ORIGINAL ARTICLE

ASSOCIATION BETWEEN MAXILLARY POSTERIOR SEGMENT DISCREPANCY AND THE ANGULATION OF MAXILLARY MOLARS IN PATIENTS WITH DIFFERENT VERTICAL GROWTH PATTERNS

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Background: The impaction of maxillary third molars causes the crowns of maxillary first and second molars to tip distally in patients with maxillary posterior segment discrepancy. The aim of this study was to compare the maxillary first and second molar angulations in patients with maxillary posterior segment discrepancy (MPSD) with non-maxillary posterior segment discrepancy (N-MPSD) and evaluate the effect of their angulations on various divergence patterns. **Methods:** A cross-sectional study was conducted using the pre-treatment lateral cephalograms of 180 subjects which were divided into two groups, i.e., MPSD and N-MPSD. The Mann-Whitney U test was applied to compare various skeletal and dental parameters between the two groups and a pairwise comparison was made among the vertical growth patterns. The Kruskal Wallis test was used to compare the mean molar angulations and overbite among the three divergence patterns. **Results:** The ratio of anterior to total palatal plane ($p \leq 0.001$) and the molar angulation ($p \leq 0.001$) showed significant differences between the MPSD and N-MPSD groups. In the MPSD group, significant differences were found between the overbite in the normo-divergent versus hyperdivergent ($p \leq 0.001$) and hypodivergent versus hyperdivergent groups ($p \leq 0.001$), and in the angulation of the first maxillary molars in the normo-divergent versus hyperdivergent groups ($p \leq 0.001$). **Conclusions:** MPSD causes reduced maxillary first and second molar angulations. A ratio of the anterior palatal plane to total palatal plane length of ≥ 0.51 was seen in patients with impacted maxillary third molars.

Keywords: Third Molar, Impacted Tooth, Open Bite, Cephalometry

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INTRODUCTION

Balanced facial proportions are a result of complimentary growth of facial structures, jaws and the teeth that are housed in the alveolar processes. These structures grow in close relation to each other and influence their spatial position and function.[1,2] Enlow's counterpart analysis states that the growth of the craniofacial complex should be studied in the context of its effects on the position of adjacent structures.[3,4] Unfavorable vertical or sagittal growth can complicate treatment mechanics and challenge the long term stability.[5,6]

The vertical growth of the face can be either normal, increased or decreased.[7] Various authors have studied the skeletal and dental characteristics attributed to the different vertical patterns.[8–10] Subjects with hypodivergent vertical growth have short faces characterized by reduced facial heights, flat mandibular plane angles and a deep overbite.[11] In contrast, subjects with a hyperdivergent growth pattern have long faces characterized by increased facial heights, steep mandibular plane angles and a reduced overbite or open bite.[12]

Malocclusion can occur as a result of either altered facial growth or local tooth size discrepancies.[13] When the facial pattern deviates from the norm, anterior and posterior dental compensations mask the underlying skeletal discrepancy.[14-16] Janson *et al*[17] studied the angulation of posterior teeth and found that permanent molars in the hyperdivergent pattern tend to tip distally in patients with skeletal open bites. However, malocclusion can also occur as a result of non-skeletal, localized arch length discrepancy. Arch length discrepancy results in crowded dentitions, ectopic eruptions and impacted teeth.[18]

A maxillary posterior segment discrepancy results when there is inadequate space for the maxillary third molars to erupt.[19] Studies have concluded that forces exerted by maxillary third molars on the roots of erupted permanent molars cause a mesial movement of the permanent first and second molar roots and extrusion which can result in an increase in facial height.[20,21] During orthodontic distalization, posterior movement of teeth acts as a "wedge" that causes an amplified effect of opening the bite anteriorly and is therefore be avoided in patients with preexisting open bite tendency.[22,23] However, the natural changes in vertical proportion resulting from the distal tipping of posterior teeth due to impacted third molars has not been evaluated.

