Original Article

Buccolingual Inclinations of First Molars among Untreated Individuals with Different Facial Pattern: A CBCT Study.

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ABSTRACT

Aim and Objective: To evaluate buccolingual inclinations of first molars among untreated individuals with different facial pattern using Cone Beam Computer Tomography (CBCT).

Material and Method: This cross-sectional study was conducted using pre-treatment CBCT records of 45 patients selected from the institutional archives, 15 each were grouped as Group 1, Group 2 and Group 3 categories (normodivergent, hypodivergent and hyperdivergent facial pattern). CBCT images were standardised by rotating the sagittal slice, so that the FH plane was oriented parallel to the true horizontal. The long axis of each first molar was determined, and the inclination of each molar was measured using the long axis and the floor of maxillary sinus. Statistical analysis was done for tooth inclination measurements to determine whether there were significant differences.

Results: The maxillary molars exhibited buccal inclination of 5.55 ± 2.52 deg, 6.54 ± 3.52 deg and 8.09 ± 2.69 deg respectively in Group 1, Group 2 and Group 3 on right side, 7.83 ± 2.44 deg, 8.31 ± 4.00 deg and 9.45 ± 2.50 deg respectively on left side. The mandibular molars exhibited lingual inclination of 8.27 ± 4.24 deg, 8.57 ± 4.04 deg and 8.91 ± 2.85 deg on right side, 7.83 ± 2.44 deg, 8.31 ± 4.00 deg and 9.45 ± 2.50 deg on left side. Statistically significant differences were found between groups 1 and 3, but not between groups 2 and 3.

Conclusion: From this study, variations in mean molar inclination values are observed between Normodivergent, Hypodivergent and Hyperdivergent groups. The conclusion drawn from the study is that there is buccal inclination in maxillary molars and lingual inclination in mandibular molars. Hyperdivergent subjects have relatively more buccal inclination in maxillary molars and lingual inclination in mandibular molars when compared to Hypodivergent subjects and Normodivergent subjects.

Key words: Buccolingual inclination, untreated adults, facial pattern.

INTRODUCTION

Facial growth pattern and its several clinical characteristics along with factors such as age, sex, and ethnic group are important in making a proper orthodontic diagnosis and treatment plan [1]. Different facial forms are influenced by the individual's genetic make-up and the environmental factors. These genetic/environmental factors may influence the orientation of maxillary and mandibular skeletal bases and the position of the dental components over these skeletal bases [2]. Facial skeletal characteristics of subjects with a vertical growth pattern include increased total face height, especially the lower anterior face height, high mandibular plane angle, clockwise mandibular rotation, short mandibular ramus, and high gonial angle. Opposite aspects are present in subjects with a horizontal growth pattern [3,4]. Regarding the dentoalveolar aspects, the maxillary dental arches of subjects with a vertical pattern are narrower, with a tendency toward posterior crossbite and anterior open bite [5,6]. Broader dental arches and accentuated overbite are observed in subjects with a horizontal growth pattern [2,5,6]. It has been suggested that subjects with long lower anterior face height have posterior teeth with greater buccal inclinations and longer functional lingual cusps and conversely that subjects with short lower anterior face height have a greater lingual inclination of the posterior teeth and longer buccal cusps. Andrews enumerated the six keys to normal occlusion which was based on study of 120 nonorthodontic normal models. The third key relates to crown inclination, which was measured from buccal crown surfaces. The collection which was considered to have ''normal'' occlusion showed lingual crown inclination for the maxillary and mandibular molars [7]. Further Computer Tomography (CT) study on dry skull was done by Tsunori et al in vertical sections of mandibular body have found that the posterior teeth lingual inclination was more in short facial type than in those with a long facial type, in vertical sections of the mandibular body [8]. The previous cone Beam Computer Tomography (CBCT) studies on buccolingual inclinations were either done on maxilla or mandible alone [9,10]. Thus no

conclusive CBCT data was available on buccolingual inclinations for different facial types.

The purpose and rationale of this study was to examine and explore, using CBCT, the buccolingual inclination of maxillary and mandibular first molars among individuals with different facial profiles. The existence of significant differences between these extreme facial patterns might have implications for distinct therapeutic approaches.

