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## Comparative Evaluation of Two Different Interocclusal Recording Materials with Panoramic Radiograph Used to Measure Sagittal Condylar Guidance in Edentulous Patients: A Clinical Study

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### ABSTRACT

**Background and Aim:** This study evaluated the reliability of two interocclusal recording materials with panoramic radiographs to measure sagittal condylar guidance in edentulous subjects.

**Material and methods:** The study comprised 30 edentulous subjects. The protrusive interocclusal records were made at the jaw relation stage using bite registration paste and Plaster of Paris for all the subjects to program the Semi-adjustable articulator, and the condylar guidance values on the right and left sides were recorded. Digital orthopantomography was taken for all the subjects and traced, and the values obtained were compared with those obtained by the protrusive interocclusal record. The condylar guidance values obtained by the various procedures were tabulated and subjected to an independent t-test and Pearson's correlation test.

**Results:** The results showed a statistically significant positive correlation ( $P < 0.0001$ ) between clinical protrusive interocclusal records (polyvinyl siloxane, Plaster of Paris) and panoramic radiographic sagittal condylar guidance values.

**Conclusions:** Within the study's limitations, the condylar guidance values obtained from the panoramic radiographic tracing can be used to calculate the mean horizontal condylar guidance in completely edentulous patients. These values can also be used to program semi-adjustable articulators, avoiding the cumbersome process of obtaining a protrusive interocclusal record.

### 1. Introduction

A prosthodontic rehabilitation aims to fabricate a prosthesis harmoniously with the patient's stomatognathic system. The most essential consideration in the oral rehabilitation of any patient is the inclination of the condylar path. The success of complex prosthodontic procedures is enhanced by the accurate simulation of the condylar path of the patient on an articulator. It enables the clinician to estimate the correlation between the path traced by the condyle during mandibular movements and the morphology of the occlusal surfaces, which, in turn, aids in restoring the occlusion without interference. Condylar guidance, by definition, is the mandibular guidance generated by the condyle and articular disc traversing the contour of the articular eminence. The condylar path is the path traveled by the mandibular condyle in the temporomandibular joint during various mandibular movements.<sup>[1]</sup> If condylar guidance is not recorded accurately, it will lead to occlusal interferences during mandibular movements. This may also increase chairside denture adjustment time, which can be frustrating for the patient and the dentist. The protrusive jaw relation is important to record and set the condylar elements of the articulator so that they will reproduce inclinations

similar or comparable to that of the patient's temporomandibular articulation.<sup>[2]</sup> Various intraoral and extraoral methods have been used to register the condyle path and adjust the condylar guidance angle accordingly. Centric and eccentric relations of the mandible can be recorded through the intraoral or positional wax method, graphic recordings, functional recordings, and cephalometrics.<sup>[3]</sup> The most popular technique for determining the horizontal condylar guidance is using an interocclusal record. Interocclusal records are commonly used because of their simplicity. The materials used as interocclusal recording medium are Plaster of Paris, wax, modeling compound, acrylic resin, zinc oxide eugenol paste, and elastomers. These materials are used to obtain centric, protrusive, and lateral interocclusal records. A protrusive interocclusal record is required to set the articulator's sagittal condylar guidance (SCG). The efficiency of different semi-adjustable articulators such as Whip Mix, Hanau 158, and Denar Mark II have been compared for the reproducibility of condylar guidance registrations. Significant differences in SCG values between these articulators have been documented when wax protrusive records were used to program them. Most studies comparing the efficiency of interocclusal recording materials were

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done on the laboratory simulated models at maximum intercuspation (MICP). Clinical studies comparing the effects of different interocclusal recording materials on the accuracy and reproducibility of horizontal condylar registrations in semi-adjustable articulators have not been studied much.<sup>[4]</sup>

The recording of protrusive and lateral interocclusal records in completely edentulous patients becomes difficult and cumbersome as the record base, in many instances, becomes loose and unstable. Furthermore, due to the absence of periodontal proprioceptors, the patient's inability to hold the mandible in protrusive and lateral position until the interocclusal material sets makes such records erroneous and fallacious.<sup>[5]</sup> The use of supplementary aids such as imaging may help in resolving the problems and establish accurate registration of sagittal condylar guidance. The outline of the articular eminence and the glenoid fossa of the temporal bone has been evaluated on panoramic radiographs and proposed to be of valuable aid in setting the condylar guidance in semi-adjustable articulators.<sup>[6]</sup> Kumar et al. found an association between the condylar guidance angle recorded by the protrusive record and panoramic radiographic image in dentulous subjects, which helps in programming semi-adjustable articulators.<sup>[7]</sup> However, changes in the condylar morphology are expected as age advances due to pathologic or physiologic causes. Thus, the need for studies arises to ascertain whether the condylar guidance angle obtained by the protrusive interocclusal record and panoramic radiographic image in completely edentulous patients correlate. Given the above, the present clinical study was conducted to compare the accuracy of two commonly employed interocclusal recording materials, Polyvinyl siloxane (PVS) and Plaster of Paris (POP), in obtaining the sagittal condylar guidance values in an arcon semi-adjustable articulator with those obtained from the tracings of their panoramic radiographic images.

