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Original Article

A Comparative Evaluation of Lateral Condylar Guidance by Clinical and Radiographic Methods – Hanau's Formula Revisited

Kanagesan Praveena, Ranganathan Ajay[1], Veeramalai Devaki[1], Kandasamy Balu[1], Selvakumar Preethisuganya, Venkatachalam Menaga[2]

Department of Prosthodontics and Crown and Bridge, JKK Nattraja Dental College and Hospital, Komarapalayam, [1]Department of Prosthodontics and Crown and Bridge, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode, Namakkal, Tamil Nadu, India, [2]Dental Surgeon, Ministry of Health, Brunei

Abstract

Background: Various clinical methods for recording the condylar guidance (CG) are the intraoral check bite method, graphic tracings, and functional recordings. Accuracy of graphic tracings is affected by patient-related factors such as neuromuscular control of the individual, stability of record bases as well as stability of recording media. The current recommended average settings using Hanau's formula questionable, and thus reassessment is needed. **Purpose:** The purpose of this study is to use radiographic technique to determine the lateral CG and compare these values with those obtained using Hanau's formula and to evaluate whether there are differences between the right and left paths of the condyles. **Materials and Methods:** Twenty completely edentulous patients were selected. Articulator was modified with sectioned protractor for obtaining per degree interval calibration. With the protrusive records, the horizontal CG (H) was adjusted and the Bennett's angle (LCG-C) was calculated using the formula. With the tracing device in the mouth, sub-mento vertex projection radiographs were obtained. Each radiograph was traced and superimposed for Bennett angle determination (LCG-M). **Results:** The median (interquartile range [IQR]) of right and left LCG-C were 15.45 (0.8) and 15.50 (0.7), respectively. The median (IQR) of right and left LCG-M were 37.00 (6.0) and 36.50 (6.8), respectively. A statistically significant difference exists between LCG-C and LCG-M. Both LCG-C and-M values exhibited no variations on both sides. **Conclusions:** Radiographic technique yielded an amplified LCG when compared to the value obtained by Hanau's formula.

Keywords: *Bennett angle, condylar guidance, Hanau's formula, radiograph, sub-mento vertex*

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Introduction

The ultimate goal of prosthetic rehabilitation is to fabricate a prosthesis that is harmonious with the patient's stomatognathic system.[1] An accurate simulation of the condylar path of patient on an articulator leads to a successful complex prosthodontic treatment.[2] The most essential consideration in the oral rehabilitation of any patient is recording the inclination of the condylar path (condylar guidance [CG]). Erroneously recorded CG leads to occlusal interferences during mandibular movements. This increases the chairside denture adjustment time, which can be annoying for both the patient as well as the prosthodontist.[3] If the individual inclination of the articular eminence is very steep or flat, guidance derived from the mean value settings may vary sufficiently, leading to the incorporation of gross inaccuracies while accomplishing occlusion.[4]

Horizontal CG (HCG) can be recorded through the intraoral or positional wax method, graphic recordings, and functional recordings. Significant errors creep

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Address for correspondence: Dr. Ranganathan Ajay, Department of Prosthodontics and Crown and Bridge, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode, Namakkal - 637 205, Tamil Nadu, India.
E-mail: jrangclassiq@gmail.com

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in during these recording methods.[5-7] The use of radiographic imaging helped in resolving the errors and establish accurate registration of HCG.[1] Numerous researches have been conducted to ascertain the existence of any correlation between clinically recorded HCG values and the one traced on radiographs. OPG, being the most commonly used diagnostic aid, has minimal radiation exposure and hence, it is preferred over computed tomography (CT) for recording the HCG.[8]

The LCG in Hanau series of articulators are being calculated using Hanau's formula; $L = \frac{H}{8} + 12$ The exact derivation and mathematical proof of this formula are unknown till date. The denominator 8 and the +12 values were subjective to interrogation with respect to their origin. However, the current recommended average settings use this formula as a gold standard to calculate LCG in Hanau series articulators. The validity of this formula is questionable, and hence, reassessment is needed to verify the reliability of the formula.

In current practice, digital CT scans are more accurate, resulting in their widespread application in dentistry. However, its exposure is greater than an ordinary radiograph. It may be argued that the application of advanced digital imaging is unwarranted for removable complete denture patients. Therefore, a novel sub-mento vertex (SMV) radiographic projection has been proposed in this present study for measuring LCG. The use of SMV projection to measure LCG yet has not been documented in the dental literature. Hence, this study aims to compare the LCG angles calculated by Hanau's formula; $L = \frac{H}{8} + 12$,(LCG-C) with the angles measured in SMV radiographic tracings (LCG-M). Furthermore, it aims to compare the right side LCG-C and-M with the left side. The null hypothesis is that there shall not be a difference between the calculated and measured values of LCG.

