

Evaluation of Occlusal Plane Inclination Using Various Facebow Systems: An *In Vivo* Study

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Abstract

Aim: The aim of this study was to evaluate the occlusal plane inclination using various facebow systems in comparison with standard cephalometric radiographs.

Materials and Methods: Twenty subjects were selected following inclusion and exclusion criteria and lateral cephalograms were taken. Occlusal Plane Inclination (OPI) between occlusal plane and Frankfort horizontal plane (FHP) was determined and taken as control group. Two maxillary impressions were made for each subject and casts were poured. Facebow transfer was made with Hanau Spring bow and Quick mount facebow and mounted on Hanau wide vue and Whip mix articulators respectively. OPA on mounted casts were measured using Universal bevel protractor and taken as test groups and compared with that of standard cephalometric values. Then all values were subjected to statistical analysis for comparison using SPSS software version 22 IBM Corp.

Results: Shows a significant difference between Cephalometric and Hanau facebow system groups 1.9° ($p = 0.046$), Cephalometric and Whip-mix facebow system groups 3.6° ($p = 0.001$) and Hanau and Whip mix facebow system groups 1.7° ($p = 0.013$).

Conclusion: Sagittal inclination of occlusal plane of maxillary casts mounted on Hanau wide vue articulator was nearer to the standard cephalometric value. Hence, the Hanau facebow system was accurate when compared to that of Quick mount facebow system.

Keywords: Occlusal Plane Inclination; Facebow; Universal Bevel Protractor

Introduction

Restoration of lost teeth should be positioned in previously occupied by natural teeth [1]. Changes in occlusal plane (OP) leads to occlusal errors in final prosthesis which further decreases prosthesis longevity and causes discomfort to the patient. Facebow helps in recording three dimensional relationship between skull and maxillary occlusal plane, then transferred to semi adjustable articulators [2]. Variations in transferring the plane from patient to articulator results discrepancies. Proper selection of facebow in conjunction with

articulator is must to minimize errors. This study was designed to evaluate occlusal plane inclination using various facebow systems in comparison with standard cephalograms.

Materials and Methods

This study was carried out in the Department of Prosthodontics, Narayana Dental College and Hospital. 20 subjects of age group between 18 - 25yrs with Angle's class I molar relation were selected from the student community. Subjects who had history of orthodontic treatment, severe crowding and severe spacing, any surgical intervention or extraction, gross dental restorations which might alter the occlusal plane, Temporomandibular joint pathologies were excluded. The entire procedure involving clinical and radiographic methods and effects of radiation were explained in detail and an informed consent was taken. Ethical clearance was obtained from institutional ethical committee.

Prior to the cephalometric technique, a small portion of lead foil (DPI Dental X-ray film, Osmanabad, Maharashtra, India) was used to position on the mesioincisal tip of right maxillary central incisor (MCI) and mesiobuccal cusp tip of right maxillary first molar (MFM) with the help of utility wax (Dentsply, Sirona, USA) (Figure 1). Then patient was positioned in Cephalostat (Planmeca Pro Max Cephalostat, Helsinki, Finland) and ear posts were inserted carefully to ensure that the head position was stable. As per the radiation protocol measures, digital lateral cephalogram were taken with mandible closed in centric occlusion. Then images were obtained in computer and extra oral radiographic films (8 x 10 inches, Fujifilm, Europe) were printed for Manual tracings.



Figure 1: Lateral cephalogram shows radiopaque markings on selected teeth.

Tracings were drawn for radiopaque markings on the mesio incisal tip of MCI and mesiobuccal cusp tip of MFM which represents OP and Frankfort Horizontal Plane(FHP) that connects the highest point in margin of right or left bony auditory meatus (Porion) and lowest point in margin of right or left bony orbit (Orbitale) (Figure 2). Occlusal plane angle between OP and FHP was measured with mathematical Set Square and geometrical protractor by taking Frankfort plane as a reference. The obtained values were taken as a control group.



Figure 2: Printed film of lateral cephalogram.

