

Effect of Direct and Indirect Facebow Transfer Methods on Horizontal Condylar Guidance Values in Dentulous Patients on Semi-Adjustable Articulator: An In-Vivo Study

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Abstract

Background: This original research study's primary objective was to assess how the horizontal condylar guidance values in dentulous patients are affected by both direct and indirect facebow transfer techniques, utilizing a semi-adjustable articulator. **Methods:** Fifteen dentulous individuals, aged between 20 and 25, were chosen as participants for this study, regardless of their gender. Two sets of upper and lower dental casts were obtained. The maxillary models were mounted using both direct and indirect facebow methods, in both maximum intercuspation and protrusive positions. The maximum intercuspation record was used to mount the mandibular models, and the protrusive record was used to programme the articulator. The resulting values of the Horizontal Condylar Guidance (HCG) were then put through the one-way ANOVA test and the Tukey post hoc test. **Results:** The HCG values obtained through direct facebow transfer method were 32.93° for the right condyle and 33.66° for the left condyle and through indirect transfer method were 33.73° for the right condyle and 33.53° for the left condyle. When using cephalometric analysis, the mean HCG values were found to be 34.13° for the right condyle and 34.133° for the left condyle. An overall statistically significant difference in HCG values was found among all the groups on right side unlike that of the left side. **Conclusion:** The indirect method was found to be closer to the value of HCG measured through cephalogram as compared to the direct method.

Key words: cephalometric analysis, facebow transfer, horizontal condylar guidance, interocclusal records, semi-adjustable articulator

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Introduction

Precise transfer of jaw relation records from patients to the articulator are essential for proper functioning of dental prosthesis, maintaining facial aesthetics, and ensuring oral health. The facebow instrument is vital in accurately transferring the relationship between the upper and lower jaws from the patient to the articulator [1]. Following the facebow transfer, the mounting of the upper dental models can be achieved using either the indirect or the direct method [2].

In the direct mounting approach, after acquiring the facebow registration, the spring bow and transfer assembly are directly positioned onto the articulator. Before mounting the maxillary cast, the bitefork index is supported by the cast support. On the other hand, in the indirect mounting method, following the facebow

registration, the bitefork transfer assembly is detached from the spring bow. Using the transfer jig and mounting platform, the bitefork is positioned onto the articulator, which enables the convenient mounting of the maxillary cast [2].

According to the Glossary of Prosthodontic Terms (GPT 9), the mandibular guidance produced by the condyle and articular disc traversing the shape of the glenoid fossa is known as the condylar guidance [1]. To record the condylar path and adjust the articulator for dentulous patients, various intraoral and extraoral methods have been utilized. Among the intraoral methods, commonly used techniques include the Lucia jig, leaf gauge, interocclusal records, and intraoral tracers. Additionally, extraoral methods such as orthopantomograms (OPGs), lateral cephalograms, and tomographs are most widely used for this purpose [3].

The literature suggests that indirect and direct mounting may or may not have any effect on the horizontal condylar guidance values. There is ambiguity in the literature available on the accuracy and practical application of clinical methods of recording condylar guidance. Therefore, utilising a semi-adjustable articulator, the objective of this study was to assess and compare the impact of direct and indirect mounting methods on the horizontal condylar guidance values in dentulous patients. In order to establish a control group, lateral cephalogram values were taken into consideration for comparison. The null hypothesis for the study states that there is no difference in the horizontal condylar guidance values irrespective of direct or indirect mounting methods.

Material and Methods

The research was conducted at the Department of Prosthodontics, SRCDSR, Faridabad, Haryana, India. Fifteen dentulous individuals, regardless of their gender, willing to participate in the study were chosen based on specific inclusion and exclusion criteria. The inclusion criteria consisted of having a class I molar relation, a complete set of teeth, being within the age range of 20-25 years, and having an overjet of 2-4mm. These criteria were used to select the appropriate subjects for the research. Exclusion criteria included subjects with any kind of malocclusion, gross attritions, any kind of progressive periodontal disease, or poor general health. The Ethical Committee approved the study protocol, informed consent form, and data collecting forms (SRCDSR/ACAD/2019/9847).

