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ORIGINAL RESEARCH

A comparative clinico-radiographic analysis of horizontal condylar guidance determined by radiographic method to interocclusal protrusive records

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Abstract

Background: The present in vivo study aims to compare the horizontal condylar guidance values in edentulous people using a manual tracing of orthopantomogram (OPG) and lateral cephalogram with the protrusive interocclusal records mounted on a semi-adjustable articulator.

Materials and method:A total of 50 patients within the age group of 55-75 years, of either sex were selected according to the inclusion and exclusion criteria and HCG angle was determined clinically by interocclusal protrusive records mounted in a semi-adjustable articulator after extraoral gothic arch tracing and compared with HCG angles obtained by manual tracing of orthopantomogram and lateral cephalogram for each patient.

Results: On comparison between the mean of three methods, the value obtained from lateral cephalogram was 10.6 degrees greater than mean values obtained from interocclusal protrusive records and 3.11 greater than OPG values, and mean OPG valueswere 7.51 greater than interocclusal records, on comparison the $p<0.001$ which is significant.

Conclusion: Clinical protrusive method for each individual is mandatory to determine accurate HCG values. Cephalometric tracing of diagnostic radiographs can delineate an idea about HCG angle before any clinical step.

Introduction

Registration of the accurate condylar path and mandibular movement of the patient on an articulator is the key to the success of appropriate oral rehabilitation. Condylar guidance is the mandibular guidance generated by the condyle and articular disc traversing the contour of the glenoid fossa. It is also defined as the mechanical form located in the upper posterior region of an articulator that controls the movement of its mobile member.Horizontal condylar guidance is the mechanical equivalent of condylar guidance i.e. the angle formed by the path of the condyle, within the horizontal plane compared with the median plane[1].

During any procedure for restoration, a prosthodontist has control over other factors but condylar guidance is independent on its own as it isa patient-controlled factor. Thus it is essential to establish an optimum occlusion that is in harmony with the patient's stomatognathic system.

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Attempt to register the horizontal condylar path started in the early 1900s when Christensen (1902) introduced "protrusive wax check bites." In the year 1908, Gysi[2] described the graphic method and since then various methods including interocclusal records, pantographic tracings, electronic jaw tracking devices, radiographic methods, etc., were used to record HCG but programming a semi-adjustable articulator with the protrusive interocclusal record is still the most popular method in clinical practice.

Gothic arch tracing remains the most commonly used method and is considered the ideal method in programming the articulator. It is a one-dimensional graphic tracing method usually recorded in the horizontal plane and can be recorded intraorally and extraoral.

However, it is difficult to use the gothic arch tracing method in cases of decreased interarch space, temporomandibular joint (TMJ) arthropathy, abnormal jaw relation, severely resorbed ridge, and excessive flabby ridges. Hence, an alternative method like radiographs is used to obtain a sagittal condylar guidance angle

Jackson (1926), Perry (1985), and Jones et al. have already indicated that cephalometric and panoramic radiography have a special role in diagnosis and treatment planning for removable prosthodontics[3].

The radiographic method of recording the horizontal condylar guidance (HCG) was introduced in the 1970s by authors such as Corbett *et al*, Ingervall, Christensen, and Slabbert to overcome the disadvantages of clinical methods. Thus, this study was aimed to evaluate and compare the correlation between HCG values in edentulous people using a manual tracing of orthopantomogram (OPG) and lateral cephalogram with the protrusive interocclusal records mounted on a semi-adjustable articulator[4-6].

If a correlation between HCG values using lateral cephalometry or panoramic radiograph tracing and protrusive interocclusal records can be established then the necessity of performing elaborate recording procedures in gothic arch tracing can be eliminated. An accurate HCG value can be determined each time from diagnostic radiographs only.

Materials and methods

The ethical clearance for this study was obtained from the ethical committee. This study was conducted on 50 completely edentulous patients of any gender within the age group of years 55-75 who reported to the Department of Prosthodontics including Crown and Bridge in Maharaja Ganga Singh Dental College and Research Centre, Sriganganagar

Recording horizontal condylar guidance setting by tracing from diagnostic radiograph

For the radiographic determination of HCG, one panoramic radiograph and a lateral cephalogram were made for each participant using a digital cephalostat.

the OPGs (Fig:1) and lateral cephalogram(Fig:2) were manually traced using the guidelines as given by Gilboa *et al*. The Frankfurt's horizontal plane (FH plane) was drawn by joining the "orbitale" (lowest point on the infraorbital margin of the orbit) and "porion" (highest point on the margin of the bony auditory meatus)

The most superior point on the glenoid fossa and most inferior point of articular eminence was identified, and the mean curvature line was obtained by joining the two points.