MATERIAL AND METHODS

This cross-sectional study was conducted at the Department of Orthodontics and Dentofacial Orthopaedics of a tertiary care government teaching institute. Pre-treatment CBCT records of 45 patients, 15 each of hyperdivergent, normodivergent and hypodivergent facial pattern categories were selected from the institutional archives of the patients who met the inclusion criteria of the study. All CBCT data used in this study was recorded from the same equipment installed in the institute using a standardised technique and exposure parameters (NEWTOM GIANO CB (3D) detector), with tube voltage of 60-90 KV, tube current 1-10 ma (pulsed mode), focal spot of 0.5mm and image resolution of 3.94 IP/mm.

Inclusion criteria included records of healthy adults in Cervical Vertebrae Maturation Index (CVMI) stage VI, patients with no prior orthodontic treatment, maxillary and mandibular first molars fully erupted and roots completely formed and complete set of medical and dental records available.

Exclusion criteria included patients with any missing or unerupted teeth in the quadrant measured, severe rotations, crossbite, craniofacial deformities or evident facial or skeletal asymmetry, presence of periapical or periodontal pathologies, periodontal bone loss, history of previous jaw surgery/trauma, malignancy, malformed teeth/ anodontia/ oligodontia or any other systemic disease/condition affecting bone metabolism.

CATEGORISATION OF STUDY SAMPLE

Images of each CBCT scan were exported to DICOM 3.0 format and assessed using NEWTOM.NNT analysis software. The angular measurements were drawn on lateral cephalometric images obtained from CBCT to group the patients based on their facial patterns. Subjects were grouped based on FMA angle (angle between FH plane and Mandibular plane) into 03 Groups **[Fig 1]**.

Group A: Normodivergent facial type (FMA = 22-25 degrees)

Group B: Hypodivergent facial type (FMA < 22 degrees)

Group C: Hyperdivergent facial type (FMA > 25 degrees)

MEASUREMENT AND COMPILATION OF DATA

The CBCT images were standardised by rotating the sagittal slice, so that the FH plane was oriented parallel to the true horizontal (a line connecting the inferior border of the orbital rims which were parallel to the floor)[Fig 2]. Guidelines as described by Masumoto et al [11] were used in defining the sagittal position of the tooth axis. A line was drawn, which passes through the midpoint of the mesio-distal crown width and the midpoint between both middle points of the mesial and distal roots at one-third the distance from the root apex. After orientating the sagittal plane, the coronal cross section was obtained in a 0.3-mm slice, using a section that best fit the right and left molar mesio-distal midpoints. The tooth axis was measured in the coronal section. The long axis of the tooth was defined as a line connecting the midpoint of the buccal and lingual cusp tips and the midpoint of the buccolingual width at the cervical base close to the furcation of the anatomic crown. Angular measurements were obtained from the long axis of each maxillary and mandibular first molar to a vertical reference line that was perpendicular to the horizontal reference line. If the crown was lingual to the roots, the inclination would be negative (-) and if it was buccal to the roots, the inclination would be positive (+).

The data obtained was compiled in MS Excel sheet and subjected to statistical analysis.

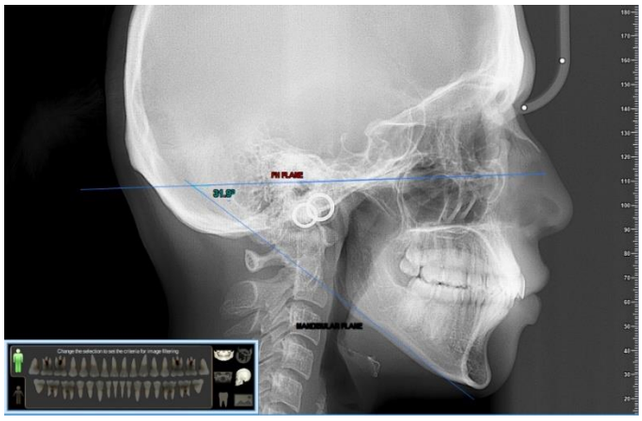


Fig 1. FMA angle (angle between FH plane and mandibular plane)

STATISTICAL ANALYSIS

The data on continuous variables is presented as Mean and Standard deviation (SD) across three study groups. The inter-study group (three groups) statistical comparison of means of continuous variables is done using analysis of variance (ANOVA) with Bonferroni's correction for multiple group comparisons on log transformed data to satisfy assumption of normality. The underlying normality assumption was tested

before subjecting each variable to ANOVA. All the results are shown in tabular as well as graphical format to visualize the statistically significant difference more clearly.

