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ORIGINAL ARTICLE

Influence of third molar space on angulation and dental arch crowding

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Abstract The influence of the third molars on mandibular incisor crowding has been extensively studied but remains controversial. The purpose of this study was to ascertain whether, in Mongolian subjects, the lower third molar can affect anterior crowding and/or the inclination of teeth in the lower lateral segments. Panoramic radiographs, 45° oblique cephalograms, and dental casts were taken from Mongolian subjects (age range 18.3–24.1 years, mean 21.0 years) exhibiting impaction of all four third molars and an Angle Class I molar relationship. The Ganss ratio was calculated using panoramic radiographs, whereas the gonial angle and angulation of lower canines, premolars and molars were measured using 45° oblique cephalograms. Little's index of irregularity was calculated using dental casts. Significant relationships between the angulation of the third and second molars and between the first molars and second premolars were found. Conversely, there was no significant correlation between the angulation of third molars, first premolars and canines. The Ganss ratio calculations showed that the lower first and second molars and the second premolars inclined mesially if there was insufficient space for the lower third molars. However, there was no significant correlation between Little's index of irregularity and third molar angulation. Furthermore, although the third molar influences the lateral segments, no obvious relationship between the third molar and anterior crowding was observed. Therefore, the angulation of the third molar appears not to cause anterior crowding.

Keywords Anterior crowding · Third molar · 45° oblique cephalogram · Irregularity index · Ganss ratio

Introduction

Mongolia, located between Russia and the People's Republic of China, has a population of around 2.8 million that, ethnohistorically, can be divided into four clusters comprising Khalkha-Mongols, Westerner Oirato Mongols, Turkic speakers and a Northeastern cluster. Khalkha-Mongols constitute the majority of modern Mongolians and are dispersed throughout the country [1]. It is well established that there are two patterns of dental variation in Mongoloid populations, known as Sundadonty and Sinodonty. The Sinodont pattern is found mainly in North and East Asia, and characterizes major populations in China, Mongolia, Japan, Korea, Northeast Asia, and North and South America [2]. Mongolians and Japanese share many features of the Mongoloid dental complex, hence study of the morphological characteristics of Mongolians is of relevance to Japanese populations.

To investigate these Mongolian morphological characteristics and compare them with Japanese, we established a collaborative anthropological research project between The Nippon Dental University and the Mongolian Health Science University to conduct surveys and experiments in the Mongolian capital city, Ulaanbaatar, between 2005 and

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2007. This study found a strong relationship between tooth crown form and malocclusion, and that crowding was related to shovel-shaped incisors, dental arch form and overbite [3]. The influence of the third molar on mandibular incisor crowding has long been discussed in dental literature and has been a provocative subject for many years. Vego [4] stated that the erupting lower third molar could exert force on adjacent teeth. Furthermore, Richardson [5] concluded in a review article that the existing evidence implicated pressure from the back of the arch and the presence of a third molar as causes of late lower arch crowding. However, it was also concluded that late crowding is a multi-factorial process and that the etiological factors may differ between individuals. Indeed, Bishara [6] concluded after a comprehensive review of literature that third molars did not play a significant (i.e. quantifiable) role in mandibular anterior crowding. The role of the third molar remains a controversial issue despite numerous attempts to clarify its role in late anterior crowding [7]. Therefore, the purpose of this study was to ascertain whether the lower third molar could affect the inclination of teeth in the lower lateral segments (i.e. canines, first and second premolars, first and second molars) and anterior crowding in Mongolian subjects.

Materials and methods

Data for this study were collected in 2006 and 2007 by a survey team belonging to The Nippon Dental University, Japan. The subjects were students attending colleges or universities in the Mongolian capital city, Ulaanbaatar, who were born in Ulaanbaatar or its suburbs and belonged to the Khalkha-Mogol grouping. The ongoing dental anthropological survey of Mongolian subjects was approved by the Committee on the Ethics of Human Experimentation, The Nippon Dental University School of Life Dentistry at Niigata (Approval No. IN-88), and all participants provided informed consent. According to ethical standards, it was necessary for the participants to be informed about the purpose of the study. Agreement was obtained before data acquisition began, which included impressions for dental casts, panoramic radiographs and cephalograms.

