Original Article

The Effect of Average Value Mounting and Facebow Transfer on Condylar Guidance Settings in a Semi-Adjustable Articulator – A Comparative Study using Digital Lateral Cephalographs in Edentulous Patients

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Abstract

Background: While we attempt to restore occlusion in completely edentulous patients there is a consensus among clinicians to articulate the cast using average value and avoid performing facebow transfer. Various studies question the application of facebow transfer in the fabrication of removable complete denture fabrication. **Aim:** This study was therefore aimed to study the effect on condylar guidance with casts mounted by the facebow method, Bonwill's method, and radiographic method. **Methods:** A cross-sectional study was performed using casts of edentulous patients attending the Department of Prosthodontics. After establishing a tentative jaw relationship using wax occlusal rims in the edentulous participants, the casts were mounted by Bonwill's method and the facebow transfer method to a semi-adjustable articulator. Protrusive records of the subjects were used to program the articulator to obtain the condylar guidance values. Digital lateral cephalographs were made both in centric and protrusive jaw relationships. The mandibular condyles were then traced and overlapped to obtain radiographic values. The condylar guidance values obtained by Bonwill's method, facebow method and radiographic method were compared using Wilcoxon's signed rank test and Mann–Whitney *U* test. The SPSS Statistics for Windows (Version 21.0. Armonk, NY, USA:IBM Corp.), and, at a probability value of 0.05, the significance of every statistical test was predetermined. **Results:** Ten edentulous 45–70 year olds participated in the study. The mean discrepancy between radiography and facebow methods was 12.8° for the right side and 12.7° for the left ($P < 0.005$). The difference between radiography and Bonwill's methods was significant ($P < 0.005$), with a mean difference of 34.3° for the right side and 34.7° for the left side. The difference between Bonwill's method and the facebow method was significant ($P < 0.005$), with a mean difference of 21.5° for the right side and 22° for the left side. **Conclusion:** The condylar guidance values obtained by clinical methods (Bonwill's and Facebow) were significantly lesser ($P < 0.005$) compared to the values obtained by radiographic method.

Keywords: *Condylar guidance, complete denture, lateral cephalograph, semi-adjustable articulator*

Introduction

Complete edentulism in the geriatric age group leads to inefficiency of the masticatory apparatus, which can consequently affect such individuals' overall health and well-being.[1] During oral rehabilitation of such individuals, the dentist should aim at achieving

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an occlusion that minimizes bone resorption of the edentulous jaws.[2] Generally, dental practitioners do not perform a facebow transfer procedure while fabricating a removable dental prosthesis. Typically, we mount the casts to an average-value articulator to simplify the denture fabrication procedure and minimize chair-side time. This may lead to improper positioning of the maxillary and mandibular cast on the articulator resulting in an unaesthetic prosthesis and transmission of undesirable forces to the supporting structure.[3]

In the literature, numerous studies question the use of a facebow in complete denture fabrication.[4,5] The use of simplified techniques has shown similar results in terms of patient acceptability and clinical efficiency when compared with removable prostheses fabricated using a facebow transfer.[4,5] Many contemporary articulators use the concepts of Bonwill's triangle and Balkwill's angle in their fabrication and advocate the mounting of casts towards the same.[3] A change in the orientation of the occlusal plane results in a change in condylar guidance reading, regardless of which method is used to mount and orient the casts on the articulator.[6] Given that condylar guidance is an unalterable posterior determinant of occlusion, it is crucial to record it precisely.[7,8] Accurate registration of the condylar path is crucial to establishing atraumatic occlusion, as it is a unique controlling factor for each patient. The cephalometric method, the facebow transfer method, and the average value method have commonly documented the variations in condylar guidance settings among dentulous individuals. Dentulous patients frequently report disparities in condylar guidance settings, according to the literature.[9] These differences were achieved using the cephalometric method, the facebow transfer method, and the average value method.[9] There is insufficient information regarding the use of Guichet's point as a third point of reference in facebow transfer among edentulous patients. Nonetheless, the study aims to compare the effect of the protrusive condylar guidance settings with casts mounted by the facebow transfer method and Bonwill's method in Artex Type AR semi-adjustable articulators (Girrbach Dental Systems, Germany) with that of the radiographic method among edentulous patients.

