Original Article

A Comparative Evaluation of Sagittal Condylar Guidance Between Dentate and Edentulous Patients Using CBCT: An in Vivo Study

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Abstract

Objective: The purpose of this study was to compare the sagittal condylar guidance (SCG) angle between dentate and edentulous patients, right and left sides, and males and females. At the same time, the study aimed to explore any statistically significant relation in values of the (SCG) angles between different age groups.

Methods: The study samples included 40 participants, 20 dentate patients (10 men and 10 women, aged from 20-49 years) were included. Similarly, 20 edentulous patients (10 men and 10 women, aged from 50-79 years) were taken on. (SCG) angles were measured for the right and left sides using (CBCT) with appropriate software. Independent samples t-test and ANOVA test were used to analyze the data.

Results: The difference in (SCG) values between dentate and edentulous patients was statistically significant at $p < 0.05$. In contrast, the recorded values of (SCG) were comparable between the right and left sides, between males and females, with no statistical differences, $p > 0.05$. Furthermore, potential statistically significant differences between the values of SCG angles and different age groups in dentate and edentulous cases were not explored.

Conclusions: There was no significant variation in the values of the SCG angles between the right and left sides simultaneously between males and females. However, a significant difference was detected in the value of SCG angles between dentate and edentulous cases. In contrast, statistically significant differences were not depicted in the values of SCG angles between different age groups in dentate and edentulous samples.

Keywords: *Sagittal condylar guidance, Cone beam computed tomography, Dentate, Edentulous.*

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Introduction

A proper and successful dental prosthesis can only be constructed when it functions harmoniously with all structures guiding mandible movement[1]. For this reason, accurate simulation of the path of the condyles and the articular disc traversing along the articular eminence (AE) slope contributes to the prognosis of complex prosthodontics procedures[2,3]. Condylar guidance is the mandibular guidance generated by the condyle and articular disc traversing the contour of the glenoid fossae[4]. Any error or failure to determine the condylar guidance precisely may lead to an unstable occlusion with occlusal interference. Identifying and correcting these errors need precious clinical time and may affect patient satisfaction[5].

Sagittal condylar guidance (SCG) is an articular parameter which is highly dependent on the articular setting during oral rehabilitation planning. It also influences dynamic tooth morphology, which aids in restoring and preserving the occlusion without interference[5].

According to the literature, many ways and techniques are used for measuring condylar guidance[5-8]. However, no clear evidence exists regarding which technique can stimulate the condylar linear pathway. Therefore, dental clinicians may depend on the average value between 22 and 65 degrees without attention to the condylar pathway steepness. This can lead to defects and imperfections in the final stage of dental prostheses and restorations[6-8].

Intra-oral wax records, functional records, and graphical tracing methods have been recommended to record the mandible's centric and eccentric movements[9]. One of the most widely used techniques for setting condylar guidance involves recording centric, protrusive, and lateral interocclusal records. The semi-adjustable articulator is usually used[10-13]. Similarly, pantographic tracing can measure condylar guidance using a fully adjustable articulator[14].

Nevertheless, these clinical methods have the disadvantages of being time-consuming, inconvenient, and inefficient. Radiographic techniques, including panoramic radiographs, computed tomograms, and lateral cephalograms, have been suggested to obtain the same goal[15-17]. Measurements acquired from these techniques mainly depend on stable landmarks. Therefore, errors that may occur because of the operators' inexperience and difficulties in controlling the neuromuscular movement of the patients can be decreased[18-21].

Cone beam computed tomography (CBCT) is a widely used radiographic technique in dentistry[19]. The 3D multiplanar sections obtained from a CBCT scan provide an improved anatomic overview of the condyle and its pathway without the superimpositions inherent in 2D radiographic images[20,22-24]. Many studies have been conducted to measure SCG angles using clinical methods, OPG, lateral cephalograms, and CBCT[1,4,5,19,25,26]. However, there is a gap in the literature regarding using CBCT to measure and compare SCG angles between dentate and edentulous patients.

