Comparative Study of the Effect of Interocclusal Recording Materials on Reproducibility of Horizontal Condylar Registrations in Arcon and Non – Arcon Articulators: A Clinical Study

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ABSTRACT

Introduction: Horizontal condylar inclination is the mechanical equivalent of condylar guidance. Different techniques to record horizontal condylar inclination are interocclusal recording materials, radiographic interpretation, extraoral recording devices. The objective of the study was to evaluate the effects of three different interocclusal recording materials on reproducibility of horizontal condylar inclination in two different semi-adjustable articulators (arcon and non-arcon) and compare with the values obtained from lateral cephalogram.

Methodology: The studied group consisted of patients with age group 20-35 years. Single protrusive record for each of three different recording materials were made with the help of custom-made protrusive guide for each volunteer. These records were used for programming two articulators for both right and left sides three times and the respective HCI values were noted. The resultant values for both the articulators and values of right side were compared with values obtained from tracing of lateral cephalogram. The results obtained were tabulated and subjected to statistical analysis.

Results: The difference in means of right and left HCI and individual values for all interocclusal recording materials in both articulators were statistically insignificant. HCI values obtained clinically with 3 different interocclusal recording materials in two different semiadjustable articulators (Right side only) compared with that obtained from lateral cephalograms was found to be statistically significant.

Conclusion: The results indicate that no statistically significant difference in inclination of the condylar path between right and left side with 3 different interocclusal recording material using arcon and non-arcon articulators. The lateral cephalograms showed the higher horizontal condylar inclination values than the clinical methods.

Key words: Articulators; Horizontal condylar inclination; Interocclusal recording materials; Lateral cephalograms

INTRODUCTION

Horizontal condylar inclination is the mechanical equivalent of condylar guidance. Different techniques to record horizontal condylar inclination are interocclusal recording materials, radiographic interpretation, extraoral recording devices and usually obtained with the protrusive interocclusal record.[1] Interocclusal recording materials include impression plaster, waxes, zinc oxide eugenol, acrylic resin, hydrocolloids, polyether and vinyl polysiloxane.[2] Condylar guidance measured from radiographs have been found to record

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more precisely than other methods. If condylar guidance is not recorded accurately, it will lead to occlusal interferences during mandibular movements. [3]

A choice as to which, arcon or non arcon semi adjustable articulators, and the interocclusal materials may be used to fabricate a prosthesis has been debated.

Thus, the purpose of this study is to compare the effects of three different interocclusal recording materials on the level of reproducibility of horizontal condylar inclination in two semi-adjustable Arcon and Non-Arcon articulators and comparing these with HCI values obtained from Lateral Cephalometric radiograph.

MATERIALS AND METHODOLOGY

- **Research Design:** The Cross- sectional, Observational Study was conducted at the Department of Prosthodontics, Kathmandu University School of Medical Sciences, Dhulikhel Hospital, Kavrepalanchowk, Nepal. The total duration of study was one year (May 2020 to April 2021). The studied group consisted of patients with age group 20-35 years visiting the dental department (Orthodontics) in Dhulikhel hospital for orthodontic treatment in which a lateral cephalometric radiograph has to be taken. Convenience sampling technique was used (meeting the inclusion and exclusion criteria).
- **Inclusion Criteria are:** Angle's class 1 molar relation**,** good oral hygiene and periodontal status and absence of signs and symptoms of temporomandibular joint disorder**.**
- **Exclusion Criteria are:** Completely edentulous patient**,** volunteers with missing anterior teeth**,** restricted mandibular movement**,** gross attrition/erosion or abrasion of teeth and who declines written informed consent. Sample size of 15 was selected with the power analysis of 80%.[1,4] Study approval was done by Institutional Review Committee Kathmandu University.

METHODS

A written consent was obtained from the volunteers selected to be a part of the study and they were explained in detail about the procedure that would be carried out.

