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The Effect Of Mounting And Facebow Transfer On Condylar Guidance: A Digital Cephalometric Analysis

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ABSTRACT

Background: *Complete edentulism significantly affects the masticatory function in older adults, necessitating effective rehabilitation strategies to restore occlusion and prevent bone resorption. The use of facebow transfer during prosthesis fabrication remains debated, with some practitioners opting for average value articulators, potentially leading to misalignment and compromised aesthetics.*

Objective: *This study aimed to compare protrusive condylar guidance settings in edentulous patients using two mounting methods—facebow transfer and Bonwill's method—against a radiographic method.*

Methods: *Ethical clearance was obtained, and 24 edentulous participants aged 45-70 were included. Participants were mounted on Artex Type AR semi-adjustable articulators using facebow and Bonwill methods, and radiographic analysis was performed with digital cephalometric imaging. Statistical analyses were conducted using SPSS, employing Wilcoxon signed-rank and Mann-Whitney U tests for comparisons.*

Results: *Condylar guidance angles measured via the radiographic method were significantly higher than those obtained from facebow and Bonwill methods ($P < 0.05$). The mean difference between radiographic and facebow methods was 13.2° (right) and 13.9° (left), while Bonwill's method differed by 33.4° (right) and 33.8° (left) from the radiographic values. A notable discrepancy of 20.8° (right) and 21.5° (left) was observed between the facebow and Bonwill methods.*

Conclusion: *The study demonstrates significant variations in condylar guidance based on the mounting method, highlighting the importance of accurate recording techniques in denture fabrication to ensure optimal occlusion and functional outcomes for edentulous patients.*

KEYWORDS*: Edentulous patients, Condylar guidance, Facebow transfer, Bonwill's method, Lateral cephalogram*

INTRODUCTION

Complete edentulism in older adults compromises masticatory function, impacting overall health and quality of life[1]. In rehabilitating these individuals, dentists aim to establish an occlusion that reduces bone resorption of the edentulous jaws[2]. Often, dental practitioners omit the facebow transfer when fabricating removable prostheses, opting to mount casts on an average value articulator. This expedites denture fabrication and reduces chair time but may improperly position the maxillary and mandibular casts, leading to an unesthetic prosthesis and potentially damaging forces on the supporting structures[3].

Several studies debate the necessity of facebow transfer for complete dentures[4]. Simplified techniques show comparable patient satisfaction and clinical outcomes to those achieved with facebow transfer[4]. Modern articulators incorporate Bonwill's triangle and Balkwill's angle and encourage mounting casts according to these concepts[3]. Changes in occlusal plane orientation influence condylar guidance readings, regardless of the mounting method[5]. Since condylar guidance is an unmodifiable posterior determinant of occlusion, accurate recording is essential[6]. Variations in condylar guidance among dentulous individuals have been documented using methods like the cephalometric, facebow transfer, and average value techniques[7]. However, there is limited information on using Guichet's point as a third point of reference in facebow transfer for edentulous patients. This study aims to compare protrusive condylar guidance settings in edentulous patients with casts mounted via facebow transfer and Bonwill's method on Artex Type AR semi-adjustable articulators (Girrbach Dental Systems, Germany) against the radiographic method.

MATERIALS AND METHODS

Prior to beginning the study, ethical clearance was secured from the Institutional Ethics Committee. Sample size was calculated based on Cohen's d formula ($d = X1\ X2/\alpha$), utilizing an 80% power from Cohen's table, resulting in $n = 10$ following a preliminary pilot study. Participants were recruited from different dental clinics and hospitals. The study details and procedures were explained to each participant in a language they understood, and written informed consent was obtained. To ensure participant selection was standardized and to minimize potential bias from skeletal or occlusal variations, specific inclusion and exclusion criteria were applied. Participants were required to be edentulous with a Class I jaw relationship and good neuromuscular control. Those with temporomandibular disorder symptoms, uncontrolled systemic conditions, history of craniofacial trauma or surgery, facial asymmetry, or hard/soft tissue abnormalities were excluded.

