

Comparative Study of Protrusive Record Accuracy with and without George Gauge for Dentulous Cases

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Abstract:

Objective: This study aimed to evaluate the accuracy of the George gauge in protrusive records. **Materials and Methods:** This clinical trial includes a total of 12 dentulous subjects aged 20 to 40 years with no signs of muscular disease or temporomandibular joint disorders were chosen. For each patient, two different protrusive records were created, one with and one without the George gauge, using polyvinyl siloxane materials. The accuracy of these two protrusive records was evaluated by measuring the amount of midline shift in both records with a digital calliper. Then these Protrusive records were used to programme the articulator and determine the specific horizontal condylar angle (HCA) value, as well as panoramic radiographs to compare clinical and radiographic values. Paired sample t-test, and one-way ANOVA test was used for parametric data analysis. SPSS Ver.23 was used for statistical analysis. **Results** The findings revealed a statistically significant difference in the accuracy of the protrusive record when done conventionally versus with the aid of George Gauge, with George Gauge providing a more accurate record. The angle obtained via panoramic radiographs was steeper than the angle obtained clinically. **Conclusions:** The George gauge aids in the accurate and simple registration of protrusive records. The condylar guidance angles determined by radiographs were greater than those determined by clinical methods using protrusive records.

Introduction:

Correct registration of the participant's condylar pathway and mandibular movement on an articulator is essential for successful oral rehabilitation and prosthetic therapy. If the condylar inclination is not properly recorded, it can lead to longer chair side adjustments due to arbitrary trimming, which can be aggravating for both the participant and the dentist.¹ Inter-occlusal records, pantographic tracings, electronic jaw tracking devices, radiographic methods, and other methods can all be used to determine horizontal condylar inclination, but in clinical practise, programming a semi-adjustable articulator with a protrusive inter-occlusal record is still the most common method.²⁻⁴ Panoramic radiographs can be utilised as an alternative to the inter-occlusal method.⁵ Gilboa et al.⁶ discovered that the radiographic outline of the articular fossa and eminence in a panoramic radiographic image is an accurate representation of equivalent despite the importance of protrusive records, several researchers have investigated the reliability of these inter-occlusal records⁸⁻¹⁶ And it has been demonstrated that recording and reproducing condylar guidance on semi-adjustable articulators is unreliable.¹⁷⁻²⁰

Inter-occlusal check biting technique errors can occur due to variants in recording material qualities and handling of the recording material, such as alteration of the recording material and unsatisfactory fitting of the casts to the obtained record.

Another problem with the conventional protrusive

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technique was that participants found it difficult to close accurately in protrusion, which was linked to a lack of voluntary neuromuscular control. The angle changes with the degree of protrusion, regardless of the material used, and the intraoral record represents only one point along the condylar path.^{18,21} to overcome the problems of conventional protrusive record, Cortes et al.²² used polyvinyl siloxane and a metal framework to achieve accurate maxilla-mandibular registration. Even though wax protrusive records did not provide consistent readings, they were still used and caused some discrepancies. Silicone bite registration material can be used instead of wax as it is more accurate, easier to use, and has superior dimensional stability.²⁰

The George Gauge®, ideal for mandibular repositioning, enables the prosthodontist to record protrusive bite registration and vertical opening without relying on the participant. The George Gauge® tool eliminates the element of surprise and is accurate and easy to use. It comes in sizes of 2mm, 3mm, and 5mm.²³ This tool measures the degree of mandible protrusion and records the mandibular position using a millimetre indicator.²⁴ Viviano et al.²⁵ observed that the George gauge can be used for the construction of obstructive sleep apnea oral appliances. The popular George Gauge was invented nearly 20 years ago by Peter T. George; a highly regarded orthodontist who specialised in sleep breathing problems. Great Lakes company purchased the George Gauge in 2014. The George Gauge can be autoclaved.²⁶

