Ref: Ro J Stomatol. 2024;70(1)
DOI: 10.37897/RJS.2024.1.15

Assessment of the clinical procedures used for determination of vertical dimension of occlusion and centric relation in edentulous patients

Cecilia Bacali[1], Anne-Marie Constantin[2], Ioana Marginean[1], Oana Almasan[1]

[1]Prosthetic Dentistry and Dental Materials Department, "Iuliu Hatieganu" University of Medicine and Pharmacy, Cluj-Napoca, Romania
[2]Histology Department, "Iuliu Hatieganu" University of Medicine and Pharmacy, Cluj-Napoca, Romania

ABSTRACT

Background and aim. This study aims to explore the most widely used methods for managing patients who are completely edentulous to determine the intermaxillary relations, also known as the centric relation and vertical dimension of occlusion.

Material and methods. The information sources have been identified through searches of medical databases. A 20-year search frame, from 2001 to 2021 was performed. The terms "occlusal vertical dimension", "totally edentulous", "complete denture", and "centric relation" were searched. The selected articles were acquired in full text, and two different authors resolved differences through conversation before evaluating them for inclusion.

Results. Following the application of the search strategy, 514 articles were identified. 172 papers were screened after duplicate records were removed. Selecting the studies to be considered for inclusion in the first stage required considering their titles, abstracts, and studies' significance to the study purpose. After obtaining the complete texts of the remaining twenty-seven papers, their relevance was evaluated.

Conclusion. The relationship between the maxillary and mandibular arches is still established by the centric relation in occlusal examination and prosthetic treatment. Many methods with low variability and high intra-technical repeatability are available for recording centric relation. There is no one standard technique for recording the vertical dimension of occlusion; instead, the clinician must choose the most comfortable approach.

Keywords: complete denture, centric relation, vertical dimension of occlusion

INTRODUCTION

Each person has a distinct temporomandibular joint relationship, the term centric relation (CR) has been used for many years to define this relationship [1]. Centric relation can be found using a variety of methods, including graphical, physiological, and guided approaches [2]. It is not possible to determine which method, functional or guided, can produce the highest reproducibility of the centric relation. In most cases, intraoral gothic arch recording can be considered more effective than guided techniques, or at least comparable [3]. An essential step in treating an edentulous patient is determining the vertical dimension of occlusion (VDO). When making a complete denture, there are several ways to determine the VDO, but it is unclear which strategy produces the most precise registration [4]. Wearing complete or removable partial dentures daily is linked to an adequate interocclusal distance. Failure of the entire denture treatment can result from incorrect VDO and/or CR determination. There are numerous approaches to estimating the vertical dimension for edentulous patient rehabilitation. Physiological resting position [5], phonetics [6], aesthetics, swallowing, craniometry [7], cephalometry [8,9], and electromyography [10,11] are a few of

Corresponding authors:
Anne-Marie Constantin
E-mail: chindris@umfcluj.ro

Article History:
Received: 20 March 2024
Accepted: 30 March 2024

these techniques. However, there is no scientific way to determine the right VDO for an edentulous patient. The terms "comfort zone", "vertical comfort range", or "preferred vertical dimension of occlusion" are preferred by some practitioners. The physiological resting position is one of the methods most used by dentists.

Fabrication of a denture requires careful consideration of the CR [12]. Centric relation determination is crucial for the development of a physiological and effective functional prosthetic treatment, as well as for the fitting of the models in the articulator in the stage that follows occlusal analysis [13,14]. Long-term denture wearers may experience jaw positioning inaccuracies, insufficient vertical occlusal dimension, and denture instability if VDO and CR are not determined properly [15-17].

The accuracy of the intermaxillary relationships is critical to the prosthesis's success in treating complete edentulousness because any error in this clinical phase can result in uncomfortable prostheses that are unable to be worn and may have detrimental effects on the oral tissues over time.