Clinically two maxillary impressions were made for each subject using irreversible hydrocolloid (Zhermack, Badia Polesine, Italy) and poured with type III dental stone as per the manufacturer instructions. The bite registration was recorded using impression compound (DPI pinnacle, Mumbai, India) The facebow records were made using 2 facebow systems - Hanau spring bow (Water pik technologies, Fort Collins, USA) and Quick mount facebow (8500 series, Whip mix corporation, Louisville, USA) and transferred to their respective articulators namely Hanau wide vue and Whip mix articulators. Orbitale and nasion minus 23 mm were used as anterior point of references in Hanau and Quick mount facebow systems respectively. Then mounting was done using dental plaster according to the manufacturer’s instructions.

In Hanau facebow system, bite fork assembly was adjusted till the orbital pointer coincided with plane of anterior reference point. Bite fork midline, vertical rod were coincided with facial midline (Figure 3). The facebow record was removed and transferred to the hanau wide vue articulator by adjusting a mounting guide or platform and cast support to the lower member of articulator with the help of thumb screws. The Ear pieces of facebow were positioned into auditory pins of articulator. Mounting was done according to manufacturer’s instructions. In Quick mount facebow system, the nasion relator was positioned to center the plastic nosepiece with the patient’s nasion and tightened the thumb screw. The horizontal toggle was adjusted such that the nasion relator shaft and bite fork shaft were on the same line (Figure 4). The facebow record was transferred to Whipmix articulator. The incisal guide pin was removed, nasion relator was slid away from center of crossbar. Thus upper frame of articulator was allowed to rest on the cross bar of facebow and 3 thumb screws were tightened. The maxillary cast was placed on to the bite registration and mounting was done.

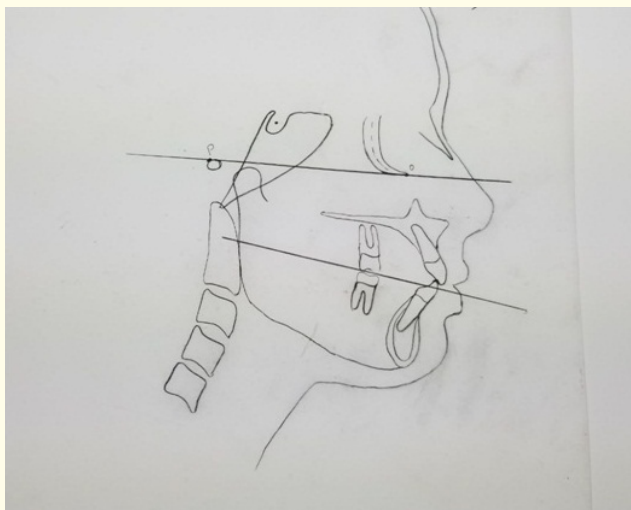


Figure 3: Showing tracing of Frankfort-Horizontal plane and Occlusal plane.



Figure 4: Orientation of maxilla using Hanau spring bow.

The angle between occlusal plane of maxillary cast and upper arm of the articulator was measured by using instrument called universal bevel protractor (UBP) (Yuzuki, Mumbai, India) [3] (Figure 5). The upper member of articulator represents FHP. With the help of cast support, the glass plate was placed against the maxillary cast and contacting occlusal surfaces indicates OP. Then the entire assembly of UBP was placed on the leveled platform in front of articulator to achieve parallelism between floor and the upper member of articulator. The horizontal base of bevel protractor was positioned such that the horizontal upper member of articulator was parallel to it and calibrated dial reading 0° was coincided with 0° of second dial. Then horizontal base was adjusted till it touches the glass plate, atleast 3 teeth and the readings were seen through the lens attached to it (Figure 6 and 7). The values obtained from Hanau wide vue and Whip mix facebow system are considered as test groups (Figure 8). The data values obtained from test groups and control group were tabulated and subjected to statistical analysis with software (SPSS Statistics software, version 22.0; IBM Corp). By using student 't' test (independent samples 't' test, paired samples 't' test the occlusal plane inclination values of mounted casts of two facebow systems and cephalometric standard values are compared and evaluated.



Figure 5: Orientation of maxilla using Quick- mount facebow.

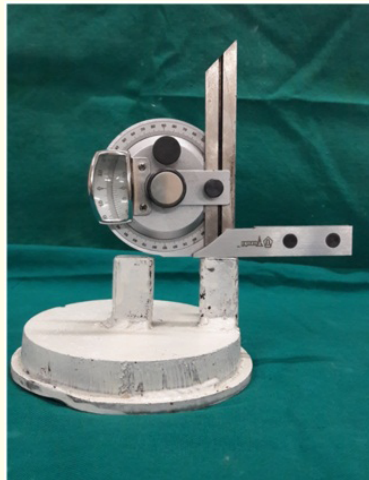


Figure 6: Modified Universal bevel protractor.