Hence, this study aims to compare the angle of sagittal condylar guidance (SCG) obtained from CBCT between dentate and edentulous patients to determine whether there is a significant difference between the two groups of patients. At the same time, the aim is also to find any statistical difference in the value of (SCG) between the right and left sides, between females and males, and between different age groups in dentate and edentulous participants.

Materials and methods

Patient selection

An ethical clearance certificate was obtained for this study from the ethical committee in the College of Dentistry, University of Sulaimani, number (205\23). A total of 40 participants enrolled and participated in this study. Twenty dentate patients (10 men and 10 women, between 20-49 years) were included. Similarly, 20 edentulous patients (10 men and 10 women, between 50-79 years) were taken on, according to previous studies[25,26]. Those patients were referred to a private dental clinic to treat their conditions. CBCT scans were prescribed for dentate and edentulous participants only when clinically indicated.

Written informed consent was obtained from each participant before taking a radiographic image and collecting clinical data. Regarding the dentate patients, inclusion criteria included individuals having an almost complete complement of natural teeth (at least three teeth in each posterior segment) with a class 1 molar relationship. Dentate patients under the age of 20 were not included in this study. This was because the size of the TMJ will continue to increase nearly until the age of twenty[27,28].

Furthermore, any patients suffering from TMJ disorders or any TMJ abnormalities were excluded. Class II and III molar relations, severe attrition, faulty restorations, and poor neuromuscular control were not included. Concerning the edentulous patients, patients with completely upper and lower edentulous arches, as well as a good neuromuscular control movement of their arches, were chosen. The patients' mandibular and maxillary ridges should be in good condition and at a height with minimum bone loss. However, this study did not take edentulous individuals with any TMJ disorders or difficulty in controlling the movement of the jaws. Additionally, any condition that contraindicates the use of radiographic images was also excluded, such as pregnancy.

CBCT Radiographic procedure

A CBCT radiographic image of the mid-facial region for each participant was achieved by the same operator using the same radiographic machine (Carestream Kodak Cs9600; Kodak). All the patients stood to get maximum intercuspation between the upper and lower arches. A special software programmer (CS 3D Imaging software; Carestream Dental) was used to program the images. Axial sections perpendicular to the condylar long axis were made (width=0.15 microns, thickness=1 mm, step=1 mm) at the level of the condyle head and inferior border of the zygomatic arch. Exposure factors were kept at 90 KVp, 3.20mA, and 40 s.

Also, a personal protection barrier was used for each patient. To find the maximum depth of the glenoid fossa, a perpendicular line connecting the deepest point of the glenoid fossa was drawn onto another line connecting the two sides of the glenoid fossa on the central section and two sections, before and after. The section with the maximum length of the perpendicular line was selected. The porion and orbitale were identified, and the Frankfort horizontal plane was constructed.

After that, a second line was constructed along the posterior slope of AE, connecting the most concave (highest) point on the glenoid fossa and the most convex (lowest) on the apical portion of AE[29,30]. The condylar inclination angles for both sides (right and left) were obtained by measuring each participant's angle between the Frankfort horizontal plane and the second constructed line (Figure 1). Finally, the same investigator achieved condylar inclination values for each patient.

Statistical analysis

The collected data from the patients were entered into a spreadsheet (Microsoft Office 365), and analysis was done using the statistical software package SPSS 29 (SPSS Inc., Chicago, IL, USA). The data were tested for normal distribution with the Shapiro-Wilk test, and the data did not deviate from normality (p-value= 0.15); subsequently, parametric tests were used. Independent samples t-test was used to compare the mean values of sagittal condylar guidance (SCG) angles between right and left sides, males and females, and between dentate and edentulous cases. A one-way analysis of variance (ANOVA) test was used to compare the mean values of SCG angles between age groups. The p-value ≤0.05 has been accepted as statistically significant.

