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Comparative Evaluation in the variation of the Occlusal Plane in relation to the Frankfort Horizontal plane on right and left sides measured using Face-Bow after orthodontic treatment

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Abstract:

Background*:)The form and inclination of the occlusal plane shows individual variation and are related to the function of the stomatognathic system and aesthetics. The cant or angulation of the plane of occlusion also has a profound effect on mandibular position, masticatory movement, upper smile attractiveness, posture and biting force. This study was intended to clinically evaluate the inclination of the posterior occlusal plane in relation to Frankfort horizontal plane on right and left side by means of face-bow transfer after orthodontic treatment in first premolar extraction cases.*

Materials and Methods*: 30 patients who reported to the Department of Orthodontics and DentofacialOrthopaedics, PSM college of Dental science and Research, Akkikavu and who satisfied the inclusion criteria were selected. Socio-demographic data of each patient was also recorded. Upper and lower impressions were made and poured in type III dental stone. Before the start of orthodontic treatment, a face-bow transfer was recorded and transferred to the Hanau Wide-vue articulator, a semi adjustable articulator. The maxillary cast was then mounted on the articulator using plaster of Paris. A glass slab was held against the posterior occlusal plane of the maxillary mounted cast. A digital protractor was placed on the glass slab and value recorded on right and left sides were compared.. After the completion of orthodontic treatment, impressions of the upper and lower arches were made again using alginate and casts were obtained. The procedure was repeated.*

Results*: After the interpretation of the results it was found that the posterior occlusal plane angulation determined clinically (using face-bow) decreased post-treatment and it was statistically significant. The mean of the pre-treatment posterior occlusal plane angle was 8.530 with standard deviation of 3.0871 whereas the mean of the post-treatment posterior occlusal plane angle was 5.930 with standard deviation of 2.6263. This indicated a decrease in the posterior occlusal plane on the right side post-treatment which was statistically significant. The mean of the pre-treatment posterior occlusal plane angle was 8.763 with standard deviation of 3.4240 whereas the mean of the post-treatment posterior occlusal plane angle was 6.240 with standard deviation of 2.65. This indicated a decrease in the posterior occlusal plane on the right side post-treatment which was statistically significant. The results also indicated that though the posterior occlusal plane angulation showed a decrease, the variation among right and left sides post treatment was not statistically significant.*

Conclusion:*From the study it can be concluded that the posterior occlusal plane angulation determined clinically, using face-bow both decreased post treatment. Though the posterior occlusal plane angulation showed a decrease, the variation among right and left sides post treatment was not statistically significant. Changes in occlusal plane inclination may predispose the patient to temporomandibular disorders. While treating the patient, the orthodontist should ensure that the occlusal plane inclination value is unchanged or decreases within limits after fixed orthodontic treatment. An increase or decrease in occlusal plane angle beyond limits may predispose the patient to temporomandibular disorders, increase instability and make treatment difficult. Further comprehensive studies should be carried out to evaluate this.*

***Key Word**: Posterior occlusal plane, occlusal plane, face-bow, Hanau.*

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I. Introduction

The form and inclination of the occlusal plane shows individual variation and are related to the function of the stomatognathic system and aesthetics[1]. A functional correlation between the inclination of the occlusal plane and the masticatory closing path has been observed[1]. The inclination of the maxillary posterior occlusal plane during growth and development can influence skeletal pattern[4] and development of malocclusion[2].

The cant or angulation of the plane of occlusion also has a profound effect on mandibular position [3], masticatory movement [4], upper smile attractiveness[5], posture and biting force. The position of the occlusal plane is determined largely by vertical growth of the maxillary teeth and its inclination is determined by growth of the dentoalveolar bone. The cant is related to the sagittal inclination of the condylar path and the guidance of the lingual concavity of the upper incisor[3]. The occlusal plane inclination in the lateral aspect can influence the magnitude of the curve of spee.

