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Clinical and radiographic evaluation of condylar guidance using different anterior reference points: An in vivo study

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Abstract

Background: Accurate recording of sagittal condylar guidance is essential for proper programming of semi-adjustable articulators and successful prosthodontic rehabilitation. The anterior reference point used during facebow transfer may influence condylar guidance values. This study evaluated the effect of two anterior reference points—Orbitale and Orbitale minus 7 mm—on condylar guidance recordings and compared them with radiographic measurements obtained from lateral cephalograms.

Materials and Methods: Ten completely dentulous subjects aged 20–40 years were included. Maxillary casts were mounted on a Hanau Wide-Vue semi-adjustable

articulator using facebow transfer. Horizontal condylar guidance values were recorded using protrusive interocclusal records with two anterior reference points: Orbitale and Orbitale minus 7 mm. Radiographic condylar guidance values were determined from lateral cephalograms. Statistical analysis was performed using paired t-tests.

Results: The mean condylar guidance values obtained from lateral cephalograms, Orbitale, and Orbitale minus 7 mm were 31.50 ± 4.47°, 30.50 ± 4.38°, and 28.25 ± 4.42°, respectively. No significant difference was observed between cephalometric and Orbitale values, whereas a significant difference was found between cephalometric and Orbitale minus 7 mm values. Orbitale demonstrated the least deviation from radiographic measurements.

Conclusion: The choice of anterior reference point significantly affects sagittal condylar guidance values. Orbitale produced values closest to those obtained from lateral cephalograms and may be considered a more reliable anterior reference point for accurate articulator programming.

Keywords: Condylar Guidance, Sagittal Condylar Inclination, Orbitale, Anterior Reference Point, Facebow Transfer, Lateral Cephalogram, Semi-Adjustable Articulator, Prosthodontics.

Introduction

Accurate reproduction of mandibular movements is essential for achieving functional occlusion and successful prosthodontic rehabilitation. Among the various determinants of occlusion, condylar guidance plays a significant role in controlling mandibular movements and influencing cusp morphology and occlusal relationships. It is defined as the mandibular guidance generated by the condyle and articular disc traversing the contour of the articular eminence during mandibular excursions.[1]

The determination of sagittal condylar guidance is an important step in programming semi-adjustable articulators for the fabrication of fixed and removable prostheses. Conventionally, protrusive interocclusal records have been widely used for recording condylar guidance because of their simplicity and ease of application in clinical practice. However, the accuracy of these records may be affected by factors such as recording techniques, patient cooperation, articulator design, and mounting procedures.[2]

Radiographic methods have been advocated as adjuncts to conventional clinical techniques for evaluating condylar guidance. Studies have demonstrated that radiographic assessment can provide a reliable estimate of sagittal condylar inclination and may serve as an objective aid in articulator programming. Shreshta et al. reported a significant correlation between condylar guidance values obtained by clinical and radiographic methods, suggesting that radiographic evaluation can be a useful supplementary tool in prosthodontic treatment planning.[3] Similarly, Gilboa et al. demonstrated a relationship between radiographic morphology of the articular eminence and condylar guidance values, emphasizing the importance of radiographic assessment in understanding mandibular movements.[4]

Recent advances in imaging techniques have further improved the accuracy of condylar guidance determination. Jerath et al. compared horizontal condylar guidance values obtained using interocclusal wax records, cone-beam computed tomography, and Gothic arch tracing, and highlighted the potential of radiographic methods in achieving precise articulator settings.[5] Likewise, Paul et al. found that preprosthetic diagnostic radiographs could provide condylar guidance values

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comparable to those obtained through conventional clinical methods.[6]

Godavarthi et al. also reported a positive correlation between radiographically determined condylar guidance and conventional protrusive record techniques, supporting the use of radiographs as a valuable adjunct in clinical practice.[7]

Accurate facebow transfer is equally important for reproducing the spatial relationship of the maxillary arch to the temporomandibular joints. The orientation of the maxillary cast on the articulator depends on the selection of an anterior reference point. Christensen emphasized that variations in facebow transfer and anterior reference point selection can influence the position of the mounted cast and subsequently affect articulator settings and occlusal outcomes.[8]

Although numerous studies have compared clinical and radiographic methods of recording condylar guidance, limited information is available regarding the influence of different anterior reference points on condylar guidance values.

