the male IG and NG.

Measurements	Impaction G		Normal G		t-Test	P-Value
	Mean	Standard Dev.	Mean	Standard Dev.		
M2–Xi (mm)	21.90	3.18	29.04	2.53	8.921	.000**
SNA (°)	74.82	11.71	81.33	2.79	2.498	.015*
SNB (°)	76.41	5.26	79.28	3.14	2.291	.025*
ANB (°)	1.78	3.05	1.28	3.91	−.548	.586
Ramal width at Xi	35.58	2.58	33.09	1.94	−3.877	.000**
Go–Gn (mm)	80.82	5.28	87	3.91	4.724	.000**
Co–Gn (mm)	126	7.57	134	3.71	4.313	.000**
Xi–Pm (mm)	74.43	4.89	80.80	2.82	5.501	.000**
Co–Go (mm)	62.02	5.61	64.04	2.99	1.538	.129
Dc–Xi (mm)	34.14	2.77	38.66	11.87	2.332	.023*
MP–SN (°)	35.48	8.92	34.09	4.07	−.678	.501
Co–Go–Gn (°)	125	6.20	125	3.82	.412	.682
(Dc–Xi)–(Pm–Xi)	33.70	6.30	32.85	4.40	−.552	.583
ANS–Xi–Pog	52.02	6.07	50.66	3.18	−.956	.343
OP–SN (°)	16	5.21	14.2	3.31	−1.445	.154
Y-axis to SN (°)	70.24	4.98	66.14	4.49	−3.166	.002*
Y-axis to FH (°)	62.90	5.53	59.42	2.61	−2.716	.009*
ANS–Gn (mm)	75.48	6.53	78.47	4.37	1.886	.064
L6–MP (mm)	33.48	2.40	34.85	3.90	1.706	.093
L6–MP (°)	76.24	5.37	83.14	6.53	4.442	.000**

* $P < 0.05$.
** $P < 0.001$.

to be highly variable and depend in many aspects on the studied population. The current study was designed to evaluate the cephalometric characteristics of mandibles in patients having third-molar impaction in order to find out if mandibular geometry contributes to the impaction as an etiological factor in the selected Saudi population living in the western region. A comprehensive evaluation of the geometry of the mandible was performed using 21 cephalometric variables, taken form different analyses to evaluate the anteroposterior and the vertical dimensions of the mandible, as well as its relationship to the cranial base.

The minimum sample size needed for this study was estimated to be 45 patients in each group. It was calculated based on the result of a pilot study on 40 patients using the following equation:

$$n = (2s^2 X t^2)/D^2$$

where n = minimum number of subjects needed to achieve significance at 0.05; s = average standard deviation for the two groups; t = t-test value at $P = 0.05$; D = half of the means standard deviation of the two groups.

The number of subjects was increased to provide adequate number for the evaluation of males and females separately.

The present study found that geometry of the mandible, which is a reflection of the growth and maturity of the mandible, seems to be different in many aspects in people having third-molar impaction which might be blamed for the impaction. The present results indicate that patients with impacted mandibular third molars had smaller retromolar space (21.28 mm) when compared to those with normally erupted third molars (27.6 mm) ($P < 0.001$). This is in agreement with previous studies (Björk et al., 1956; Ricketts, 1972; Schulhof, 1976; Forsberg et al., 1989). Moreover, Ricketts, 1972 and Schulhof, 1976 have concluded that a retromolar space less than 21 mm is associated with impaction group and 31 mm or more is associated with normally erupted third molars. In the present study, the retromolar space was found to be 21.28 mm in the impaction group and 27.6 mm in the normal ones. Legovic et al. (2008), however, concluded that the presence of adequate space for mandibular third molars does not guarantee its normal development. The author believes that these numbers can be used as references to clinically predict third-molar impaction at a later age, around the age of 18 years when most of the remodeling of the ramus is completed and the third molars are ready to erupt. In addition, they can be used as references to evaluate the space availability in the posterior dental segments, especially when attempting molar distalization.

In the present study, different linear measurements were used to evaluate the MAPDs. Ramal width seems to contribute strongly to the impaction of third molars as it was significantly increased in the impaction group as compared to the normally erupted group. The increased ramal width was attributed to the failure of remodeling resorption of the anterior border of the ramus (Björk, 1963; Richardson, 1977; Behbehani et al., 2006) which provides inadequate sagittal space distal to second molars in the mandibles (Richardson, 1977).

At the same time, mandibular body length (Go–Gn) was smaller in the impaction group (79.28 ± 5.23 mm) ($P < 0.002$). This agrees with the findings of Broadbent (1943), Björk (1963), and Capelli (1991) and disagrees with the findings of Dierkes (1975) and Kaplan (1975) who did not show any significant difference in the mandibular length between subjects with impacted and erupted third molars. However, the present results showed that effective mandibular length was insignificantly decreased in the IG. This disagrees with the findings of Björk (1963).

MVDs were also investigated using different measurements, which included condylar axis length, ramal length, and vertical alveolar height. In the present study, the increased vertical alveolar height was the only vertical measurement that was associated with the impaction of third molars.