## 2. Material and methods

After approval from the Institutional Ethical Committee of Punjab Government Dental College and Hospital, Amritsar (No. 2868/MDS), this study was conducted on thirty edentulous patients reporting to the Department of Prosthodontics, Crown and Bridge, for treatment with complete denture prosthesis. The written informed consent was obtained from all the patients enrolled. Inclusion criteria included completely edentulous patients with well-formed ridges, good neuromuscular control, adequate inter-maxillary space, and class I ridge relation. Exclusion criteria included patients with temporomandibular disorders, inadequate control of jaw movements, and conditions that contraindicated radiograph use.

### *Clinical method for recording sagittal condylar guidance (SCG)*

For each individual, preliminary impressions of the edentulous arches were made using impression compound (Roxel, Impression Composition, Ashoo Sons Wazirpur, Delhi, India). They were poured in Type II dental plaster (Dentex, Prevest Denpro Limited, Jammu, India), thus obtaining a set of maxillary and mandibular casts. On the preliminary cast thus obtained, autopolymerizing acrylic resin (Pyrex rapid repair, Pyrex polymers, Roorkee, India) custom trays were fabricated. Border molding was carried out using low-fusing impression compound (DPI, Pinnacle Tracing Sticks, The Bombay Burmah Trading Corporation Ltd, India) and secondary impressions were made using zinc oxide eugenol impression paste (DPI Impression paste, The Bombay Burmah Trading Corporation Ltd, India) for each patient and were poured in Type III dental stone (Dentstone, Neelkanth, Ortho Dent Pvt. Ltd Jodhpur, India), thus obtaining a set of maxillary and mandibular master casts. After obtaining master casts from each individual, auto-polymerizing acrylic resin was used to fabricate record bases, and wax occlusal rims were made of modeling wax (DPI Modelling wax, The Bombay Burmah Trading

Corporation Ltd, India). This study used an arcon Artex CR semi-adjustable articulator and earpiece-type face bow (Artex CR Amanngirrbach Herrchaftswiesen 1 Koblach, Germany). Maxillary and mandibular occlusal rims were adjusted to the patient's required vertical dimension. The midline was marked on the maxillary occlusal rim. The face bow record was transferred to the articulator. The maxillary cast was secured to the articulator using Type II dental plaster. A tentative centric jaw relation was recorded, and a mandibular cast was mounted on the articulator. Maxillary and mandibular occlusal rims were prepared with impression compound. The mandibular occlusal rim was reduced by 3 mm, and Hight's extraoral tracers were attached to the maxillary and mandibular occlusal rims.

The patient was trained and guided in executing the mandibular movements to give arrow point tracing. When the patient was proficient enough to give arrow point tracing, the tracing plate was prepared, and Gothic arch tracing was obtained on the tracing plate. When definite arrow point tracing with sharp apex was made, a plastic sheet was secured with sticky wax over the tracing plate with two holes made, one at the apex of the arrow point tracing and the other on protrusive tracing 6 mm from the apex of the arrow point. The intraoral centric record was made using Plaster. After the material was set, rims were transferred to the articulator to verify the centric relation. After removing the centric relation record, occlusal rims with tracer assembly were again placed in the patient's mouth. The protrusive interocclusal record was made using the polyvinyl siloxane (Jet Bite, Coltene whale-dent Pvt. Ltd. Switzerland) and Plaster of Paris interocclusal record material (Figs. 1a & 1b) one by one and sagittal condylar guidance values on the articulator for all the patients with both the materials were recorded and tabulated. The entire procedure was carried out for all the patients.



Fig. 1a. Interocclusal records using Polyvinyl Siloxane.



Fig. 1b. Interocclusal records using Plaster of Paris.