Therefore, the present study was undertaken to clinically and radiographically evaluate condylar guidance using Orbitale and Orbitale minus 7 mm as anterior reference points and to determine which reference point provides values closest to those obtained from lateral cephalograms.

Materials and Methods

Study Design and Participants

This in vivo observational comparative study was conducted in the Department of Prosthodontics, Crown and Bridge, and Implantology. Ten completely dentulous subjects aged between 20 and 40 years with Angle's Class I occlusion and healthy temporomandibular joints were selected for the study.

Inclusion Criteria

- Completely dentulous subjects aged 20–40 years.
- Angle's Class I molar relationship.
- Healthy temporomandibular joints with no signs or symptoms of dysfunction.
- Absence of extensive restorations affecting occlusion.

Exclusion Criteria

- History of temporomandibular disorders.
- Presence of parafunctional habits.
- Missing teeth, except third molars.
- Severe malocclusion or extensive prosthetic restorations.
- Previous orthodontic treatment affecting occlusal relationships.

Armamentarium

The materials used in the study included:

- Hanau Wide-Vue semi-adjustable articulator.
- Hanau spring bow facebow.
- Irreversible hydrocolloid impression material.
- Type III dental stone.
- Modeling wax for protrusive interocclusal records.
- Vernier caliper.
- Lateral cephalometric radiographic unit.
- Tracing paper, acetate sheets, protractor, and measuring instruments.

Clinical Procedure

Maxillary and mandibular impressions were made using irreversible hydrocolloid impression material and poured in Type III dental stone to obtain diagnostic casts. Maxillary casts were mounted on a Hanau Wide-Vue semi-adjustable articulator using a facebow transfer, while mandibular casts were mounted using maximum intercuspation records.

For recording protrusive interocclusal records, each subject was guided into a protrusive mandibular position

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of approximately 6 mm from centric occlusion. Wax interocclusal records were obtained and verified for accuracy. Condylar guidance values were programmed on the articulator using two different anterior reference points:

1. Orbitale (conventional anterior reference point).
2. Orbitale minus 7 mm.

The horizontal condylar guidance inclination was recorded separately for each anterior reference point on both sides of the articulator, and mean values were calculated.

Radiographic Evaluation

Lateral cephalograms were obtained for all subjects under standardized exposure conditions. Tracings were performed on acetate sheets placed over the radiographs. The Frankfort Horizontal Plane was established by joining the Orbitale and Porion landmarks. The sagittal condylar guidance angle was determined by tracing the protrusive condylar path and measuring its inclination relative to the Frankfort Horizontal Plane using a protractor.

The radiographic measurements were considered the reference values and were compared with the articulator values obtained using the two anterior reference points.

Statistical Analysis

The recorded data were tabulated and subjected to statistical analysis using SPSS software. Mean and standard deviation were calculated for all measurements. Comparison between condylar guidance values obtained from lateral cephalograms, Orbitale, and Orbitale minus 7 mm was performed using paired t-tests. A p-value of less than 0.05 was considered statistically significant.

Observations and Results

Comparison of protrusive condylar guidance angle values obtained from 4 different anterior reference points and radiographic tracings. (Table 1)

A total of 10 dentulous subjects were included in the study. Condylar guidance values were obtained using lateral cephalograms, Orbitale as the anterior reference point, and Orbitale minus 7 mm as the anterior reference point. The data were analyzed using descriptive statistics and paired t-test.

The mean condylar guidance value obtained from lateral cephalograms was 31.50 ± 4.47°. The mean condylar guidance values obtained using Orbitale and Orbitale minus 7 mm were 30.50 ± 4.38° and 28.25 ± 4.42°, respectively.

Comparison between Lateral Cephalogram and Orbitale

The mean condylar guidance value recorded using Orbitale was slightly lower than that obtained from lateral cephalograms. However, paired t-test analysis revealed no statistically significant difference between the two methods ($t = 1.984$, $p = 0.079$). The mean difference between the two measurements was approximately 1.0°, indicating a close agreement between the articulator values obtained using Orbitale and the radiographic values. (Table 2 and Graph 1)

Comparison between Lateral Cephalogram and Orbitale Minus 7 mm

The mean condylar guidance value obtained using Orbitale minus 7 mm was lower than that obtained from lateral cephalograms. Statistical analysis demonstrated a significant difference between the two methods ($t = 4.703$, $p = 0.001$). The mean difference was approximately 3.25°, indicating that lowering the anterior reference point by 7 mm resulted in underestimation of condylar guidance values (table 3 and graph 2).