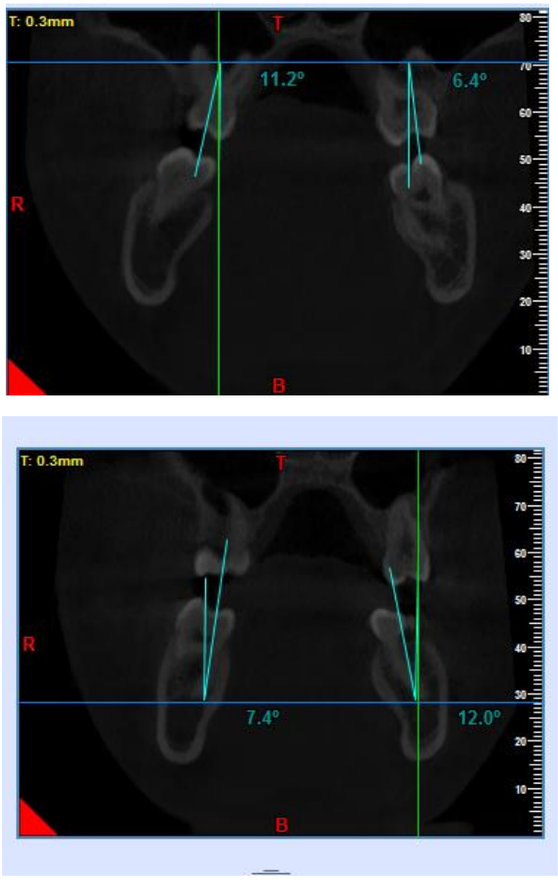


Fig 2: The upper angle formed by the intersection of the maxillary right and left first molar tooth axes and the lower angle formed by the intersection of the mandibular right and left first molar tooth axes

In the entire study, the p-values less than 0.05 are considered to be statistically significant. All the hypotheses were formulated using two tailed alternatives against each null hypothesis (hypothesis of no difference). The entire data is statistically analyzed using Statistical Package for Social Sciences (SPSS ver 21.0, IBM Corporation, USA) for MS Windows.

RESULTS

Intraexaminer testing revealed no statistical difference in repeated measurements (P<.05). Table 1 shows the mean, SD, and range of the upper and lower convergent angles of all three groups. In all groups, the maxillary molars showed buccal inclination, and mandibular molars showed lingual inclination. In addition, the mandibular molars were more lingually inclined in magnitude than the maxillary molars were buccally inclined.

Inter-Group Comparison of mean right upper molar angular measurement:

Distribution of mean ± SD of right upper molar angular measurements in Group 1, Group 2 and Group 3 is 5.55 ± 2.52 Deg, 6.54 ± 3.52 Deg and 8.09 ± 2.69 Deg respectively. Distribution of mean right upper molar angular measurement is significantly higher in Group 3 compared to Group 1 (P-value<0.05). Distribution of mean upper molar angular measurement did not differ significantly between groups 1 and 2 as well as between groups 2 and 3 (P-value>0.05 for both)(Table No.1,Fig .3).

Inter-Group Comparison of mean left upper molar angular measurement:

Distribution of mean ± SD of left upper molar angular measurements in Group 1, Group 2 and Group 3 is 5.16 ± 1.18 Deg, 6.07 ± 2.00 Deg and 7.65 ± 2.76 Deg respectively. Distribution of mean left upper molar angular measurement is significantly higher in Group 3 compared to Group 1 (P-value<0.05) Distribution of mean upper molar angular measurement did not differ significantly between groups 1 and 2 as well as between groups 2 and 3 (P-value>0.05 for all) (Table No.1,Fig .3).

Inter-Group Comparison of mean right lower molar angular measurement:

Distribution of mean ± SD of right lower molar angular measurements in Group 1, Group 2 and Group 3 is 8.27 ± 4.24 Deg, 8.57 ± 4.04 Deg and 8.91 ± 2.85 Deg respectively. Distribution of mean right higher angular measurement is significantly lower in Group 3 compared to Groups 1 and 2 (P-value<0.05 for both). Distribution of mean lower molar angular measurement did not differ significantly between groups 1 and 2 (P-value>0.05)(Fig .4, Table No.2).