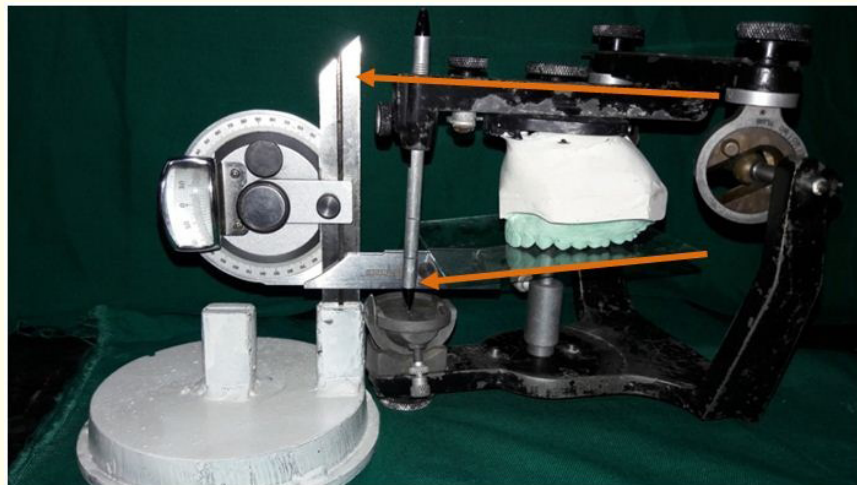


Figure 7: Angle measurement on Hanau wide view articulator.



Figure 8: Angle measurement on Whip mix articulator.

Results

The obtained mean values of cephalometric method, Hanau facebow and Whip mix facebow systems were $5.45^\circ \pm 3.017^\circ$, $7.35^\circ \pm 2.159^\circ$ and $9.05^\circ \pm 2.625^\circ$ respectively as shown in table 1. The mean difference of test groups and control group and among test groups of 1.9° , 3.6° and 1.7° respectively shown in table 2. Occlusal plane of mounted casts on Hanau wide vue articulator shows closer value to control group when compared to the Whip mix articulator.

S. no	Group	N**	Mean (degrees)	Standard Deviation (degrees)
1.	Cephalometric	20	5.45	3.017
2.	Hanau wide vue	20	7.35	2.159
3.	Whip mix	20	9.05	2.625

Table 1: Mean angle values of mounted casts on Hanau wide vue, whip mix articulators and standard cephalometric method.
N**: Total number of subjects.

S. no	Inter groups	MD* (degrees)	P value
1.	Hanau and Cephalometric	1.9	0.046
2.	Whip mix and cephalometric	3.6	0.001
3.	Whip mix and Hanau	1.7	0.013

Table 2: Intergroup comparison among test groups and control group.
MD*= Mean Difference.

Discussion

In prosthetic rehabilitation, Occlusal plane represents an important craniofacial point of reference and is essential for maintaining the physiologic status of stomatognathic system [4]. Occlusal plane inclination is an important factor for diagnostic purpose and basis for planning long span fixed prosthesis in dentulous subjects [5]. Accurate transfer of occlusal plane angle can significantly affect function and esthetics and it has implications in the field of orthognathic surgery [6,7]. Faulty orientation may endanger the interaction between tongue and buccinator muscle [8]. The changes in the existing plane produces deflective occlusal contacts in centric and eccentric positions which further increases the parafunctional activity which leads to occlusal trauma, temporomandibular joint pain, muscle spasm, and periodontal problems [9,10].

Digital radiography was considered in this study to obtain quality image and to maintain record storage and radiation exposure was reduced upto 80% [11,12]. Printed films were used for manual tracing. Lead foil was selected as radiopaque marker [13,14]. Semi adjustable articulators were chosen for this study to be used with respective facebows. They accept facebow transfer and they reproduce maxillomandibular relationship accurately than non adjustable and mounting is not so complicated as in fully adjustable articulator [15].