Comparison of Deviations from Lateral Cephalogram

To assess the accuracy of the two anterior reference points, deviations from the radiographic values were calculated. The mean deviation from the lateral

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cephalogram was 1.00 ± 1.59° for Orbitale and 3.25 ± 2.19° for Orbitale minus 7 mm. Comparison of these deviations revealed a highly significant difference ($t = -5.014$, $p < 0.001$). The deviation observed with Orbitale minus 7 mm was significantly greater than that observed with Orbitale (table 4 and graph 3).

The findings demonstrated that condylar guidance values obtained using Orbitale closely approximated those obtained from lateral cephalograms and did not differ significantly. In contrast, Orbitale minus 7 mm produced significantly lower condylar guidance values and exhibited greater deviation from radiographic measurements. Therefore, Orbitale was found to be a more reliable anterior reference point for determining sagittal condylar guidance on a semi-adjustable articulator.

Discussion

Condylar guidance is one of the most important determinants of occlusion and plays a crucial role in the successful rehabilitation of patients requiring prosthodontic treatment. Accurate recording of sagittal condylar inclination allows proper programming of semi-adjustable articulators, thereby minimizing occlusal discrepancies and reducing chairside adjustments. Hanau emphasized that the accurate simulation of mandibular movements is fundamental to the establishment of harmonious occlusion and balanced articulation.[9]

Condylar guidance is primarily determined by the morphology of the temporomandibular joint and the inclination of the articular eminence. Okeson described it as an anatomical determinant of occlusion that directly influences cusp height, fossa depth, and posterior disocclusion during eccentric mandibular movements.[10] Similarly, Bhalaji stated that condylar guidance is a fixed factor that cannot be altered clinically and therefore must be accurately transferred to the articulator for successful prosthodontic outcomes.[11]

In the present study, the mean condylar guidance value obtained from lateral cephalograms was 31.50 ± 4.47°, while the values obtained using Orbitale and Orbitale minus 7 mm were 30.50 ± 4.38° and 28.25 ± 4.42°, respectively. Statistical analysis revealed no significant difference between the lateral cephalogram and Orbitale values ($p = 0.079$), whereas a significant difference was observed between the lateral cephalogram and Orbitale minus 7 mm values ($p = 0.001$). These findings indicate that the selection of the anterior reference point significantly influences the condylar guidance values programmed on a semi-adjustable articulator.

The close agreement between the cephalometric and Orbitale values observed in the present study may be attributed to the fact that Orbitale serves as an anatomical landmark of the Frankfort Horizontal Plane, which is also used during cephalometric analysis. Davis and Mackay demonstrated the reliability and reproducibility of cephalometric measurements when stable anatomical landmarks are used, supporting the validity of radiographic assessment in determining condylar guidance.[12]

The significantly lower values obtained with Orbitale minus 7 mm suggest that alteration of the anterior reference point changes the orientation of the mounted maxillary cast relative to the hinge axis. Weinberg reported that variations in anterior reference point selection during facebow transfer can affect cast orientation and consequently influence articulator settings and occlusal relationships.[13] The findings of the present study support this concept and demonstrate that lowering the anterior reference point results in underestimation of sagittal condylar inclination.

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Corbett et al. reported a close relationship between the functional condylar path and the inclination of the articular eminence, emphasizing the anatomical basis of condylar guidance determination.[14]Similarly, Isberg and Westesson observed that the steepness of the articular eminence significantly affects condylar movement patterns within the temporomandibular joint.[15] These observations support the use of radiographic methods for evaluating sagittal condylar inclination.

Recent studies have further validated the role of radiographic techniques in condylar guidance determination. Paul et al. reported that condylar guidance values obtained from preprosthetic radiographs demonstrated good correlation with clinically recorded values and could serve as a reliable adjunct for articulator programming.[16] Doshi et al. also found a strong association between radiographic and clinical methods of condylar guidance determination and concluded that radiographic assessment may improve the accuracy of prosthodontic rehabilitation.[17]

Jerath et al. compared condylar guidance values obtained using interocclusal records, CBCT, and Gothic arch tracing and reported that radiographic methods provide highly reproducible measurements with reduced operator-dependent variability.[18] Likewise, Shreshta et al. observed a significant correlation between clinical and radiographic methods of condylar guidance assessment and suggested that radiographic evaluation can be used as a supplementary diagnostic tool.[19]