Inter-Group Comparison of mean left lower molar angular measurement:

Distribution of mean ± SD of left lower molar angular measurements in Group 1, Group 2 and Group 3 is 7.83 ± 2.44 Deg, 8.31 ± 4.00 Deg and 9.45 ± 2.50 Deg respectively. Distribution of mean right higher angular measurement is significantly higher in Group 3 compared to Groups 1 and 2 (P-value<0.05 for both). Distribution of mean left lower molar angular measurement did not differ significantly between groups 1 and 2 (P-value>0.05 for all) (Fig .4, Table No.2).

There is slight buccal inclination in maxillary molars and mandibular molars have a slight lingual inclination in Group 3 compared to Group 1 and group 2.

DISCUSSION

The success of an orthodontic treatment plan depends upon the proper root position of not only the anterior teeth but also the posterior teeth. The inclination of the teeth is an important component of treatment planning and smile designing. Preadjusted Edgewise Alliances available have inbuilt torque to provide an appropriate inclination to the teeth for better aesthetics and long term stability. This inbuilt torque system was developed by Dr. Andrews with his experiment on static occlusion of 120 dental casts with "normal" untreated occlusion. The third key to occlusion described by Andrews discusses about the crown inclination and it has been highlighted that maxillary and mandibular posterior teeth crowns had lingual inclination [7].

Table 1 Inter-group comparison of means of right and left upper molar angular measurements

	Group 1 (Normodivergent) (n=15)		Group 2 (Hypodivergent) (n=15)		Group 3 (Hyperdivergent) (n=15)		P-value (Inter-Group)		
Measurements	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Group 1 v Group 2**	**Group 1 v Group 3**	**Group 2 v Group 3**
Right Upper Molar (Deg)	5.55	2.52	6.54	3.52	8.09	2.69	0.999^{NS}	0.033^{*}	0.257^{NS}
Left Upper Molar (Deg)	5.16	1.18	6.07	2.00	7.65	2.76	0.999^{NS}	0.236^{NS}	0.479^{NS}

P-value by analysis of variance (ANOVA) with Bonferroni's correction for multiple group comparisons (on log transformed data to satisfy assumption of normal distribution). P-value<0.05 is considered to be statistically significant. *P-value<0.05, NS-Statistically non-significant.

Various authors have used different methodology to study buccolingual inclination of posterior teeth. Ross et al. demonstrated a mean mandibular molar lingual inclination [10]. However the study was done on dental casts, and was not supported with radiographic evidences. The 3D visualization of irregular tooth and root morphology and uneven cuspal wear in dental casts posed a problem in assessing the long axis of the tooth. Study on use of CT for buccal roots of maxillary molars was done by Mitra and Ravi [12], also a study using a line connecting the centre of occlusal groove to the furcation for the molar axis was done by Barrera et al[13], and use of long axis to pass through the mid-point at one-half of the crown width and the mid-point at one-third of the distance from the root apex by Kasai and Kawamura [9].These studies were done on either maxillary or mandibular molars alone. A quick practical and a realistic method for measuring buccolingual inclination of mandibular canines and first molars described was done Shewinvanakitkul et al using CBCT and its analysing software like DICOM [14]. The images provided an unobstructive view of canines and molars, thereby allowing a transverse analysis that could potentially help differentiate between skeletal and dental transverse discrepancies. Further studies were done by Marshal et al, Sayania et al measured the long axis of the lower first molars to be a line from the central groove to the middle of the

Table 2 Inter-group comparison of means of right and left lower molar angular measurements.