Lateral cephalometric radiograph (Planmeca (Promax)] ,66 kV, 5 mA, 18.7 s)

Patient positioning based on the same principle as given by Broadbent. Lateral cephalometric radiograph of right side was taken. Horizontal condylar guidance values were obtained from tracing the lateral cephalogram on acetate tracing paper. Orbitale (Or), lowest point in the margin of the orbit and Porion (Po), highest point on the external auditory meatus were identified. These two reference points were joined by the straight line representing Frankfurt's horizontal plane. The most superior point on the glenoid fossa (Fs) and most inferior point on the articular eminence (Ae) were identified and marked. The two reference points (Fs and Ae) were joined by a straight line representing the posterior slope of articular eminence. The angle formed by the intersection of two lines: Frankfurt's horizontal plane and posterior slope of articular eminence was measured using a protractor to represent the horizontal condylar inclination(fig.1).[5]

Articulators and interocclusal record materials used: Arcon (Hanau Wide-Vue), Non arcon (Hanau H2) semiadjustable articulators and Hanau springbow were selected for the study. The interocclusal recording materials used were: Aluwax, Vinyl Polysiloxane and Polyether.

Determination of Condylar Inclination by interocclusal records: Preliminary impressions (two pairs for arcon and non-arcon articulators) for maxillary and mandibular arch were made

using irreversible hydrocolloid impression material (Coltene, India) for each volunteer. Casts were made by pouring the impressions with dental stone (Kalstone, India). Maxillary bite record was made using impression compound with bitefork and facebow record was made. Facebow transfer was done on semi-adjustable articulators, arcon (fig.2) and non-arcon and maxillary casts were mounted. Mandibular casts were mounted onto the maxillary cast at maximal intercuspal position using bite registration wax (Aluwax- MDM Corporation, Delhi) (fig.3).

The protrusive records were made with the help of custom-made protrusive guide, single bite record of different interocclusal recording materials [Aluwax- MDM corporation, Delhi, Polyvinylsiloxane/Vinylpolysiloxane- 3M ESPE, Germany and Polyether- 3M ESPE, Germany] were made for each volunteer. Each record then was used to programme an articulator for the determination of horizontal condylar guidance angles.

Articulator preparation: Before the facebow was attached to the respective articulators, zeroing of the articulator was done.

- In Hanau Wide-Vue articulator, the protrusive inclination of both the condylar guidances will be adjusted to 30 degrees, Bennett angles of both condylar guidances to 30 degrees and the incisal guide to 0 degree
- In Hanau H2 articulator, the protrusive inclination of both the condylar guidances will be adjusted to 70 degrees, Bennett angle to 0 degree and the incisal guide to 0 degree.

Fabrication of the Protrusive Guide: A custom-made protrusive guide was fabricated prior to obtaining the protrusive interocclusal record. The use of anterior jig provides the desired amount of interocclusal space and protrusion for the registration material and practically eliminates the risk of mandibular deviation due to muscle fatigue.[1]

The jig was fabricated as: Autopolymerizing acrylic resin (Dentsply,India) was used to fabricate a custom-made anterior jig on casts mounted on Hanau Wide-Vue articulator. Separating medium was applied to the anterior teeth of the maxillary and mandibular cast. Articulator was adjusted with protrusion of 6 mm with an increase in vertical height by 3 mm (fig.4). Then, auto-polymerizing acrylic resin was used to cover the incisal third of incisors teeth. After polymerization, the protrusive guide was retrieved from the cast, trimmed and adjusted in the articulator. The jig when placed in mouth guides the mandibular anterior teeth repeatedly to the same protrusive edge to edge position (fig. 5). This position allows 6 mm of anterior movement from the maximal intercuspal position to provide space for the bite registration material.