**Radiographic method for recording condylar guidance**

Each patient's orthopantomogram (OPG) was obtained to determine the sagittal condylar guidance. The head position of all the patients was aligned similarly with the help of a laser-guided system and cephalogram provided in the machine (Orthophos XG 5 Sirona Dental GmbH Salzburg, Austria). All images were made at a potential difference of 70 kV and a current of 10 mA by the same operator. A Radio-opaque line depicting the outline of the articular eminence and glenoid fossa was traced on the tracing acetate sheets. The Frankfort plane was used as the reference plane for this study. The outline of the glenoid fossa and articular eminence was marked as point 'A,' depicting the deepest point in the glenoid fossa, and point 'B,' the highest point on the articular eminence. A line was drawn joining the points A and B. The angle formed by the line joining points A and B to the line representing the Frankfort horizontal plane was measured and read as the sagittal condylar guidance angle obtained. The above-mentioned procedure was carried out in all the patients. The data thus obtained was tabulated and subjected to statistical analysis using the paired t-test and Pearson correlation test.

**3. Results**

Sagittal condylar guidance angles of 30 edentulous patients using protrusive interocclusal records with Plaster of Paris and PVS were compared with those from tracing of orthopantomogram. Sagittal condylar guidance obtained using the protrusive interocclusal record with Plaster varied from 26-30o on the right side and 26-32o on the left side, with PVS from 25-32o on the right side and 26-32o on the left side. The mean SCGA with Plaster was 28.37±1.27 and 28.63±1.5 degrees on the right and left sides, and with PVS, 28.37±1.73 and 28.53±1.59 degrees on the right and left side, respectively. Statistical comparison of various means using a paired t-test at a significance level of 0.05 showed that the mean difference between right and left sagittal condylar guidance obtained from the radiographic method, with PVS and POP, was statistically insignificant. The mean difference in sagittal condylar guidance values between clinical and radiographic methods was statistically significant on both the right and left sides (Tables 1 and 2).

Table 1. Comparison of right and left mean sagittal condylar guidance values with polyvinyl siloxane, plaster of Paris, and panoramic radiographic method (paired t-test).

Variables	Right vs. Left				Difference of Mean	P-value	Significance
	Mean	SD	Mean	SD			
Right Radiographically vs. Left Radiographically	31.77	4.09	31.83	4.53	-0.06	0.873	Not significant
Right clinical polyvinyl siloxane vs. Left clinical polyvinyl siloxane	28.37	1.73	28.53	1.59	-0.16	0.596	Not significant
Right clinical Plaster of Paris vs. left clinical Plaster of Paris	28.37	1.27	28.63	1.5	-0.26	0.354	Not significant

Table 2. Comparison of mean sagittal condylar guidance values between panoramic radiographic method and clinical method with polyvinyl siloxane, plaster of Paris (paired t-test).

Variable	I		II		Difference of Mean	P-value	Significance
	Mean	SD	Mean	SD			
Right radiographically vs. right clinical polyvinyl siloxane	31.77	4.09	28.37	1.73	3.4	0.001	Significant
Right radiographically vs. right clinical plaster of Paris	31.77	4.09	28.37	1.27	3.4	0.001	Significant
Right clinical polyvinyl siloxane vs. Right clinical plaster of Paris	28.37	1.73	28.37	1.27	0.001	1	Not significant
Left radiographically vs. left clinical polyvinyl siloxane	31.83	4.53	28.53	1.59	3.3	0.001	Significant
Left radiographically vs. Left clinical plaster of Paris	31.83	4.53	28.63	1.5	3.2	0.001	Significant
Left clinical polyvinyl siloxane vs. Left clinical plaster of Paris	28.53	1.59	28.63	1.5	0.1	0.676	Not significant

The panoramic values were approximately 3 degrees higher than clinical recordings. However, the Pearson correlation test using simple linear regression analysis and panel data estimation approach revealed that panoramic values could be used to estimate sagittal condylar guidance as the correlation coefficient was significant between these two methods. (Figs. 2

and 3) This was based on an estimation equation:  $y=a+bx$  where x and y are the variables, 'a' is the intercept point of the regression line and the y-axis, and 'b' is the slope of the regression line. Hence, this implies that the anatomic contours can be predicted based on this equation.

