Evaluation of Hanau’s formula in determination of lateral condylar guidance: A clinical research study

Sanjay Vasant Bhawsar, Ashlesha Subhash Marathe¹, Sadekh Abdul Ansari²
Department of Prosthodontics, MGV’s KBH Dental College and Hospital, Nashik, ¹Department of Prosthodontics, SMBT Dental College and Hospital, Sangamner, ²Department of Prosthodontics, Aditya Dental College, Beed, Maharashtra, India

Abstract

Statement of Problem: The accuracy and reliability of the methods used for programming the semi-adjustable articulators determine the accuracy in occlusion. The current recommended average settings using the Hanau’s formula commonly used by clinicians is questionable, and thus reassessment is needed. This study was carried out to evaluate and compare the lateral condylar guidance: (1) Using the Hanau’s formula and the computerized jaw tracking device (Kinesiograph). (2) On the right and left sides using both these methods.

Materials and Methods: A total of 20 completely edentulous patients (14 male and 6 females) within 40–60 years of age were selected. Jaw relation was recorded followed by face bow transfer. Extraoral Gothic arch tracing was recorded; three protrusive records were obtained and condylar guidance was calculated. Lateral condylar guidance was then calculated using Hanau’s formula, followed by the computerized jaw tracking device. A comparative evaluation was done of the obtained values. The same investigator worked with each of the study participants for the purpose of standardization.

Results: The lateral condylar guidance values obtained using the Hanau’s formula ranged from 14 to 17° while those obtained using the computerized K7 jaw tracking device ranged from 8 to 40°. Bennett angle values, obtained using the jaw tracking device and Hanau’s formula showed statistically significant differences (P < 0.05) using paired t-test (at 95% confidence interval). Bennett angle values of the right and left sides found using the Hanau’s formula were almost similar. Difference in the Bennett angle values of the right and left sides were found using the jaw tracking device. However, this difference was not statistically significant (P > 0.05).

Conclusion: Based on the results, dentist and dental technicians should consider reassessing the current recommended average settings and use of the Hanau’s formula for programming the semi-adjustable articulators.

Key Words: Articulator, condylar guidance, temporomandibular joint

INTRODUCTION

The aim of every dentist is to fabricate restorations in harmony with the patient’s functional movements, to avoid interferences and subsequent disharmony in the stomatognathic system. Dental articulators accurately simulate patient’s mandibular movements and aid in restoring occlusion. Programming semi-adjustable articulators requires two condylar adjustments, the condylar guidance and Bennett angle obtained using interocclusal records and the Hanau’s formula, respectively. The accuracy and reliability of the methods for programming the articulators will determine the accuracy in occlusion.

Christensen in 1902 proposed the use of a protrusive interocclusal record for programming the articulator. Sir Rudolph Hanau in 1930 suggested the use of the
Hanau’s formula, \( L = \frac{H}{8} + 12 \) to calculate lateral condylar guidance for adjusting his articulators. Dentists have continued to use these criteria to program semi-adjustable articulators till date.\(^1\) All existing Hanau models and some other types of articulators still require the use of the Hanau formula for that purpose. Some models of the Hanau articulator can accept lateral interocclusal records, but even in those models, the Hanau formula has been used for verification of lateral condylar guidance.\(^2\)

Mandibular movements are complex, and this fact needs to be considered and understood in the use of articulators. Over the years, there have been attempts to accurately reproduce the jaw movements on articulators. The more accurate these articulators have been in simulating mandibular movements; the more complex they have become in design. Fully adjustable articulators simulate mandibular movement most accurately. However, their usefulness is limited due to the complexity of record making and articulator adjustment. Semi-adjustable articulators are adjusted using individual static records, the reliability of which has been always been questionable. These articulators do not simulate the patient’s temporomandibular joint (TMJ) anatomy and are based on average condylar settings.\(^2,^3\)

The balancing side condyle during lateral excursions moves forward, downward, and medially. However, the same condyle moves only forward and downward and in a path parallel to that of the other condyle during the protrusive movement. Weinberg stated, “The protrusive condylar inclination is considered accurate enough to be used for the downward component of the balancing movement,” but the condylar path on the balancing side during lateral excursions is different from the condylar path in protrusive movements.\(^1,^4\)