According to Critchlow et al.²⁷ the accuracy of jaw relations records is critical in preventing dental prosthesis failure. The horizontal condylar guiding angles of a panoramic radiograph can be used to precisely programme the semi-adjustable articulator, yielding results comparable to clinical protrusive

records.²⁷⁻³¹ There was little information available about the George Gauge and protrusive record errors. George gauge bite can be used during registration to overcome errors that may occur during intraoral protrusive recording. The study's goal was to assess the accuracy and reproducibility of condylar angle values obtained using two different interocclusal protrusive records, with and without George gauge, in a bio-art, A7 Plus, semi-adjustable articulator, and to compare those values to the direct measured HCA on panoramic radiographs. The null hypothesis of this clinical study was that there were no differences in accuracy or reproducibility of condylar angle in articulator to those values obtained with panoramic radiographic images between protrusive record registration with and without George Gauge device.

Material and methods:

Study design, participant's criteria, and sample size calculation:

This study was a prospective clinical trial that used a non-randomized cross-over study design to assess the accuracy of protrusive records in 12 dentulous participants.

The sample size was selected according to Shreshta et al.²⁸ and Tannamala et al,⁴ 2012. A sample size of 12 participants was calculated for the paired t-test using PASS 2008 software, with an alpha (α) of 0.05 and a power of 0.80. The participants were all healthy, with no muscular disease or signs and symptoms of temporomandibular joint disorders. With ages ranging from 20 to 40 years old, they were chosen from the university's prosthodontic clinic. This study was approved by the Research Ethics Committee under the number: A27060722.

The ethical guidelines of the University of Mansoura, Faculty of Dentistry, for conducting a clinical study were followed in the development of this clinical study. The participant was informed about the clinical procedure and signed informed consent for participation in this study.

Clinical procedures:

For every participant, the following was done: Maxillary and mandibular impressions were done using addition silicon impression material and poured in type IV Extra-hard dental stone (BMS DENTAL GYPSUM TYPE IV, Italy). Mounting of the maxillary cast was done on a bio-art, A7 Plus, semi-adjustable articulators using Bio-art Elite face bow (Figure 1), then the mandibular cast was mounted in relation to the maxillary one according to the centric occlusal record.

Two protrusive records were done for every participant both with the conventional technique and with the aid of George Gauge, occlusal registration device, (George gauge; Great Lakes Orthodontics Ltd) using bite registration silicone material (DENU Bite Sil, Vinyl Polysiloxane Bite Registration Material, HDI Inc., Korea).



Figure 1: Face bow transfer for mounting of the maxillary cast

The participant was asked to do the protrusive record until about edge-to-edge relation, and 5 mm protrusion. The conventional protrusive bite was done as mentioned by Shreshta et al.²⁸ using an anterior Lucia jig. The protrusive record was obtained by instructing each participant to move his/her mandible directly forward to edge-to-edge position and by approximately 5 mm, and a protrusive record was recorded using bite registration silicone material. At first, putty silicon was used to produce the anterior Lucia jig. The patient was educated to move the mandible forward till the anterior teeth were in edge-to-edge relationship / and 5mm protrusion then closed without puncturing the jig. Consequently, the silicone bite registration material (DENU Bite Sil, Vinyl Polysiloxane Bite Registration Material, HDI Inc., Korea) was introduced stuck between the occlusal surfaces of the maxillary and mandibular teeth. The second protrusive record was obtained with the aid of George Gauge device. The device consisted of the instrument body and a 2-mm bite fork (Figure 2). The registration procedure included the following steps. The lower turn screw of the instrument body was loosened, and the mandibular incisor clamp was sided forward.