Arriola-Guillén *et al*[19] determined the angulations of maxillary first and second molars and found these to be reduced by as much as 7° and 14°, respectively, in patients with posterior segment discrepancy. If this can cause the crowns of erupted first and second molar teeth to tip distally and create a wedge effect, careful diagnosis is needed to implement efficient treatment plans. In our study, we aimed to find an association between maxillary posterior segment discrepancy and its effect on the vertical skeletal and dental measurements of patients with different divergence patterns.

MATERIAL AND METHODS

We performed a cross-sectional study in our orthodontic clinics after obtaining an exemption from the institutional ethical review committee of The Aga Khan University, Karachi. Data were collected from the patient's pre-treatment orthodontic records that included dental casts, orthopantomogram and lateral cephalograms using a non-probability purposive sampling technique. Arriola-Guillén *et al*[19] reported the mean length of the palatal plane as 45.96±2.72mm and 43.62±3.63mm in patients presenting with and without maxillary posterior segment discrepancy. Keeping the $\alpha = 0.05$ and power of study (β) as 80%, it was concluded that we needed at least 90 subjects per group in this study. Based on this, the total sample of 180 was divided into two groups; subjects and without maxillary posterior segment discrepancy (MPSD and N-MPSD, respectively). The values of FMA were used to further divide subjects in three vertical patterns as hypo-divergent <21°, normo-divergent 25±4°, hyper-divergent >29°.

All subjects selected were aged between 18 and 35 years within the age of eruption of third molars. We included only good quality standardized radiographs where maxillary third molars were clearly visible with mesioangular impaction of maxillary third molars positioned at or above the cemento-enamel junction of the adjacent second molar. Maxillary posterior segment discrepancy was diagnosed by the principal investigator when the third molars were clinically absent and seen in the orthopantomograms in a mesioangular direction contacting the roots of adjacent permanent second molars. The sample characteristics were homogenized for all parameters except those under study. Patients with a history of fixed or removable orthodontic treatment, underlying craniofacial syndromes or anomalies such as oro-facial clefts or trauma to the maxillo-mandibular region or dentition were excluded from this study. The variables studied were identified on lateral cephalograms using View Pro-X software (Rogan-Delft, Veenendaal, The Netherlands) by the principal investigator. The cephalometric vertical skeletal parameters identified and measured included the mandibular plane angle (FMA), anterior facial height (AFH), posterior facial height (PFH) and Jarabak's ratio (PFH/AFH). [Figure-1] The cephalometric dental parameters identified and measured were first molar angulation (M1), second molar angulation (M2), total palatal plane length (A′P′), anterior palatal plane length (A′6′), and the ratio A′6′/ A′P′. [Figure-2] Overbite was measured and recorded on the patient's dental casts with the help of a millimeter rule. [Figure-2] The Intra-class correlation coefficient (ICC) was used to eliminate any measurement errors by remeasuring 30 randomly selected cephalograms. The results showed a strong agreement between the two sets of the readings. [Table-1]

Data were analyzed using SPSS version 20.0. The normality of data was assessed using the Shapiro Wilk test which generated non-normal distribution, therefore non-parametric tests were applied. The Mann-Whitney U test was used to compare the means of linear and angular measurements between genders which showed insignificant differences; therefore, data were not further stratified. Mean molar angulation were compared among various divergence patterns using the Kruskal Wallis test. The pairwise comparison of molar angulations and overbite among the three divergence patterns in both the groups was made using the Mann-Whitney U test. A p-value ≤ 0.05 was taken as statistically significant.