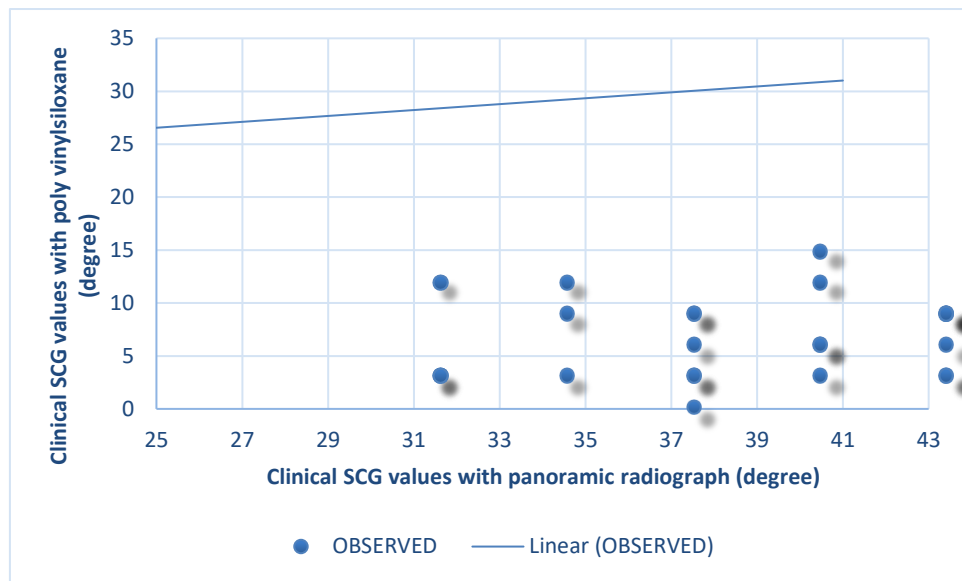


Fig. 2. Shows a positive correlation between panoramic radiograph and clinical sagittal condylar guidance values with Poly vinylsiloxane.

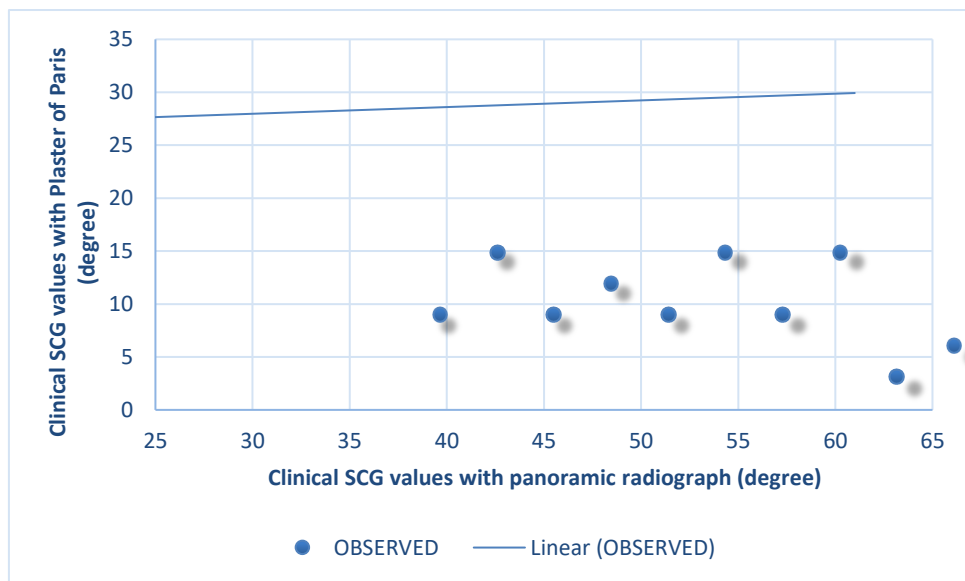


Fig. 3. Positive correlation between panoramic radiograph and clinical sagittal condylar guidance values with plaster of Paris.

#### 4. Discussion

Restoring the patient's occlusion during prosthodontic rehabilitation of edentulous patients is crucial to coincide with the centric relation and provide a balanced occlusion free of interferences. Condylar guidance is an important determinant of achieving these goals. Various intraoral and extraoral methods have been used to register the condyle path and adjust the condylar guidance angle. The most popular technique for determining the horizontal condylar guidance is using an interocclusal record. Various interocclusal record materials commonly used are Plaster, wax, polyether, polyvinyl siloxane (PVS), bisacryl composite, and zinc oxide eugenol (ZOE).<sup>[8]</sup> Comparative studies using interocclusal recording materials to record SCGA have shown that the selection of the material is an important factor to be considered. In the present study, Plaster of Paris and polyvinyl siloxane were used to obtain protrusive interocclusal records, as plaster records have dimensional accuracy similar to polyvinyl siloxane.<sup>[9]</sup> The condylar guidance inclination's reported