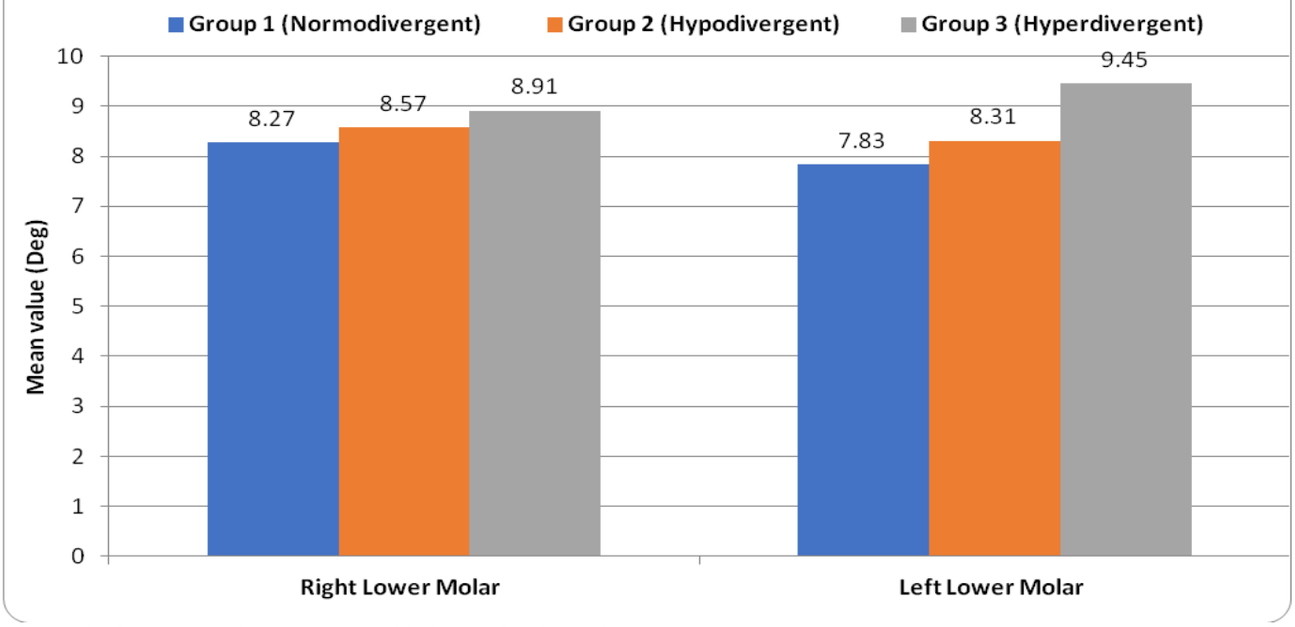
	Group 1 (Normodivergent) (n=15)		Group 2 (Hypodivergent) (n=15)		Group 3 (Hyperdivergent) (n=15)		P-value (Inter-Group)		
Measurements	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Group 1 v Group 2**	**Group 1 v Group 3**	**Group 2 v Group 3**
Right Lower Molar (Deg)	8.27	4.24	8.57	4.04	8.91	2.85	0.999^{NS}	0.006^{**}	0.014^{*}
Left Lower Molar (Deg)	7. .83	2.44	8.31	4.00	9.45	2.50	0.500^{NS}	0.403^{NS}	0.999^{NS}

P-value by analysis of variance (ANOVA) with Bonferroni's correction for multiple group comparisons (on log transformed data to satisfy assumption of normal distribution). P-value<0.05 is considered to be statistically significant. *P-value<0.05, **P-value<0.01, NS-Statistically non-significant.

The facial and dental characteristics of an individual depend upon the genetic makeup and various environmental factors effecting the same. It is well documented in the literature that the individual with different facial patterns (sagittal and vertical) have different facial and dental features. Various authors have studied the buccolingual inclinations of posterior teeth among individuals with different facial patterns. However, the studies available in the literature are disorganised, heterogeneous, thereby resulting in more confusion than clarity.

root apices and concluded that the molars of maxilla and mandible were upright in adult individuals than in children[15,16]. In present CBCT study, Masumoto et al guidelines were used in defining the sagittal position of the tooth axis [11] and the tooth axis was measured in the coronal section. The long axis of the tooth was defined as a line connecting the midpoint of the buccal and lingual cusp tips and the midpoint of the buccolingual width at the cervical base close to the furcation of the anatomic crown. Angular measurements were obtained from the long axis of each maxillary and mandibular first molar to a vertical reference line that was perpendicular to the horizontal reference line.