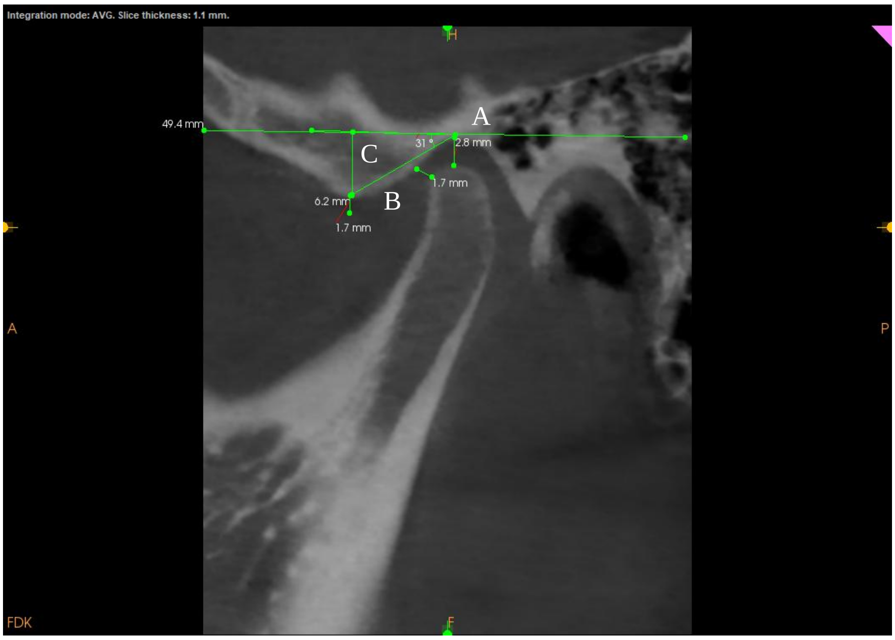

Figure 1: Condylar guidance obtained for a participant using CBCT. A: FH plane (Frankfort horizontal plane), B: Line from most superior to most inferior point of the curvature of glenoid fossa, C: Sagittal condylar guidance angle; angle made by intersection of line A and B.

Results

The sample was composed of 40 subjects. Considering dentate status, 20 patients were dentate and 20 were edentulous. (Table 1) shows the frequency, mean, and standard deviation of the value of SCG angles for both dentate and edentulous patients, right and left sides, males and females. No significant difference was found between the (SCG) angle obtained for the right and left sides for either dentate or edentulous groups. Similarly, there was no statistically significant difference in the value of (SCG) angles between genders for either dentate or edentulous groups, as depicted in Table 1.

The average mean value of SCG angles for the dentate group in this sample is 34.55, while it is 30.35 for the edentulous group.

This shows that the dentate group in this sample has, on average, a higher mean value for SCG angle than the edentulous group. A two-tailed t-test for independent samples showed that the difference in the value of SCG angles between dentate and edentulous patients was statistically significant, $t(73.29) = 3.4$, $p = 0.007$, 95% confidence interval [1.72, 6.58], as seen in (Figure 2) and (Table 1). The dentate group has been divided into three age gaps (20-29), (30-39), and (40.49), respectively. In the same manner, the edentulous group involves three age gaps (50-59), (60-69), and (70-79), (Figure 3).

A one-way analysis of variance (ANOVA) showed no significant differences in the value of SCG angles among age groups in dentate and edentulous cases or between the right and left sides.

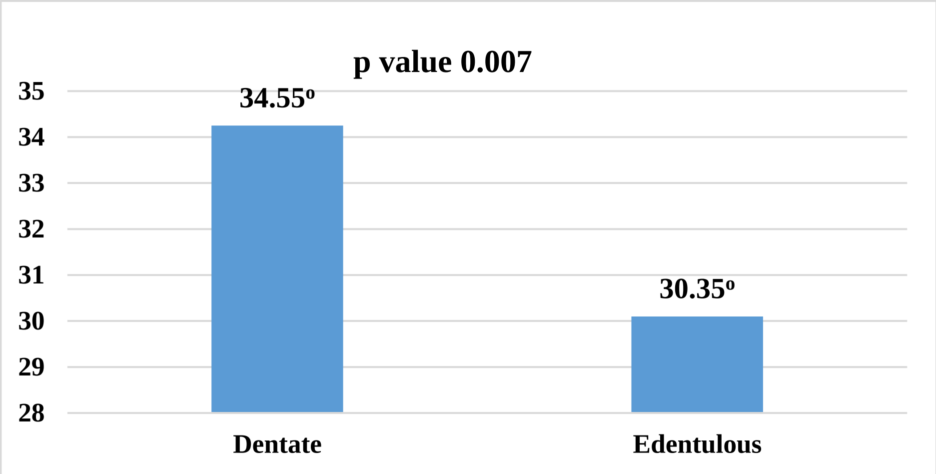

Figure 2: Mean of SCG angle values for dentate and edentulous patients.