Bonwill's Method

Maxillary and mandibular casts were mounted onto an articulator using the patient's centric relation record (Imprint, 3M ESPE, USA). The mandibular occlusal plane was aligned to intersect with a line connecting Bonwill's triangle and Balkwill's angle (26°). A protrusive interocclusal record was created using an extraoral tracer assembly and central bearing plate by guiding the mandible forward by 6 mm. Condylar inclination values for the left and right sides were documented using this protrusive record.

Facebow Method

The maxillary and mandibular casts were then removed from the articulator, and the tracer was detached from the maxillary occlusal rim. A facebow transfer (Artex Rotofix, Girrbach Dental Systems, Germany) was conducted, marking a point 43 mm above the incisal edge of the right lateral incisor on the lateral wing of the nose using an indelible pencil. The facebow was adjusted to an individually localized anterior reference point using a height-adjustable locator rod. Maxillary casts were mounted on a semi-adjustable articulator (Artex, Girrbach Dental Systems, Germany) using an indirect mount. The mandibular cast was then positioned using the centric relation record, and the previously obtained protrusive interocclusal record was employed to calibrate the condylar guidance on the articulator. Condylar inclination values for both sides were recorded.

Radiographic Method

A digital panoramic and cephalometric system (Planmeca Proline XC, Germany) was used to capture lateral cephalographs of each participant, with occlusal rims and attached tracers in place. Radiographs were taken in both maximum intercuspation and protrusion positions using standard parameters (68 kV, 5 mA) and a Broadbent cephalostat to maintain consistent head positioning. Digital cephalographs were then traced on acetate matte tracing paper (0.003 inches, 8 × 10 inches), marking a midfacial horizontal reference plane along the line connecting Porion to Guichet's point. This reference plane served as a guide for overlapping cephalographs. The protrusive condylar path was determined by connecting the condyle centers on the overlapped cephalographs in centric relation and protrusion. The angle between the midfacial horizontal reference plane and the protrusive condylar path was recorded as the protrusive condylar angle.

Statistical Analysis

Statistical analyses were conducted using SPSS Statistics for Windows (Version 21.0, IBM Corp., Armonk, NY, USA). The significance level for all statistical tests was set at p = 0.05. Condylar guidance values obtained via Bonwill's, facebow, and radiographic methods were compared using the Wilcoxon signed-rank test and the Mann–Whitney U test.

RESULTS

Twenty four edentulous participants, aged between 45 and 70 years, visited the outpatient department of prosthodontics involved in the in-vivo cross-sectional study. The condylar guidance angles of the right and left sides obtained from lateral cephalograms were higher when compared to the other two methods. The mean difference between the radiographic and facebow methods was 13.2° for the right side and 13.9° for the left side, which was statistically significant ($P < 0.05$). [Table 1]. The mean difference between the radiographic and Bonwill's methods for the right side was 33.4° and for the left side was 33.8°, which was statistically significant ($P < 0.05$) [Table 2]. The mean difference between Bonwill's method and the facebow method for the right side was 20.8° and for the left side was 21.5°, which was statistically significant ($P < 0.05$) [Table 3]. The comparison between right and left side condylar guidance values obtained by the radiographic method was 0.5° ($P = 0.83$) and by the facebow method was 0.4° ($P = 0.80$). There was no significant difference between the right and left sides in Bonwill's method [Table 4].