Ogawa etal[4] found that there was a significant correlation between the inclination of the occlusal plane and the direction of the closing path during mastication. The evaluation of the geometric and mathematical relationships between dental occlusion and rotations of the occlusal plane in the sagittal plane showed that each degree of rotation of the occlusal plane will result in a half millimeter change in the dental occlusal relationship [6].The cant of the maxillary occlusal plane may be a mechanism for the development of mandibular lateral displacement malocclusion and a therapeutic functional approach based on occlusal plane control was suggested. Motoyoshi[7]etal stated that lateral inclination of the occlusal plane affected posture by inducing cervical spine displacement causing asymmetrical stress distribution in this area. Shimazakietal[8]compared the mandibular stress distribution and displacement of the cervical spine using FEM to clarify the association between morphological and functional characteristics and head posture and suggested that lateral inclination of the occlusal plane and imbalance between the right and left masticatory muscles antagonistically act on displacement of the cervical spine.

In patients[10] undergoing orthodontic therapy, the occlusal plane is regulated primarily by differential tooth movement, produced by intraoral arch wires and springs, intermaxillary elastics and extraoral appliances[6]. Occlusal plane inclination changes can occur due to mesial molar movement, and by extrusion and intrusion of incisors and molars. In patients with fine posterior occlusion the occlusal plane should be maintained during orthodontic treatment or post treatment stability will be affected[9] .

Small angular differences in the inclination of the occlusal plane during or after orthodontic treatment may result in significant occlusal disharmony which could affect masticatory muscle balance causing functional disharmony, temporomandibular dysfunction and relapse [10].

The occlusal plane is a two-dimensional representation of a three-dimensional phenomenon. A cephalogram when used to evaluate the inclination of the occlusal plane has certain shortcomings; a cephalogram shows a two-dimensional view of the 3-dimensional occlusal plane and if the occlusal plane inclination varies on left and right side, an arbitrary middle line is taken as representative which may not detect variations .Cephalometric evaluation of the inclination of occlusal plane has to be supplemented by clinical evaluation to accurately determine if there is a change in the plane of occlusion on right and left side after orthodontic treatment.

This study was intended to clinically evaluate the inclination of the posterior occlusal plane in relation to Frankfort horizontal plane on right and left side by means of face-bow transfer after orthodontic treatment in first premolar extraction cases. Currently there is a lack of reliable scientifically accepted data published in peer reviewed, indexed journals regarding accurate clinical evaluation of the inclination of the posterior occlusal plane using face bow.

The aims and objectives of the present study are to

1.Determine if there will be a change in the inclination of the posterior occlusal plane in relation to the Frankfort horizontal plane after orthodontic treatment in first premolar extraction cases, using a face-bow.

2.Evaluation of the difference in posterior occlusal plane inclination on right and left side in orthodontically treated patients clinically using face-bow.

II. Material And Methods

The study was carried out on patients who reported for fixed orthodontic treatment to the Department of Orthodontics and DentofacialOrthopaedics, PSM Dental College, Thrissur. Informed consent was duly signed by the patient. Approval was obtained from the institutional ethical committee before the start of the study.

Study design: Cohort study
Study Location: This is a post graduate study done in the Department of Orthodontics and Dentofacial Orthopaedics, PSM Dental College and research institute, Thrissur, Kerala, India.
Sample size:30 patients.
Sample size calculation: For 90 %confidence, the sample size was determined as 30. Patients chosen for the study were of the same ethnic origin i.e. south Indian population .The cervical vertebrae maturation method was used to confirm their growth completion.

Inclusion criteria:

1. Adolescents with permanent dentition excluding third molars.
2. First premolar extraction cases were selected.
3. Non-surgical cases.
4. Patients who were not re-treated.
5. Patients older than 18 years.
6. No serious illness.
7. Absence of abnormal dental defects such as impaction, transposition of teeth and congenitally missing teeth.
8. Patients without periodontal disease.

Exclusion criteria:

1. Patients in mixed dentition period.
2. Patients with gross skeletal discrepancy.
3. History of prosthodontic treatment or plastic surgery.
4. Patients with facial asymmetry.
5. Craniofacial trauma.
6. Congenital anomaly.