A third reference line passing through the same points was extended to intersect Frankfurt's Horizontal Plane. This angle was measured with a protractor and was considered as an HCG angle.

For lateral cephalogram, only the right horizontal condylar guidance is traced. Since the sensor of the digital Cephalostat is placed on the right side of the subject and the source of the X-ray was on the left side.

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Figure 1: Orthopantomogram (OPG) tracing

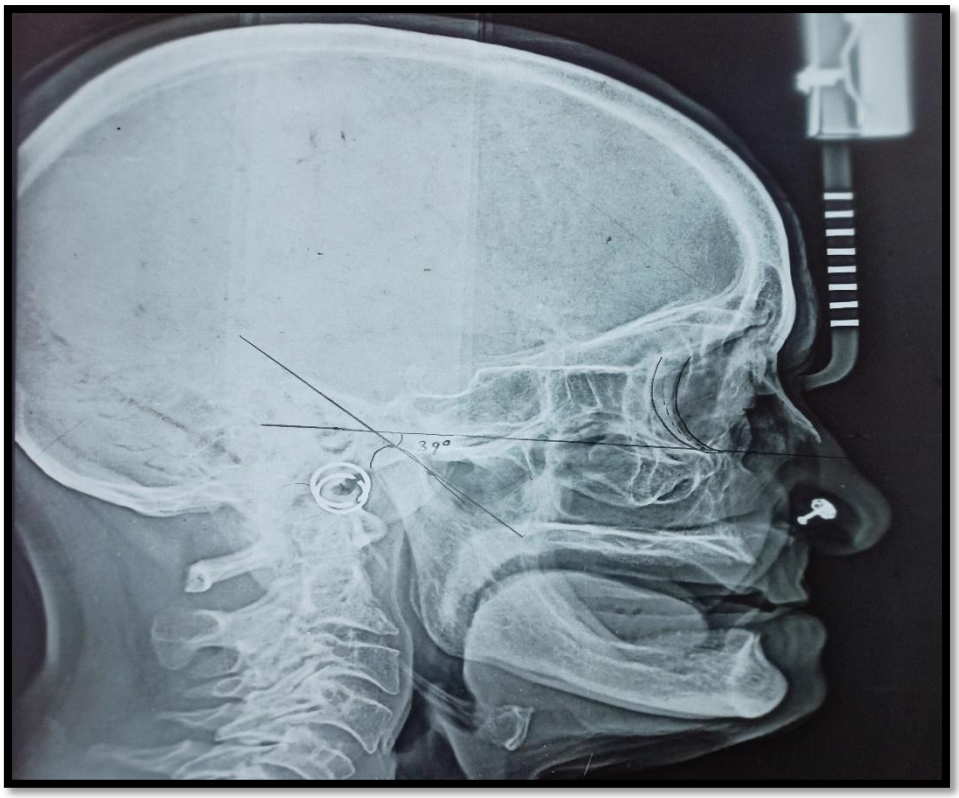

Figure 2: Lateral cephalogram tracing

Clinical method to determine HCG

For the clinical HCG registration, maxillary and mandibular primary impressions were made with Impression compound (Y-DENT, MDM Corporation, Delhi, India) for each of the 50 participants, and casts were poured with Type II dental stone (DENTICO, Neelkanth health care Pvt Ltd.).Custom trays were fabricated by cold-cure acrylic resin (pyrax polymer, India) and the final impressions with zincoxide-eugenol impression paste(DPI Impression Paste, Mumbai, India) was done after proper border molding with green stick compound(DPI PINNACLE, Mumbai, India).Master casts were poured with Type III dental stone(GemStone, Shruti products Pvt. Ltd). Occlusal rims of proper dimension were fabricated on a trial denture base of 2-mm thickness. Facebow records were made to mount the maxillary cast on the Hanau™ Wide-Vue Articulator. After taking tentative vertical jaw relation, gothic arch