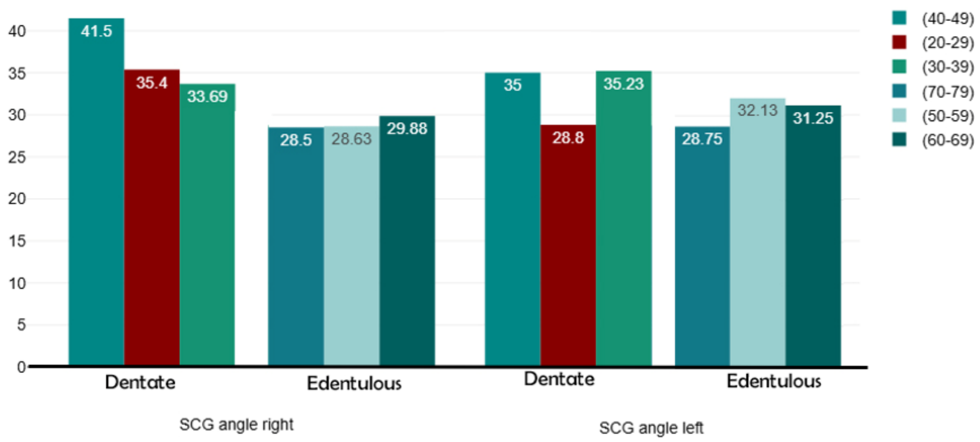

Figure 3: A bar chart showing the distribution of SCG angle values across the age groups.

Table 1: Descriptive data analysis with a t-test showing the differences in SCG between dentate and edentulous, right and left sides, as well as between sexes, in both dentate and edentulous samples.

	Variables	Frequency	Minimum	Maximum	Mean ± Std.	p-value
Dentulous state	Dentate	20	29	40	34.55 ± 3.12	0.007
	Edentulous	20	22	37	30.35 ± 5.83	
Side Dentate	Right	10	24	46	34.9 ± 5.03	0.39
	Left	10	23	41	33.6 ± 4.41	
Side Edentulous	Right	10	18	38	29.1 ± 6.41	0.306
	Left	10	22	39	31.1 ± 5.77	
Sex Dentate	Male	10	29	40	35.4 ± 3.13	0.233
	Female	10	29	39	33.7 ± 3.02	
Sex Edentulous	Male	10	24	37	31.3 ± 5.36	0.481
	Female	10	22	37	29.4 ± 6.42	

Discussion

Registering individual articular parameters, such as sagittal condylar guidance (SCG), Bennett angles, and immediate side shift (ISS), is crucial in analyzing and planning oral rehabilitation. This involves maintaining and restoring critical functions, such as mastication, speech, chewing, and esthetics[31,32].

Among these parameters SCG has a highly significant impact that dominates dynamic tooth morphology. The SCG can be described as the angle formed between the protrusive condylar path and the Frankfort plane, or another horizontal reference plane such as Camper's plane (ala of the nose to the tragus), or the axis-orbital plane[31,32]. Therefore, finding the individual value of the condylar path will ensure better diagnosis, treatment plan mapping, and more precise prosthetic restorations, eliminating the time required for correction and adjusting of occlusal interruptions[5,31,32].

Many clinical, radiological, and instrumental procedures have been intended for condylar path registration[33]. Among these techniques, CBCT is the most accurate and noninvasive method of measuring the curvature of the glenoid fossa[34]. At the same time, the CBCT scan has shown the highest reliability rate among all other techniques for measuring SCG angle[35].