Simulation of the patient’s lateral condylar path on the articulator would require the medial wall of the condylar element to be the same distance apart as the inner wall of the patient’s glenoid fossae.\(^2\) Moreover, the mandible may easily deviate to one side while recording the protrusive movement, resulting in inaccurate condylar guidance readings on the articulator. The complete dentures constructed on such an articulator will not have a balanced occlusion when returned to the patient’s mouth.\(^3\)

According to Beu, Jack Stern (1960) stated that the Hanau’s formula was never considered to be exact; rather it was an approximate starting point. Sir Rudolph Hanau developed the formula as “a security blanket.”\(^5\) Javid and Porter found a significant difference in the means of the condylar readings using lateral interocclusal record and the Hanau’s formula.\(^1\) Knap and Ziebert suggested a technique in oral reconstruction using the Hanau Model 130-28. In their technique, protrusive and lateral interocclusal records are used to determine the condylar guidance elements and proposed that a similar technique can be used in the construction of complete dentures.\(^1\) Ortman suggested a procedure in which the occlusion is further “milled with the registered condylar guidance inclination increased and then decreased 5°.” If the condylar guidance inclinations were accurate, these additional procedures would not be necessary.\(^1\) According to Weinberg, the lack of individual working condylar motion affects cusp height. This results in a lack of balanced occlusion in the complete dentures.\(^4\)

The purpose of this study was to use the computerized jaw tracking device to determine the lateral condylar guidance 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. The null hypothesis to be tested is that no difference exists among the condylar guidance values obtained using Hanau’s formula and the jaw tracking device and between the right and left paths of the condyles using both the methods.

**MATERIALS AND METHODS**

Patients reporting to the Department of Prosthodontics were screened to select the subjects for the proposed research. No attempt was made to maintain a fixed male-to-female ratio. The inclusion criteria consisted of completely edentulous patients between 40 years and 60 years, with good maxillary and mandibular ridges, Class I ridge relationship and good neuromuscular control. Patients with TMJ signs and symptoms, with resorbed ridges, poor neuromuscular control, Class II and Class III ridge relationship, and large tongue were excluded. Based on these criteria, 20 (14 males and 6 females) patients were enrolled. Convenience sampling was done due to the constraints in the time duration of the study, and no other studies were available to estimate the mean difference in the groups and estimated the standard deviation. Informed consent was taken from the subjects after approval for the study from the Ethical Committee.

Preliminary and definitive impressions of the maxilla and mandible were made in medium fusing impression compound (Maarc; Thane, Maharashtra, India), and low fusing impression compound (DPI, Mumbai, Maharashtra, India) with zinc oxide eugenol (DPI, Mumbai, Maharashtra, India), respectively. Permanent record bases were fabricated in the heat cure acrylic resin (Trevlon HH, Dentsply, Gurgaon, Maharashtra, India). Occlusal rims made in modeling wax (Prodent, Ratnagiri, Maharashtra, India) were adjusted to the desired vertical dimension using Niswonger’s method.\(^6\) Centric relation was recorded using interocclusal checkbite method. Hinge axis
Bhawsar, et al.: Evaluation of Hanau’s formula in determination of lateral condylar guidance

was recorded using Hanau Springbow (Whipmix, Louisville, KY, USA) and transferred to the Hanau Wide–Vue (Whipmix, Louisville, KY, USA) articulator using a mounting jig followed by mounting the lower cast.