Making of protrusive interocclusal records: The customized protrusive jig was inserted over the maxillary anterior teeth and the volunteers were trained to protrude the mandible as guided by the jig. A single protrusive interocclusal record was made with each material aluwax, vinylpolysiloxane (fig.6) and polyether and was transferred to each of the articulators. All records were trimmed of the excess material such that only the imprint of cusp tips remained on the record (fig.7). The semi adjustable articulators were programmed to obtain the readings for horizontal condylar inclination for both the right and left sides three times for each interocclusal record material.

Thus, summing up the methodology, with each interocclusal recording material, a single protrusive record was obtained. With these records, HCI values for each articulator were programmed (on the right and left sides) for the three times, and the values were noted for each time. Therefore, 9 records (from 3 materials) for 15 samples gave 135 HCI readings for a side

(270 readings for both right and left sides) for each articulator.

Horizontal condylar inclination values obtained from each protrusive interocclusal recording material from arcon as well as non-arcon articulator were averaged and compared with values obtained from lateral cephalometric radiograph.

Statistical Data Analysis:
The data thus obtained were tabulated and subjected to statistical analysis using statistical software (Statistical Package for Social Sciences, v- 25, SPSS). Descriptive statistical analysis was performed to calculate the means along with their corresponding standard deviations. For each of three interocclusal recording materials, the difference in both the semiadjustable articulators was tested by using the independent sample t test. One-way Analysis of Variance (ANOVA) was used to analyze the difference between the mean HCI values obtained from the lateral cephalogram with that obtained clinically. Tukey's HSD test was used to differentiate the statistically significant difference in means compared within the groups. A p value of <0.05 was considered statistically significant (95 % confidence interval).

RESULTS

Descriptive statistics: The cross-sectional study was conducted on 15 (12 females, 3 males) volunteers between 20-35 years of age visiting the Department of Orthodontics, Dhulikhel hospital, Kavrepalanchowk, Nepal following the inclusion criteria. HCI values were recorded three times in both the articulators (Hanau Wide-Vue and Hanau H2) for both right and left sides with the same recording medium and were averaged to decrease observation bias. HCI values were obtained radiographically for the right side.

Comparison was done between the mean HCI values as obtained from two articulators using all the three recording media for both the right and left side individually. Independent sample t-test was then used to find the difference in means of HCI values as obtained from two articulators using all the three recording media individually for both right and left sides, which showed statistically insignificant difference ($p>0.05$) as shown in table 1 and illustrated with bar chart: fig.8,9 and 10.

When One-way ANOVA was applied between the groups (Aluwax, Polyvinylsiloxane, Polyether and Lateral Cephalogram), statistically significant data were observed ($p = 0.000$). With Post Hoc analysis (Tukey HSD), the significance level was observed where HCI values obtained clinically were matched against that obtained from Lateral Cephalograms (Table 2).

The significance level observed when HCG values obtained clinically with 3 different interocclusal recording materials in two different semiadjustable articulators (Right side only) compared with that obtained from Lateral Cephalograms was statistically significant ($p<0.05$).

Table 1: Independent sample t-test for comparison of HCI values using 3 different interocclusal recording materials between both articulators on right and left sides individually

Interocclusal Recording Materials		Mean ± SD		p value
		Hanau Wide-Vue	Hanau H2	
Aluwax	Right	34.33 ± 5.07	37.55 ±5.37	0.10
	Left	34.55 ± 6.73	38.00 ± 6.01	0.15
Polyvinyl siloxane	Right	34.44 ± 5.59	35.11 ± 4.05	0.71
	Left	33.77 ± 5.61	37.33 ± 4.78	0.07
Polyether	Right	34.55 ± 4.98	35.11 ± 3.69	0.73
	Left	34.22 ± 5.59	37.33 ± 4.48	0.10