Table 1: Mean difference in condylar guidance angles (degrees) between the radiographic and facebow methods for both right (R) and left (L) sides among subjects, analyzed using the Wilcoxon signed-rank test

Variable	N	Mean	Standard Deviation	Mean Difference	Z	P
Radiographic method (R)	24	40.3	5.15	13.2	-2.609	0.006*
Facebow Method (R)	24	27.1	4.17			
Radiographic method (L)	24	40.7	4.58	13.9	-2.808	0.001*
Facebow Method (L)	24	26.8	4.27			

N- number of patients, * Statistically significant

Table 2: Mean difference in condylar guidance angles (degrees) between the radiographic method and Bonwill's method for both right (R) and left (L) sides among subjects, analyzed using the Wilcoxon signed-rank test

Variable	N	Mean	Standard Deviation	Mean Difference	Z	P
Radiographic method (R)	10	43.3	6.65	33.4	-2.409	0.025*
Bonwill's method (R)	10	9.9	2.78			
Radiographic method (L)	10	43.7	6.08	33.8	-2.409	0.001*
Bonwill's method (L)	10	9.9	2.78			

N- number of patients, * Statistically significant

Table 3: Mean difference in condylar guidance angles (degrees) between Bonwill's method and the facebow method for both right (R) and left (L) sides among subjects, analyzed using the Wilcoxon signed-rank test

Variable	N	Mean	Standard Deviation	Mean Difference	Z	P
Bonwill's Method (R)	24	10	3.0	20.8	-2.96	P<0.0001*
Facebow method (R)	24	32	5.5			
Bonwill's Method (L)	24	11	3.2	21.5	-2.92	P<0.0001*
Facebow method (L)	24	33	5.8			

N- number of patients, * Statistically significant

Table 4: Comparison of condylar guidance angles (degrees) between the radiographic, facebow, and Bonwill's methods for both right (R) and left (L) sides within a subject group, analyzed using the Mann-Whitney U test

Variable	N	Mean	Standard Deviation	Mean Difference	Z	P
Radiographic Method (R)	24	42.2	6.15	0.5	0.150	0.83
Radiographic method (L)	24	42.9	5.90			
Facebow method (R)	24	29.04	4.96	0.6	0.2	0.80
Facebow method (L)	24	30	3.4			
Bonwill's method (R)	24	10	2.56	0	0.001	0.11
Bonwill's method (L)	24	10	2.56			

N- number of patients

DISCUSSION

The primary aim of treating an edentulous patient is to restore oral functionality, with a particular emphasis on preserving residual alveolar bone. A common perception among dental practitioners is that occlusal interferences in removable prostheses are insignificant due to the cushioning effect of the mucosa, which helps

to absorb and dissipate forces[8]. However, these interferences may destabilize the prosthesis, potentially leading to bone resorption over time[8]. The condylar path, shaped by the articular eminence, is crucial in influencing mandibular movement. Therefore, in designing occlusion for edentulous patients, restorative dentists should aim to create harmony between the occlusal surfaces of artificial teeth and the condylar path to enhance chewing efficiency and safeguard the residual alveolar ridge[9]. This study aimed to compare condylar guidance values derived through clinical methods with those obtained through radiographic analysis, examining potential implications of any discrepancies between the values.

Previous studies have shown no significant difference in treatment outcomes between conventional techniques (which use a facebow) and simplified methods (without a facebow) in creating complete dentures[10,11]. Heydecke *et al*.[12] found that esthetic appearance, denture stability, and overall satisfaction were actually higher without facebow transfer, and there were no notable differences in chewing efficiency, comfort, speech, or ease of maintenance. Some studies[13,14] also reported similar or improved outcomes without the use of a facebow. A ten-year follow-up by Kawai *et al*.[15] highlighted that the simplified approach was more cost-effective than traditional methods involving facebow transfer. Consequently, our study was designed to measure condylar guidance using the facebow transfer method and Bonwill's method, with comparisons to radiographic methods based on the midfacial horizontal plane.