Materials And Method

Ethical clearance was obtained from the institutional ethical committee before commencement of the study. The sample size determination was done using Cohen's d method ($d = \underline{X1- X2}/\alpha$ For 80% power, from the table of Cohen's; $n = 10$) after conducting a pilot study. The study participants were recruited from the Department of Prosthodontics, College of Dentistry. The details and study procedure were explained to the participants in the language that they understood, and written consent was obtained from them. To standardize the selection of study participants and avoid bias in the study because of any skeletal and occlusal aberrations, some inclusion and exclusion criteria were followed. Edentulous subjects with a class I jaw relationship and good neuromuscular control were included in the study. The anatomic reference planes used in the study are described in Figure 1. Edentulous subjects with class I jaw relationship and good neuromuscular control were included in the study. Subjects with signs and symptoms of temporomandibular disorders, a history of uncontrolled systemic disorders, a history of craniofacial surgery/trauma, facial asymmetries, and hard and soft tissue abnormalities were excluded from this study.

Bonwill's method

The maxillary and mandibular casts were mounted onto the articulator using the patient's centric relation record (Imprint, 3M ESPE, USA) [Figure 2d]. During the mounting procedure, the mandibular occlusal plane is oriented so that it intersects the line connecting Bonwill's triangle and Balkwill's angle (26°) [Figure 2a-c]. The protrusive inter-occlusal record was made using an extra-oral tracer assembly and central bearing plate by asking the patient to bring the mandible forward by 6 mm in protrusion. The condylar inclination values for the right and left sides were noted using the protrusive record [Figure 2e].

Facebow method

The patient's maxillary and mandibular casts were then de-mounted from the articulator, and the tracer was removed from the maxillary occlusal rim. A face-bow transfer Artex Rotofix, Girrbach Dental Systems, Germany) was done by marking a point 43 mm above the proposed incisal edge of the right lateral incisor, with an indelible pencil on the lateral wing of the nose [Figure 2f]. To adjust the facebow to an individually localized anterior reference point, the Artex Rotofix was retrofitted with a height-adjustable locator rod, and maxillary casts were mounted on a semi-adjustable articulator (Artex, Girrbach Dental Systems, Germany) using an indirect mount [Figure 2g]. The mandibular cast was then mounted using the pre-existing centric relation record. The protrusive interocclusal record made earlier is now used to adjust the condylar guidance settings on the articulator [Figure 2h]. The values were noted for both right and left side condylar inclination.

Radiographic method

A digital panoramic and cephalometric system (Planmeca Proline XC, Germany) was used to make the patient's

lateral cephalographs. The occlusal rims with tracers attached were used to record the radiographs at both the maximum intercuspation and protrusion of the study participants. The study used a standard parameter (68 kV, 5 mA) exposure and a Broadbent cephalostat to regulate the participants' head position. The digital cephalographs were traced for the condyles on the Acetate matte tracing paper (0.003 inches, 8 × 10 inches). The midfacial horizontal reference plane was marked with the line connecting Porion and Guichet's point. This midfacial reference plane serves as a guide over which the two cephalographs are overlapped. The protrusive condylar path is established by joining the centers of the condyles in overlapped cephalographs in centric relation and protrusion. The angle between a midfacial horizontal reference plane and the protrusive condylar path was recorded as a protrusive condylar angle [Figure 3a and b].

Statistical analysis

The SPSS Statistics for Windows (Version 21.0. Armonk, NY, USA: IBM Corp.), and, at a probability value of 0.05, the significance of every statistical test was predetermined. The condylar guidance values obtained by Bonwill's method, facebow method, and radiographic method were compared using Wilcoxon's signed rank test and Mann–Whitney U test.