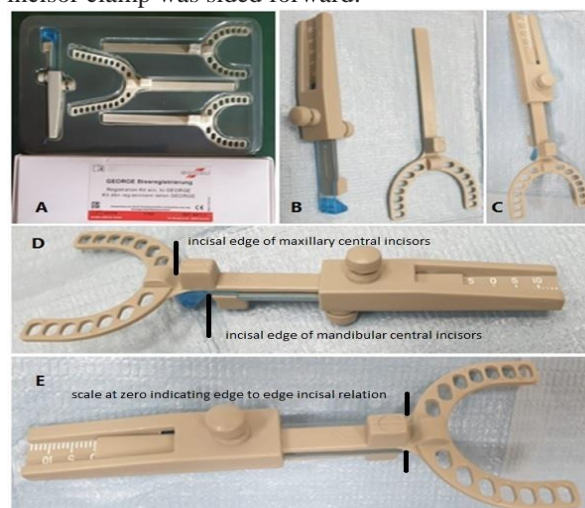


Figure 2: (A) George gauge, (B) The fork with 2 mm thickness, (C) In assembled form, (D) In protrusion about 5mm as presented on the scale, and (E) In edge-to-edge relations where the scale at zero gradation.

To fit the mandibular anterior teeth into the mandibular incisor notch while the lower midline indicator overlap the midline of the mandibular central incisors. Then, the lower turn screw was tightened and the George Gauge was removed from the patient's mouth. The

upper turn screw of the instrument body was loosened to let the bite fork Move freely back and forth. With the mandibular teeth centered into the lower incisor notch and the upper teeth centered in the open notch on the bitefork, the patient mandibular positions were registered. The following positions were to be registered: edge-to-edge and 5 mm protrusion which was calibrated on to the millimeter scale of the device.

A silicon bite registration material was injected on each prong of the bite fork of the device the participant's mouth with the upper incisor notch centered over the maxillary incisors then the mandible was guided into the lower incisor notch, (figure 3).

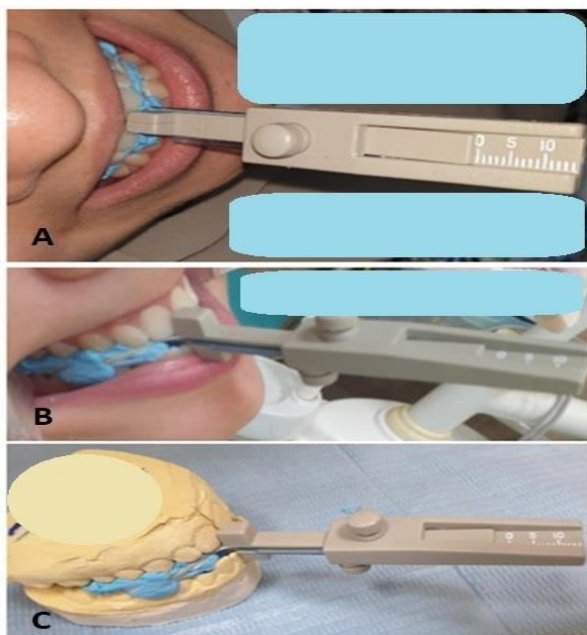


Figure 3: A silicon protrusive records using George Gauge device, (A) In edge to edge incisal position, (B) In protrusive relation, (C) transference on the cast to check its stability.

Each protrusive record (either the conventional without George gauge or the one obtained with the aid of George gauge) was used for programming the articulator and determining the horizontal condylar angles which were then tabulated. Using the panoramic radiographs, the horizontal condylar angle was measured according to tannamala et al,⁴. This angle was calculated in relation to the horizontal plane of the frank fork (figure 4). A panoramic radiographic image was taken of each patient using Frankfurt which was returned to the same operator took all radiographs at the same time with the same panoramic radiographic unit (Gendex GXDP 700, Hatfield, USA.). The images were captured at 66 kV and 13 mA. The panoramic radiographic unit includes an anatomically aligned light, and a cephalostat was used to keep the patient's head in the same position.