Table 2: Post Hoc Tukey HSD tests for comparison of HCI values using 3 different interocclusal recording materials between both articulators (right side) and lateral cephalogram

		p value
Aluwax Hanau Wide-Vue right	Aluwax Hanau H2 right	.576
	PVS Hanau Wide-Vue right	1.000
	PVS Hanau H2 right	1.000
	Polyether Hanau Wide-Vue right	1.000
	Polyether Hanau H2 right	1.000
	Lateral Cephalogram	**.000***
Wax Hanau H2 right	Wax Hanau Wide-Vue right	.576
	PVS Hanau Wide-Vue right	.616
	PVS Hanau H2 right	.833
	Polyether Hanau Wide-Vue right	.656
	Polyether Hanau H2 right	.833
	Lateral Cephalogram	**.024***
PVS Hanau Wide-Vue right	Wax Hanau Wide-Vue right	1.000
	Wax Hanau H2 right	.616
	PVS Hanau H2 right	1.000
	Polyether Hanau Wide-Vue right	1.000
	Polyether Hanau H2 right	1.000
	Lateral Cephalogram	**.000***
PVS Hanau H2 right	Aluwax Hanau Wide-Vue right	1.000
	Aluwax Hanau H2 right	.833
	PVS Hanau Wide-Vue right	1.000
	Polyether Hanau Wide-Vue right	1.000
	Polyether Hanau H2 right	1.000
	Lateral Cephalogram	**.000***
Polyether Hanau Wide -Vue right	Aluwax Hanau Wide-Vue right	1.000
	Aluwax Hanau H2 right	0.656
	PVS Hanau Wide-Vue right	1.000
	PVS Hanau H2 right	1.000
	Polyether Hanau H2 right	1.000
	Lateral Cephalogram	**.000***
Polyether Hanau H2 right	Wax Hanau Wide-Vue right	1.000
	Wax Hanau H2 right	0.833
	PVS Hanau Wide-Vue right	1.000
	PVS Hanau H2 right	1.000
	Polyether Hanau Wide-Vue right	1.000
	Lateral Cephalogram	**0.000**

*denotes significant difference.

