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Comparative analysis of sagittal condylar guidance obtained through clinical intraoral tracing and cone beam computed tomography in completely edentulous patients

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Abstract

Background: Precise recording of sagittal condylar guidance (SCG) plays a pivotal role in successful prosthodontic rehabilitation, particularly in the fabrication of complete dentures using semi-adjustable articulators. Conventional clinical methods such as intraoral Gothic arch tracing are subject to inaccuracies due to operator variability, patient cooperation, and anatomical limitations. The advent of Cone Beam Computed Tomography (CBCT) offers a promising alternative for obtaining consistent and reproducible alternative by directly measuring bony anatomical landmarks.

Objective: This study aims to evaluate and compare the sagittal condylar guidance values obtained through clinical intraoral Gothic arch tracing and CBCT. It also aims to determine whether CBCT can reliably replace conventional clinical methods in programming semi-adjustable articulators.

Methods: Twenty completely edentulous patients meeting strict inclusion criteria were selected for the study. After obtaining primary and secondary impressions, maxillomandibular relations were recorded and transferred to a Hanau Wide-View semi-adjustable articulator using an arbitrary facebow. Intraoral Gothic arch tracings were performed, and protrusive interocclusal records were used to program the articulator. SCG values were then derived. For comparison, CBCT scans were analyzed to determine condylar guidance angles using reference lines between the glenoid fossa and articular eminence in relation to the Frankfort Horizontal plane. Data were analyzed using descriptive statistics and independent t-tests.

Results: The mean SCG values using intraoral tracing were $26.05^\circ \pm 5.45$ (right) and $25.58^\circ \pm 5.09$ (left), while CBCT yielded values of $29.25^\circ \pm 6.47$ (right) and $28.57^\circ \pm 5.88$ (left). Statistically significant differences ($p < 0.05$) were found between clinical and CBCT methods. A strong positive correlation was observed, suggesting both methods are reliable, with CBCT showing slightly higher precision.

Conclusion: CBCT provides an accurate, reproducible, and less technique-sensitive method for recording SCG, especially in patients with compromised anatomical or neuromuscular function. Although traditional methods remain viable, CBCT can serve as a reliable adjunct or even a replacement for clinical techniques in appropriate cases.

Keywords: Sagittal condylar guidance, CBCT, gothic arch tracing, edentulous patients, semi-adjustable articulator

Introduction

Materials and Methods

This study was carried out at the Department of Prosthodontics, Government Dental College & Hospital, Patiala. Ethical approval was obtained from the Institutional Ethical Committee Board. Twenty completely edentulous subjects (age range: 50-75 years) with well-developed ridges and healthy mucosa participated in the study.

All patients underwent complete denture fabrication using standard clinical protocols. Primary impressions were made using impression compound, followed by border molding with low-fusing compound and final impressions with zinc oxide eugenol paste. Master casts were poured in type III dental stone. Record bases and occlusal rims were fabricated using self-cure acrylic and wax.

Vertical dimension and centric relation were established using conventional methods.

Maxillary casts were mounted using an arbitrary facebow transfer. Mandibular casts were mounted using centric records. Intraoral Gothic arch tracers (Biotracer) were used to perform functional mandibular tracings. The centric point and 6 mm forward protrusive point were marked, and interocclusal records were made using polyvinyl siloxane material. These records were used to program the horizontal condylar guidance of a Hanau Wide-Vue articulator.

For radiographic evaluation, CBCT scans were obtained using a Vatech Ez3D-I unit with parameters set at 94 kV, 7 mA, and 3.6 seconds of exposure. Patients were instructed to remain still, and head position was stabilized using a head holder. Using the software, sagittal sections were analyzed. A line joining porion and orbitale (Frankfort horizontal plane) and another from the highest point of the glenoid fossa to the apex of the articular eminence were drawn. The angle formed by the intersection of these lines represented the sagittal condylar guidance.