Inclination of lower posterior teeth (L6–MP angle) was also assessed in the two groups. Interestingly, the angle was significantly reduced in the impaction group. This agrees with the findings of several investigators (Ricketts, 1972; Björk, 1963; Begg, 1954; Richardson, 1977; Shiller, 1979; Capelli, 1991). They, except Björk, demonstrated that the initial angulation of the lower third molar to the mandibular plane can be a factor in predicting impaction. Those studies based their conclusion on evaluating the path of eruption of the third molar itself which was difficult to evaluate in the present study, in which the first molar inclination to mandibular plane was used instead.

Assessing the rotational and angular measurements of the mandibles revealed that the orientations of mandibular plane, occlusal plane and gonial angle are indifferent between people having impacted third molars and those who do not. This disagrees with Sakuda et al. (1976), and Leighton and Hunter (1982) who demonstrated larger mandibular plane angle and occlusal plane angles to Sella–Nasion (S–N) in patients having dental crowding, who are expected to have impacted third molars, as compared to patients having spacing.

The present findings also disagree with Behbehani et al. (2006) who found that small mandibular plane and gonial angles are associated with an increased risk for mandibular impaction. The only measurement that was found different was the *Y*-axis angle (to SN) which was larger in the IG when compared to the NG. This agrees with Breik and Grubor (2008) who found that brachyfacial subjects have a lower incidence of mandibular third-molar impactions. This was explained by the fact that greater growth potential of the mandible is expected in brachyfacial subjects. However, it seems that growth pattern has no effect on the impaction of third molar in the Saudis living in the Western region. This is because the other measurements that determine the growth pattern such as the lower face height and mandibular arc angle and mandibular plane angle were found to be indifferent between the IG and the NG. In addition, the Saudis in the western region are characterized by large mandibular plane, occlusal plane and *Y*-axis angles (Hassan, 2006).

Breik and Grubor (2008) findings contradict those of Behbehani et al. (2006) in explaining the effect of the rotational growth of the mandible on the resorption of the anterior border of the ramus and consequently on third-molar impaction. Breik and Grubor (2008) believe that growth potential is greater in brachyfacial growth pattern, which allows more remodeling resorption of the anterior border of the ramus. Behbehani et al. (2006) believe that vertical growth of condylar, which is associated with forward mandibular growth, predisposes to less resorption of the anterior border of the ramus and consequently to greater third-molar impaction. The present findings disagree with the two theories. Although the ramal width was found increased in the IG, the growth pattern was indifferent between the IG and the NG.

The sample was further divided into males and females to see if there is any gender difference in mandibular geometry as related to the impaction of third molars. Both impaction groups (FIG and MIG) were compared to the corresponding normal groups.

Patients in both MIG and FIG had smaller retromolar spaces, larger ramal width and more backward inclination of the posterior teeth, when compared to their corresponding normal groups. However, most of the remaining differences between IG and NG were found among males. Males with impacted third molars were found to have more retruded A and B points and an increased *Y*-axis than those with normally erupted third molars.

In addition, MAPDs were significantly smaller only in MIG, which disagrees with the findings of Richardson (1977) who found smaller mandibular length in the FIG as compared to the FNG. They also disagree with Kaplan (1975) who found no significant sex predilection when comparing impacted group to the erupted group. This observed sex variability among the different studies seems to be due to the variability of the timing of mandibular skeletal maturity between males and females and among the different populations. Interestingly, the present findings indicate that MAPDs can be considered as influencing factors on the impaction of mandibular third molars in males but not in females, possibly due to the presence of late mandibular growth in males, which continues until the age at which third molars are about to erupt. In females, mandibular growth rate decreases tremendously at menarche, which is greatly affected by environmental factors such as health and socioeconomic conditions and energy balance related to physical activities, rather than genetics. In Saudi females, the estimated age for menarche is 13.05 (Babay et al., 2004), which is different from many other populations (Thomas et al., 2001). This variability in the timing of menarche among the different populations can explain the variability seen in the literature regarding the sex predilection as related to third-molar impaction.

The present study represents the first study to evaluate the geometry of the mandible as related to third-molar impaction in the Saudi population. Future studies are required to evaluate other possible factors such as the tooth mass which if evaluated together with MAPDS (Tooth size-jaw size discrepancy) can give more accurate understanding of the effect of MAPDs on third-molar impaction in the Saudi population and to find predictors for impaction in the Saudi population. In addition, future studies are required to investigate the etiology of upper third molars.

5. Conclusion

The high frequency of mandibular third molar in the Saudis living in the Western region can be attributed to certain skeletal and dental features. Lack of retromolar space distal to second molar seems to be the main etiological factor for third-molar impaction. Other specific dental and skeletal mandibular features can also be blamed for the impaction of third molars. These include:

- the presence of wide mandibular ramus in both sexes.
- upright lower posterior dentition in both sexes
- shorter MAPDs especially in males.
- hyperdiverged *Y*-axis especially in males
- increased posterior alveolar height especially in females.

However, angular and rotational measurements of the mandibles such as mandibular and occlusal planes, mandibular arc and gonial angles seem to be irrelevant to the impaction of third molars.

These features should be considered when assessing third molars, especially when formulating a long-term orthodontic treatment plan.

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