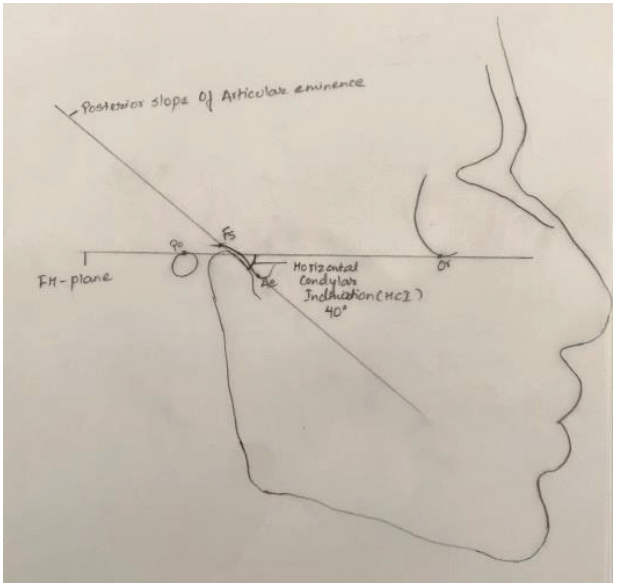

Figure 1: *Horizontal condylar guidance angle tracing*

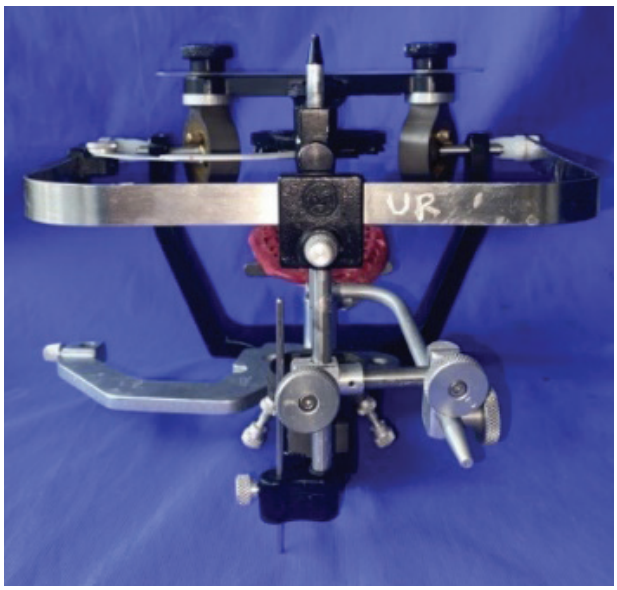

Figure 2: *Facebow transfer in Hanau Wide-Vue articulator*

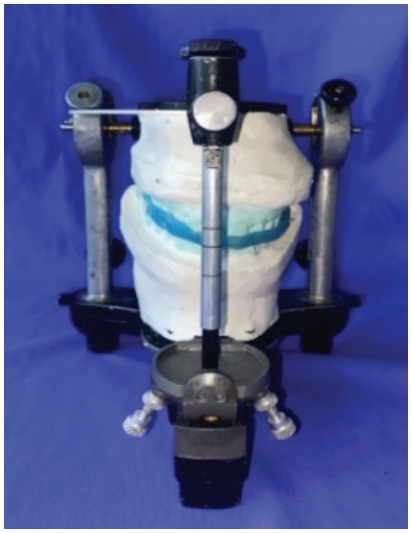

Figure 3: *Mounting of mandibular cast with aluwax bite record in maximum intercuspation in Hanau H2 articulator*