Panoramic radiographs, 45° oblique cephalograms and dental casts were taken from 34 modern Mongolians belonging to the Khalkha-Mongol grouping. Inclusion criteria were: (1) Angle Class I molar relationship, (2) all four third molars impacted, (3) all teeth were caries-free, (4) no previous dental treatment, (5) no anomalies of crown morphology, (6) no orthodontic treatment in either maxillary or mandibular arch. All 45° oblique cephalograms were taken with the teeth in maximum intercuspation and oriented at the Frankfort horizontal plane. All radiographs were traced by hand on matte acetate sheets and measured by a single investigator to eliminate inter-examiner variability. Subject age ranged between 18.3 and 24.1 years, with a mean age of 21.0 years. The ratio of available space to the third molar crown width (Ganss ratio) [8] was calculated using panoramic radiographs (Fig. 1). Gonial angle and the axial inclination (mesio-distal tip) to the occlusal plane (OP) and mandibular plane (MP) of the lower canines (L3), premolars (L4 and L5) and molars (L6, L7 and L8) were measured [9] from 45° oblique cephalograms (Fig. 2). On the dental casts, the sum of displacements from anatomic contact points to contact points between lower canines was measured using a pair of sliding digital calipers (Mitutoyo Manufacturing Co. Ltd, Kawasaki, Japan) to an accuracy of 0.05 mm, and Little's index of irregularity [10] was calculated. Based on this index, the subjects were divided into two clusters: Class I normal occlusion (<3.5 mm) comprised 10 females and 4 males, whereas Class I crowding (3.5 mm and over) comprised 10 females and 10 males. Comparison of mean values for selected dimensions between these 'normal' and 'crowded' clusters was made using Student's *t* test. *F* tests were used to compare variances and gender differences within clusters. Spearman's single rank correlation coefficients were used to investigate any correlation between Little's index of irregularity, Ganss ratio, gonial angle, and the angulation of the lower canines, premolars and molars. In order to obtain Spearman's single rank correlation coefficients, data for both clusters were gathered and a total of 34 samples were employed in the analysis.

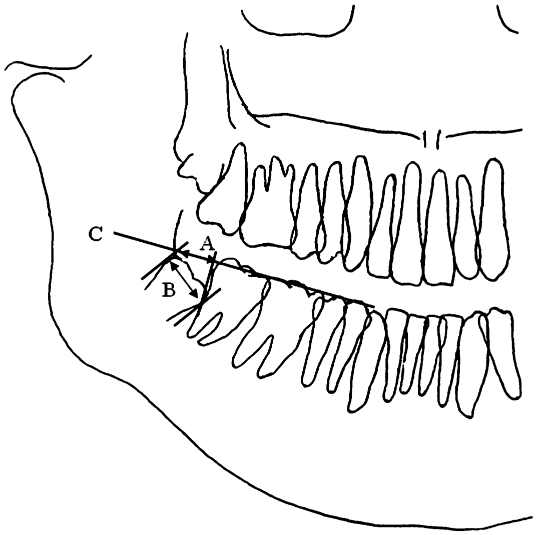

Fig. 1 Panoramic radiograph measurement for assessment of the third molar space. *A* Distance between distal border of second molar crown and anterior border of ramus measured on occlusal plane, *B* width of third molar crown, *C* occlusal plane. The Ganss ratio = *A*/*B*