Based on the findings of this clinical study, there was no statistically significant difference between the right and left condylar guidance angle values achieved by the CBCT technique in either the dentate or edentulous group.

This finding agrees with other studies[19,34-39]. Contrarily, El Gheriani and Winstanley[21], and Zamacona et al. have declared significant differences between the left and right condylar guidance values[2]. The heterogeneity of their samples, a mix of wholly and partially edentulous participants, may have caused the differences in Zamacona et al.'s findings[2].

Additionally, statistical significance variation in the SCG values was not observed between genders. This result is also comparable to other studies[30,37,40]. According to the outcome of this study, a statistically significant difference in the values of SCG inclinations was noticed between dentate and edentulous cases, which disagrees with the Das et al. study[36]. This could be because OPG, which is less precise than CBCT[30], was used to measure SCG in the Das et al. study[,34,35]. Moreover, recording sagittal condylar guidance in edentulous patients is more technique-sensitive, and the chances of error are also high if methods other than CBCT are used[36].

Depending on the data obtained in this study, no statistically significant correlation was discovered between SCG angles and age groups, either in dentate or edentulous patients. This finding is inconsistent with other published studies, which found a reduction in the value of SCG angles with increasing age[30,41]. These results are derived from flattening of the condylar head as people become older[42]. The small sample size may be one of the factors that prevented a similar result from being seen in this study.

Regarding the clinical methods for registration of SCG angle, operator's skill and experience, variations in polymerization shrinkage of those materials used for recording are main and cumbersome disadvantages[19]. Alternatively, using radiographical techniques can reduce these limitations as they depend on stable bone landmarks[19]. Otherwise, panoramic radiography still has many drawbacks[25]. These include the orientation of the reference plane and the head and parallax distortions due to the difficulty of distinguishing the outline of the articular elevation from the lower border of the zygomatic arch[23,25]. Furthermore, overlapping of many anatomical structures makes panoramic images unsuitable for measuring the SCG angle. On the other hand, a 3D image can be provided by CBCT scans without any superimposition[22,29]. Likewise, the articular eminence and glenoid fossa can be easily identified and distinguished from adjacent structures. Furthermore, the advent of CBCT has offered radiographic scans associated with less radiation exposure and more accurate and reliable results, which has raised its application in dentistry[22,29.]

Nevertheless, CBCT scans are expensive compared with other techniques[30]. Indeed, more studies should be performed to find the predictability of SCG values in edentulous patients using CBCT. This would simplify the procedure for creating expectable occlusal schemes in complete upper and lower arch implant rehabilitations and implant-supported over-denture dental prostheses. In this study, only 40 patients were included, which can be regarded as a small sample size.

Conclusion

Despite this study's small sample size, it can be summarized that no significant difference exists between the right and left sagittal condylar guidance angles (SCG) in dentate and edentulous patients. Correspondingly, no statistical difference was seen in the values of sagittal condylar guidance angles (SCG) between males and females for either right or left sides. However, the difference in values of SCG inclinations between dentate and edentulous cases was statistically significant, $p = 0.007$. On the other hand, no statistically significant differences were detected between the SCG angles and age groups. Further studies are needed that use a larger sample size in an edentulous population to determine the value of SCG in this generation using CBCT. This would contribute to initiating occlusal schemes during prosthodontic treatments.