Procedure methodology

Upper and lower impressions were made and poured in type III dental stone. Before the start of orthodontic treatment, a face-bow (Hanau Spring-Bow;Ref 010328-000) transfer was recorded and transferred to the Hanau Wide-vue articulator,(Hanau 010885-000;Waterpik Technologies) a semi adjustable articulator. The maxillary cast was then mounted on the articulator using plaster of Paris. A glass slab was held against the posterior occlusal plane of the maxillary mounted cast. A digital protractor (In size 2170-1) was placed on the glass slab and value recorded on right and left sides were compared.

The measurements were entered into an Excel spreadsheet for statistical evaluation. The patients underwent therapeutic extraction of first premolars followed by fixed orthodontic treatment with 0.022 inch slot MBT prescription. The average treatment time was 18-21 months. After the completion of orthodontic treatment, impressions of the upper and lower arches were made again using alginate and casts were obtained. The face-bow transfer was recorded (using a Hanau spring-bow) which was then be transferred onto the Hanau Wide-vuearticulator (Hanau 010885-000;Waterpik Technologies), a semi adjustable articulator. The maxillary cast was then mounted on the articulator.

A glass slab was held against the posterior occlusal plane of the maxillary mounted cast. A digital protractor (Insize 21701) was placed on the glass slab and value recorded on both right and left sides and compared. Thus the change in inclination of the occlusal plane following orthodontic treatment was accurately assessed 3 dimensionally.

Statistical analysis

The data was entered in to excel worksheet and analysis performed using SPSS 20. Descriptive statistics was carried out. Results on continuous measurements are presented on mean±SD and results on categorical measurements are presented in number/percentage. For continuous variables Kolmogorov-Smirnov test was used to assess the normality of the data. Paired t test was used to assess the significance difference between pre and post values. P value 0.05 was considered as level of significance.