Some studies reported that the mean values of occlusal plane inclination in cephalometric method were 9.61° [16], 8.7° [12], 10.4° [2], 6.1° [17], 9° [8], 14.6° [18], 11.2° and 10.7° [19]. The obtained mean value in this study was $5.45^\circ \pm 3.017^\circ$.

In previous studies, mean values of Hanau facebow system were $10.77^\circ \pm 2.60^\circ$ [2], $10.69^\circ \pm 2.44^\circ$ [8], $7.79^\circ \pm 0.47^\circ$ [20] and 13.77° [2,8,18,21]. Obtained value of this study was $7.35^\circ \pm 2.159^\circ$ and closely related to the study of Abdullah., *et al* [21].

The mean difference found between occlusal plane angle of maxillary mounted casts on Hanau wide vue articulator and standard cephalometric method was 1.9° . This result was coincides with the studies of Nazir N., *et al.* and Shetty S., *et al.* who got results with a mean difference of 1.161° and 1.9° [2,8].

In this study, Axis-Orbital plane was selected to transfer the occlusal plane orientation is situated 7 mm below Frankfort plane [17,22]. It results inferior positioning of mounted casts on Hanau wide vue articulator. Thus, occlusal plane shifted downwards anteriorly by paralleling the horizontal upper member of Hanau articulator [23].

Previous studies reported that the mean angle value of Whip mix articulator were $12.7^\circ \pm 6.4^\circ$, $8.90^\circ \pm 0.91^\circ$, 23.0° [18,20,21]. The current study reveals mean value of this system was $9.05^\circ \pm 2.625^\circ$. The mean difference found between occlusal plane angle of maxillary mounted casts on Whip mix articulator and standard cephalometric method was 3.6° . This is similar to the studies of Nazir N., *et al.* 3.5° , Shetty S 3.6° , and Ramasamy M., *et al.* 3° for fixed value nasion indicator; who were used Artex Grrrbach articulator in which facebow was positioned by nasion relator [2,3,8].

The mean difference between Hanau and Whip mix facebow systems was 1.7° . This result is similar to the difference between Artex articulator and Hanau articulator [2]. This is because crossbar of facebow was positioned approximately not exactly in region of orbitale [24,25]. It results more inclination of mounted casts on Whip mix articulator when compared to the Hanau wide vue articulator. From these results, maximum angle was obtained in Quick mount facebow system compared to Hanau facebow system and cephalograms. Using Pearson correlation, the accuracy of two facebow systems in transferring the occlusal plane to their respective articulators was determined in comparison with cephalometric gold standard. The correlation value found between Hanau wide vue and cephalometric method was 0.163, Whip mix articulator and cephalometric method was 0.017 and Whip mix and Hanau wide vue articulator was 0.34. Hence, Hanau wide vue articulator was comparatively more accurate than Whip mix articulator.

So, to improve the success of rehabilitation procedures, Hanau facebow system would be the better choice in transferring the occlusal plane from patient.

Limitations of this Study

1. Sample size is small.
2. There is no equal gender distribution.
3. Due to morphological variations location of nasal notch was difficult with nasion relator which can be moved in and out but not up and down.

A study with large sample size including facial forms and different skeletal class relations may yield better results.

With the advent of CAD-CAM technology, virtual articulators became popularised to improve the designing of dental prosthesis [26]. Further studies were needed to compare and evaluate the occlusal plane angulation with virtual articulator to that of conventional method.

Conclusion

Within the limitations of the study, the following conclusions were drawn:

- The mean value of occlusal plane inclination of mounted casts on Hanau and whip mix articulators was $7.35^\circ \pm 2.159^\circ$ and $9.05^\circ \pm 2.625^\circ$ respectively.
- The mean value of occlusal plane inclination in standard cephalometric method was $5.45^\circ \pm 3.017^\circ$.
- Sagittal inclination of occlusal plane of maxillary casts mounted on Hanau wide vue articulator was nearer to the standard cephalometric value.

Hence, the Hanau facebow system was accurate when compared to that of Quick mount facebow system.

- The mean value of occlusal plane inclination in standard cephalometric method was $5.45^\circ \pm 3.017^\circ$.
- Sagittal inclination of occlusal plane of maxillary casts mounted on Hanau wide view articulator was nearer to the standard cephalometric value.

Hence, the Hanau facebow system was accurate when compared to that of Quick mount facebow system.

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