Materials and Methods

This study was presented to and approved by the institutional ethical committee (No: VDCW/IEC/39/2016). Twenty completely edentulous patients were selected for the study. No attempt was made to maintain a fixed male-to-female ratio. The age range of the patients was between 40 and 60 years with favorable maxillary and mandibular ridges, adequate bilateral-protrusive movements and no clinical signs of temporomandibular joint dysfunction. Patients whose condition contraindicates radiographs refused to give informed consent, and with severely resorbed alveolar ridges were excluded from the study.[9] Basic information about the study was explained in brief to the patient.

The semi-adjustable articulator (Hanau™; Wide-Vue Articulator, WhipMix Corporation, USA) was used in the study. To obtain more accurate readings, sectioned modified protractors, graduated at per degree interval, were attached onto the inner side of the graduated markings on the condylar element and at Bennett calibration on each side in alignment with the markings bilaterally. L-shaped extenders made from 23G orthodontic wire were attached onto the reference zero line bilaterally.[10] Maxillary (split-cast) and mandibular master casts were obtained after primary and secondary impression procedures. After establishing the vertical dimension, casts were mounted on the articulator by direct face-bow transfer.

With definite Gothic arch tracing, the centric and protrusive inter-occlusal records were made by poly vinyl-siloxane material (Jet bite, Coltene-Whaledent Pvt. Ltd., Delhi, India). Right and left lateral inter-occlusal records were obtained with dental plaster (Kaldent, Kalabhai Karson Pvt. Ltd., Mumbai, India) based on the distance traveled from the centric relation point (5 mm) and the placement of the tracing needlepoint on the previously scribed border movement line.[11,12] With the protrusive records, the HCG (H) was adjusted, and the Bennett's angle (L) was calculated using the formula;. $L = \frac{H}{8} + 12$. Lateral inter-occlusal records were used to stabilize the mandible in lateral position while SMV radiographic procedures and to correct occlusal errors, thereby obtaining balanced complete dentures.[13]

With the tracing device and inter-occlusal records positioned in the mouth, three cranial radiographs in SMV projection (centric, right, and left lateral) for each patient were obtained (Simplex X-ray, DX-300; G-XR-1793; Ge Medical Systems X-ray South Asia Ltd., Bangalore, India) with a constant head position maintained by craniostat. Radiographs were made using an exposure of 60 kV, 15 mA for 0.8 s and then processed in an automatic processor [Figure 1].[14] Each radiograph was traced on the transparent acetate tracing sheet. The centers of the foramina spinosa (trans-spinosa axis [TSA]) were connected, and the mid-sagittal line bisecting TSA was drawn to serve as the midline of the base of the skull.[14,15] The midline was projected as a parallel lines through the right and left condylion medialis , which served as a reference planes [RP] to trace the balancing medial condylar movement. The tracings with left and right lateral mandibular positions were overlapped on the centric condylar position tracing

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Figure 1: Sub-mento vertex radiograph

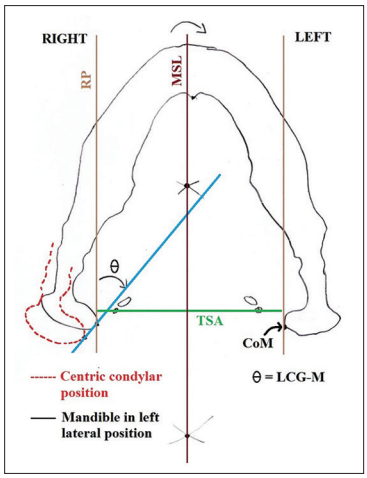


Figure 2: Superimposed tracings showing centric and eccentric condylar positions

sheet using the midline [Figure 2]. The CoM in centric and balancing positions served as two points for a line. The angle formed between this line and the RP was measured and recorded as Bennett's angle (L). Statistical analyses were performed using the Statistical Package for the Social Sciences SPSS software (ver. 18.0; SPSS Inc., Chicago, IL, USA). The obtained values were subjected to normality test and found to be skewed. Hence, Mann–Whitney-U test was applied to compare bilateral LCG-C, bilateral LCG-M, and between LCG-C and LCG-M. A $P < 0.05$ was considered to be statistically significant.

Results

Tables 1 and 2 show the median (interquartile range) of LCG-C (right, left) and LCG-M (right, left), respectively. There is no statistically significant difference between the sides in both LCG-C ($P = 0.9$) and LCG-M ($P = 0.63$). While comparing the LCG-C and LCG-M [Table 3], there exists a statistically significant difference ($P = 0.000$).