Fig1.After placement of bite fork

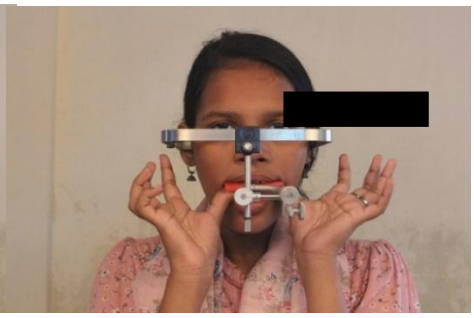

Fig2.Frontal view of face-bow assembly

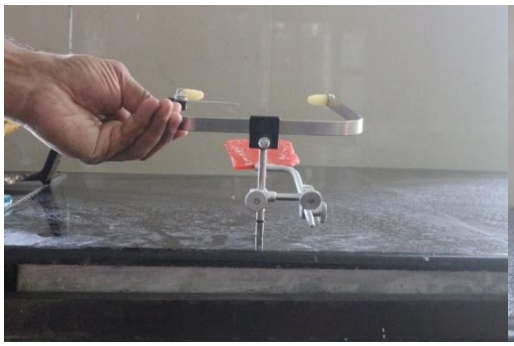

Fig 3.Face-bow assembly before mounting

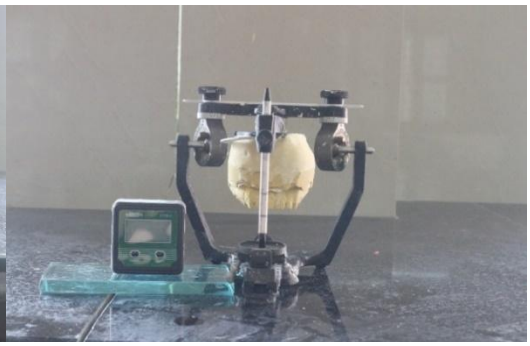

Fig 4. Mounted maxillary cast with digital protractor

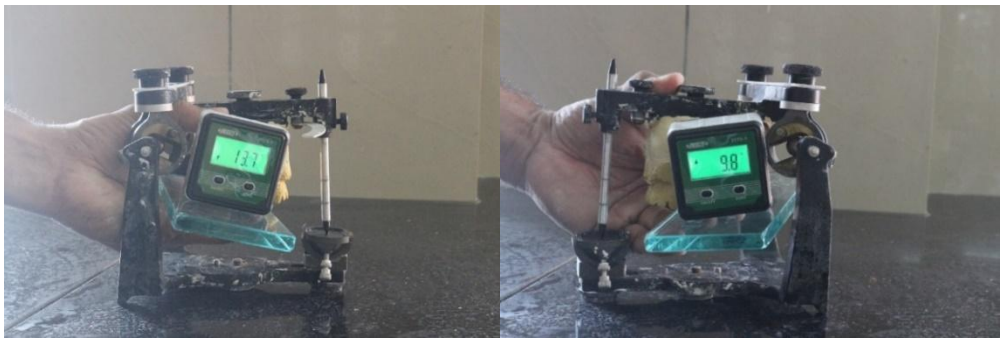

Fig.5. Measurement of occlusal plane angle on right and left sides

III. Result

Descriptive statistics of the data which included mean and standard deviation for the right and left posterior occlusal plane were calculated and are given in tables I-III . The P value was applied to all measurements to determine significance. The correlation was determined using Pearson correlation coefficient and P-value. After the interpretation of the results, it was found that the posterior occlusal plane determined clinically (using face-bow) decreased post treatment and it was statistically significant.

Table I compared the pre-treatment and post treatment angulation of posterior occlusal plane on the right side. The mean of the pre-treatment posterior occlusal plane angle was 8.530 with standard deviation of 3.0871 whereas the mean of the post-treatment posterior occlusal plane angle was 5.930 with standard deviation of 2.6263. This indicates a decrease in the posterior occlusal plane on the right side post-treatment. The P-value was 0.0001 which was statistically significant.

Table II compared the pre-treatment and post treatment angulation of posterior occlusal plane on the left side. The mean of the pre-treatment posterior occlusal plane angle was 8.763 with standard deviation of 3.4240 whereas the mean of the post-treatment posterior occlusal plane angle was 6.240 with standard deviation of 2.6574. This indicated a decrease in the posterior occlusal plane on the right side post-treatment. The P-value was 0.0001 which was statistically significant.

Table III compared the pre-treatment posterior occlusal plane angulation on right and left side and post treatment posterior occlusal plane angulation on right and left sides. The pre-treatment posterior occlusal plane had a P-value of 0.782 and the post-treatment posterior occlusal plane had a P-value of 0.6512. This indicated that there was high correlation between the values and the difference between pre-treatment posterior occlusal plane angulation and post-treatment posterior occlusal plane angulation was not statistically significant. Though the posterior occlusal plane angulation showed a decrease, the variation among right and left sides post treatment was not statistically significant.

Table no 1(10 Bold)**:**Comparison of pre-treatment and post treatment Posterior occlusal plane inclination values on right side.

	Mean	Std. Deviation	P value (paired t test)
Pre-treatment posterior occlusal plane	8.530	3.0871	0.0001
Post-treatment posterior occlusal plane	5.930	2.6263	

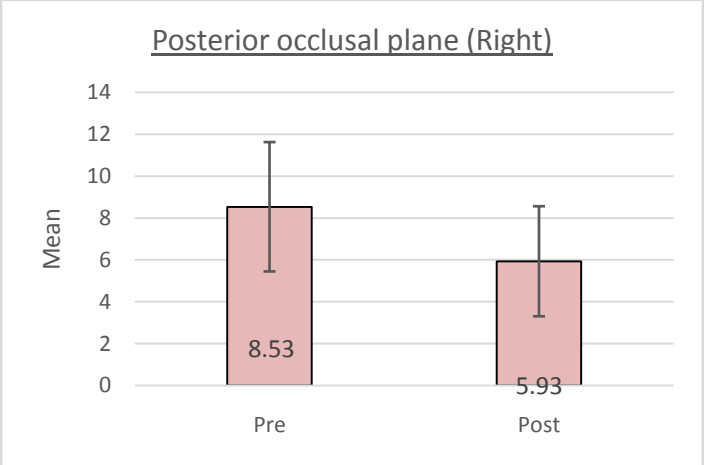

Table no 2 Comparison of pre-treatment and post treatment Posterior occlusal plane inclination values on left side.