Fig 3 **Inter-Group Distribution of Mean Right and Left Lower Molar Angular Measurements**



Ross et al. demonstrated a mean mandibular molar lingual inclination of 7.1+ 4.6 degree in subjects between the ages of 9.5 and 41.5 years [10] which is in support of the present study. During analysis of the current study, variations in mean molar inclination values are observed between Normodivergent, Hypodivergent and Hyperdivergent faced groups. It was observed that there was mandibular molar lingual inclination in hyperdivergent faces. A CT scan based study done on male Asiatic Indians showed a relationship similar results in which there was an lingual inclination of 10.18 degree + 4.8 degree between the tooth axis and the bone axis [17]. Berrera et al reported 4.05 degree of buccal inclination in maxillary molars, where as Alkhatib and Chung reported buccal inclination of 4.85 + 4.22 degree in maxillary molars and lingual inclination of 12.60 + 5.29 degree in mandibular molars. This current study shows buccal inclination maxillary molars and lingual inclinations of mandibular molars which is in support of studies done by Berrera et al. and Alkhatib and Chung [13,18].

Tsunori et al linked the buccolingual inclination of molars and vertical facial type, and concluded that short facial types have more lingual inclination of mandibular molars tendency [8]. However the current study shows more inclination of mandibular molars in hyper divergent faces.

The limitations of this study include relatively smaller sample size. Further studies are recommended considering both sagittal and vertical characteristics involving different malocclusions.

CONCLUSION

The numerous factors that influences buccolingual inclination of the posterior teeth may be the reason for a wide range of inclination present in untreated subjects. Variations in mean molar inclination values were observed between Normodivergent, Hypodivergent and Hyperdivergent faced groups. Maxillary first molars in untreated adults had an buccal inclination and mandibular first molars in untreated adults had an lingual inclination. Maxillary molars are naturally more upright than mandibular molars. Hyperdivergent subjects have relatively more buccal inclination in maxillary molars whereas have relatively more lingual inclination is noted in mandibular molars when compared to Hypodivergent subjects and Normodivergent subjects.

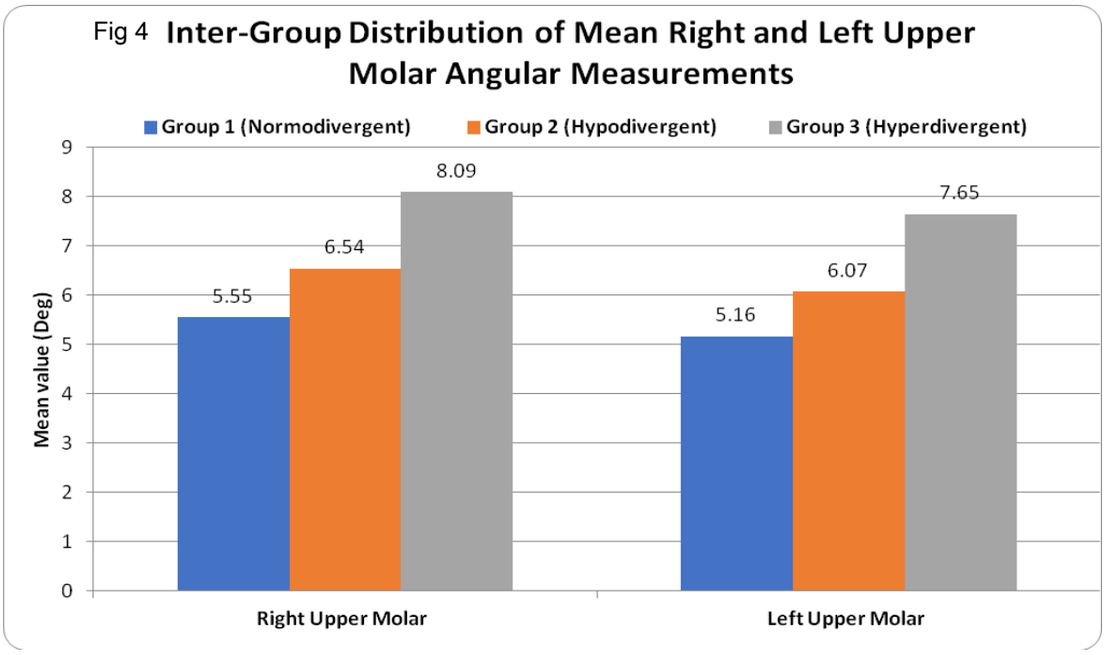


Fig 4

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