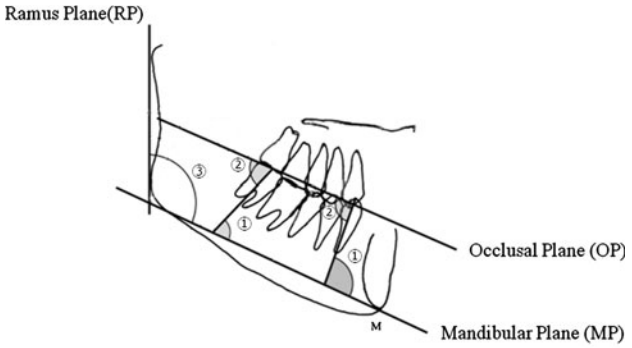

Fig. 2 Oblique cephalometric radiograph measurement. ① Angulation of mandibular teeth to MP; ② angulation of mandibular teeth to OP; ③ gonial angle. Point M is the most inferior point on the mandibular symphysis. The mandibular plane is the line passing through Point M tangential to the inferior border of the mandible. The occlusal plane is the line passing through the midpoint of U3 and L3 and that of U7 and L7. The ramus plane is the line tangential to the posterior border of the mandibular ramus

Statistical significance was accepted at $P < 0.05$. Descriptive statistics were calculated with Stat View (SAS institute, version 5.0 for Macintosh). Measurement errors were analyzed by a procedure of double determination measurements using paired *t* tests (with statistical significance set at $P < 0.05$) for systematic errors and the method described by Dahlberg [11] for random errors.

Results

No systematic errors were observed in this study between: first and second measurements for the Ganss ratio on panoramic radiographs; gonial angle and angulations of lower canines, premolars and molars on the 45° oblique cephalograms; and Little's index of irregularity on dental casts. Random measurement errors ranged from 0.10 to 0.32 mm for the ratio of available space to the third molar crown width and for Little's index of irregularity. Random measurement errors for the parameters measured from the 45° oblique cephalograms ranged from 0.50° to 0.90°.

Table 1 shows basic descriptive statistics for the 'normally occluding' and 'crowding' clusters. Significant differences were found to exist between the two clusters in two parameters: angulation of lower second premolar to occlusal plane in male subjects and angulation of lower first premolar to occlusal plane in female subjects. For Little's index of irregularity, there was a significant difference between the 'normal occlusion' and 'crowding' clusters.

Table 2 shows basic descriptive statistics for gender differences. Significant differences were noted for Little's index of irregularity between males and females in both 'normal occlusion' and 'crowding' clusters.

Table 3 shows correlation coefficients between all measurement parameters. There were no statistically significant correlations between the angulation of lower third molars and that of L3–L7. However, significant correlations were noted among the angulations of L3–L7. L3-to-MP and L4-to-MP were significantly correlated with the gonial angle, and L5-to-MP, L5-to-OP, L6-to-MP, L7-to-MP, L8-to-MP, and L8-to-OP were each significantly correlated with the Ganss ratio. There were also significant negative correlations between Little's index of irregularity and L4-to-OP and L5-to-OP.

Discussion

Systematic errors in our method were relatively small and deemed highly unlikely to bias results. No significant differences were found between first and second measurements, and the ranges of random measurement errors were very small compared to mean values.

Interpretation of third molar angulation from panoramic radiographs has been reported to be unreliable and not to accurately reflect the true orientation [12]. Kamegai [9] reported that the 45° oblique cephalogram gave a truer representation and a better view of the third molar and the tooth in the lateral segment because the lateral segment became parallel to the film. Thus, in present study, panoramic radiographs were used to calculate the Ganss ratio and 45° oblique cephalograms were used to measure angles between the tooth axis of teeth in the lateral segments and of the third molars.

Regarding the comparison between the 'normal occlusion' and 'crowding' clusters, significant differences were noted in two measurement parameters. For the 'crowding' cluster, the angulation of lower second premolars in males, and of lower first premolars in females, was significantly inclined mesial to the occlusal plane compared with the 'normal occlusion' cluster. However, no significant differences were observed in the other measurement parameters for the lateral segment, and the tooth axis of the 'crowding' cluster was not necessarily different from that in the 'normal occlusion' cluster. There were no significant differences between males and females in either cluster. A significant gender difference was seen only for Little's index of irregularity in each cluster. Thus, measurement data for males and females were combined. Correlation coefficients between all measurement parameters were calculated for 34 samples (14 males and 20 females).