The aim of this study is to investigate the most popular techniques for finding the intermaxillary relations, or the centric relation and vertical dimension of occlusion, in treating the completely edentulous patient.

MATERIAL AND METHOD

The "Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols Statement" (PRISMA) recommendations were adhered to in presenting this review.

The eligibility criteria were as follows: the inclusion criteria were complete dentures, complete dentition, age between 50 and 80 years, no systemic disease, no motor or sensory disability (no joint pain or limitation in mouth opening), full articles, clinical studies, no mucosal lesions, no temporomandibular disorders, no bone interventions, no endo-osseous implant. The exclusion criteria were partial dentures, partial dentition, age under 50 years, systemic diseases, craniofacial deformities, facial asymmetries or cleft palate, no available abstract, case reports, inoperable flaccid mucous membranes, temporomandibular disorders, bone augmentation interventions, dental implants.

Medical database searches were used to find the information sources. The following medical databases, PubMed (Medline), and Embase were the subject of an extensive automated search to perform systematic analysis. A 20-year search frame, from 2001 to 2021 was applied. To find relevant studies, the following subject search approach was employed: "(occlusal vertical dimension) AND (totally edentulous)", "(occlusal vertical dimension) AND (totally edentulous) AND (complete denture)", "(centric relation) AND (totally edentulous)", "(centric relation) AND (totally edentulous)) AND (complete denture)". Every article's title and abstract were manually screened by two authors, and when in doubt, they discussed whether the research should be taken into consideration. The chosen articles were obtained in their entirety and evaluated for inclusion by two separate authors (A-M.C., I.M.), who arbitrated disagreements through discourse. The reason for exclusion was noted for every article that was rejected. In the first stage, the titles, abstracts, and studies' relevance were taken into consideration when selecting the studies to be included. The selection process of the research was carried out by two researchers, who extracted the relevant articles (A-M.C., I.M.) and approved the relevant publications. A third researcher verified the collecting procedure and acknowledged the decision (C.B.). The full texts of the remaining papers were acquired, and their suitability was assessed.

RESULTS

Selection of sources of evidence

Five-hundred and fourteen articles were retrieved, after applying the search strategy (42 from PubMed and 472 from other databases). Following the removal of duplicate records, 172 papers underwent screening. In the first stage, the titles, abstracts, and studies' relevance to the study debate were taken into consideration when selecting the studies to be included. The full texts of the maintaining twenty-seven documents were acquired, and their suitability was assessed. The search and decision-making processes are described in a PRISMA representation (Figure 1).

The following studies have been retrieved for the review (Table 1).

Table 2 summarizes the characteristics of the chosen studies, including the type of study, the comparison methods of determination, and any limitations or technical difficulties with the techniques employed.

Figure 2 depicts the DVO study pattern or development over time (number of selected studies/year).

As the figure shows, an almost constant number of studies were found on the topic over time and a significantly increased number of studies (a maximum number) in 2021.

DISCUSSION

Determining and reestablishing the vertical occlusion dimensions (VDO) is a component of the overall protective measure for enhancing life quality [22,23]. Additionally, the evaluation of VDO after aspect is based on the restoration or establishment