Measurements were repeated by a second observer to ensure inter-observer reliability. All data were tabulated and subjected to statistical analysis using SPSS software (version 26). Mean, standard deviation, and Pearson's correlation coefficients were calculated. Paired and independent t-tests were used to evaluate intra-group and inter-group differences.



Fig 1: Intraoral gothic arch tracer application



Fig 2: Arrowhead tracing

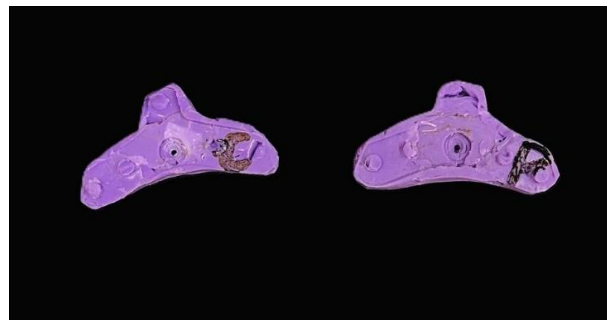


Fig 3: Centric and protrusive records obtained after tracing



Fig 4: Patient positioned in the CBCT machine

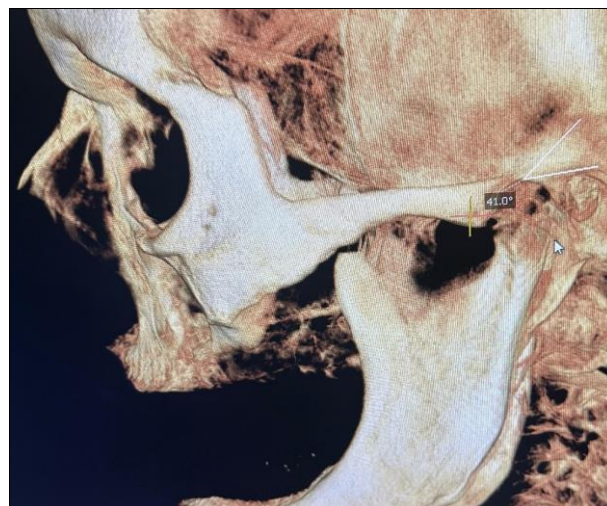


Fig 5: Condylar guidance angle obtained from CBCT

Results

The mean SCG obtained by intraoral Gothic arch tracing was $26.05^\circ \pm 5.45$ on the right side and $25.58^\circ \pm 5.09$ on the left side. The CBCT-derived SCG was $29.25^\circ \pm 6.47$ (right) and $28.57^\circ \pm 5.88$ (left). The differences in values were statistically significant ($p < 0.05$), with CBCT consistently yielding slightly higher angles.

No significant asymmetry was observed between the left and right sides in both techniques, suggesting bilateral symmetry

in condylar paths for most participants. Pearson's correlation showed a strong positive relationship ($r = 0.87$) between values derived from both methods, indicating good reliability and consistency.

Intra-observer reproducibility was excellent, with minimal variance ($<1^\circ$) in repeated measurements. Bland-Altman plots further supported agreement between the methods, though minor deviations were more common at higher SCG values.

Discussion

Prosthodontics emphasizes restoring oral function and aesthetics, particularly in edentulous patients where accurate recording of sagittal condylar guidance angles (SCGA) is vital for programming articulators. Accurate articulator programming ensures balanced occlusion and minimizes intraoral adjustments.

Clinical methods, like intraoral Gothic arch tracing, are commonly used due to their accessibility and cost-effectiveness. They are advantageous but limited by factors such as patient compliance, neuromuscular control, and tissue resiliency—especially in elderly or compromised individuals. These limitations can reduce the accuracy and reproducibility of condylar recordings.

To overcome these challenges, radiographic techniques such as CBCT offer a standardized, non-invasive, and highly accurate alternative. CBCT provides three-dimensional imaging based on hard tissue landmarks, avoiding soft tissue distortion and operator-dependent errors. Our study supports previous findings that radiographic methods yield slightly higher SCGA values than clinical methods—likely due to the use of static anatomical references and exclusion of soft tissue dynamics.