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tracing(Fig 4) was done to make centric and 6-mm protrusive records with Type II dental plaster(Fig 5, 6) (DENTICO, Neelkanth health care Pvt Ltd.). The protrusive check bite was used to register the right and left HCG values on the Hanau™ Wide-Vue articulator. The Hanau articulator was modified with the attachment of a protractor to the condylar assembly to record the angle accurately(fig : 3). The data recordings will have five sets of values for all participants (n = 50), i.e., the right and left HCG angle obtained by protrusive interocclusal records, right and left HCG by cephalometric tracing of panoramic radiographs, and the right HCG angle obtained by lateral cephalogram tracings. Since the sensor of the digital cephalostat is placed on the right side of the subject and the source of the X-ray was on the left side, the values of the right side of the lateral cephalogram were considered for the tabulation of correlation between the three methodsthan the data collected was subjected to statistical analysis.

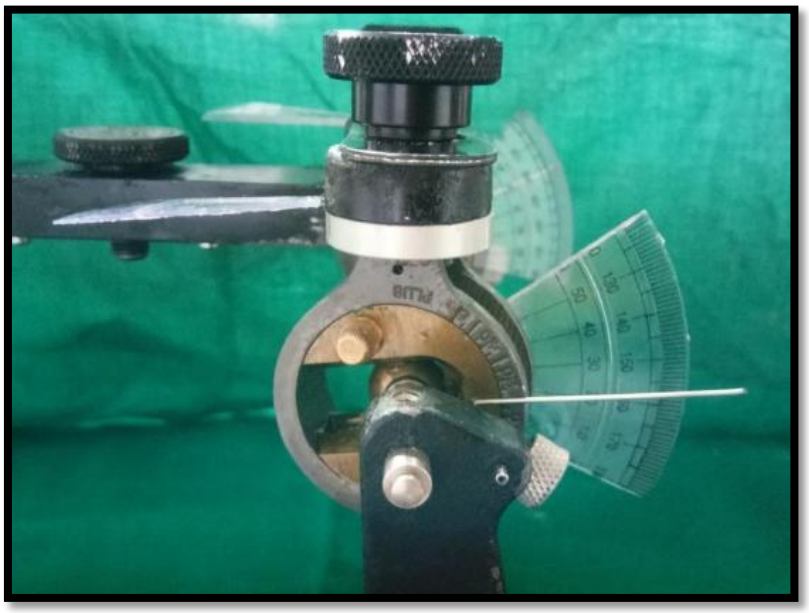

Figure 3: Modified Hanau wide VUE articulator

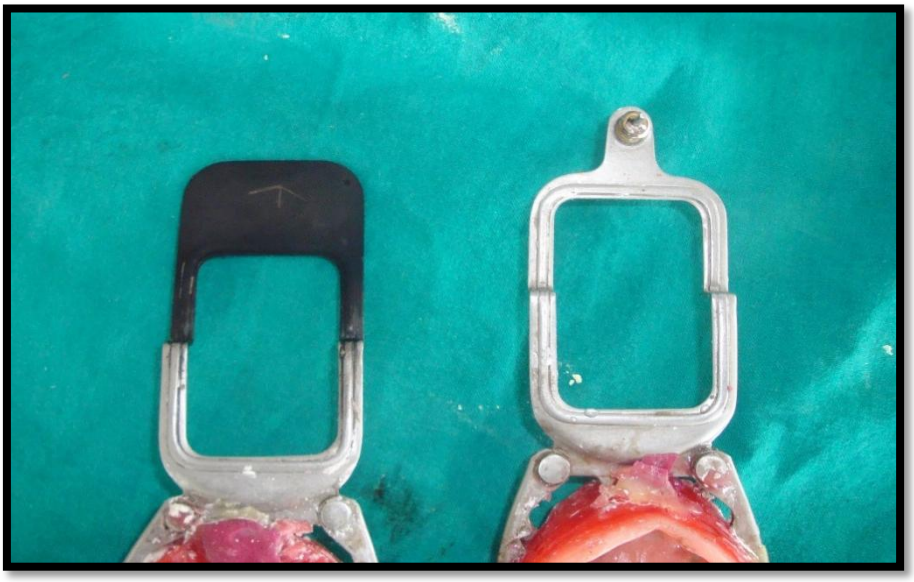

Figure 4: Arrow point tracing

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Figure 5: Interocclusal records taken