Recent CBCT-based investigations have demonstrated superior visualization of the articular eminence and condylar morphology compared with conventional two-dimensional radiographs. Rohanian et al. reported that CBCT-derived condylar guidance values exhibit high reliability and may serve as an accurate alternative to conventional protrusive records.[20] In addition, Kundu et al. demonstrated that three-dimensional imaging techniques provide improved assessment of anatomical landmarks and enhance the precision of articulator programming.[21]

In the present study, the mean deviation from the radiographic value was 1.00° for Orbitale and 3.25° for Orbitale minus 7 mm. The significantly smaller deviation associated with Orbitale indicates that it more accurately reproduces the anatomical orientation of the maxilla relative to the temporomandibular joint. Clinically, such accuracy is important because even small discrepancies in condylar guidance settings may affect cusp morphology, occlusal harmony, and prosthesis longevity.

The limitations of the present study include the relatively small sample size and the use of lateral cephalograms rather than advanced three-dimensional imaging modalities. Furthermore, only completely dentulous subjects with normal occlusion were evaluated. Future studies involving larger sample sizes and CBCT-based assessment may provide additional insight into the influence of anterior reference point selection on articulator programming.

Within the limitations of this study, Orbitale demonstrated the closest agreement with lateral cephalometric measurements and may therefore be considered a more reliable anterior reference point than Orbitale minus 7 mm for determining sagittal condylar guidance on a semi-adjustable articulator.

Conclusion

Within the limitations of the present study, it can be concluded that the choice of anterior reference point significantly influences the sagittal condylar guidance values obtained on a semi-adjustable articulator. The mean condylar guidance value recorded using Orbitale (30.50 ± 4.38°) showed close agreement with the value obtained from lateral cephalograms (31.50 ± 4.47°), with

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no statistically significant difference between the two methods. In contrast, the values obtained using Orbitale minus 7 mm (28.25 ± 4.42°) were significantly lower than the radiographic values.

The deviation from cephalometric measurements was significantly smaller when Orbitale was used as the anterior reference point, indicating greater accuracy and reliability in reproducing sagittal condylar inclination. These findings suggest that Orbitale provides a more accurate orientation of the maxillary cast during facebow transfer and results in articulator settings that closely approximate anatomical condylar guidance.

Therefore, Orbitale may be recommended as a reliable anterior reference point for programming semi-adjustable articulators in routine prosthodontic practice. Further studies with larger sample sizes and advanced three-dimensional imaging modalities are recommended to validate these findings.

Legend Tables, Graphs and Figures

Table 1: Comparison of protrusive condylar guidance angle values obtained from 4 different anterior reference points and radiographic tracings.

Sample	Lateral Cephalogram (°)	Orbitale (°)	Orbitale minus 7 mm (°)
1	32.5	30.0	27.5
2	30.9	30.0	27.5
3	35.0	32.5	30.0
4	39.0	40.0	37.5
5	30.2	27.5	25.0
6	32.0	30.0	25.0
7	23.1	25.0	22.5
8	26.0	25.0	25.0
9	34.1	32.5	32.5
10	32.2	32.5	30.0

Table 2: Comparison of condylar guidance values obtained using lateral cephalogram and Orbitale

Method	N	Mean (°)	SD	t-value	p-value
Lateral Cephalogram	10	31.50	4.47	1.984	0.079
Orbitale	10	30.50	4.38		

Table 3: Comparison of condylar guidance values obtained using lateral cephalogram and Orbitale minus 7 mm

Method	N	Mean (°)	SD	t-value	p-value
Lateral Cephalogram	10	31.50	4.47	4.703	0.001*
Orbitale minus 7 mm	10	28.25	4.42		