In our study, 20 completely edentulous patients were evaluated. SCGAs recorded by CBCT were significantly higher than those obtained by Gothic arch tracing:

- **Right side:** 29.16° (CBCT) vs 26.05° (clinical)
- **Left side:** 27.45° (CBCT) vs 25.57° (clinical)

A strong positive correlation was observed ($r = 0.762$), aligning with studies by Verma, Ailsinghani, Naqash, Arindam, and others. Radiographic methods generally show a 2° - 10° higher SCGA than clinical techniques, but the clinical relevance of this difference may be minimal in routine cases. However, in patients with skeletal discrepancies, TMJ disorders, or difficulty performing mandibular movements, CBCT is a valuable alternative.

CBCT also facilitates interdisciplinary collaboration in complex cases involving implant-supported prostheses, TMJ evaluation, or orthognathic surgery. However, its use is limited by cost, availability, and radiation exposure, and should be guided by clinical necessity, not employed indiscriminately.

Though our findings support CBCT as a reliable alternative, clinical methods remain practical and effective for most patients. Graphic methods like Gothic arch tracing offer acceptable accuracy when performed under optimal conditions, especially with cooperative patients.

This study is limited by its small sample size and single-center design. Future multicenter studies with larger patient groups are necessary to establish normative CBCT-based SCGA values and define acceptable thresholds for clinical use.

In conclusion, while CBCT offers clear advantages in accuracy and reliability, clinical techniques remain essential in daily prosthodontic practice. The choice of method should

reflect patient-specific needs, clinical resources, and procedural goals.

Conclusion

Accurate recording of maxillomandibular relationships is essential in complete denture prosthodontics, particularly the determination of the sagittal condylar guidance angle (SCGA). While clinical methods like intraoral Gothic arch tracing are time-tested and cost-effective, they are limited by patient-related factors such as neuromuscular control and tissue resilience. In contrast, CBCT offers a more precise, time-efficient alternative by using static hard tissue landmarks.

This study compared SCGA values obtained using Gothic arch tracing and CBCT in 20 completely edentulous patients, with values recorded on both right and left sides. Key findings include:

- **Right side SCGA:**
 - Clinical: $26.05^\circ \pm 5.45$
 - CBCT: $29.16^\circ \pm 7.00$
 - No significant difference ($p = 0.125$)
- **Left side SCGA:**
 - Clinical: $25.58^\circ \pm 5.09$
 - CBCT: $27.45^\circ \pm 4.61$
 - No significant difference ($p = 0.230$)
- **Right vs. left comparisons** within each method showed *no significant difference* (Clinical: $p = 0.777$; CBCT: $p = 0.367$)
- **Overall mean SCGA:**
 - Clinical: $25.81^\circ \pm 5.21$
 - CBCT: $28.31^\circ \pm 5.91$
 - *Statistically significant difference* ($p = 0.049$)
- **Pearson correlation** between methods: $r = 0.762$ ($p < 0.001$), indicating a strong positive correlation

The findings of this study indicate that CBCT can serve as a reliable and reproducible method for recording SCGA in completely edentulous patients. While it provides slightly higher values than clinical methods, the strong correlation supports its use as a valid alternative.

In clinical practice, CBCT is especially beneficial for patients with compromised anatomy or neuromuscular control, where traditional methods may fall short. Though not a universal substitute, CBCT enhances diagnostic precision and can help reduce procedural errors when used judiciously.

Conclusion

Both clinical and CBCT methods yielded reliable SCGA measurements, with CBCT offering a more standardized and objective assessment. Although the difference in values may not always be clinically critical, CBCT's advantages become evident in complex or compromised cases.

Prosthodontists should consider patient-specific factors, treatment complexity, and resource availability when selecting between conventional and radiographic methods for articulator programming.

Despite limitations due to sample size and single-center scope, this study highlights CBCT's growing relevance in prosthodontics. Further large-scale, multicenter research is recommended to establish normative SCGA values and refine clinical protocols for its application.

Conflict of Interest

Not available.

Financial Support

Not available.

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