Results

Ten 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 [Figure 4]. The mean difference between the radiographic and facebow methods was 12.8° for the right side and 12.7° for the left side, which was statistically

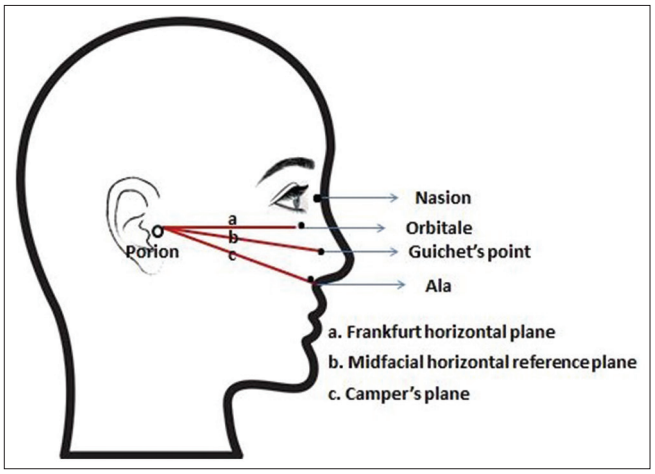

Figure 1: Various reference planes, posterior and anterior reference points

Table 1: The mean difference comparing the radiographic method and facebow method for both right (R) and left (L) sides condylar guidance (degrees) among subjects using the Wilcoxon signed rank test

Variable	*n*	Mean	Standard Deviation	Mean Difference	*Z*	*P*
Radiographic method (R)	10	42.30	6.15	12.8	−2.809	0.007
Facebow Method (R)	10	29.50	4.97			
Radiographic method (L)	10	42.70	5.58	12.7	−2.814	0.001
Facebow Method (L)	10	30.00	5.27			

n=subjects

Table 2: The mean difference comparing radiographic and Bonwill's method for both right (R) and left (L) sides condylar guidance (degrees) among subjects using Wilcoxon signed rank test

Variable	*n*	Mean	Standard Deviation	Mean Difference	*Z*	*P*
Radiographic method (R)	10	42.30	6.15	34.3	−2.809	0.029
Bonwill's method (R)	10	8.00	2.58			
Radiographic method (L)	10	42.70	5.58	34.7	−2.809	0.001
Bonwill's method (L)	10	8.00	2.58			

n=subjects

Table 3: The mean difference comparing Bonwill's and facebow methods for both right (R) and left (L) sides condylar guidance (degrees) among subjects using Wilcoxon signed rank test

Variable	*n*	Mean	Standard Deviation	Mean Difference	*Z*	*P*
Bonwill's Method (R)	10	8.00	2.58	21.5	−2.970	*P*<0.0001
Facebow method (R)	10	29.50	4.97			
Bonwill's Method (L)	10	8.00	2.58	22	−2.913	*P*<0.0001
Facebow method (L)	10	30.00	5.27			

n=subjects

Table 4: The comparison between radiographic, facebow, and Bonwill's method for both right (R) and left (L) sides condylar guidance (degrees) within a group among subjects using the Mann–Whitney *U* test

	n	Mean	Standard Deviation	Mean Difference	*Z*	*P*
Radiographic Method (R)	10	42.3	6.14	0.4	0.153	0.91
Radiographic method (L)	10	42.7	5.57			
Facebow method (R)	10	29.5	4.97	0.5	0.2	0.85
Facebow method (L)	10	30	5.27			
Bonwill's method (R)	10	8.0	2.58	0	0.001	0.99
Bonwill's method (L)	10	8.0	2.58			