Two radio-opaque lines in the temporal bone region are consistently visible on panoramic radiographs. The first points of the curvatures were identified. These two lines were joined by a straight line representing the mean curvature line. Angles were measured at the point

represents the articular eminence and fossa outline, while the second represents the zygomatic arch's

inferior border. Radiographic image traces were created. A horizontal reference line was formed by joining the orbit ale and porion. The superior and inferior horizontalplane parallel to the floor of the mouth where the mean curvature line intersected the



Figure 4: Horizontal Condylar angle as determined on the Panoramic radiograph inrelation to the Frankfort horizontal plane.

horizontal reference line. To determine the accuracy of each protrusive record either by using George gauge or without (figure 5), the amount of midline shift was determined in relation to a standard reference point corresponding to the mid-point of the incisal table mesio-distally. The deviation of the incisal post touching the incisal table from that point represents the amount of midline shift in each protrusive record.

An articulating paper (Bausch, 12 Murphy Drive, Nashua, NH 03062, United States of America) was used to determine the point of deviation, incisal post-incisal table trace that was made with each protrusive record. For standardization, the trace that was done by articulating paper on the incisal table by the incisal pin according to each protrusive record was measured in relation to a reference line on the incisal. Table (This line was 2.5 mm from the reference point at the middle of the incisal table).

The distance perpendicular to this line was measured using a digital calliper (figure 6). The measured distance was subtracted from 2.5 to determine the actual amount of midline shift. The recorded data were tabulated to be statistically analysed.

Statistical analysis

The recorded values were tabulated and statistically analysed using the computer software Statistical Package for the Social Sciences Ver. 23 (SPSS). The Shapiro test was used to determine the normality of the continuous data The paired t-test was used to compare the midline deviation in each protrusive record. The mean of right and left horizontal condylar angles obtained clinically by the two protrusive records was



Figure 5: The conventional prtrusive record transferred on the articulator (the point of deviation at the contact between the incisal post and incisal table was present and this point was determined for measurement by articulating paper).

compared to that obtained by direct measuring on panoramic radiographs using one-way ANOVA followed by the Post Hoc test. Results were considered significant at $P \leq 0.05$.



Figure 6: The meaurment of midline shift (Accuracy) on the articulator for Protrusive record using digital caliper.

Result:

Clinical findings

The protrusive records with the aids of George Gauge were found to be more easily recorded in comparison to the conventional method. The amount of protrusion can be guided accurately by the George Gauge. By measuring the amount the amount of midline shift, the protrusive record that done by aiding of George gauge bite showed more accuracy.

The horizontal condylar angle measured through the panoramic radiograph was steeper than that recorded clinically either with or without the aid of George gauge.

Statistical findings

The accuracy of protrusive record with and without the George gauge (midline deviation):

The descriptive analysis of data of midline deviation revealed that the Mean \pm standard deviation of midline deviation of protrusive record without George gauge was 1.00 ± 0.21 while that for protrusive record with George gauge was 0.09 ± 0.08 . P Paired Sample t- test revealed statistically significant difference between them where $P= 0.001$ (Table 1).

variables	Protrusive record without George gauge	Protrusive record with George gauge
Mean \pm SD	1.00 ± 0.21	0.09 ± 0.08
Minimum (mm)	0.75	0
Maximum (mm)	1.4	0.23
Paired Sample t- test	T value	18.13
	P value	.000*

Table 1: Comparison of the amount of midline deviation on the incisal table of the articulator

* Statistically significant at $P \leq 0.05$

The mean of right and left horizontal condylar angle obtained clinically through protrusive record without George gauge (conventional protrusive record) was 30.4° and the protrusive record with George gauge was 32.2° . The mean Horizontal condylar angle measured on the panoramic radiograph was 39.1° , (Figure 7).

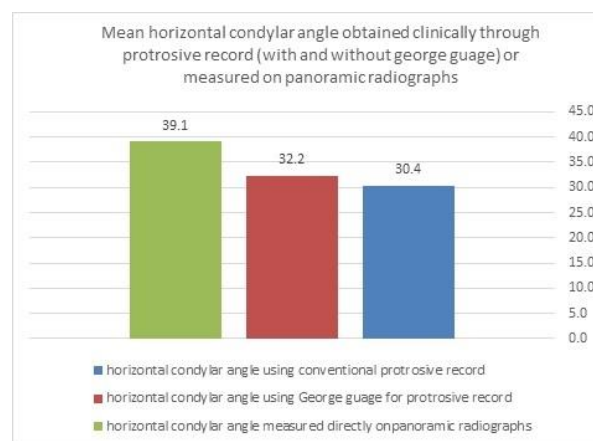


Figure 7: Bar graph of the mean of Horizontal condylar angle obtained clinically through Protrusive record with and without George gauge in addition to Horizontal condylar angle measured directly on the panoramic radiograph.