The horizontal condylar guidance values obtained from the lateral cephalogram for each patient were classified as Control group. The values obtained by direct facebow transfer were categorized as Group A (study group) and those by indirect facebow transfer were categorized as Group B (study group) as seen in Table 1.

Table 1: Sample Grouping

Group	Name
Lateral cephalogram	Control group
Direct facebow transfer	Group A (Study Group)
Indirect facebow transfer	Group B (Study Group)

Radiographic Assessment

Lateral cephalograms were taken for both the right and left sides of all participants. A line to create the Frankfort horizontal plane (FHP) connected the orbitale, the lowest point of the orbit, and the porion, the highest point of the external auditory meatus. Then, another line was drawn from the most anterosuperior point on the glenoid fossa to the most convex point on the articular eminence following the posterior slope of the articular eminence. By measuring the angle between the Frankfort horizontal plane and the posterior slope of the articular eminence, the condylar inclination angle was calculated as illustrated in Figure 1.

Clinical Methods

Two sets of impressions were made using irreversible hydrocolloid (Algitex, DPI, India) for each subject. The casts were poured into dental stone (Zodenta Neelkanth, Mittal Den Pro & Surgicals, India). Split casts were prepared for each maxillary cast followed by the facebow record (HANAU™ Spring Bow, Whip Mix Corporation, USA).



Figure 1: Magnified horizontal condylar guidance

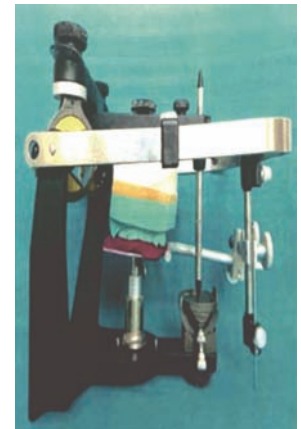


Figure 2: Direct mounting method

Articulator Preparation

The semi-adjustable articulator used in this study was the HANAU Wide Vue Articulator, manufactured by Whip Mix Corporation in the USA. It is equipped with condylar guidance that is graduated at 5-degree intervals, ranging from -20 to 60 degrees. In this study, AUTO-CAD software was used to make a drawing of a circle with markings at per degree interval and the printout was attached to the condylar guidance for accurate readings as shown in Figure 3. The articulator was calibrated to the zero position as per the instructions provided in the Hanau™ manual.



Figure 3: Indirect mounting method



Figure 4: Programming of the articulator using protrusive record

Direct Mounting Method

The spring bow's ear pieces were used to attach the bow to the condylar ends of the HANAU™ articulator once the facebow record was made. The orbitale pointer on the spring bow's top was then aligned with the indicator on the articulator's underside by adjusting the anterior elevator. Once properly aligned, the anterior elevator was secured by tightening the thumbscrew. The bite fork index was supported by the cast support followed by mounting of the maxillary cast was done using the dental plaster (Neelkanth DENTICO, Neelkanth Healthcare Pvt Ltd, India) as shown in Figure 4.

Indirect Mounting Method

After the face bow transfer was completed, the cast support was removed and the mounting record jig was further screwed to the lower member. The transfer assembly's spring bow was removed, and the assembly was then fastened to the jig. The cast support was then raised to give the bitefork index the support it needs once the transfer assembly had been safely mounted onto the mounting platform. The maxillary cast was carefully seated into the imprints of the modeling compound (Y-DENTS, MDM Corporation, India) and was mounted using the dental plaster as shown in Figure 5.

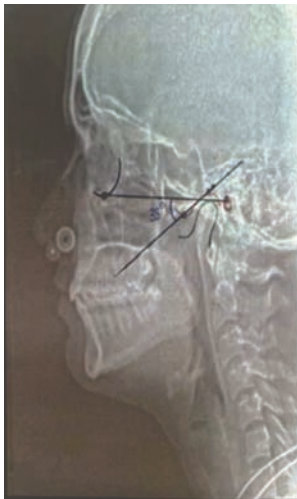


Figure 5: Horizontal condylar guidance values from cephalometric readings

Interocclusal Records and Programming of the Articulator

The centric relation record (Figure 5) was made using bite registration material (Jet Bite, Coltene, Florida) which was further placed on the maxillary cast, and utilizing this the mandibular casts were mounted using dental plaster as shown in Figure 6.