n=subjects

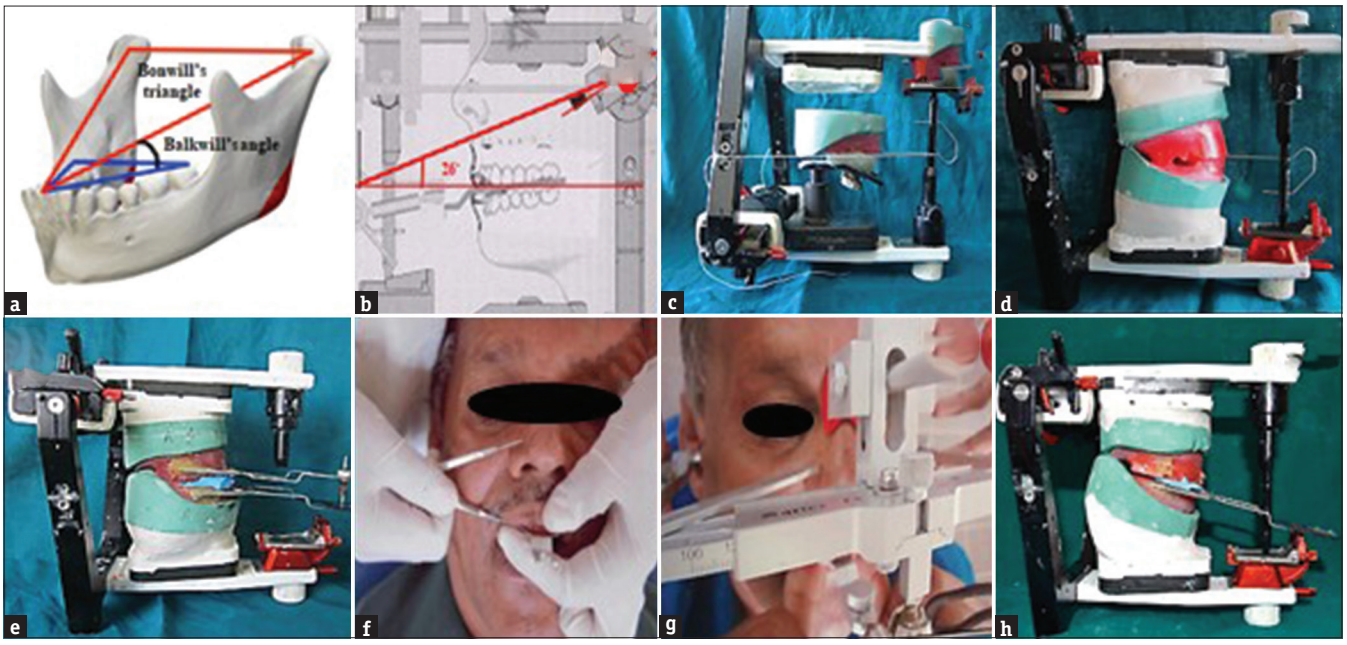

Figure 2: Representation of Bonwill's triangle in relation to mandibular occlusal plane with Balkwill's angle (26°) (a, b) Mounting of casts according to Bonwill's method (c, d) and estimation of condylar guidance values using inter-occlusal record (e), Measuring 43mm from the proposed lateral incisor edge on the lateral wing of nose, which represents Guichet's point (f), Facebow transfer with modified height adjustable mechanism (g), Programming of the articulator using interocclusal record (h), Not correctly labeled. Lateral cephalographs are (e) and (f)

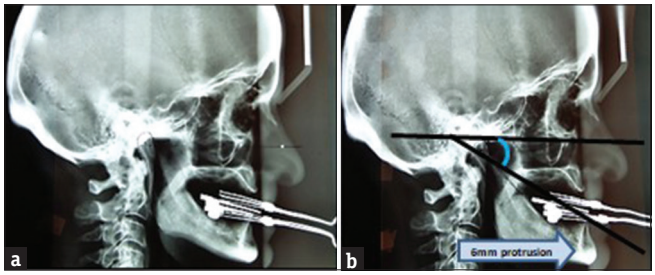

Figure 3: Lateral cephalographs made in centric relation and in protrusion (a, b)

significant ($P < 0.005$). [Table 1]. The mean difference between the radiographic and Bonwill's methods for the right side was 34.3° and for the left side was 34.7°, which was statistically significant ($P < 0.005$) [Table 2]. The mean difference between Bonwill's method and the facebow method for the right side was 21.5° and for the left side was 22°, which was statistically significant ($P < 0.005$) [Table 3]. The comparison between right and left side condylar guidance values obtained by the radiographic method was 0.4° ($P = 0.91$) and by the facebow method was 0.5° ($P = 0.85$). There was no significant difference between the right and left sides in Bonwill's method [Table 4].