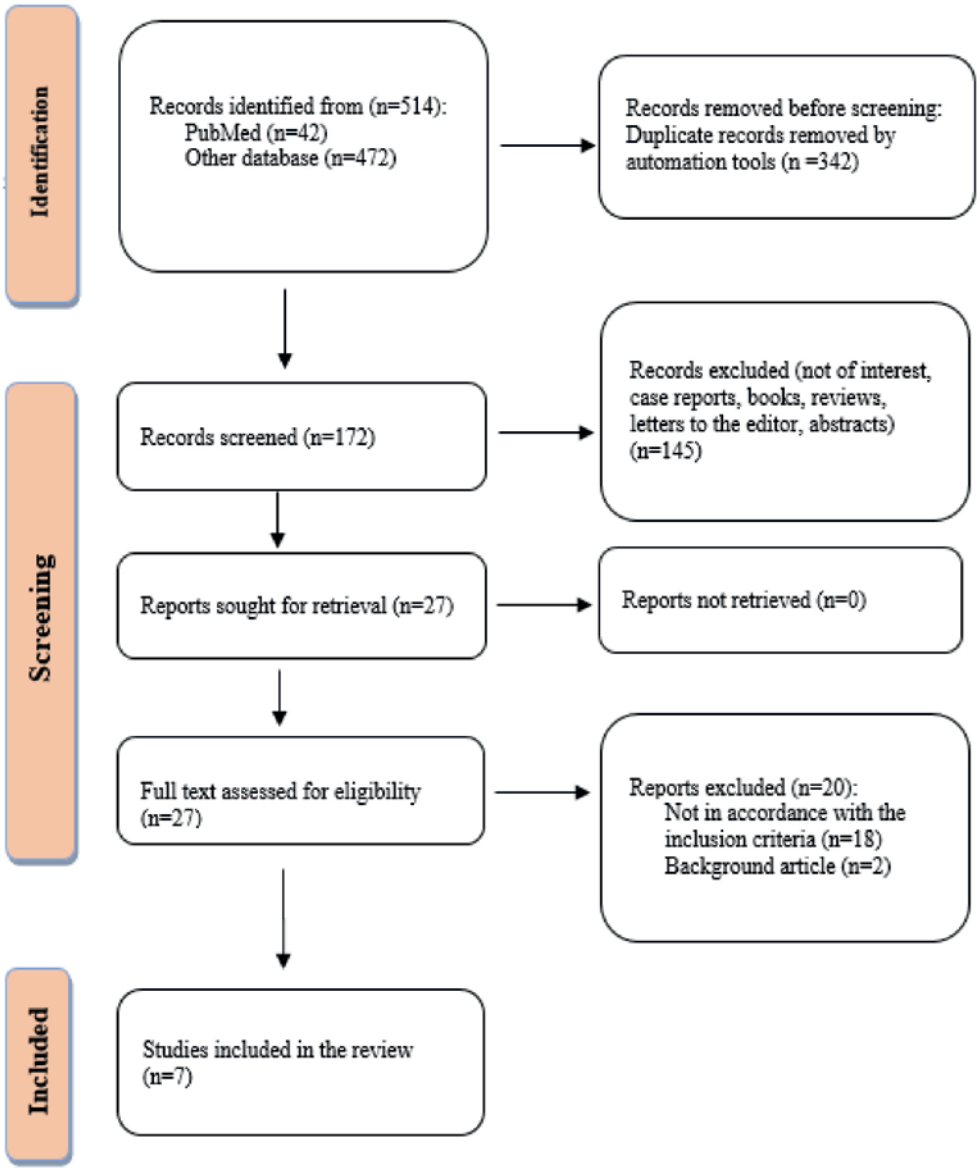

FIGURE 1. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols Statement (PRISMA) adapted research and decision-making process