The protrusive interocclusal record was made using bite registration material (Jetbite, Coltene, Florida) by instructing the patient to close in edge-to-edge relation. The articulator was adjusted to get the appropriate horizontal condylar guidance values when the protrusive record was attached to the mandibular cast, as depicted in Figure 7.

The horizontal condylar guidance values obtained from the cephalometric records served as the control group. The values of horizontal condylar guidance obtained from both the direct and indirect mounting methods were recorded and subjected to analysis using the Tukey's post hoc analysis after the one-way Analysis of Variance (ANOVA) test.

Results

In order to do the statistical analysis, Microsoft Excel 2013 was used. The mean horizontal condylar guidance (HCG) values obtained through direct face-bow transfer were 32.93° for the right condyle and 33.66° for the left condyle. On the other hand, the horizontal condylar guidance values obtained through the indirect transfer method were 33.73° for the right condyle and 33.53° for the left condyle. The mean HCG values obtained through cephalometric analysis were 34.13° for the right condyle and 34.133° for the left condyle, as presented in Tables 2 and 3.

The ANOVA test's statistical analysis findings revealed a significant difference ($p < 0.05$) between each group. There was a statistically significant difference between the direct approach and the cephalometric method, according to additional analysis using Tukey's post hoc test. However, no statistical difference was observed between the indirect method and the cephalometric method.

Discussion

According to GPT-9, the angle created by the movement of the condyles in the sagittal plane relative to the horizontal plane is known as the horizontal condylar inclination¹. Horizontal condylar guidance can be assessed both clinically and radiographically. Extraoral methods such as panoramic radiographs, tomographs, and lateral cephalograms can be utilized for this purpose. Intraoral methods involve the use of jigs, intraoral tracers, and protrusive wax records. In a semi-adjustable articulator, the condylar guidance is established by incorporating protrusive or lateral interocclusal registrations. These methods enable the determination and adjustment of horizontal condylar guidance for effective dental treatment [4].

Facebow transfer includes transferring to an articulator the spatial relationship between the maxillary arch and significant anatomical reference points. This allows for accurate mounting of the maxillary

**Table 2: Horizontal condylar guidance values on right side
(One-way ANOVA test, Tukey's Post hoc test)**

	Mean±SD	N	95% CI		P value	Post hoc pairwise comparison
			Upper	Lower		
Group A	32.93±3.535	15	30.97	34.89	0.01	A*B – 0.052
Group B	33.73±3.432	15	31.83	35.63		A*Control – 0.031
Control Group	34.13±3.357	15	32.27	35.99		B*Control – 0.333

**Table 3: Horizontal condylar guidance values on left side
(One-way ANOVA test, Tukey's Post hoc test) Condylar guidance on Left Side (N=15)**

	Mean±SD	95% CI		P value	Post hoc pairwise comparison
		Upper	Lower		
Group A	33.66±3.61	31.663	35.671	0.15	A*B – 0.999
Group B	33.53±3.42	31.639	35.427		A*Control – 0.451
Control Group	34.13±3.83	32.010	36.256		B*Control – 0.069

cast on the articulator. Horizontal condylar guidance can be recorded using two methods of facebow transfer: direct and indirect. In direct mounting, the facebow registration is obtained from the patient, and then the ear bow halves are detached. The remaining transfer assembly is placed directly onto the articulator to mount the maxillary cast. On the other hand, indirect mounting involves removing the transfer assembly from the spring bow. The transfer assembly is then positioned on the articulator using a transfer jig, facilitating the mounting of the maxillary cast [4].

An incorrect facebow record can result in improper occlusion, where the way the upper and lower teeth come together is not aligned correctly. Occlusal interferences caused by this misalignment can impede normal mandibular movements. Consequently, this can lead to prolonged chairside adjustment time and the need for arbitrary trimming of the teeth, which can be frustrating for both the patient and the dental surgeon [4].

The existing literature has emphasized that despite various methods and instruments used for recording horizontal condylar guidance (HCG), including interocclusal records and different types of facebow transfers, there has been limited exploration of the impact of facebow transfer methods on HCG values [3]. One factor that has been overlooked is the distinction between direct and indirect facebow transfers. In the present study, the objective was to examine the influence of direct and indirect facebow transfers on HCG values in dentulous patients utilizing a semi-adjustable articulator, with lateral cephalogram values serving as a control. The main rationale behind this investigation is that the indirect facebow transfer method does not rely on an anterior reference point.