Lateral cephalometric analysis was employed to estimate the condylar guidance for both right and left sides by measuring the angle between the protrusive condylar path and the midfacial horizontal reference plane[7,16]. Consistent with earlier research[7,17], this study found that clinical methods yielded lower condylar guidance values compared to radiographic measurements. Furthermore, a wide range of condylar guidance values (5°–55°) has been reported in clinical studies[8,18-20], prompting some practitioners to rely on average settings based on published mean values[21,22]. The Bonwill method, incorporated into articulators as an equilateral triangle with 4-inch sides connecting the condyles and mandibular incisors, simplifies the alignment process. In this study, using Bonwill's triangle yielded an average condylar guidance value of 8° ± 2.58° for both sides. Comparisons with radiographic and facebow measurements revealed statistically significant differences ($P < 0.005$).

Using average condylar guidance values simplifies articulator programming, but this approach assumes that the patient falls within the range of these average values, which can sometimes lead to inaccuracies[23]. Importantly, the reference plane plays a critical role in such comparisons; the radiographic and facebow methods used Guichet's plane, while Bonwill's method relied on a predefined occlusal plane within the articulator[24,25]. Manufacturers recommend a 30° condylar guidance setting for the Artex articulator when using Bonwill's method, considerably higher than the average of 8° observed in this study.

Weinberg[26] noted that using different anterior reference points, as recommended by various facebow systems, may alter the occlusal plane by ±16 mm, impacting eccentric condylar readings and cusp inclinations without affecting centric occlusion. Though Bonwill's method does not employ a facebow, the occlusal plane orientation was noticeably lower than in casts mounted via the facebow method. This study found a mean difference of 21.5° and 22° in condylar guidance angles between clinical methods on the right and left sides, respectively.

According to Craddock[27], horizontal condylar guidance exerts its greatest influence in the molar regions. A 10° increase in condylar guidance causes the molars to be positioned 0.5 mm further apart when the mandible moves into an end-to-end relationship, while a 10° decrease brings them 0.5 mm closer. This discrepancy is a concern with Bonwill's method, which recorded an average value of 8°, as opposed to the 30° setting recommended for the Artex articulator, potentially leading to occlusal prematurities in the premolar and molar regions. Improper occlusal plane selection has been linked to denture instability and decreased chewing efficiency, as highlighted by Okane *et al*.[28] and Krueger *et al*.,[29] who reported occlusal errors in the balancing side when vertical positioning errors are large in complete dentures.

The study also examined differences between right and left condylar guidance values as measured radiographically, finding a mean difference of 0.4° between sides, which was statistically insignificant (P =

0.91). Bilateral asymmetry in condyles or articular eminences, variations in anatomy and angulation, disc configuration and position during condyle movement, and the force vectors of the musculature involved in mandibular disocclusion may explain these variations, as proposed by Bell *et al*.[16].

A key limitation of this study is the "resilient and resilient-like effect" of supporting tissues, which Hanau[30] noted as a significant source of error in maxilla-mandibular relationship registration in edentulous subjects. Additionally, as this study was conducted with a small sample size of Indian patients, generalization of the results may be limited.

CONCLUSION

This study provides valuable insights into the impact of mounting methods on condylar guidance in edentulous patients, highlighting significant differences in condylar guidance angles obtained through the facebow transfer method, Bonwill's method, and radiographic analysis. Notably, radiographic measurements consistently yielded higher condylar guidance angles than those recorded via clinical methods, indicating a need for precise measurement techniques.

The findings underscore the critical importance of accurately recording condylar guidance to optimize the design and function of removable prostheses, particularly for preserving residual alveolar bone and enhancing masticatory efficiency. Given the observed discrepancies between methods, dental practitioners must carefully consider their choice of mounting technique, as reliance on average values may fail to accommodate individual anatomical variations.

Moreover, the study advocates for the integration of radiographic assessments into clinical practice to provide a more informed basis for setting condylar guidance. This approach could significantly enhance the overall quality of care for edentulous patients, ultimately leading to improved prosthetic outcomes and increased patient satisfaction.

Future research is warranted to further explore the implications of these findings on clinical protocols, as well as to validate the use of Guichet's point in facebow transfer for edentulous individuals. By prioritizing accurate condylar guidance recording, dental professionals can better serve their patients and ensure optimal restorative results.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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