	Mean	Std. Deviation	P value (paired t test)
Pre-treatment posterior occlusal plane	8.763	3.4240	0.0001
Post-treatment posterior occlusal plane	6.240	2.6574	

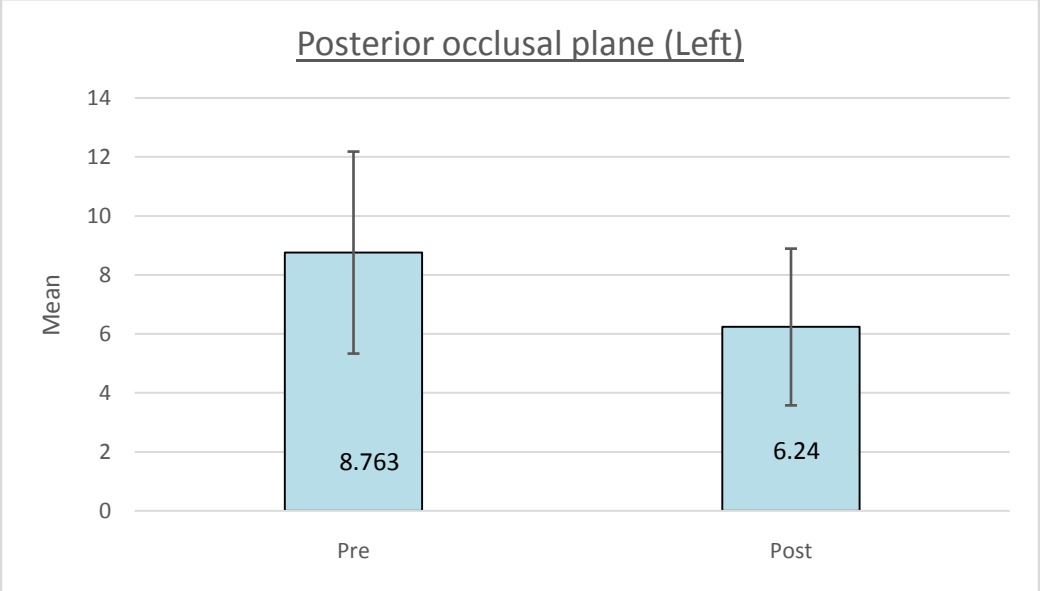

Table no 3 Correlation of pre-treatment and post-treatment right and left posterior occlusal plane inclination values.

	Side	Posterior occlusal plane		P value (independent t test)
		Mean	Std. Deviation	
Pre- treatment	Right	8.530	3.0871	0.782
	Left	8.763	3.4240	
Post-treatment	Right	5.930	2.6263	0.6512
	Left	6.240	2.6574	

IV. Discussion

The main treatment objectives of clinical orthodontics are establishment of functional occlusion, achieving occlusal stability after treatment and improved dentofacial esthetics. Establishing the appropriate occlusal plane is an essential factor. The form and inclination of the occlusal plane are related to the function of the stomatognathicsystem , esthetics [18], masticatory movement [4], biting force and posture [8]. It shows individual variation and during growth and development can influence skeletal pattern. The inclination of the occlusal plane is influenced by various factors including vertical growth of the maxillary plane, growth of the dentoalveolar bone [2], etc.

The occlusal plane has been classified

a.By Tanaka etal[2] into

1.Conventional occlusal plane.

2.Anterior occlusal plane.

3.Posterior occlusal plane.

b. Fushimaetal[3] classified maxillary occlusal plane into

Anterior occlusal plane.

Posterior occlusal plane.

c. Bhat etal[18]

1.Bisected occlusal plane. (Downs)

2.Functional occlusal plane.(Wits,Steiners,Ricketts).

d. Burstoneetal[9]

1.Upper plane of occlusion.

2.Lower plane of occlusion.

Orthodontic treatment modifies the position and angulation of teeth and attempts to place them in an ideal functional and esthetic position. The patient's occlusal characteristics including the inclination of the

occlusal plane may be modified during orthodontic treatment. Small angular differences during orthodontic treatment can result in significant occlusal changes which in turn can influence masticatory muscle balance causing functional disharmony. The role of occlusion in functional disorders of the masticatory system including temporomandibular disorders continues to be a controversial topic in orthodontics [13,14,15].