No significant correlation was found between the angulation of the lower third molar and that of the other teeth in the lateral segment (i.e. canine, premolars, first and second molars), whereas significant correlations were noted among the angulations of the different teeth in the

Table 1 Descriptive statistics for normal occlusion and crowding clusters

	Normal occlusion			Significance	Crowding		
	n	Mean	SD		*n*	Mean	SD
Male							
L3-to-MP	4	94.55	4.96	ns	10	94.38	10.42
L4-to-MP	4	94.60	3.82	ns	10	95.13	7.45
L5-to-MP	4	92.85	5.07	ns	10	88.38	7.23
L6-to-MP	4	87.65	3.02	ns	10	86.38	6.86
L7-to-MP	4	78.70	6.74	ns	10	80.25	4.70
L8-to-MP	4	54.40	6.51	ns	10	63.00	2.48
L3-to-OP	4	90.70	4.86	ns	10	88.13	8.07
L4-to-OP	4	91.10	3.06	ns	10	88.88	5.47
L5-to-OP	4	89.00	4.26	*($P = 0.0470$)	10	82.00	7.22
L6-to-OP	4	84.05	3.77	ns	10	79.75	5.04
L7-to-OP	4	75.20	7.47	ns	10	74.00	4.99
L8-to-OP	4	50.30	6.55	ns	10	56.88	2.34
Gonial angle	4	117.10	5.15	ns	10	115.75	9.39
Ganss ratio	4	0.55	0.12	ns	10	0.62	0.24
Little's index of irregularity	4	2.40	0.27	**($P < 0.0001$)	10	7.46	1.51
Female							
L3-to-MP	10	95.60	3.94	ns	10	94.45	8.79
L4-to-MP	10	98.35	4.01	ns	10	96.95	6.66
L5-to-MP	10	90.30	3.18	ns	10	93.35	7.16
L6-to-MP	10	84.80	4.37	ns	10	86.05	4.34
L7-to-MP	10	75.75	5.37	ns	10	76.75	5.07
L8-to-MP	10	54.40	12.16	ns	10	66.00	18.66
L3-to-OP	10	91.15	3.75	ns	10	86.60	6.02
L4-to-OP	10	94.05	4.66	*($P = 0.0453$)	10	89.85	4.05
L5-to-OP	10	87.00	3.26	ns	10	86.60	4.09
L6-to-OP	10	80.50	5.03	ns	10	79.25	3.40
L7-to-OP	10	71.15	6.30	ns	10	69.95	5.53
L8-to-OP	10	49.80	13.58	ns	10	54.70	18.66
Gonial angle	10	119.45	4.27	ns	10	119.55	5.31
Ganss ratio	10	0.52	0.10	ns	10	0.56	0.15
Little's index of irregularity	10	1.66	0.83	**($P = 0.0008$)	10	4.08	1.61

ns not significant

*$P < 0.05$, **$P < 0.01$

lateral segment. Dahlberg [13] suggested that the last tooth to develop in each field tends to be the most variable in size and shape, adapting Butler's field theory to the human dentition. This variability is considered to be due to a greater environmental influence during their development linked to a decreased intrinsic genetic control over tooth formation from the early to the late developing teeth within each field [14]. The irregular developmental path of third molars in human beings and the great variability in their course of eruption may explain the absence of a significant correlation between the angulation of this tooth and others in the lateral segment.

Perera [15] reported that rotational growth of the mandible appears to be a key causative factor in crowding of the mandibular incisor region. In the present study, positive correlations were revealed between L3-to-MP and the gonial angle, and between L4-to-MP and the gonial angle. As the gonial angle became wider, the canine and first premolar became more distally inclined. Thus, the maxillofacial morphology and dento-alveolar compensation appear to influence not only the axis of teeth in the anterior segment but also that of the canine and first premolar.