TABLE 1. The included studies of the review

Number	Reference
1	Vinnakota DN, Edamadaka N, Reddy PS, Duggineni CR. Comparison of patient satisfaction between complete dentures fabricated using "conventional" and "cephalometric angular reconstruction" vertical dimension procedures: A multicenter randomized clinical trial. J Indian Prosthodont Soc. 2022;22(1):82-91. doi: 10.4103/jips.jips_336_21 [8]
2	Geerts GA, Stuhlinger ME, Nel DG. A comparison of the accuracy of two methods used by pre-doctoral students to measure vertical dimension. J Prosthet Dent. 2004 Jan;91(1):59-66. doi: 10.1016/j.prosdent.2003.10.016 (5)
3	Huamani J, Watanabe R, Huamani J, Salcedo-Moncada D, Alvitez-Temoche D, Mayta-Tovalino F. Accuracy between Functional Swallowing and Knebelman Craniometric Method to Measure Occlusal Vertical Dimension in Total Denture Wearers: A Quasi-experimental Study. J Int Soc Prev Community Dent. 2021 Apr 15;11(2):152-157. doi: 10.4103/jispcd.JISPCD_380_20 (18)
4	Sushma R, Roy MS, Sanyal PK, Joshi A, Vande A, Kore AR. A clinical comparative study to assess the efficacy of a new centric registration technique with a conventional technique. J Indian Prosthodont Soc. 2019 Oct-Dec;19(4):290-295. doi: 10.4103/jips.jips_126_19 (19)
5	Aredes JE, Fassina NA, Macchi RL. Centric relation registration with intraoral central bearing on curved vs. flat plates with rim trays in edentulous patients. Acta Odontol Latinoam. 2021 Apr 1;34(1):35-42. English. doi: 10.54589/aol.34/1/035 (20)
6	Thakur M, Jain V, Parkash H, Kumar P. A comparative evaluation of static and functional methods for recording centric relation and condylar guidance: a clinical study. J Indian Prosthodont Soc. 2012 Sep;12(3):175-81. doi: 10.1007/s13191-012-0154-5 (21)
7	Enkling N, Enkling-Scholl J, Albrecht D, Bornstein MM, Schimmel M. Determination of the occlusal vertical dimension in edentulous patients using lateral cephalograms. J Oral Rehabil. 2018 May;45(5):399-405. doi: 10.1111/joor.12624 (9)

TABLE 2. Characteristics of the selected studies

Study	Type of study	Number of patients / examiners	Determined parameter	Compared methods	Results
Vinnakota et al, 2022 [8]	multicentric, parallel-group, equivalent, and triple-blind trial	120 in each group	VDO	comparison of the computerized cephalogram and the Willis method calculation	no significant difference in the determined vertical dimension
Geerts et al, 2004 [5]	Statistical comparison of the accuracy of repeated measurements	20 predoctoral student examiners - 1 patient	VDO	Willis occlusometer – caliper method	the caliper method was significantly more reliable
Huamani et al, 2021 (18)	prospective, quasi-experimental study	32 patients	VDO	functional swallowing and the Knebelman craniometric method	good agreement between methods
Sushma et al, 2019 (19)	randomized controlled trial	60 patients	CR	Dawson's bimanual technique vs. the authors' patented technique	the patented technique took 9-10 times less time, and both approaches were shown to be equally accurate
Aredes et al, 2019 (20)	prospective study	17 patients	CR	with acrylic tray with edge and center support using a curved plate or a flat plate	the records obtained with the flat plate were significantly more retrusive than with the curved plate
Thakur et al, 2012 (21)	prospective randomized study	28 patients	CR and horizontal condylar guidance	interocclusal wax methods vs. extraoral Gothic arch	the mean guidance value of the Gothic arch tracing was higher on both sides
Enkling et al, 2018 (9)	two prosthodontists independently evaluated VDO of a dental prostheses	36 patients	VDO	digital lateral cephalograms	the use of lateral cephalography as a diagnostic parameter is not recommended