The study was carried out in two steps. In the first step, extraoral tracers were attached to the occlusal rims. Extraoral Gothic arch tracing was recorded, and an arrow point tracing was obtained [Figure 1a and b]. Protrusive records were obtained using type I dental plaster (Kalabhai Karsol Pvt. Ltd., Mumbai, Maharashtra, India) mixed with anti-expansion solution (MP Sai Enterprises, Mumbai, Maharashtra, India) [Figure 1c]. A set of three records was taken for each patient. These records were used to program the articulator and determine the condylar guidance. Hanau’s formula was then used to determine the lateral condylar guidance. In the second step, patient’s three-dimensional mandibular movements were recorded using the electronic jaw tracking device (K7 Evaluation system, Myotronics, USA) [Figure 2a]. A magnet was attached to the midline of the lower occlusal rim [Figure 2b]. The electronic jaw tracking device was assembled following the manufacturer’s recommendations. The subjects were then guided into protrusive and lateral movements, also into opening and closing of their mouths. All jaw movements were registered using the computerized software. In order to achieve consistency and to avoid any misunderstanding between initial instructions to the patient about the registration of jaw movements, the same investigator worked with each of the study participants. Calibration of device was done after each patient. The zero reading was ensured before the start of recording of the patient’s value. The scans that recorded lateral movements in the frontal plane were evaluated further [Figure 3a]. Graphical analysis of the lateral path was carried out [Figure 3b] and the lateral condylar guidance was calculated using the following mathematical equation based on the trigonometric principle to calculate the slope (S) of the curve:

\[ S = \frac{Y_{n+1} - Y_n}{X_{n+1} - X_n} \]

\[ \text{Vertical distance (v) = } S \times \text{Horizontal distance (h)} \]

\[ \angle (\Theta) = \tan(S) \]

Three points on the curve were selected as \( X_1, Y_1; X_2, Y_2; X_3, Y_3 \); with respect to \( X \)- and \( Y \)-axes. The tan value of the slope gives the angle (\( \Theta \)) which denotes the lateral condylar guidance.\(^{[7-9]}\)

The K7 jaw tracking device designed for practical use in the dental office is reported to offer an effective and simple way to record three-dimensional mandibular movements in minimum time, with improved patient comfort and devoid of human error. It records jaw movements in sagittal, horizontal, and coronal planes with a high degree of accuracy.\(^{[10]}\)

Groups were classified as Hanau’s formula-Right (R), Hanau’s formula-Left (L), Kinesiograph-Right (R), and Kinesiograph-Left (L). The Excel and SPSS (SPSS Inc., Chicago, IL, USA) software packages were used for data entry and analysis. The values obtained using the two methods exhibited variation [Graph 1] and were statistically analyzed. \( T \)-test for independent samples used at 95% confidence interval (CI) were used to determine whether statistically significant differences exist between the lateral condylar guidance values obtained using the two methods and values of the right and left sides in both these methods [Table 1]. The \( P < 0.05 \) was considered statistically significant. All the hypotheses were formulated using two-tailed alternatives against each null hypothesis.

RESULTS

This study included 20 patients (14 males and 6 females) in the age group of 40–60 years. Table 1 presents mean values and standard deviation obtained using the two methods and of right and left sides. \( T \)-test for independent samples at 95% CI was used to determine whether statistically significant differences exist between the lateral condylar guidance values obtained using the two methods and the values of right and left sides using these methods. The level of significance was set at \( P = 0.05 \). The lateral condylar guidance values were obtained using the two methods.

Figure 1: (a) Extraoral Gothic arch tracing, (b) Arrow point tracing, (c) Protrusive and centric records

Figure 2: (a) Jaw tracking device assembly, (b) Magnet attached to midline of mandibular occlusal rim
The values obtained using Hanau’s formula ranged from 14 to 17° while those obtained using the computerized K7 jaw tracking device ranged from 8 to 40°. Statistical analysis showed that the Bennett angle values obtained using the Hanau’s formula and the computerized K7 jaw tracking device had statistically significant differences ($P < 0.05$). Bennett angle values of the right and left sides found using the Hanau’s formula were almost similar. Difference in the Bennett angle values of the right and left sides were found using the jaw tracking device. However, this difference when analyzed ($t$-test for independent samples) was not statistically significant ($P > 0.05$).