Discussion

The main objective of treating an edentulous patient is to re-establish oral function while emphasizing the preservation of residual alveolar bone.[10] There is a general perception among dental practitioners that the occlusal interferences in the removable prosthesis are not important since the underlying mucosa provides a damping effect thereby dissipating the undesirable forces.[10] However, these interferences may cause instability in the prosthesis, which has been associated with underlying bone resorption.[10] The condylar path along the articular eminence is an important factor that influences mandibular movements. The restorative

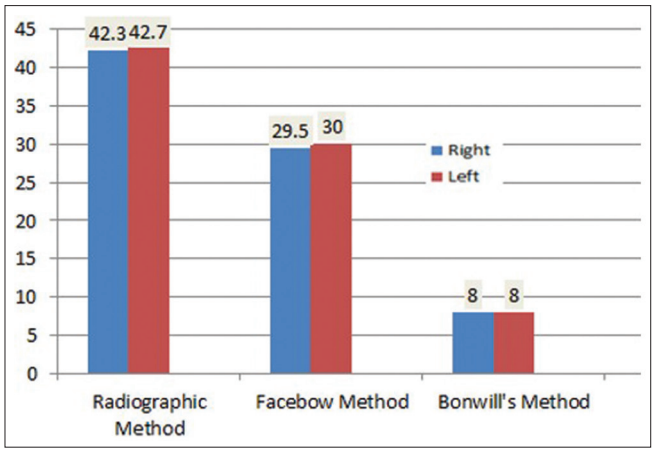

Figure 4: Showing comparison between the condylar guidance values by radiographic method, facebow method, and Bonwill's method

dentist while designing the occlusion for an edentulous individual should attempt to provide harmony between the occlusal surfaces of artificial teeth and the condylar path. This results in an improved masticatory efficiency while preserving the residual alveolar ridge at the same time.[11] Hence, our present study attempts to compare the condylar guidance values obtained by clinical methods with that of radiographic method and an attempt is made to discuss the possible consequences that may result due to the differences in the values.

Previously published various studies[12-15] reported that there was no difference in the treatment outcomes when conventional (using facebow) or simplified (without facebow) technique was used in the fabrication of removable complete denture prostheses. Heydecke *et al.*,[16] demonstrated in their study that the esthetic appearance, denture stability, and general satisfaction were significantly better without facebow transfer. It was also observed that there was no significant difference in masticatory efficiency, comfort, ability to speak, and ease of maintaining denture hygiene.

Nascimento *et al.*,[17] and Kumar *et al.*,[18] demonstrated better results without the use of facebow. A 10-year follow-up study by Kawai *et al.*,[19] also indicated that the simplified method remains more cost-efficient than the traditional method using facebow transfer. Hence this study was designed to measure the condylar guidance values obtained by the facebow transfer method and Bonwill's method among edentulous patients. The measured values were compared with those obtained by the radiographic method, with reference to the midfacial horizontal plane.

Lateral cephalometric analysis was used in the study to estimate the condylar guidance of the subjects, the right and left side angulations were measured between the protrusive condylar path and midfacial horizontal reference plane.[9,20] The condylar guidance values obtained by clinical methods were lesser than those obtained with radiographic method. Various studies[9,21,22] have demonstrated that clinical methods gave lesser values than those determined by radiographic methods.

Many studies[10,23-27,38] show wide variations (5°- 55°) in condylar guidance values measured by clinical methods, hence many clinicians use average condyle guidance settings taken from mean published values.[28,29] The use of an articulator to Bonwill's theory of occlusion appears simple and easy to use, wherein the casts are mounted to an equilateral triangle with 4-inch sides connecting both the condyles and mesio-incisal line angles of mandibular central incisors, the values of the dimensions of the equilateral triangle were the outcome of Bonwill's observation.[3]

Hence, the next method used in our study was by mounting the casts to Bonwill's triangle and the mean value obtained for the right and left side was 8°±2.58°. The comparison of this method with that of the radiographic and facebow methods was statistically significant ($P < 0.005$). The utilization of average or mean condylar guidance value permits a simplified approach for programming the articulator provided the patient falls within the range of average values. The limitation of using this average value approach lies in determining how much a patient falls within the average condylar guidance value.[30]

The reference plane is an important parameter to be considered for comparison, the radiographic and facebow methods used Guichet's plane to measure the condylar guidance angle, whereas Bonwill's method uses an average established occlusal plane incorporated in the articulator fabrication.[31,32] The condylar guidance angle that the manufacturers recommend[3] while mounting the cast to Bonwill's method for the Artex articulator is 30°, which is substantially higher than the value of 8° obtained in this study.