Various studies have investigated the change in inclination of the occlusal plane. These are mostly cephalometric studies and clinical studies have been limited. Cephalometric studies show a 2-dimensional view of the occlusal plane and does not detect variations on right and left sides. This study was an attempt to evaluate the difference in posterior occlusal plane inclination on right and left side in orthodontically treated patients, clinically using face-bow. The sample consisted of patients who had undergone first premolar extraction as part of orthodontic treatment.

The posterior occlusal plane [2] a plane drawn from the cusp tip of upper second premolar to midpoint of upper second molar at the occlusal surface was used. The posterior occlusal plane was selected as it was easy to identify on the study model, convenient and closely related to functional occlusal plane. It was related to the Frankfort horizontal plane, the FH plane which was determined clinically utilizing porion and orbitale as reference points. The FH plane was selected as some studies have indicated that within an individual the plane does not vary significantly over time and was used as the plane of reference in several studies.

Clinically a Hanau Wide –Vuearcon articulator with Hanau spring bow, an earpiece face-Bow was used. A face-bow[22] is a calliper like device used to record the spatial relationship of the maxillary arch to anatomic reference points and then transfer this relationship to an articulator. It orients the cast in the same relationship to the opening axis of the articulator present in the mouth. The accuracy of face-bow transfer is influenced by various factors: horizontal reference plane, an anterior point of reference, the type of face-bow and articulator used, the skills of the operator, and the accuracy of the material used for the records [22]. The face-bow, records and transfers the relation of the patient's maxillary cast and external auditory meatus to the articulator. The reference plane for the Hanau Spring-Bow is the axis-orbitale plane (a line joining the superior border of the external auditory meatus and orbital notch) with the anterior point of reference, the orbitale[22]. The relation thus obtained is transferred onto the Hanau Wide-Vue articulator. It is universally accepted that upper arm of the articulator represents the Frankfort horizontal plane [20].The hanau articulator was selected for the study because studies have shown that the sagittal inclination of the occlusal plane obtained using the Hanau Wide-Vue more closely approximated the sagittal inclination of the occlusal plane found on the lateral cephalogram[22]. It has also been found that Hanau, a semi-adjustable articulator provided more accurate results regarding the sagittal inclination of the occlusal plane than a fully adjustable articulator like the Denar[12].Palasakaretal[11] in his clinical and cephalometric study compared the sagittal inclination of the occlusal plane with the Frankfort horizontal plane on a face bow transfer to semi-adjustable and fully adjustable articulators and concluded that the Hanau wide vue articulator most closely replicated the inclination of the occlusal plane and was more accurate.

N.R.Y.Zenab etal[17] conducted a cephalometric study to investigate if there were changes in occlusal plane inclination after fixed orthodontic treatment in patients with dentoalveolarbimaxillary protrusion. They concluded that the average occlusal plane inclination change was -0.41° meaning that occlusal plane inclination became smaller compared to before treatment. This is in agreement with the present study which indicates a decrease in occlusal plane inclination post treatment. This study is also in agreement with the findings of Braun etal[6] who observed occlusal plane inclination change in his study. He hypothesised that the change was because of the use of class II elastics that caused posterior dental extrusion.

Fushimaetal[3]in his cephalometric study stated that in patients with flat occlusal plane anterior movement of the mandible leads to separation of the posterior teeth. The mandible is able to adapt to an anterior position to evade interference in the posterior dentition and to obtain occlusal stability. This reduces the chances of temporomandibular disorders. This is not seen in patients with steep occlusal plane. The decrease in post treatment occlusal plane inclination values seen in this study favor improvement in occlusal stability.

Braun etal[6]in his study defined geometric and mathematical relationships between dental occlusion and angular change of occlusal plane in the sagittal view. They concluded that there is approximately 0.5 millimeter change in the occlusal articulation relationship for each degree of occlusal plane angular change in either downward and backward or upward and forward directions. The study also revealed that if the premolars are in an end on class II relation, a 7.2 ° downward and backward rotation or steepening of the occlusal plane will result in a change to class I occlusion and if the premolars exhibit a class III relationship, an upward ,forward rotation or flattening of 7.2 °of the occlusal plane will result in a change to class I occlusion. The decrease in post treatment functional occlusal plane and posterior occlusal plane inclination angles in this study was less than 7.2 ° indicating that there is minimal change in occlusal articulation relationship at the end of treatment.