**DISCUSSION**

Bennett’s angle and movement are directly proportional to the side lateral shift; and from the analysis of effects that they have on occlusal morphology we infer, that bigger is the side lateral shift, more distal will be the working and balancing sulcus in the superior teeth, lower will be the cusps of the posterior teeth, and the greater will be the concavity of the anterior teeth (over jet). On the contrary, the smaller is the side lateral shift, the higher may be the cusps of the posterior teeth. Therefore, there is a close relationship between the pattern of Bennett’s movement and the anatomy of the teeth since during the movement, the cusps must not interfere with the antagonist ones but must move through some well-identified ways of escape which are actually sulcus and cusps. All the above confirms the great importance of the registration and the clinical evaluation of the Bennett angle.\[11\]

Hanau concluded that there was a definite relationship between the inclinations of the horizontal and lateral control settings. He found the lateral settings to consistently range around 15°. Stern insisted that the “Formula” was never exact. Hanau believed more accurate records could be made once all the teeth were set. He further proposed that remounts and equilibrations were necessary to refine the occlusion. The engineer did not want to tell the profession to simply set the lateral controls at 15°. That would suggest a step backward to an average value instrument.\[5\] Based on the results, dentist and dental technicians should consider reassessing the current recommended average settings and use of the Hanau’s formula for programming the semi-adjustable artillculators through further research.

A statistically significant difference in the range of the lateral condylar guidance value was obtained using the Hanau’s formula and the computerized jaw tracking device. Thus, the data supports rejection of the null hypothesis for this variable. The variations in these values will affect the occlusion in the patient’s mouth, assuming a wider variation exists in the mouth. The difference in values could be due to the high sensitivity of the computerized device. Other studies that have been carried out have similar inferences. Hernandez et al. found that the mean right and left Bennett angle were lower than suggested means for setting articulators.\[12\] Ratzmann et al. found out that the mean horizontal condylar guidance value recorded with the JMA electronic recording system was significantly higher compared to the values of the protrusive wax record and no agreement found between the different methods.\[13\] Celar and Tamaki demonstrated statistically significant differences between articulator setting and Cadiax compact measurement ($P < 0.05$) and concluded Cadiax compact to have reasonable accuracy for the clinical application.\[14\]

Lateral condylar guidance values exhibited variation on both sides using Kinesiograph. Thus, the data supports rejection of the null hypothesis for this variable also. It can be assumed that the TMJ anatomy may exhibit asymmetry on the right and left sides of the patient. The variation observed may be due to the effect of TMJ anatomy, laxity of TMJ ligament, and muscles of mastication.\[15\] Similarly, Zamacona et al. also found angular differences in condylar between the left and right sides of their
The values obtained using the Kinesigraph may be considered more reliable to determine the condylar guidance as it possesses certain advantages over the traditional Gothic arch tracing method used.

Few studies regarding the use of jaw tracking device for recording the lateral condylar guidance have been documented in the literature. This study can be a step toward evaluating the validity of the conventionally followed protocols in dentistry today and to find more reliable means to overcome their shortcomings. Taking into consideration the quick evolution of the technologies and their applications in dentistry, use of electronic devices like the jaw tracking device may lead to more accurate settings of the articulator to provide a more precise tool for diagnosis and treatment plans at the clinical and laboratory levels. To minimize occlusal error in complete dentures that require balanced occlusion and in fixed partial denture occlusion, a semi-adjustable instrument programmed using the jaw tracking device may be used while recognizing the shortcomings of the instrument so that less clinical time is spent to harmonize occlusion.

However, further research on a larger sample size needs to be carried out. If this holds true, more accurate devices such as kinematic facebow and fully adjustable articulator can be used for further evaluation. Similar study can be carried out in dentulous subjects. Evaluation on the accuracy of restorations fabricated using the condylar settings obtained from the computerized jaw tracking device should also to be carried out. Comparison of Bennett angle measured by lateral check bite and the computerized device can be useful for clinicians.

CONCLUSION

Statistically significant differences exist in a range of the lateral condylar guidance values obtained using the Hanau’s formula and computerized jaw tracking device. Lateral condylar guidance values exhibited variation on both sides using Kinesigraph unlike those using Hanau’s formula. Based on the results, dentist and dental technicians should consider reassessing the current recommended average settings and use of the Hanau’s formula for programming the semi-adjustable articulators.