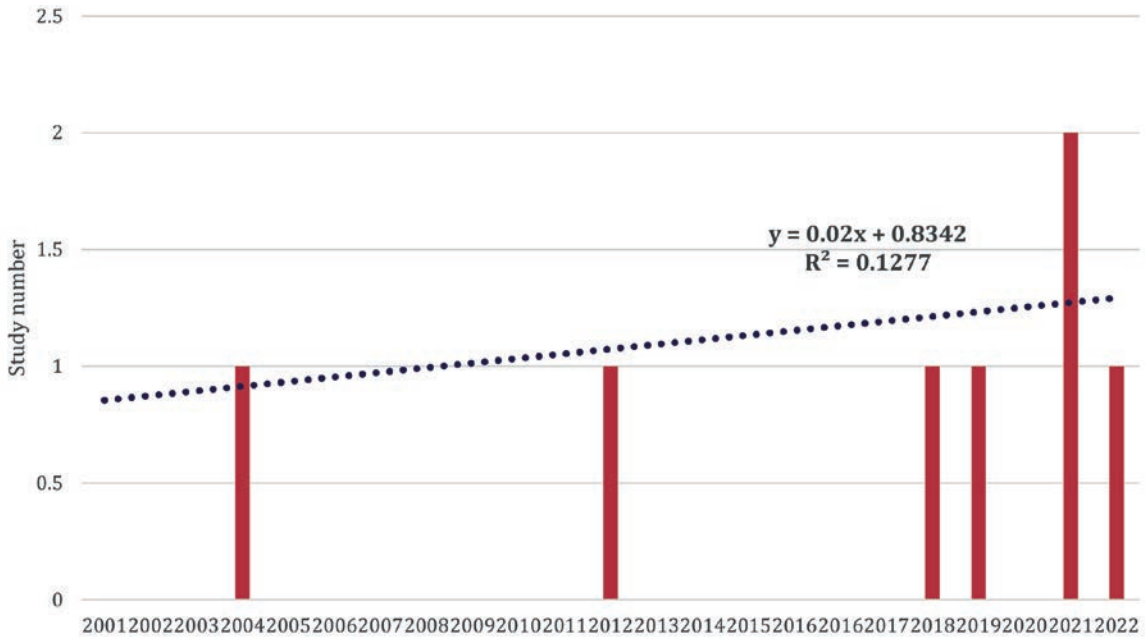

FIGURE 2. Clinical studies comparing the VDO and CR measurement techniques according to years

of the aesthetic integrity of the lower third of the face [7].

The prosthetic treatment is based on the clinical application of available distances for interocclusal space, the potential stability of the vertical rest dimensions, and the means of VDO change. There is a range of values for the distance between interocclusal distances between numerous dental normal individuals who function with a higher or lower interocclusal distance than the standard of three mm. The vertical rest dimension (VDR) is a three-dimensional interval with small variations related to VDR changes over time. With all of these, muscle atrophy may result in a decrease in tone, which may have an

impact on VDR. Successful VDO restoration can be achieved through appropriate diagnosis and treatment planning [24].

There are currently two main approaches used to determine VDO: pre-extraction methods and post-extraction methods. Pre-extraction techniques primarily use intraoral measurements, profile tracing, and cephalometric analysis to transfer the VDO of the natural dentition to the new prostheses. The mandibular resting position, facial aesthetics, swallowing pattern, measurements of craniofacial landmarks, cephalometric analysis, phonetics, and preexisting prostheses are the foundation for post-extraction methods. For routine clinical use, all currently available techniques have some advantages. However, there fails to be a single reliable way to find DVO. Using a combination of techniques to estimate VDO will help the clinician overcome the limitations of different methods [7]. Facial measurements can be used in any manner to obtain the vertical dimension of the occlusion area for patients without pre-extraction records. Facial measurements can be recorded with a modified digital caliper Vernier [25]. Following a clinical examination, edentulous individuals can have their upper and lower dentures made and the previously mentioned facial dimensions (including the vertical occlusal dimension at rest) measured (both with and without the denture in the mouth).

Numerous studies concluded that the position of the mandible should not be the only factor considered when determining VDO due to the significant variation and instability of the mandible in the resting position. Individuals differ in their physiological resting positions, not only between dentists' determinations but even within and between sessions with the same patient. Numerous factors, including pain, fear, anxiety, lip activity, head posture, prosthesis wear, parafunctional habits, recording time, tissue weight, and the method used to achieve the resting position, have been found to influence this mandibular position [23]. Furthermore, the interocclusal distance can adjust to the VDO loss, masking and underestimating the VDO determined by the resting position [7].