Figure 4: *Adjustment of Hanau Wide-vue articulator with 6 mm protrusion*

Figure 5: *Protrusive anterior jig in mouth*

Figure 6: *Protrusive inrerocclusal record with polyvinylsiloxne*

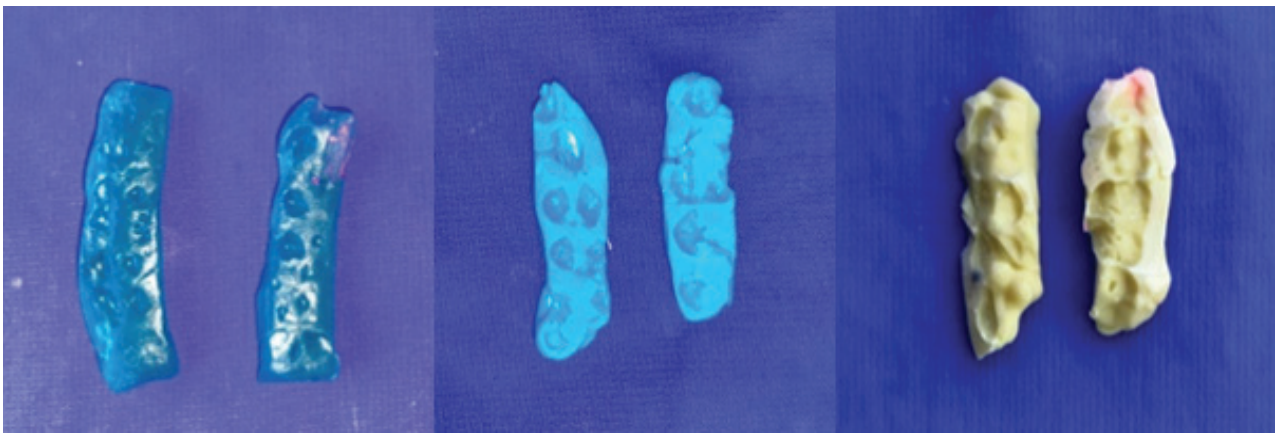

Fig. 7: Aluwax, vinylpolysiloxane and polyether bite registration records

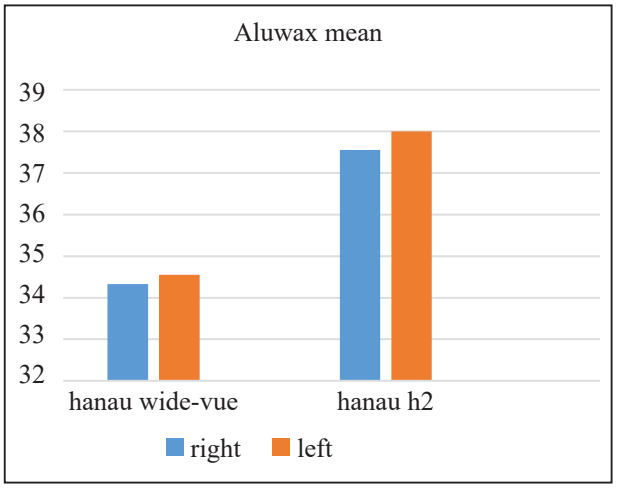

Fig 8: Comparison of means of two different articulators in right and left sides using Aluwax materials by applying independent t test

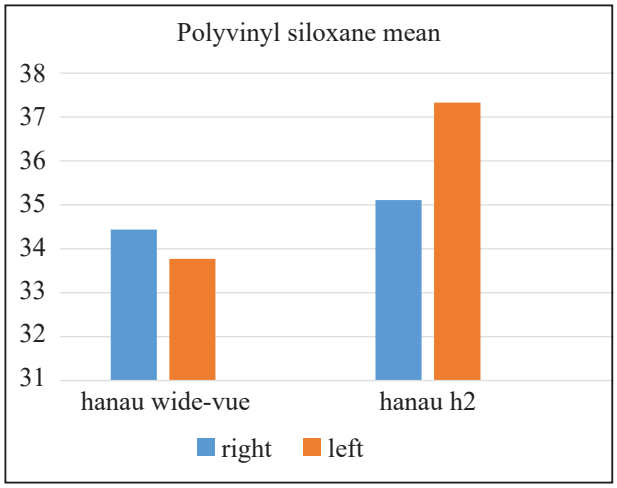

Fig 9: Comparison of means of two different articulators in right and left sides using polyvinyl siloxane/vinyl poly siloxane materials by applying independent t- test

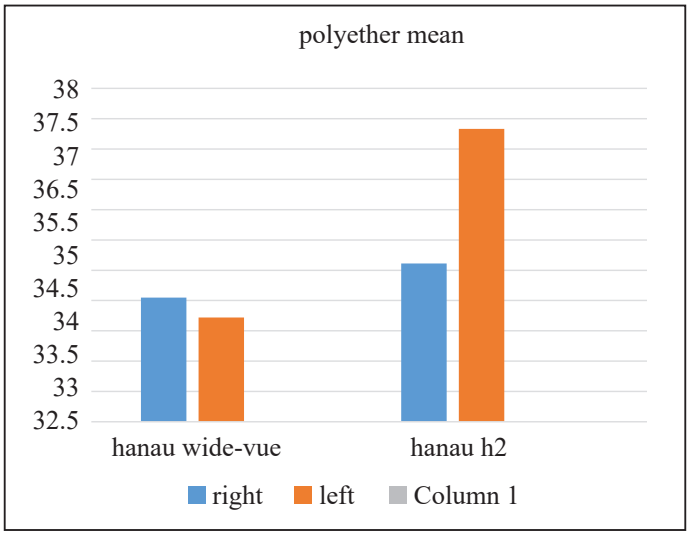

Fig 10: Comparison of means of two different articulators in right and left sides using polyether materials by applying independent t- test

DISCUSSION

The purpose of the study was to compare the effects of three different interocclusal recording materials (Aluwax, Polyvinylsiloxane and Polyether) on reproducibility of horizontal condylar inclination registrations in arcon (Hanau Wide-Vue) and non-arcon (Hanau H2) articulators and compare with the values obtained from the lateral cephalogram. The data were obtained from 15 volunteers (12 females and 3 males) with the age group between 20-35 years that met the inclusion criteria.

In this clinical study, when comparing HCI values between the right and left side with all the three recording materials in both arcon and non-arcon articulators, no significant difference was noted. However, significant difference was noted when HCI values obtained clinically (Right side only) were compared with that obtained from Lateral Cephalograms.