Figure 6: Interocclusal centric and protrusive plaster records

Results

The HCG values obtained in three methods are presented in graph 1

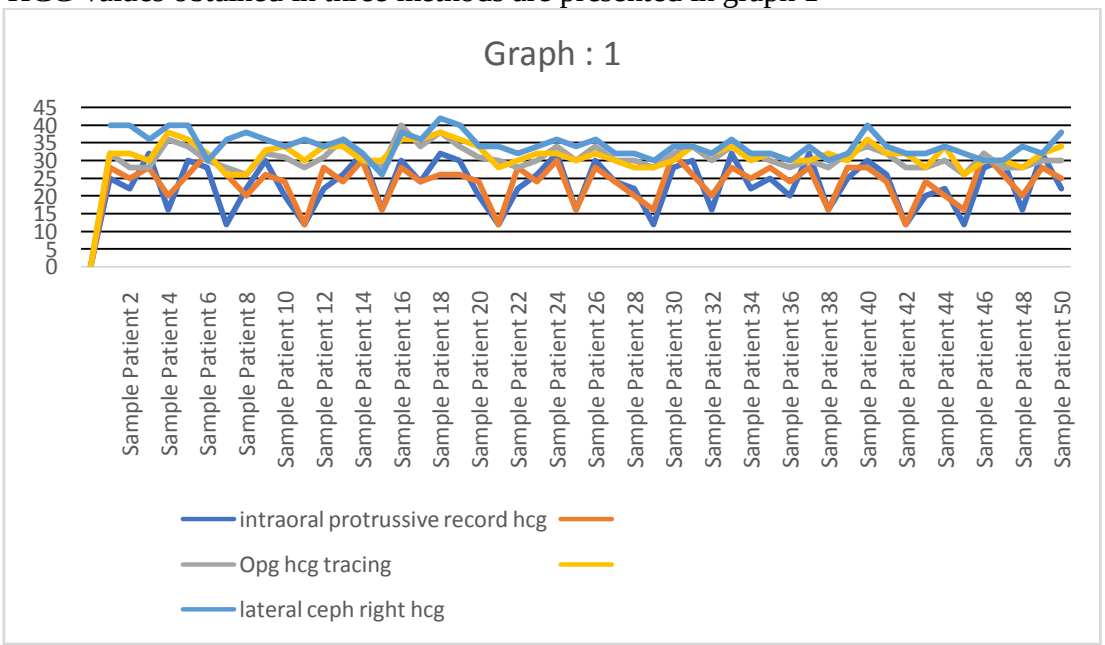

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TABLE 1: Comparing left horizontal condylar guidance obtained from interocclusal records andOPG.

left	N	Mean ± SD	t value	P-value
Group 1	50	24.02±5.220	32.54	0.00*
Group 2	50	31.66±2.939	71.51	

*Statistically signify
t-test applied

TABLE. 2 Comparing right horizontal condylar guidance obtained from interocclusal records and OPG.

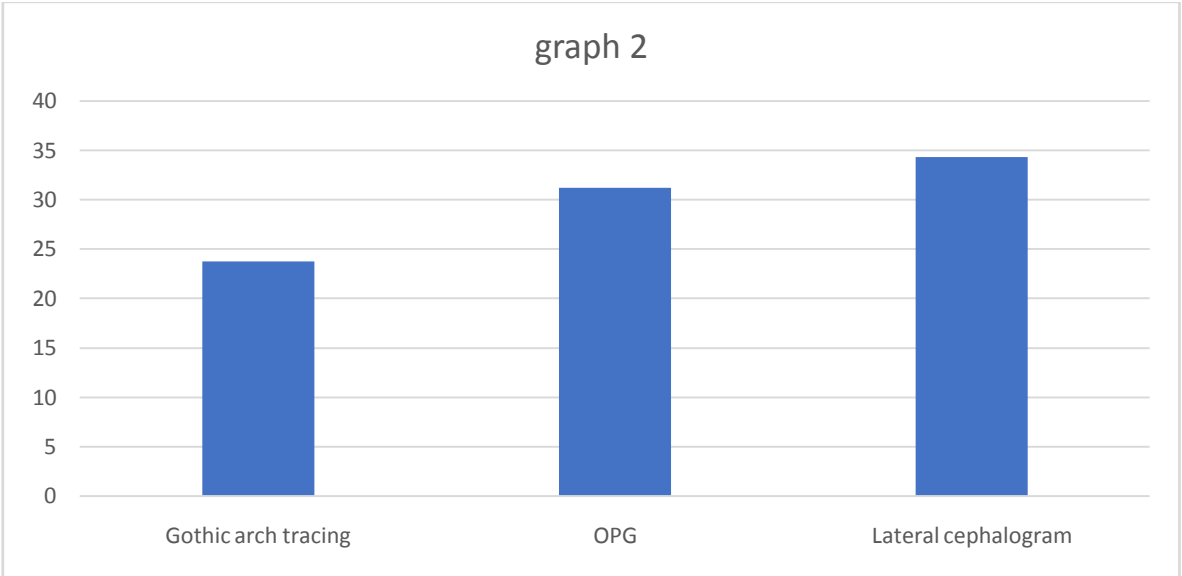
Right	N	Mean ± SD	t value	P-value
Group 1	50	23.46 ± 6.591	25.17	0.00*
Group 2	50	30.90 ± 2.991	73.03	