RESULTS

The comparison of means of dental and skeletal parameters showed insignificant differences for skeletal parameters FMA, AFH, PFH and ratio PFH/AFH. For dental parameters, significant differences were found between the two groups for M1 ($p \leq 0.001$), M2 ($p \leq 0.001$), A′6′ ($p \leq 0.001$) and ratio A′6′/ A′P′ ($p \leq 0.001$). [Table-2]. The Kruskal Wallis test showed significant differences for both the first and second molar angulations ($p \leq 0.001$) amongst all three divergence patterns in the N-MPSD group. In the MPSD group, significant differences were found only for the first molar angulation ($p \leq 0.017$), whereas second molar angulation showed insignificant differences. There were insignificant differences ($p > 0.05$) between the overbite in the three divergence patterns between the N-MPSD and MPSD groups. [Table-3]. In the N-MPSD group, significant differences ($p < 0.001$) were found for overbite and second molar angulation in the normodivergent versus hypodivergent pair, and overbite, first and second molar angulation in the hypodivergent versus hyperdivergent pair. In the MPSD group, significant differences ($p < 0.001$) were found between overbite and first molar angulation in the normodivergent versus hyperdivergent pair, and overbite in the hypodivergent versus hyperdivergent pair. [Table-4]

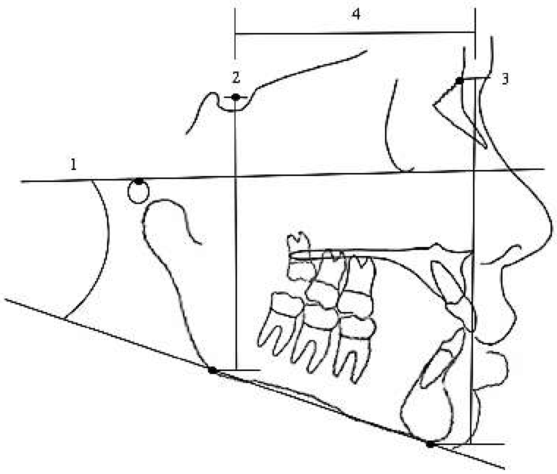

Figure-1: Cephalometric Vertical Skeletal Parameters

1. Mandibular plane angle (FMA°):	Angle formed between the Mandibular Plane and Frankfurt Horizontal
2. Posterior Facial Height (PFH):	Linear distance between S and Go
3. Anterior Facial Height (AFH):	Linear distance between N and Me
4. Jarabak's Ratio (PFH/AFH):	The ratio of posterior facial height over anterior facial height

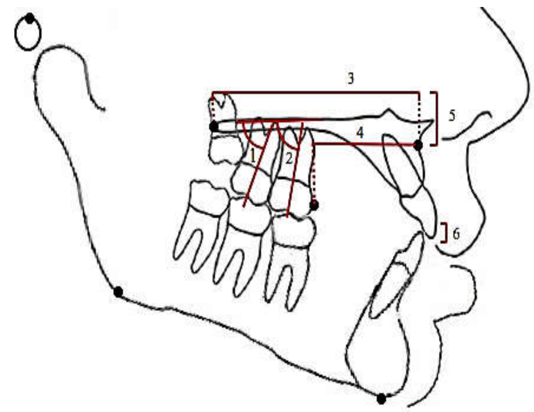

Figure-2: Cephalometric Dental Parameters

1. First molar angulation (M1°):	Angle formed between the long axis of first molar and palatal plane
2. Second molar angulation (M2°):	Angle formed between the long axis of second molar and palatal plane
3. Total palatal plane length Point-A′ to Point-P′ (A′P′):	Linear distance between Point A′ and Point P′
4. Anterior palatal plane length Point-A′ to Point-6′ (A′6′):	Linear distance between Point A′ and Point 6′
5. Ratio A′6′/ A′P′:	Ratio of anterior palatal plane to total palatal plane length
6. Overbite:	Vertical overlap of upper and lower incisors

Table-1: Interclass correlation coefficient

Parameter	1st Reading (n = 30)	2nd Reading (n=30)	ICC
FMA°	24.43	24.80	0.969
AFH (mm)	120.57	121.03	0.999
PFH (mm)	78.83	79.2	0.999
M1°	81.00	81.20	0.977
M2°	72.13	72.50	0.999
A′P′ (mm)	49.70	49.93	0.977
A′6′ (mm)	26.33	26.20	0.997

n=30. ICC: Intra-class Correlation Coefficient. >0.75 Excellent agreement, 0.4–0.75 Fair agreement, <0.4 Poor agreement