Weinberg[33] reported that using different anterior reference points as recommended by different facebow systems, may raise or lower the occlusal plane by ± 16 mm. This results in affecting the eccentric condylar readings subsequently influencing the cusp inclines of the fabricated restoration and that has no effect on centric occlusion. Bonwill's method used in our study, however, did not employ the facebow, but the orientation of the occlusal plane certainly changed and was lower in comparison to that of the casts mounted by the facebow method. A mean difference of 21.5° and 22° for the right and left side condylar guidance angle respectively, were observed in our study between the two clinical methods.

Craddock[34] suggested that the influence of horizontal condylar guidance was greatest in the second and third molar areas. The author observed that a positive 10° change in the condylar guidance from the actual condylar guidance of the individual would bring the molars 0.5 mm farther apart when the mandible was protruded in an end-to-end relationship. He also noted that a negative 10° change from the actual condylar guidance of the individual would bring the mandible 0.5 mm closer, which is the cause of concern with the findings of condylar guidance values obtained by Bonwill's method. Moreover, the manufacturer of the Artex articulator recommends setting the condylar guidance at 30° while mounting the casts using Bonwill's method. However, the observations in our study gave an average value of 8° in the casts mounted using this method. Hence considerable prematurities could be expected in the premolar and molar regions while using Bonwill's method. Okane *et al*.,[35] opined that an improperly selected occlusal plane may result in denture instability and masticatory inefficiency. Krueger *et al*.,[36] also state that if the vertical positioning error is large, occlusal errors in the balancing side are produced in complete dentures.

The mean difference between the right and left side of the condylar guidance using the radiographic method was found to be 0.4°, which was not statistically significant (P = 0.91). The difference between right and left-side condylar guidance values as proposed by Bell *et al*.,[20] is due to the difference in the path followed by the mandibular condyle during protrusion. The possible reasons for diversion include bilateral asymmetry between condyles or the articular eminences, anatomy, and angulation of the condyles related to the glenoid fossa, the configuration of the disc, position of the disc during condyle translation, and resultant vectors of the force of the musculature responsible for the mandibular disocclusion. The study's limitations include real effect, which plays a role in the clinical methods of edentulous subjects. Hanau pointed out the "resilient and like effect"[37] of the supporting tissues as the chief source of error in registering maxilla-mandibular relationships. The study was performed on Indian patients with a small sample size and hence the results may not be generalized.

Conclusion

The radiographic method showed higher condylar values in comparison with the facebow and Bonwill's method. The study also observed that a change in orientation of the occlusal plane as seen with the clinical methods caused a change in condylar guidance values. The values obtained by the facebow method were closer to the radiographic values, whereas the observations by Bonwill's method gave an average value of 8°. The manufacturer's recommendation while using this method is 30°, with a difference of 22°.

Clinical significance

Many factors influence the cuspal height and angle provided in restoration, with condylar inclination being considered a major factor. Since condylar guidance is a patient-derived measurement, a clinical method must estimate it more accurately. When the value differs from the actual patient's values, it can lead to intra-oral occlusal discrepancies, even though the prosthesis appears normal in the articulator. A patient's steep condylar inclination allows for steeper inclines on the cusps of the teeth in the prosthesis, and vice versa. If the horizontal condylar guidance angle in the articulator is steeper than that in the patient, the resulting restoration will have cusps with overly steep inclines. This leads to a positive error, and an occlusal interference may occur during a protrusive or nonworking excursion. If the articulator's cusp inclines are not as steep as the patient's, the occlusal surface will be flatter and the cusp inclines will be shallower in both protrusive and nonworking excursions and this is called a negative error.

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Conflicts of interest

There are no conflicts of interest.

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