The result revealed that, (one-way ANOVA) there were statistically significant difference among the three groups where $P=0.001$, (Table 2). Post Hoc test revealed that the direct measuring of HCA on panoramic radiographs was statistically higher from that obtaining the HCA through the protrusive record either conventionally without the George gauge or that with aids of George gauge where $P = 0.001$. Although the value of HCA obtained by the aid of George gauge was higher than that obtained conventional without

George gauge but this difference was statistically not significant where P = 0.096 (Table 3).

Table 2: Comparison of the mean of right and left horizontal condylar angles obtained by clinical methods (protrusive record with and without George gauge) with that measured on panoramic radiographs

variables		Horizontal condylar angle through Protrusive record without George gauge	Horizontal condylar angle through Protrusive record with George gauge	Horizontal condylar angle measured on the panoramic radiograph
Mean ± SD		30.4 ± 2.4	32.2± 2.3	39.1 ± 3
Minimum		27	30	35
Maximum		35	37	45
One-way ANOVA	F value	42.8		
	P value	.000*		

* Statistically significant at P ≤ 0.05

Table 3: Bonferroni Post Hoc test for pair comparisons of the methods for HCA

variables	Horizontal condylar angle through Protrusive record without George gauge - Horizontal condylar angle through Protrusive record with George gauge	Horizontal condylar angle through Protrusive record without George gauge - Horizontal condylar angle measured on the panoramic radiograph	Horizontal condylar angle through Protrusive record with George gauge - Horizontal condylar angle measured on the panoramic radiograph
Bonferroni Post Hoc Test P-value	0.096	.000*	.000*

* Statistically significant at P ≤ 0.05

Discussion:

For any successful prosthodontic rehabilitation treatment, the horizontal condylar angle is a critical measurement for programming articulators. This is important to restore the patient’s occlusion free of interference.¹³ in addition to constructing OSA

appliances.²⁵ Settings condylar angle for a semi-adjustable articulator must be programmed quickly

and accurately to replicate functional and para-functional movements. Inefficient treatment planning and incorrect treatment will result from inaccurate programming.³² There are various ways for calculating the horizontal condylar angle. One method involves using intraoral protrusive record to compute the angle on the articulator.¹⁸

In this study bite registration silicon was used instead of wax in protrusive record done either with the aid of George gauge or without it. The main worry regarding the wax protrusive method is the distortion and difficulty of having the participant repeat the same protrusive position. The existing literature has repeatedly suggested this method is unreliable , unrepeatable, invalid, and arbitrary. Silicone bite registration material can be

used instead of wax since it is more accurate, easier to use, and has better dimensional stability.^{20, 29} To overcome the inadequacies of the wax inter-occlusal approach and improve its reliability, modifications to the wax protrusive method were developed. This approach included the use of silicon as a protrusive guide, which allowed the participant to protrude the mandible in the same position each time the record was made.²² In this study, the null hypothesis of no difference in accuracy was not supported, there were statistically significant differences between the protrusive records with or without the George gauge, where George gauge provide a more accurate result with a decreased amount of midline shift. The significant differences shown can be explained by that the George gauge had maxillary and mandibular midline indicators than can accurately guide the mandible in centered protrusive position without any shift effect of the muscles. The conventional protrusive record had some limitations therefore; Cortes et al.²² used polyvinyl siloxane and a metal framework to achieve accurate maxilla-mandibular registration, overcoming the limitations of conventional protrusive records. The result of this study differs from other research done by Viviano et al.²⁵ who found that there was no difference in outcomes for appliances constructed using the George Gauge™ Registration (GGR) and the Sibilant Phoneme Registration (SPR).HCG angle determination using protrusive inter-occlusal records is a multi-step clinical procedure that requires precise expertise and experience. As a result, many practitioners depend on HCG settings on average values (e.g., 33°). When the horizontal condylar path inclination is very flat or very steep, mean value settings may produce inaccuracies and impair balanced occlusion.^{6,34,35}