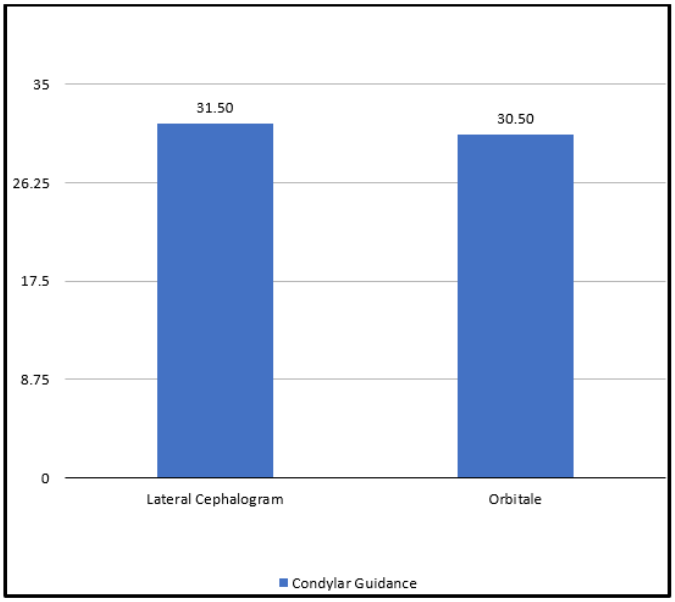
*Statistically significant ($p < 0.05$)

Table 4: Comparison of deviation from lateral cephalogram

Parameter	N	Mean Difference (°)	SD	t-value	p-value
Orbitale	10	1.00	1.59	-5.014	<0.001*
Orbitale minus 7 mm	10	3.25	2.19		

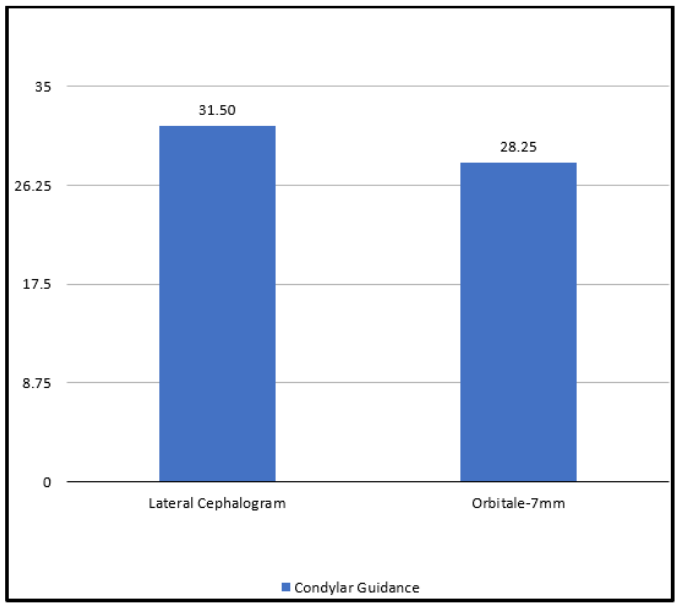
*Highly significant ($p < 0.001$)

Graph 1: Comparison of Condylar Guidance Obtained Using Lateral Cephalogram and Orbitale



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Graph 2: Comparison of Condylar Guidance Obtained Using Lateral Cephalogram and Orbitale minus 7 mm