In the present study, several factors were implemented to minimize errors and improve the accuracy of the measurements. Firstly, bite registration material (Coltene, Jetbite), was used for recording maximum intercuspation and protrusive interocclusal records. This choice of material ensures precise registration of the occlusal relationship between the upper and lower teeth, providing reliable data for programming the articulator. The second factor that contributed to reducing errors was the use of a split cast. By employing a split cast, the observer was able to carefully examine and confirm the absence of any gaps between the primary and secondary bases of the cast. This thorough evaluation ensured that the mounted cast was securely positioned and accurately replicated the patient's occlusal relationship, thereby enhancing the reliability and accuracy of the articulator programming. By incorporating these measures, the study aimed to enhance the precision and validity of the data obtained, allowing for more reliable assessments of the horizontal condylar guidance values in dentulous patients.

For the current study, lateral cephalograms were obtained for each participant subsequent to which cephalometric tracings were performed. By measuring the angle between Frankfurt's horizontal plane and the posterior slope of the articular eminence (AE), the horizontal condylar guidance (HCG) values were determined. This methodology allowed for the accurate assessment of HCG values in the selected dentulous subjects. Several advantages offered by the lateral cephalogram method include the use of standardized bony landmarks and the ability to be repeatable and standardized thus enabling it to be used as a control group. The values were further used to decide which method out of direct and indirect methods gave HCG values closer to those obtained from lateral cephalogram.

In the present study, the mean HCG value obtained through direct face-bow transfer for the right condyle was 32.93°, and for the left condyle, it was 33.66°. On the other hand, the HCG values obtained

through the indirect transfer method were 33.73° for the right condyle and 33.53° for the left condyle. Additionally, the mean HCG values acquired through cephalometric analysis were 34.13° for both the right and left condyles.

The findings of the study revealed that both the direct and indirect methods of measuring condylar guidance resulted in lower values compared to the measurements obtained through cephalometric analysis. Also, an overall significant difference in HCG Values was found among all the control and study groups on right side whereas there was no significant difference on the left side. On the right side, a statistically significant difference between the direct approach and the cephalometric method was discovered using Tukey's post hoc pairwise comparison. However, no significant difference was observed between the indirect method and the cephalometric method. There was no pairwise difference in the left side measurements among direct and indirect and cephalometric methods. Both of these findings suggested that the indirect method produced measurements close to those obtained through cephalograms partially rejecting the null hypothesis.

The findings of the present study align with a previous study conducted by Mishra et al [3], where the mean HCG values obtained through the indirect facebow transfer were closer to the values obtained from lateral cephalograms. This similarity in results suggests consistency and reinforces the validity of the findings. Furthermore, the results of the present study are in accordance with the HANAU™ manual, which states that indirect facebow transfer is more accurate than direct facebow transfer [5,6]. These outcomes can be attributable to a number of things, including improved mounting stability, easier access to the cast, and the articulator's upper and lower parts being parallel to one another. These factors contribute to enhanced precision and reliability in measuring and transferring condylar guidance values.

In conclusion, the study suggests that the indirect method of measuring condylar guidance provides results that are more similar to the values obtained through cephalometric analysis. This indicates that the indirect method may offer a more accurate representation of condylar guidance compared to the direct method.

As the sample size in the current study was limited, further studies are required to explore the complete depth of the understanding regarding the effect of various face bow transfer methods on HCG values in dentulous patients with larger sample sizes and diverse populations.

Conclusion

Considering the limitations of the study the choice of the facebow transfer method may have a clinical relevance. On the right side, there was a statistically significant difference in the horizontal condylar guidance (HCG) values between the direct method, cephalometric readings, and the indirect method. This suggests that the method of face-bow transfer used can influence the resulting HCG values. Considering the lack of significant differences in the mean HCG values obtained from lateral cephalograms and indirect face-bow transfer on both the right and left sides, it suggests that the indirect method of face-bow transfer may provide a more accurate representation of the HCG values. It is important to note that these conclusions are based on the specific parameters and limitations of the study and further research with may be necessary to validate these findings.

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