Table-2: Comparison of means of skeletal and dental parameters between N-MPSD and MPSD groups

	Parameters	N-MPSD (n= 90) (means±SD)	MPSD (n= 90) (means±SD)	*p*-value
Skeletal parameters	**FMA°**	24.4±6.0	25.4±6.6	0.346
	AFH (mm)	122.2±9.6	120.9±10.0	0.425
	PFH (mm)	81.4±7.8	79.4±9.2	0.064
	Ratio	66.7±6.1	65.9±8.1	0.368
Dental Parameters	**Overbite** (mm)	3.6±2.2	2.9±2.4	0.139
	M1°	83.9±5.3	80.0±6.3	0.001**
	M2°	78.1±7.4	72.3±6.7	0.001**
	A′P′ (mm)	49.3±4.0	49.2±4.4	0.446
	A′6′ (mm)	21.4±2.5	25.2±3.8	0.001**
	Ratio	0.4±0.03	0.5±0.04	0.001**

N-MPSD: Non- Maxillary Posterior Segment Discrepancy Group
MPSD: Maxillary Posterior Segment Discrepancy Group
N = 180, SD: Standard Deviation, $p \leq 0.05$*, $p \leq 0.001$**
Mann – Whitney U test

Table-3: Comparison of molar angulations in different vertical patterns (n=30)

Parameters	Hypodivergent (means±SD)	Normo-divergent (means±SD)	Hyperdivergent (means±SD)	*p*-value
Non-Maxillary Posterior Segment Discrepancy group				
M1º	86.6±4.2	83.7±4.9	80.9±5.3	0.001**
M2º	82.2±5.6	76.6±7.8	74.8±6.8	0.001**
Overbite	5.4±1.7	3.1±2.4	2.1±1.7	0.147
Maxillary Posterior Segment Discrepancy group				
Parameters	**Hypodivergent (means±SD)**	**Normo-divergent (means±SD)**	**Hyperdivergent (means±SD)**	***p*-value**
M1º	81.2±5.8	81.3±6.2	77.6±6.2	0.017*
M2º	73.5±6.4	72.6±6.7	71.4±6.9	0.567
Overbite	4.3±2.1	2.9±1.8	1.0±2.1	0.095

N=180, SD: Standard Deviation, $p \leq 0.05$*, $p \leq 0.001$** Kruskal-Wallis Test

Table-4: Pairwise comparison of means of dental parameters among various divergence patterns

Parameters	Normo vs Hypo (*p*-value)	Normo vs Hyper (*p*-value)	Hypo vs Hyper (*p*-value)
Non-Maxillary Posterior Segment Discrepancy Group			
Overbite	0.001**	0.102	0.001**
M1º	0.165	0.101	0.001**
M2º	0.010*	0.343	0.001**
Maxillary Posterior Segment Discrepancy Group			
Parameters	Normo vs Hypo (*p*-value)	Normo vs Hyper (*p*-value)	Hypo vs Hyper (*p*-value)
Overbite	0.107	0.001**	0.001**
M1º	0.736	0.009*	0.065
M2º	0.295	0.887	0.412

N = 180, $p \leq 0.05$*, $p \leq 0.001$** Mann – Whitney U test

DISCUSSION

The stability of orthodontic treatment is contingent upon a multitude of factors such as ideal finishing dental relationships, the retention protocol and favorable pattern of skeletal growth.[5] Since skeletal growth cannot be successfully controlled by the orthodontist without patient compliance long term retention should be an imperative consideration.[6] Vertical skeletal discrepancies are the most challenging etiological factors responsible for the development of malocclusion and dental factors that can complicate management and stability of these problems should therefore be eliminated. In our study, we aimed to identify an association between maxillary posterior segment discrepancy and its effect on the vertical skeletal and dental measurements of patients with different divergence patterns.