References

1. Kumari VV, Anehosur GV, Meshramkar R, Nadiger RK, Lekha K. An in vivo study to compare and correlate sagittal condylar guidance obtained by radiographic and extraoral gothic arch tracing method in edentulous patients. Eur J Prosthodont. 2016;4(1):12-6.
2. Zamacona JM, Otaduy E, Aranda E. Study of the sagittal condylar path in edentulous patients. J Prosthet Dent. 1992;68(2):314-7.
3. Prasad DK, Shah N, Hegde C. A clinicoradiographic analysis of sagittal condylar guidance determined by protrusive inter-occlusal registration and panoramic radiographic images in humans. Contemp Clin Dent. 2012;3(4):383-7.
4. The glossary of prosthodontic terms. Ninth edition. J Prosthet Dent. 2017;117(5S):e1-105.
5. Pelletier LB, Campbell SD. Comparison of condylar control settings using three methods: a bench study. J Prosthet Dent. 1991;66(2):193-200.
6. Isaacson D. A clinical study of the condyle path. J Prosthet Dent. 1959;9(6):927-35.
7. Aull AE. Condylar determinants of occlusal patterns: Part I. Statistical report on condylar path variations. J Prosthet Dent. 1965;15(5):826-49.
8. Payne JA. Condylar determinants in a patient population: electronic panto-graph assessment. J Oral Rehabil. 1997;24(2):157-63.
9. Preti G, Scotti R, Bruscagin C, Carossa S. A clinical study of graphic registration of the condylar path inclination. J Prosthet Dent. 1982;48(4):461-6.
10. Posselt U. Physiology of occlusion and rehabilitation. 2nd ed. Oxford: Blackwell Science; 1968. pp 121-32.
11. Mohl ND, Zarb GA, Carlsson GE, Rugh JD. A textbook of occlusion. Chicago: Quintessence; 1988. pp 139-40.
12. Zarb GA, Bolender CL, Eckert SE, Fenton AH, Jacob RF, Mericske-Stern R. Prosthodontic treatment for edentulous patients: complete dentures and implant-supported prostheses. 13th ed. St. Louis: Mosby; 2004. p 294.
13. Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 5th ed. St. Louis: Mosby; 2004. p 294.
14. Curtis DA, Sorensen JA. Errors incurred in programming a fully adjustable articulator with a pantograph. J Prosthet Dent. 1986;55(4):427-9.
15. Gilboa I, Cardash HS, Kaffe I, Gross MD. Condylar guidance: correlation between articular morphology and panoramic radiographic images in dry human skulls. J Prosthet Dent. 2008;99(6):477-82.