L5-to-MP, L5-to-OP, L6-to-MP, L7-to-MP, L8-to-MP, and L8-to-OP were each significantly correlated with the Ganss ratio. Based on these results, the third molar would be inclined mesially if there was insufficient space for the development and/or eruption. The second premolar, first molar, and second molar could also be inclined mesially in this situation. Richardson [5] advocated that pressure from the back of the arch arising from the presence of a third

Table 2 Descriptive statistics in gender difference

	Male			Significance	Female		
	n	Mean	SD		*n*	Mean	SD
Normal occlusion							
L3-to-MP	4	94.55	4.96	ns	10	95.60	3.94
L4-to-MP	4	94.60	3.82	ns	10	95.35	4.01
L5-to-MP	4	92.85	5.07	ns	10	90.30	3.18
L6-to-MP	4	87.65	3.02	ns	10	84.80	4.37
L7-to-MP	4	78.70	6.74	ns	10	75.75	5.37
L8-to-MP	4	54.40	6.51	ns	10	54.40	12.16
L3-to-OP	4	90.70	4.86	ns	10	91.15	3.75
L4-to-OP	4	91.10	3.06	ns	10	93.05	4.66
L5-to-OP	4	88.00	4.26	ns	10	87.00	3.26
L6-to-OP	4	84.05	3.77	ns	10	80.50	5.03
L7-to-OP	4	75.20	7.47	ns	10	71.15	6.30
L8-to-OP	4	50.30	6.55	ns	10	49.80	13.58
Gonial angle	4	117.10	5.15	ns	10	119.45	4.27
Ganss ratio	4	0.55	0.12	ns	10	0.52	0.10
Little's index of irregularity	4	2.40	0.27	*($P = 0.0150$)	10	1.66	0.83
Crowding							
L3-to-MP	10	94.38	10.42	ns	10	94.45	8.79
L4-to-MP	10	95.13	7.45	ns	10	96.95	6.66
L5-to-MP	10	88.38	7.23	ns	10	93.35	7.16
L6-to-MP	10	86.38	6.86	ns	10	86.05	4.34
L7-to-MP	10	80.25	4.70	ns	10	76.75	5.07
L8-to-MP	10	63.00	2.48	ns	10	66.00	18.66
L3-to-OP	10	88.13	8.07	ns	10	86.60	6.02
L4-to-OP	10	88.88	5.47	ns	10	89.85	4.05
L5-to-OP	10	83.00	7.22	ns	10	86.60	4.09
L6-to-OP	10	79.75	5.04	ns	10	79.25	3.40
L7-to-OP	10	74.00	4.99	ns	10	69.95	5.53
L8-to-OP	10	56.88	2.34	ns	10	54.70	18.66
Gonial angle	10	115.75	9.39	ns	10	119.55	5.31
Ganss ratio	10	0.62	0.24	ns	10	0.56	0.15
Little's index of irregularity	10	7.46	1.51	**($P = 0.0047$)	10	4.08	1.61

ns not significant

*$P < 0.05$, **$P < 0.01$

molar was a cause of late lower arch crowding, but that other factors may also contribute to this process. Although early removal of third molars is generally recommended, orthodontists should be aware of the potential influence of a developing third molar on the dentition during and after orthodontic treatment. Improving mandibular third molar angulation by orthodontic treatment (with premolar extraction) could facilitate their extraction by oral surgery. Elsey and Rock [16] used panoramic radiographs for their study and reported that first premolar extraction treatment showed an improvement in third molar angulation by a mean of 7°. Data from Saysel et al. [17] supported the concept that orthodontic treatment involving premolar extraction improves mandibular third molar angulation, but did not compare changes on the right and left sides. Haavikko et al. [18] reported that no statistical differences between left and right side values were found when using panoramic radiographs for angular measurements of third molars. In the present study, panoramic radiographs and 45° oblique cephalograms were used to measure only the right side. Previous research suggests that unilateral measurement is adequate for analysis.