Arcon and Non- arcon articulators: The mean HCI values obtained from all the recording media did not defer in registering the condylar inclination for both arcon and non-arcon articulators. However, the result from the present study is in contrast with the study done by Goyal et al.[6], where the mean difference in HCI value between arcon and non-arcon articulators was found to be very highly significant (p=0.001) on the right side whereas on the left side, the difference was highly significant (p=0.0.03). The difference may be attributed to the inconsistent protrusion among volunteers unlike the present study where a fixed protrusive distance of 6 mm is secured with a jig. Similarly, the findings of this study do not agree with the study done by Sharma et al.[1] This may be due to the use of two different aluwax bite records for arcon and non-arcon articulators in contrast to the present study where single aluwax record was used to program both the articulators. This finding is in accordance with the study done by Patil et al.[4], Prajapati et al.[7] which shows the statistically insignificant results between the arcon and non-arcon articulators.

Hanau Wide-Vue (arcon) and Hanau H2 (non-arcon) using the Hanau spring bow were selected for the study because they are manufactured by the same manufacturer, both of them accept the facebow transfer with Hanau spring bow and they both have provision to make use of the orbitale as the anterior point of reference which helps eliminate errors thus induced by selecting different facebows, as stated by Weinberg.[8] Also, change in anterior reference point in a face bow transfer cause a change in orientation of the occlusal plane and results in different protrusive condylar guidance values and casts are significantly closer to the anatomic position whenever orbitale is used as the third point.[7]

Interocclusal record materials: The result of independent sample t-test comparing mean HCI values obtained with 3 recording media (Aluwax, PVS and Polyether) shows no statistically significant HCI values registered in both the articulators Hanau Wide-Vue and Hanau H2. [p value= 0.10, 0.71 ,0.73 (right side) and 0.15, 0.07, 0.10 (left side) for Aluwax, PVS and Polyether respectively). The study done by Sharma et al.[1] shows statistically significant difference of HCI values recorded by Aluwax on arcon and non-arcon articulator which is in contrast to the present study that may be due to the inconsistency in mandibular position during bite registration with permissive anterior jig combined with rigidity of the wax that does not allow unhindered mandibular closure. The study by Patil et al.[4] do not confirm the findings of this study at least for the Aluwax which may be due to the difference in tempering procedure done prior to occlusal recording. Wirth et al.[9] point out that interocclusal records have dimensional stability at temperatures tolerated in the mouth provided reasonable care in handling is used. Aluwax is subjected to distortion by improper handling or when it is too thin in a section. With

>2mm thickness of wax record, the registration errors can be avoided but there is difficulty to close precisely in protrusion because of the resistance offered by Aluwax that can lead to the mandibular deviation. This is attributed to the lack of voluntary neuromuscular control. The controlled vertical stop (anterior jig here) forms a tripod effect between the anterior teeth and the condyles. Thus, the volunteer is able to use the musculature without conflicting proprioception from deflective tooth contacts.

Also some correlation exists between the extent of protrusion and horizontal condylar guidance angle, the distance of protrusion is recommended to be kept constant.[10,11] A custom-made protrusive guide with protrusion of 6 mm was fabricated to achieve the desired amount of protrusion and interocclusal space for the registration material and also practically eliminates the risk of mandibular deviation due to muscle fatigue.[1]To obtain protrusive record, 6mm of protrusion is chosen. Normal function occurs within this range of movement. If the amount of protrusion is <6 mm, the force that condylar element exerts on the housing is too less for self-adjustment, and the articulator will not be sensitive enough. If the amount of protrusion is >6 mm, the condyle moves beyond the eminence and the horizontal angle obtained, becomes less steep.[12]