*Statistically signify
t-test applied

TABLE3. Comparing right horizontal condylar guidance obtained from interocclusal records and lateral cephalogram.

Right	N	Mean±SD	T value	P-value
Group 1	50	23.46± 6.591	25.17	0.00*
Group 3	50	34.36± 3.397	71.51	

*Statistically signify
t-test applied



Graph 2: presents the comparison between the mean of three methods, the value obtained from lateral cephalogram was 10.6 degrees greater than mean values obtained from interocclusal protrusive records and 3.11 greater than OPG values and mean OPG values were 7.51 greater than interocclusal records.

Discussion

Condylar guidance is very important in edentulous patients. If not recorded accurately it will lead to occlusal interference during mandibular movements. The condylar guidance in semi-

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adjustable articulators is set by individual protrusive and lateral interocclusal registrations. The purpose of the protrusive jaw relation is to set the condylar elements of the articulator so they will reproduce inclinations that are exact or nearer to the patient's temporomandibular articulation. The methods used to record condylar guidance clinically are either extra-oral or intra-oral methods. Gysi and McCollumadvocated the use of extraoral methods in edentulous patients.

CORBETT NE et al. studied the condylar movements and confirmed that in protrusion the condylar head follows closely the anatomical form of the articular eminence.

If the individual inclination of the articular eminence is very steep or flat, guidance obtained from the average value settings may differ sufficiently to cause problems such as posterior dis-occlusion. Accurate simulation of mandibular movements enables the fabrication of prosthetic restorations where cusp height and inclination of teeth are compatible with the condylar guidance. When the casts are mounted on a semi-adjustable articulator by use of facebow and condylar guidance is adjusted individually by protrusive records, a close approximation of mandibular movements can be obtained.

The mean of right and left HCG obtained was 23.74. The mean values obtained were in accordance with a study by Banasret al[7], where the average values of condylar inclination range from 22 to 65, Literature suggests that the right and left eminences rarely have the same slants and contours. The difference in the mean condylar guidance inclination for the right and left sides are within 5 degrees of each other as stated by Rmfjord and Ash. The smaller mean differences between the right and left HCG angles are in accordance with the studies done by Csado et al[8], Shrestha et al[9], Prasad et al[10], Rahul Paul et al[11], Bisma Amin et al[12].

Higher mean values are reported in studies done by Tannamala et al[13], Konarket al[14] , Donald A Curtis (1989), Zamacona (1992), higher values were noted as those studies were done on dentulous subjects and younger subjects where the angulation decreases with age as stated by **DANIEL ISSACSON (1958)[15]**

For the radiographic determination of HCG in this study, one panoramic radiograph and a lateral cephalogram were made for each subject using a digital cephalostat.

The variations of HCG angle measured from the panoramic radiograph was found to be 26 degrees to 40 degrees . These data were consistent with studies done by Zamacona et al, Hobo and Mochizuki, Lundeen and Wirth, Preti et al, dos Santos et al, Csado et al who found wide variations of HCG angle ranging from 5 degrees to 55 degrees. Due to these differences between individuals, there would be little justification for using articulators in which inclination cannot be adjusted