Miyazaki etal[16] in his study compared the post treatment stability of occlusion in adults and adolescents with crowding or maxillary protrusion treated with four premolar extractions and edgewise mechanics. They concluded that adults showed an increase in overjet and overbite after treatment which may be due to anterior

and posterior intrusion and extrusion after fixed orthodontic treatment. These changes can result in occlusal plane change. This is in agreement with the findings on this study which showed a decrease in occlusal plane inclination.

Graber etal[19]stated that occlusal plane angle, the dentoskeletal relationship of the occlusal plane to the Frankfort horizontal plane had a range of 8-12 ° (+/- 2 °). During orthodontic treatment, the original occlusal plane value should be maintained or decreased. Values greater or lesser than the normal range indicate more difficulty in treatment and increased post treatment instability. The results of this study are in agreement with this. Both the functional occlusal plane and posterior occlusal plane showed a post-treatment decrease which favors increased post orthodontic stability.

The posterior occlusal plane angle evaluated clinically using a face-bow also showed a decrease on both left and right sides post-treatment. Comparable studies for this clinical finding have not been reported in the literature till now. Though the posterior occlusal plane angulation showed a decrease, the variation among right and left sides post treatment was not statistically significant.

Celaretal[21]in their retrospective cephalometric study evaluated the association of anterior and posterior occlusal planes with different malocclusions and skeletal patterns. They found a mean posterior occlusal plane angle of 14.6 ° in normal subjects. In this study, the mean of the pre-treatment posterior occlusal plane on the right side was 8.530 and it was 8.763 on the left side. This is less than the mean observed in the study by Celaretal . This may be because of the difference in ethnicity of the study group.

Burstone etal[9] stated that patients who present for treatment may have relatively good posterior occlusion and changing the cant of occlusion to achieve good occlusion should also involve altering the axial inclination of the posterior teeth. This could lead to problems of instability and make treatment more difficult. The results of this study are in disagreement with the findings of Burstoneetal.

In the present study, when the mean values of the posterior occlusal plane angulation on right and left sides were compared, the pre-treatment and post-treatment posterior occlusal plane angulation differences on right and left side were not statistically significant. Though the posterior occlusal plane angulation showed a decrease, the variation among right and left sides post treatment was not statistically significant. The study is first of its kind and comparable studies using face-bow to evaluate the occlusal plane clinically in orthodontic patients are unknown.

Within the limits of the study it may be concluded that changes in occlusal plane inclination after orthodontic treatment beyond normal limits may predispose the patient to temporomandibular disorders. Further comprehensive studies are needed in this regard.

Limitations of the study.

Small sample size.

Sexual dimorphism was not considered.

V. Conclusion

The study was conducted to evaluate the difference in posterior occlusal plane inclination on right and left sides in orthodontically treated patients clinically using face-bow and to determine if there will be a change in the inclination of the posterior occlusal plane in relation to the Frankfort horizontal plane after orthodontic treatment .From the study it can be concluded that the posterior occlusal plane angulation determined clinically using face-bow both decreased post treatment. Though the posterior occlusal plane angulation showed a decrease, the variation among right and left sides post treatment was not statistically significant.

The results of this study indicate that there is a decrease in the inclination of the occlusal plane. This may be due to mesial molar movement, extrusion of first and/or second premolar, posterior and anterior intrusion and extrusion after fixed orthodontic treatment.

Changes in occlusal plane inclination may predispose the patient to temporomandibular disorders. While treating the patient, the orthodontist should ensure that the occlusal plane inclination value is unchanged or decreases within limits after fixed orthodontic treatment. An increase or decrease in occlusal plane angle beyond limits may predispose the patient to temporomandibular disorders, increase instability and make treatment difficult. Further comprehensive studies should be carried out to evaluate this.

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