Right and left side HCI: Statistically, non-significant mean differences existed in HCI values when compared between the right and left side with all the three recording materials in both arcon and non-arcon articulators. The smaller mean differences between the right and left HCI angles are in accordance with the studies done by [6,13,14,15]. However, the HCI values on both right and left sides were found to be statistically significant for Aluwax when compared between both arcon and non-arcon articulators in a study done by Sharma et al.[1], which is in contrast to the present study, owing to the difference in fabricating anterior jig, where the author reports intraoral adjustment of jig as opposed to prefabricated jig adjusted in an articulator before taking the record in the present study. Similarly, el-Gheriani and Winstanley[16] and Zamacona et al.[17], have reported significant variation between the left and right condylar guidance values in contrast to the present study which may be attributed to the heterogenity of the sample – a mix of partially edentulous and completely edentulous subjects whereas in the present study the sample was more homogeneous consisting of only dentulous subjects. The finding is further confirmed as the literature suggests that the right and left eminences seldom have exactly the same slants, contours and declivities.[18]

Radiographic and clinical methods: The significance level observed when HCG values obtained clinically (Right side only) compared with that obtained from Lateral Cephalograms was statistically significant. However, this finding is in contrast with that of Goyal et al.[6] They found the mean difference in sagittal condylar values obtained from the non-arcon articulators and cephalometric tracings were statistically significant whereas no significant difference was found in the mean sagittal condylar values obtained from the arcon articulator and cephalometric tracings. This may be attributed to observer bias as the present study had manual cephalometric tracing. Patil et al.[4] found the statistically significant difference in the HCI values obtained using Aluwax in both arcon and non-arcon from that obtained from lateral cephalograms. But no statistically significant difference was found for PVS and polyether when compared with lateral cephalograms.

The use of customized protrusive jig allows the use of any interocclusal recording materials used here in the clinical practice despite their properties and that results in least possible

errors in occlusion in the prosthesis. But in the articulators, accurate reading of the condylar guidance is not feasible because these instruments have a numerical scale with increments of 5 degrees. For precise readings of the condylar angle, this scale has to be customized with increments of 1 degree. Gilboa et al.[19] reported a high degree of correlation between articular morphology and panoramic images and suggested that the inclination of the articular eminence in a panoramic image may be of value in setting the condylar guidance in semi-adjustable articulators. Lateral cephalogram was used in this study for recording the condylar guidance. Davis and Mackay in their study suggested that lateral cephalogram is better in terms of patient exposure, which is 4-5 times less than the panoramic radiographs. Image quality was improved and there were fewer faults in the images. But there is a need to expose the patient twice to obtain the HCI values of both right and left sides.[20] Due to the inaccuracies of the interocclusal record technique that can be from impression making to programming the articulator with interocclusal record material with inherent errors of up to 30 degrees, the radiographic articular eminence may have clinical significance.[10]

LIMITATIONS OF THIS STUDY

1. The sample size was small and data may not represent whole of Nepalese population.
2. There was unequal gender distribution among the volunteers.
3. Angle's Class II and III cases had not been included in this study, which may show varied HCI values and generalization of the study results was limited to Angle's Class I cases.
4. Arbitrary hinge axis and semiadjustable articulators were used.
5. Digital tracing wasn't done for lateral cephalograms.
6. The method of recording interocclusal relations and interpretation of condylar inclination values from the articulator is subjected to vary between examiners.

Future studies with inclusion of other parameters like the use of fully adjustable articulators with extraoral recording devices, larger sample sizes, comparing both the right and left sides with lateral cephalogram, HCI recorded at different levels of protrusion, reviewing the values with two or more observers can provide more predictable results.

CONCLUSION

Within the limitations of the study, there is no statistically significant difference in inclination of the condylar path between right and left side of both arcon and non-arcon articulators and also in two different semi-adjustable articulators arcon and non-arcon. Fabricating a jig for a protrusive record on an articulator gives lower values of HCI clinically than that for a radiographic method, however consistent HCI values with all the studied recording materials show that any of these materials, with a prefabricated jig, may be used interchangeably to find HCI.

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