If pressure by the third molar causes anterior crowding, the teeth in the lateral segment would be expected to incline mesially. In the present study, there were significant negative correlations between the Little's index of irregularity and L4-to-OP and L5-to-OP, but no significant correlations were revealed between the occlusal plane and the angulation of any other teeth. Furthermore, there were no significant correlations between tooth angulation relative to

Table 3 Spearman's single rank correlation coefficients

	L3-to-MP	L4-to-MP	L5-to-MP	L6-to-MP	L7-to-MP	L8-to-MP	L3-to-OP	L4-to-OP
L3-to-MP	–							
L4-to-MP	0.79** ($P < 0.0001$)	–						
L5-to-MP	0.46** ($P = 0.0048$)	0.54** ($P = 0.0005$)	–					
L6-to-MP	0.39** ($P = 0.0198$)	0.42* ($P = 0.0111$)	0.44** ($P = 0.0072$)	–				
L7-to-MP	ns	ns	0.37* ($P = 0.0243$)	0.40* ($P = 0.0162$)	–			
L8-to-MP	ns	ns	ns	ns	ns	–		
L3-to-OP	0.73** ($P < 0.0001$)	0.44** ($P = 0.0064$)	ns	ns	ns	ns	–	
L4-to-OP	0.57** ($P = 0.0002$)	0.74** ($P < 0.0001$)	ns	ns	ns	ns	0.71** ($P < 0.0001$)	
L5-to-OP	ns	ns	0.76** ($P < 0.0001$)	ns	0.38* ($P = 0.0219$)	ns	ns	0.34* ($P = 0.0401$)
L6-to-OP	ns	ns	ns	0.69** ($P < 0.0001$)	ns	ns	ns	ns
L7-to-OP	ns	ns	ns	ns	0.83** ($P < 0.0001$)	ns	ns	ns
L8-to-OP	ns	ns	ns	0.35* ($P = 0.0364$)	ns	0.88** ($P < 0.0001$)	ns	ns
Gonial angle	0.36* ($P = 0.0304$)	0.37* ($P = 0.0242$)	ns	ns	ns	ns	ns	ns
Ganss Ratio	ns	ns	0.49** ($P = 0.0019$)	0.44** ($P = 0.0062$)	0.36* ($P = 0.0308$)	0.72** ($P < 0.0001$)	ns	ns
Irregularity index	ns	ns	ns	ns	ns	ns	ns	−0.36* ($P < 0.0312$)

	L5-to-OP	L6-to-OP	L7-to-OP	L8-to-OP	Gonial angle	Ganss ratio	Irregularity index
L3-to-MP							
L4-to-MP							
L5-to-MP							
L6-to-MP							
L7-to-MP							
L8-to-MP							
L3-to-OP							
L4-to-OP							
L5-to-OP	–						
L6-to-OP	ns	–					
L7-to-OP	ns	0.50** ($P = 0.0017$)	–				
L8-to-OP	ns	ns	ns	–			
Gonial angle	ns	ns	ns	ns	–		
Ganss Ratio	0.34* ($P = 0.0408$)	ns	ns	0.70** ($P < 0.0001$)	ns	–	
Irregularity index	−0.45** ($P < 0.0053$)	ns	ns	ns	ns	ns	–

ns not significant

*$P < 0.05$, **$P < 0.01$

the mandibular plane and Little's index of irregularity. Kaplan [19] reported that the presence of third molars did not produce a greater degree of lower anterior crowding or rotational relapse after cessation of retention after orthodontic treatment. Based on Kaplan's research, Bishara [6] expressed that the theory that third molars exert pressure on the teeth mesial to them could not be substantiated. Conversely, Zachrisson [20] reported that a mesially directed force is an important cause of increased mandibular incisor crowding in early teenagers and young adults and that the presence of a developing mandibular third molar with insufficient space could be a cause of late mandibular arch crowding. Niedzielska [21] expressed that movement in the buccal segment results in rotation and mesial drift of the canine because of its position at the point of greatest curvature of the dental arch. From our study data, it can be concluded that no strong relationship exists between the angulation of the third molar and the level of anterior crowding. The lack of significant correlations between the tooth axis of most teeth (except premolars) in the lateral segment and Little's index of irregularity suggests that the angulation of teeth in the lateral segment has little relationship with anterior crowding.

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