average interocclusal registration values vary from 21-64 degrees.<sup>[10, 11]</sup> The average sagittal condylar guidance in the present study was found to be  $28.37 \pm 1.73$  and  $28.53 \pm 1.59$  with polyvinyl siloxane and  $28.37 \pm 1.27$  and  $28.63 \pm 1.5$  degrees with Plaster on right and left sides respectively which is also within this range. Also, there was an insignificant difference in right and left SCGA obtained by protrusive interocclusal records with both materials, which are by studies.<sup>[12-16]</sup> Various radiographs, such as orthopantomograms, lateral cephalograms, and tomographs, can be used to aid in setting condylar guidance angles in semi-adjustable articulators.<sup>[17]</sup> The panoramic used radiographs of dry human skulls to determine the sagittal condylar guidance. A significant correlation was found between the sagittal inclination of the anatomic articular eminence outline and the corresponding panoramic radiographic image for both the right and left sides.<sup>[10, 11]</sup> Accurately measuring structures on panoramic radiographs is possible, provided sufficient care is taken for head positioning.<sup>[18]</sup> In the present study, the

panoramic machine used has a light source and cephalogram that helps in the accurate positioning of the patient, thus reducing the inherent errors associated with orthopantomography. The sagittal condylar guidance angles obtained from tracings of orthopantomogram varied from 25 to 40 on the right side and 25 to 41 degrees on the left side; the mean angle was  $31.77 \pm 4.09$  and  $31.83 \pm 4.53$  degrees on the right and left side, respectively. The values on the two sides were comparable, and the difference in mean SCGA between the two sides was statistically insignificant. Thus, the present study's findings were based on other studies showing insignificant differences between right and left mean sagittal condylar guidance.<sup>[3, 6, 7, 13, 15, 16, 19, 20, 21]</sup> The panoramic sagittal condylar guidance values were, on average, 3 degrees higher than those obtained from protrusive interocclusal records with polyvinyl siloxane and Plaster. These results are comparable to the studies done by Prasad et al., and Gilboa et al., and many other studies that show higher radiographic sagittal condylar guidance values.<sup>[3, 10, 22-25]</sup> However, SCGA values for the radiographic method were lower in the study by Patil et al.<sup>[14]</sup> This variability may be explained by the fact that quantitative measurements on OPG are difficult because of magnification differences and image distortions and depend on the operator's perception.

The present study also compares condylar guidance inclination determined by clinical and radiographic methods. The mean difference between both methods was found to be statistically significant both on the right and left sides, which also agrees with other studies done by various investigators.<sup>[5, 14, 26, 27]</sup> However, results were incongruent with the findings of the studies by Khalikar et al. and Shah et al. Godavarthi et al.<sup>[6, 13, 20]</sup> In the present study, mean SCG values with two different interocclusal materials, when compared, no significant difference was found between the two materials on both the right and left side. A highly significant correlation exists between the materials on both the right and left sides, showing high reproducibility to obtain SCG values for programming semi-adjustable articulators in edentulous patients. The present study observed a strong correlation between the right and left side by clinical method with Plaster, polyvinyl siloxane, radio, and graphic sagittal condylar guidance values. The simple linear regression analysis of the data (Figs. 2 and 3) also showed that panoramic radiographic values in the present study could be used to program arcon semi-adjustable articulators for edentulous patients. Several other studies also found a positive correlation between radiographic and clinical methods similar to the present study. It showed that panoramic radiographic values can be used to program semiadjustable articulators.<sup>[15, 16, 19, 20, 22, 27, 28]</sup> Results were inharmonious with the findings of the studies where they found a negative correlation between clinical and radiographic methods and concluded that the radiographic method is unreliable to program semi-adjustable articulators.<sup>[12, 13, 21]</sup> Although a significant correlation between the two methods showed that a panoramic radiographic method may be used to set the condylar guidance values on the Arcon semi-adjustable articulator, the results of this study need to be cautiously interpreted due to inherent mechanical limitations in the articulators and 2-dimensional radiographs used. Further research using a larger sample size is recommended.

## 5. Conclusion

Within the limitations of this study, it was concluded that the clinical sagittal condylar guidance values obtained from setting protrusive interocclusal records on semi-adjustable arcon articulator are comparable with the values obtained from tracings of the panoramic images in edentulous subjects. There was no significant difference between the interocclusal record materials.

## Conflict of Interest

The authors declared that there is no conflict of interest.

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