16. Santos JD, Nelson J, Nummikoski PS. Geometric analysis of occlusal plane orientation using simulated ear-rod facebow transfer. J Prosthodont. 1996;5(3):172-81.
17. Christensen LV, Slabbert JC. The concept of the sagittal condylar guidance: biological fact or fallacy. J Oral Rehabil. 1978;5(1):1-7.
18. Rashid MO. Cone Beam Computerized Tomography in Dental Clinic: Where and When to Use? Sulaimani Dent J. 2017;4(special issue):25-30.
19. Shreshta P, Jain V, Bhalla A, Pruthi G. A comparative study to measure the condylar guidance by the radiographic and clinical methods. J Adv Prosthodont. 2012;4(3):153-7.
20. Dos Anjos Pontual ML, Freire JS, Barbosa JM, Frazão MA, dos Anjos Pontual A. Evaluation of bone changes in the temporomandibular joint using cone beam CT. Dentomaxillofac Radiol. 2012;41(1):24-9.
21. El Gheriani AS, Winstanley RB. Graphic tracings of condylar paths and measurements of condylar angles. J Prosthet Dent. 1989;61(1):77-87.
22. Mohammed DA. Anthropometric Dimensions of Nasopalatine Canal measured by Cone Beam Computed Tomography among Kurdish Population. Sulaimani Dent J. 2016;3(2):90-7.
23. White SC, Pharaoh MJ. Oral radiology: principles and interpretation. 8th ed. St. Louis: Mosby; 2019. pp 175-7.
24. Langland OE, Langlais RP, Preece JW. Principles of dental imaging. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2002. p 202.
25. Mawani D, Muddugangadhar BC, Das A, Mukhopadhyay A. Comparative evaluation of condylar inclination in dentulous subjects as determined by two radiographic methods: Orthopantomograph and cone-beam computed tomography-An in vivo study. J Indian Prosthodont Soc. 2019;19(2):113-9.
26. Acharya S, Pandey A, Sethi S, Meena MK. A comparative study of condylar guidance setting obtained from interocclusal records and panoramic radiographs in both dentulous and edentulous subjects. Dent J Adv Stud. 2015;3(II):085-90.
27. Lei J, Liu MQ, Yap AU, Fu KY. Condylar subchondral formation of cortical bone in adolescents and young adults. Br J Oral Maxillofac Surg. 2013;51(1):63-8.
28. Sülün, T. Cemgil, T. Duc, J.-M.P. Rammelsberg, P. Jäger, L. Gernet, W. Morphology of the mandibular fossa and inclination of the articular eminence in patients with internal derangement and in symptom-free volunteers. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endodontol. 2001;92(1):98-107.
29. Lassmann Ł, Nowak Z, Orthlieb JD, Żółtowska A. Complicated Relationships between Anterior and Condylar Guidance and Their Clinical Implications-Comparison by Cone Beam Computed Tomography and Electronic Axiography-An Observational Cohort Cross-Sectional Study. Life (Basel). 2023;13(2):335.
30. Das A, Muddugangadhar BC, Mawani DP, Mukhopadhyay A. Comparative evaluation of sagittal condylar guidance obtained from a clinical method and with cone beam computed tomography in dentate individuals. J Prosthet Dent. 2021;125(5):753-7.
31. Hong SJ, Noh K. Setting the sagittal condylar inclination on a virtual articulator by using a facial and intraoral scan of the protrusive interocclusal position: A dental technique. J. Prosthet. Dent. 2021;125(3): 392-5.
32. Lepidi L, Galli M, Mastrangelo F, Venezia P, Joda T, Wang HL, Li J. Virtual Articulators and Virtual Mounting Procedures: Where Do We Stand? J Prosthodont. 2021;30(1):24-35.
33. Lepidi L, Galli M, Mastrangelo F, Venezia P, Joda T, Wang HL, Li J. Virtual Articulators and Virtual Mounting Procedures: Where Do We Stand? J Prosthodont. 2021;30(1):24-35.
34. Kumar RV, Gowda ME, Shashidhar MP. Clinicoradiographic comparison of sagittal condylar guidance angle determined by dynamic and radiographic methods. J Dent Def Sec. 2022;16(2):123-9.
35. Ailsinghani SB, Vikhe D, Palekar U, Saraf V, Hajira N, Madanshetty P. Comparison Of Sagittal Condylar Angle Obtained Using Cone Beam Computed Tomography And Interocclusal Record Materials-An In Vivo Study.(2022). Int J Life Sci Pharma Res;12(1):L72-82.
36. Das R, Giri TK, Kanrar B, Mukherjee S. A comparative evaluation of sagittal condylar guidance obtained by the protrusive interocclusal record and panoramic radiographic tracing in both dentulous and edentulous patients. J Oral Res Rev. 2023;15(1):21-7
37. Dragus, A.C., Mihai, A., Tanase G. Burlibasa, M., Cristache C.M. Intra-individual Left–Right Side Differences of Sagittal Condylar Inclination (SCI) in Different Skeletal Classes. Healthcare. 2023;11(9):1341.
38. Kwon O.K, Yang SW, Kim JH. Correlation between sagittal condylar guidance angles obtained using radiographic and protrusive occlusal record methods. J Adv Prosthodont.

2017;9(4):302-7.
39. Sirana P, Kumar N, Malhotra A, Singhal N, Chaudhary N. Comparative Analysis of Sagittal Condylar Guidance Recorded by Intraoral Gothic Arch Tracing and Panoramic Radiograph in Completely Edentulous Patients. J Contemp Dent Pract. 2018;19(11): 1301-5.
40. Alshali RZ, Yar R, Barclay C, Satterthwaite JD. Sagittal condylar angle and gender differences. J Prosthodont. 2013;22(7):561-5.
41. Sreelal T, Janardanan K, Nair AS, Nair AS. Age changes in horizontal condylar angle: A clinical and cephalometric study. J Indian Prosthodont Soc. 2013;13(2):108-12.
42. Mathew AL, Sholapurkar AA, Pai KM. Condylar Changes and Its Association with Age, TMD, and Dentition Status: A Cross-Sectional Study. Int J Dent. 2011; 2011(2):1-7.