Comparison of means of skeletal measurements showed insignificant differences between the two groups, indicating MPSD does not have a detrimental effect on the vertical skeletal relationship. In contrast, comparison of means of dental parameters between the MPSD and N-MPSD groups showed significant differences between M1, M2, A′6′ and ratio A′6′/ A′P′, with insignificant differences overbite and A′P′. Celar *et al*[24] described the ratio A′6′/A′P′ as the total palatal plane length occupied by maxillary teeth anterior to the first molar. This ratio has been reported as 0.46 by other authors.[19] Our results showed maxillary posterior segment discrepancy was present in subjects when the ratio A′6′/A′P′ was greater than 0.51. This concept was first proposed by Sato[25] in his papers on the denture frame analysis and the relationship of posterior tooth-to-denture-base to developing mesio-occlusion. Our results along with those of other studies[19,24] are in agreement substantiating A′6′/A′P′ to be a viable parameter for the measurement of maxillary posterior segment discrepancy which should be considered when deciding between extraction or non-extraction treatment modalities.

Our study found the first and second maxillary molar crowns were more distally inclined in the MPSD group with a mesial movement of their roots. The means of both first and second maxillary molars were reduced by approximately 3º and 6º, respectively. Arriola-Guillén *et al*[19] studied the angulation of maxillary molars in both MPSD and N-MPSD groups and their results were in concordance with ours. Fayad *et al*[21] also studied molar inclinations in relation to eruption of third molars. The authors support the hypothesis that eruption pressure from unfavourably positioned third molars cause the roots of adjacent teeth to tip in a mesial direction with a synchronised distal movement of their crowns.[19,21] However, as investigated in our study, this distal movement of maxillary molar crowns did not create a wedge effect.

The inclinations of the first and second molars showed significant differences between the different vertical patterns in the N-MPSD group. Our results and those of other studies indicate the greatest distal movement of the maxillary molars is seen in the hyperdivergent group presenting with or without maxillary posterior segment discrepancy.[19,26] Hyperdivergent Class II patients would be at the greatest risk of reduced molar angulations complicating treatment modalities if uncontrolled mechanics are employed. Although insignificant differences were seen in overbite between the three different vertical patterns, this can be attributed to the well understood nature of dental compensations of anterior teeth that aim to reduce the severity of underlying sagittal and skeletal problems.[15–17]

All parameters were studied using a digitized 2-dimensional imaging modality. The OPG and lateral cephalograms do not allow the clinician to ascertain the buccolingual distance of third molars from adjacent second molar roots. Furthermore, difficult landmark identification and superimposing structures weaken the validity of the results when utilizing 2-dimensional images in spite of them being of the highest quality. Both the angulation and the transverse distance of the impacted teeth can be better studied using a 3-dimensional CBCT.

This study aimed to promote critical assessment of maxillary third molars in patients who are at a risk of developing posterior segment discrepancy. Analysis such as the ratio A′6′/ A′P′ has proven to be useful in identification of this condition. However, a cause-effect relationship between vertical skeletal pattern and posterior tooth angulations cannot be identified using a cross sectional study design. Therefore, we recommend a prospective study to establish a stronger association between the discrepancy and angulation of maxillary molars.

CONCLUSIONS

Based on the results it was found maxillary posterior segment discrepancy had no significant effect on vertical skeletal relationships. The length of the anterior palatal plane was greater in patients with posterior segment discrepancy and impacted maxillary third molars. Although there was reduced maxillary first and second molar angulations, patients with maxillary posterior segment discrepancy showed no significant difference in the overbite.

AUTHORS' CONTRIBUTION

MF, DSM: Contributed equally in the conceptualization of this study and its design. DSM: Conducted data collection and analysis and interpretation both authors contributed in the write-up and proof reading.

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