Self-guided mandibular positioning methods and techniques (occlusal separator or progressive curve ruler) can be used, as well as electromyography to verify the centric relation and the resulting physiological inocclusion space [26].

Muscle activity measured by electromyography and bite force is unaffected by oral rehabilitation. VDO plays a significant role in bite force and water swallowing following oral function rehabilitation [26].

A useful technique for estimating DVO is the swallowing technique, which has a close connection with the mandibular movement trajectory during swallowing. The extension of the mandibular trajectory during swallowing may change if there is a greater than 3 mm increase in VDO (free or physiological inocclusion space) [27].

A new approach for determining VDO based on cephalometry revealed that it is possible to predict the location of Gn (Gnathion) by tracing four cephalometric landmarks: Nasion (N), Anterior Nasal Ridge (ANR), Porion (P), and Gonion (G). This can be done by using angular reconstruction. Consequently, it can be employed for determining the lack of measurements during the prosthetic replacement of missing teeth [28]. Lateral cephalometric radiographs have been the standard tool used in angular cephalometric reconstruction. Cephalometric analysis has undergone a three-dimensional (3D) revolution in the last ten years. The practice of using two-dimensional (2D) and 3D cephalometric data simultaneously in most applications is supported by the small differences in angular cephalometric values obtained from 2D lateral cephalograms and 3D CT reconstructions [29].

The quality of life and patient satisfaction with new dentures are enhanced when intermaxillary relationships are established accurately [30]. The distance between the chin and the nose septum is measured using the Willis occlusometer, also known as the Willis gauge [5], and can also be used to record the interocclusal freeway space [30].

The Knebelman craniometric method provides an almost optimal VDO value in occlusal harmony and balanced occlusion. It determines the eye-ear distance or the distance between the anterior wall of the auditory canal and the outer corner of the eye. The development of a predictive model that uses the right or left eye-to-ear distance to determine VDO in dentate and edentulous individuals is influenced by age, gender, and face type [18].

The measuring equipment can be improved or modified for increased repeatability in measurements. The craniometer can be altered by attaching air-bubble levels to the outside surface of the long arm and the lower surface of the nasal spine plate. These adjustments guarantee accurate craniometer positioning, both horizontally and vertically, when recording vertical occlusal dimensions [31].

When estimating the DVO in edentulous patients wearing complete dentures, the functional swallowing method and the craniometric method are in good agreement [18].

The two main determinants of masticatory function are bite force and the number of occlusal units for individuals with complete dentition or the occlusal contact area in partially edentulous individuals. Occlusal registration, achieved in the intercuspal position using a silicone material, is the most widely used technique for measuring the occlusal contact area [32]. There are now several new technologies

available for occlusal assessment. T-Scan is an automated system that captures the temporal distribution of occlusal contacts [33,34]. By using consecutive measurements in a laboratory setting, the method offers a trustworthy estimate of the total occlusal force and can also be used to analyze the bite pressure distribution in the dental arches, as an essential sign of the masticatory system's health is the biting force [35]. However, between the digital dentures and traditional dentures, no noticeable clinical variations were noticed [36].

A technique for improving recording precision can be obtained using one of the two main digital occlusal analyzers available (T-Scan and OccluSense), which method involves the use of digital occlusal detectors [34]. The occlusal contacts can be located with enough accuracy using both conventional techniques, like 100- and 200-µm articulating paper, and digital techniques, like T-Scan and virtual occlusion [37].

Even though the denture satisfies all traditional prosthetic requirements, not all wearers of full dentures can adjust to it. After a period of one year to five years, the wear of a complete denture is determined by several factors, including denture quality, user integrity and satisfaction, age, gender, marital status, education, family income, length of time since maxillary tooth loss, mandibular ridge height, and frequency of dental visits following prosthesis installation [38]. The primary determinants of complete prosthesis wear after one and five years are prosthetic quality and user satisfaction. After one year, the percentage of users who actually used their complete dentures increased with education level, satisfaction level, the presence of sufficient stability, and the existence of free functional space. Dropout rates are higher in the first year compared to other times. Five years later, users who were satisfied and had a stable denture were more likely to use their complete denture [1].