The smaller mean differences between the right and left HCG angles are in accordance with the studies done by Csado et al, Shrestha et al, Prasad et al. These values are statistically not significant but clinically and radiographically, the value of HCG angles was higher in the right side as compared to the left side. This difference might be attributed to the chewing patterns that most of the individuals favor the right side for chewing which could be related to more wear of the right articular eminence as compared to the left. Previous studies which were conducted in dentate individuals reported that the mean HCG angles were higher than that of the present study which was conducted in completely edentulous patients. Csadoet al reported the mean HCG angles obtained by panoramic radiograph in dentulous individuals were higher than that of the completely edentulous individuals and concluded the correlation of flattening of articular eminence could be related to aging. They also found the rate of deformation is significantly higher in completely edentulous individuals than the individuals with maintained occlusion. The findings from the present study and Csado et al suggested that it is necessary to provide prosthetic and occlusal rehabilitation after the extractions for the prevention of the anatomical changes in the temporomandibular joint.

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The mean HCG difference between panoramic radiographic tracing and protrusive interocclusal records was 7.051°. A study conducted by Prasad KD et al. also showed that the different values obtained by the two methods were highly significant. A study by Gross et al, comparing the radiographic image of the sagittal condylar path inclination and its actual anatomic outline in dry skulls found that the radiographic values were on an average 7° greater than the skull values. Gilboa et al. found the same mean difference of 7°; Paul et al found a mean difference of 7.03 between two whereas Tannamala et al. and Kumari et al. claimed the radiographic values were on average 4° and 13° greater, respectively. These inconsistencies may be attributed due to overlapping of the mandibular notch, coronoid process, zygomatic arch around TMJ in an OPG. it is difficult to distinguish between these two closely approximated radiopaque lines, one depicting the outline of the articular eminence and fossa, the second one indicating the inferior border of the zygomatic arch.

There are some limitations of the radiographic method concerning panoramic distortion, head and reference plane orientation, and difficulty in distinguishing the articular eminence outline from the zygomatic arch. The positions of these two lines relative to each other may vary if there is a change in beam direction due to positioning errors.

lateral cephalogram values were 10.6 degrees greater than values obtained from interocclusal protrusive records and 3.11 greater than opg values and OPG values were 7.51 greater than interocclusal records, on comparison the p-value < 0.001, which is highly significant. The mean right HCG values obtained from lateral cephalogram were greater than those of obtained from OPG and interocclusal protrusive records, a similar trend was seen in studies done by Paul et al(2018), Krishna prasad (2012), Konark(2021)

These results differed from the findings of Galagali et al. (2016)[16], where they found that panoramic radiographs showed a higher HCG value than that of lateral cephalogram. This anomaly may be explained by the fact that these investigators had taken into account separately two lateral cephalograms of either side in the dentate population, while the present study attempted the tracings on lateral cephalograms which showed overlapping of the right and left sides as the sensor was present only in the right side.

The difference in condylar guidance by the interocclusal record method and diagnostic radiographs is because Condylar pathways are not solely dictated by the bony contour of articular eminence of TMJ but influenced by the soft-tissue attachments, thickness, and shape of articular disc and ligaments.

On the basis of the results of this study, it is not justified to omit the use of radiographic techniques. Clinical protrusive method for each individual is mandatory to determine accurate HCG values. Cephalometric tracing of diagnostic radiographs can delineate an idea about HCG angle before any clinical step, which will help the operator to choose the type of articulator and select posterior teeth.

Conclusion

Within the limitation of the study, it was concluded that:

1. The mean HCG values obtained from OPG were on a mean of 7.51 degrees greater than the interocclusal protrusive records.
2. Clinical protrusive method for each individual is mandatory to determine accurate HCG values.
3. Cephalometric tracing of diagnostic radiographs can delineate an idea about HCG angle before any clinical step, which will help the operator to choose the type of articulator and select posterior teeth.
4. Right HCG values were slightly greater than the left side.
5. Within the sample the mean horizontal condylar guidance in completely edentulous patients in north western Rajasthan recorded was 23.74.

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Limitations of the study include

1. Smaller sample size
2. Condylar pathways are not solely dictated by the bony contour of the articular eminence of TMJ but may be influenced by the soft-tissue attachments, thickness, and shape of the articular disc and ligaments.
3. Inability to accurately distinguish the right and the left sides of the individual in the two-dimensional lateral cephalometric image.
4. Manual cephalometric tracing method was used instead of digital imaging software.
5. Errors of manual cephalometric tracing might arise at tracing stage, during landmarks identifications and misreading of measurements as cephalometric analyses are dependent to human judgment.

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