Table 1: Statistical analysis of the values obtained

|                     | Mean  | S.D.  | t     | d.f. | P    |
|---------------------|-------|-------|-------|------|------|
| Hanau’s formula-right | 15.4  | 0.6633| 2.5417| 38   | <0.05|
| Kinesigraph-right    | 19.693| 7.3323|       |      |      |
| Hanau’s formula-left  | 14.75 | 1.0062| 2.5038| 38   | <0.05|
| Kinesigraph-left     | 19.376| 7.9911|       |      |      |
| Hanau’s formula-right | 15.4  | 0.6806| 0.3773| 38   | >0.05|
| Hanau’s formula-left  | 13.256| 0.6882|       |      |      |
| Kinesigraph-right    | 19.693| 7.5   | 0.3537| 38   | >0.05|
| Kinesigraph-left     | 19.376| 8.1   |       |      |      |

7-test for independent samples used at 95% CI. S.D.: Standard Deviation, d.f.: Degree of freedom, CI: Confidence interval

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

ACKNOWLEDGMENT

We would like to thank Dr. Sanjay Bhawswar for providing us the equipment, knowledge, and noble guidance regarding the use of jaw tracking device.

REFERENCES

1. Javid NS, Porter MR. The importance of the Hanau formula in construction of complete dentures. J Prosthet Dent 1975;34:397-404.
2. Tanaka H, Beu RA. A new semi-adjustable articulator. Part I. Concept behind the new articulator. J Prosthet Dent 1975;33:10-6.
3. Thomas SE. Mandibular and articulator movements. a. Part III. J Prosthet Dent 1962;12:292-297. b. Part V. J Prosthet Dent 1963;13:866-7. c. Part VII. J Prosthet Dent 1964;14:279-89.
4. Weinberg LA. An evaluation of basic articulators and their concepts Part I and II. J Prosthet Dent 1963;13:645-63.
5. Engelmeier RL, Belles DM, Starcke EN. The history of articulators; The Contributions of Rudolph L. Hanau and his company – Part I. J Prosthodont. 2010;19:409-18.
6. Niswonger ME. The rest position of the mandible and the centric relation. J Am Dent Assoc. 1934;21:1572-9.
7. el-Gheriani AS, Winstanley RB. The Gothic arch (needle point) tracing and condylar inclination. J Prosthet Dent 1987;58:838-42.
8. el-Gheriani AS, Winstanley RB. Graphic tracings of condylar paths and measurements of condylar angles. J Prosthet Dent 1989;61:77-87.
9. Eichhold WA, Chen MS, Welker WA. A formula to determine the lateral condylar guidance from intraoral needlepoint tracings. J Prosthet Dent 1986;56:698-701.
10. Wessberg GA, Epker BN, Elliot AC. The reliability of a mandibular kinesiograph. Hawaii Dent J 1984;15:8-10.
11. Fanucci E, Spera E, Otria L, Barfattini A Jr, Fusco N, Mylonakou I, et al. Bennett movement of mandible: A comparison between traditional methods and a 64-slices CT scanner. Oral Implantol (Rome) 2008;1:15-20.
12. Hernandez AI, Jasinevicius TR, Kaleinikova Z, Sadan A. Symmetry of horizontal and sagittal condylar path angles: An in vivo study. Craniomaxillofacial R 2010;28:60-6.
13. Ratzmann A, Mundt T, Schwahn C, Langforth G, Hutzen D, Gedrange T, et al. Comparative clinical investigation of horizontal condylar inclination using the JMA electronic recording system and a provocative wax record for setting articulators. Int J Comput Dent 2007;10:265-84.
14. Ceter BA, Tamaki K. Accuracy of recording horizontal condylar inclination and Bennett angle with the Cadiax compact. J Oral Rehabil 2002;29:1076-81.
15. Oksanen JP. Functional anatomy and biomechanics of the masticatory system. Management of Temporomandibular Disorders and Occlusion. 5th ed. St. Louis: Mosby; 2003. p. 3-28.
16. Zamacono JM, Otsuyu E, Aranda E. Study of the sagittal condylar path in edentulous patients. J Prosthet Dent 1992;68:314-7.

How to cite this article: Bhawswar SV, Marathe AS, Ansari SA. Evaluation of Hanau’s formula in determination of lateral condylar guidance: A clinical research study. J Indian Prosthodont Soc 2015;15:326-30.

Source of Support: Nil, Conflict of Interest: None declared.