Both protrusive records obtained in this study were also used to adjust the HCG angle of the bio-art, A7 Plus, semi-adjustable articulators. The present study attempted to evaluate the accuracy of two protrusive record methods for HCG determination and compare it

with the radiographic measuring method. For standardization of the study, all radiographs were taken

with the same digital machine operated by a single operator following the manufacturer's recommendations to eliminate image distortion and magnification errors.⁶In this study, a statistically significant difference was found between mean HCG angles obtained from protrusive interocclusal record and panoramic radiographic tracing. The mean HCG difference between panoramic radiographic tracing and protrusive interocclusal records without and with using George gauge was 8.7 and 6.9° respectively. Paul et al.⁷ and Gilboa et al.⁶ found nearly the same mean difference of 7.03°, and 7° respectively. ; whereas tannamala et al.⁴ and kumari et al.³⁵ claimed the radiographic values were on average 4° and 13° greater, respectively. These inconsistencies occur in an OPG due to overlapping of the mandibular notch, coronoid process, and zygomatic arch around the TMJ. It is difficult to distinguish between these two closely approximated radiopaque lines, one displaying the outline of the articular eminence and fossa and the other indicating the inferior border of the zygomatic arch, without the use of any accessory aid.³⁶in the present study, HCG values determined by protrusive method without and with George gauge were 27-35 and 30-37 respectively, whereas tracing of panoramic radiographs was 35-45. This wide variation is in agreement with the findings of previous investigators like Paul *et al.*,⁷ who found that protrusive record method were 17°-45°, whereas cephalometric tracing of panoramic radiographs and lateral cephalogram yielded HCG values ranging from 27° to 47° and 31°-50°, respectively.

In the present study, mean HCG values obtained from interocclusal protrusive records either without or with George gauge and obtained from panoramic radiographic tracing were 30.4, 32.2, and 39.1 respectively. These results were in agreement with the study by Prasad et al.³⁷ and Paul et al.⁷condylar pathways are influenced not only by the bony contour of the TMJ's articular eminence, but also by the soft tissue attachments, thickness, and shape of the articular disc and ligaments. As a result, the accuracy level of horizontal condylar angle guidance determination by the radiographic method is called into question because differentiation in soft tissue imaging is blurry in panoramic radiographs, so radiographic method is always of greater value.³⁸ clinical protrusive method for each individual is mandatory to determine accurate HCAG values.

Tannamala et al.⁴ stated that the protrusive condylar guidance angles gained by panoramic radiographs could be used to programme semi-adjustable articulators. This differs from Singh et al.³⁹ who mentioned that radiographic tracing cannot be used independently for programming articulator due to its inability of soft tissues imaging, the unreliability of determining landmarks, image distortion, and structural

superimposition.the George gauge can also help guide the mandible to the desired extent of protrusion. It can also be used to determine how much the temporomandibular joint has improved by measuring the

improvement in mandibular movement in the forward direction. The George gauge device can be used to transfer maxilla-mandibular relationships to the scanner for CAD/CAM dental prosthesis construction.

One of the study's limitations is the small sample size. Further research can be conducted to assess the long-term effect on TMJ of the oral appliance (stabilization splint or mandibular advancement prosthesis) constructed with the aid of George gauge and that constructed with a conventional protrusive record.

Conclusions:

According to the findings of this study, and within the limitation of this study, the George Gauge device can be utilised during the protrusive record to allow for an easy and accurate recording of the mandible's protrusive position. Furthermore, George Gauge can be used to determine the amount of protrusion.

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