Table 1: Comparison between right LCG-C and left LCG-C

Group	Median (IQR) (°)	Mean rank	*P*
Right LCG-C	15.45 (0.8)	20.28	0.9*
Left LCG-C	15.50 (0.7)	20.72	

*P>0.05, statistically insignificant. IQR: Interquartile range, LCG-C: Calculated lateral condylar guidance

Table 2: Comparison between right LCG-M and left LCG-M

Group	Median (IQR) (°)	Mean rank	*P*
Right LCG-M	37.00 (6.0)	21.38	0.63*
Left LCG-M	36.50 (6.8)	19.62	

*P>0.05, statistically insignificant. IQR: Interquartile range, LCG-M: Measured lateral condylar guidance

Table 3: Comparison between LCG-C and LCG-M

Group	Median (IQR) (°)	*Z*	*P*
Right			
LCG-C	15.45 (0.8)	-5.418	0.000*
LCG-M	37.00 (6.0)		
Left			
LCG-C	15.50 (0.7)	-5.422	0.000*
LCG-M	36.50 (6.80)		

*P<0.05, statistically significant. IQR: Interquartile range, LCG-C: Calculated lateral condylar guidance, LCG-M: Measured lateral condylar guidance

Discussion

The present study is the first to assess the LCG or Bennett angle by radiograph and it may be a method to evaluate the validity of the conventionally followed Hanau's formula to record LCG. The use of SMV radiography for measuring LCG has not been documented in the literature yet. Berger was the first to use SMV projection in cephalometrics. The SMV cephalometric analysis has been developed to facilitate the measurement of the craniofacial complex from the basilar view.[16]

Based on the results of this study, clinicians should consider reassessing the present recommended average settings and the use of Hanau's formula for programming the articulator by means of further research. A significant difference between LCG-C and LCG-M was established in this study, and therefore, the null hypothesis is rejected. The variations in these obtained values will definitely affect the balanced occlusion in the patient's mouth. Concerning the sides, LCG-C and-M values exhibited no significant variations. There are few researches that produced similar inferences with different techniques. Bhawsar, in 2016, found a significant difference in the LCG obtained by

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using the Hanau's formula and kinesiograph. However, there was no significant difference between the sides. The LCG values through kinesiograph were obtained by a mathematical equation based on the trigonometric principle.[9] Celar and Tamaki demonstrated significant differences between articulator setting and Cadiax compact measurement and concluded that Cadiax compact had reasonably accurate LCG for clinical application.[17] Hernandez *et al*. found no significant differences between the right and left LCG. They have considered the immediate side shift (ISS) movement of the orbiting condyle in calculating the Bennett angle.[18] Fanucci *et al*. compared the LCG measured by an average value articulator and by CT. They did not consider the ISS and concluded that the LCG obtained by articulator were consistent with the CT.[19]

Tissue resiliency, height of residual ridges, the stability of denture bases, adequate inter-arch distance, coordination of neuromuscular complex, experienced clinician, patient's co-operation, and protracted clinical procedure are the hurdles and limitations of the Gothic arch technique.[20] Bahaa El-Din *et al*. compared the Gothic arch tracing method and cone beam imaging in recording the LCG and concluded that there was no difference in the Bennett angle and ISS measured by either method.[21] There are some limitations of the radiographic method such as magnification, distortion, the orientation of the head and RP, and difficulty in distinguishing the anatomical landmark outlines, especially with respect to foramina and condylar poles. Although there were difficulties, the landmarks were traced out of the SMV projection radiographs. The LCG is strongly determined by the medial glenoid fossa wall and the ISS. In the present study, LCG-M was measured between two points and ISS was not taken into account, leading to amplified LCG values. Ghodsi and Rasaeipour assessed the average condylar inclinations using electronic pantograph and found that the ISS significantly affected the BA/LCG.[22] According to Boulos *et al*., intraoral records eschew the ISS movement.[23] Hence, the obtained LCG using either intraoral record (two-point registration) method or Hanau formula will be greater than the LCG recorded by pantograph. This was in agreement with several other studies.[18,23-29]

Even a semi-adjustable articulator should be considered as a diagnostic articulator when used for fixed dental prosthetic rehabilitation procedures. Similar study can be carried out in dentulous patients considering the ISS. Evaluation on the accuracy of restorations fabricated using the condylar settings obtained from the computerized jaw tracking device also has to be carried out. Comparison of LCG measured by lateral check bite, computerized jaw tracking device, and SMV radiograph can be useful for clinicians for further conclusion. In this study, amplified LCG-M resulted as the ISS was overlooked.

Conclusions

Within the limitations of the study, the following conclusions were deduced;

1. Concerning the sides, there is no significant difference within LCG-C and LCG-M
2. There exist a huge difference between the LCG-C obtained from the Hanau's formula and LCG-M obtained from the SMV projection radiographs.

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Conflicts of interest

There are no conflicts of interest.

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