Graph 3: Comparison of Difference in Condylar Guidance from Lateral Cephalogram

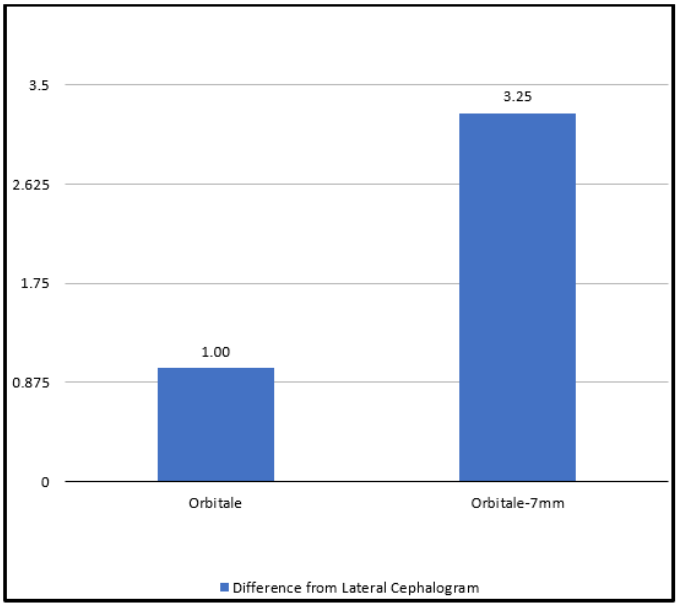


Figure 1

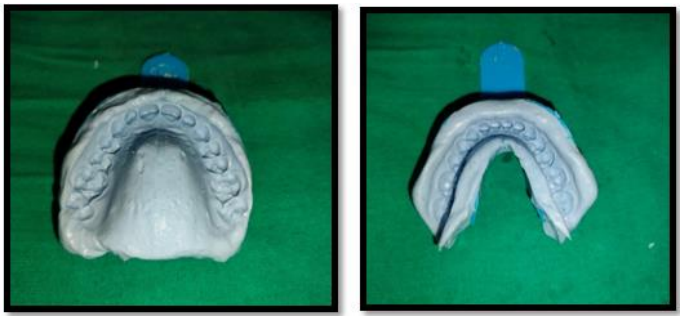


Figure 2

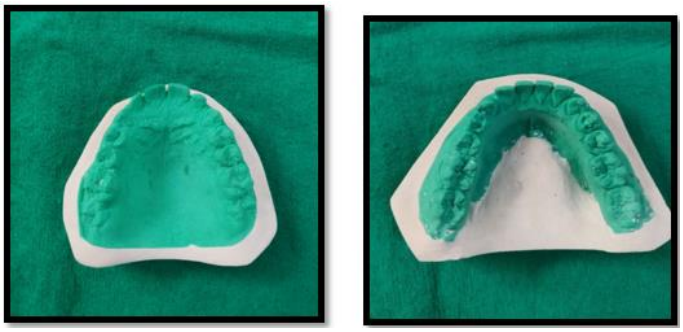


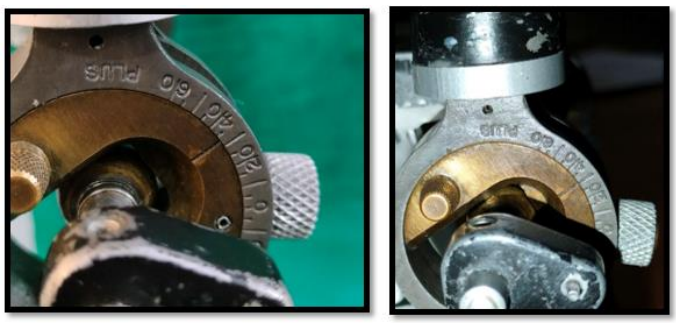
Figure 3



Figure 4



Figure 5



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Figure 6

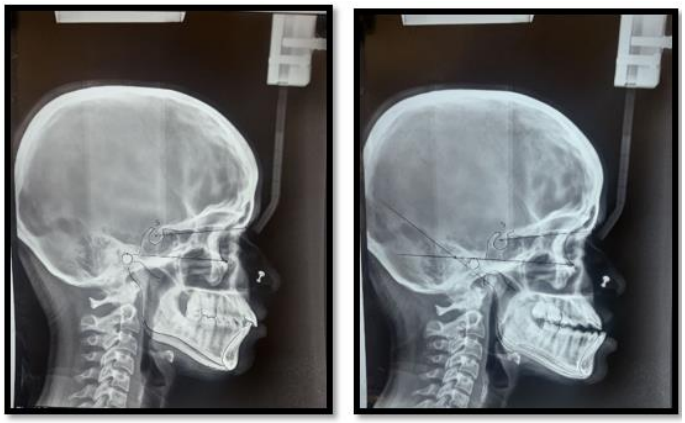
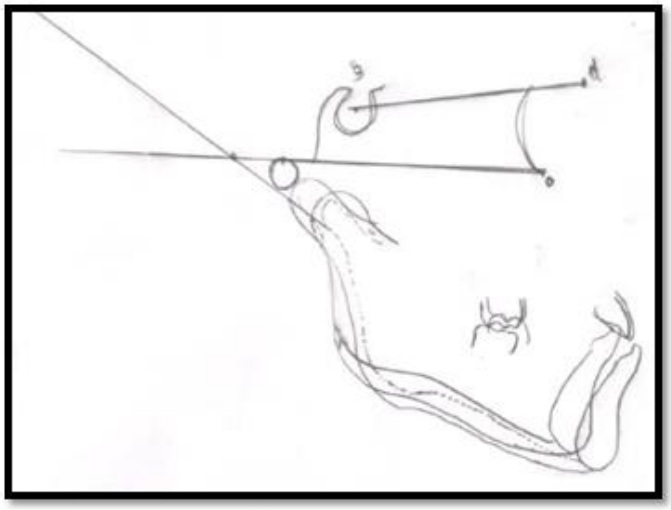


Figure 7



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