Among the limitations of the review are the small number of patients who were included in the studies and insufficient patient follow-up time. There is no standard or method to compare the effectiveness of the many different VDO measurement techniques.

There is a lack of clinical studies comparing the methods of VDO and CR evaluation in completely edentulous patients. Furthermore, insufficient research has been done on the long-term negative effects of errors or discrepancies in the applied measurement techniques. Further research and a longer, comprehensive follow-up will be necessary in the future.

CONCLUSION

In occlusal examination and prosthetic treatment, the maxillary and mandibular arches' relationship is still determined by the CR. There are numerous techniques for recording RC that have a small amount of variability and a high level of intra-technical repeatability. There may be differences in the accuracy of documentation of the expert evaluation of complete denture quality and patient comfort as determined by their subjective assessment. The clinician must select the approach that is most proficient from among the various approaches utilized to record VDO because there is no one standard technique. VDO values are correlated with several body and facial landmarks. Combined methods of determination of the VDO and CR are highly suggested to be used for increased clinal precision.

Conflict of interest: none declared
Financial support: none declared

REFERENCES

1. Zonnenberg AJJ, Türp JC, Greene CS. Centric relation critically revisited – What are the clinical implications? *J Oral Rehab.* 2021;48:1050-5. doi: 10.1111/joor.13215
2. De Moraes Melo Neto CL, Dos Santos DM, De Magalhães Bertoz AP, Moreno ALDM, Goiato MC. Comparison of Techniques for Obtaining Centric Relation Based on the Reproducibility of the Condylar Positions in Centric Relation – A Systematic Review. *Eur J Dent.* 2022;16:251-7. doi: 10.1055/s-0041-1735903
3. de Moraes Melo Neto CL, da Silva EVF, de Sousa Ervolino IC, Dos Santos DM, de Magalhães Bertoz AP, Goiato MC. Comparison of different methods for obtaining centric relation: a systematic review. *Gen Dent.* 2021;69:31-6. PMID: 33350953.
4. Satin SR, Goodacre BJ, Masri R. Comparing the accuracy of occlusal vertical dimension transfer in CAD–CAM dentures. *J Prosthodont.* 2023;jopr.13669. doi: 10.1111/jopr.13669
5. Geerts GAVM, Stuhlinger ME, Nel DG. A comparison of the accuracy of two methods used by pre-doctoral students to measure vertical dimension. *J Prosthet Dent.* 2004;91:59-66. doi: 10.1016/j.prosdent.2003.10.016
6. Igic M, Krunic N, Aleksov L, Kostic M, Igic A, Petrovic M, Dacic S, Igic S, Igic A. Determination of vertical dimension of occlusion by using the phonetic vowel "O" and "E". *VSP.* 2015;72:123-31. doi: 10.2298/VSP1502123I
7. Alhajj MN, Khalifa N, Abduo J, Amran AG, Ismail IA. Determination of occlusal vertical dimension for complete dentures patients: an updated review. J Oral Rehab. 2017;44:896-907. doi: 10.1111/joor.12522
8. Vinnakota D, Edamadaka N, Reddy Ps, Duggineni C. Comparison of patient satisfaction between complete dentures fabricated using "conventional" and "cephalometric angular reconstruction" vertical dimension procedures: A multicenter randomized clinical trial. *J Indian Prosthodont Soc.* 2022;22:82. doi: 10.4103/jips.jips_336_21
9. Enkling N, Enkling-Scholl J, Albrecht D, Bornstein MM, Schimmel M. Determination of the occlusal vertical dimension in edentulous patients using lateral cephalograms. *J Oral Rehab.* 2018;45:399-405. doi: 10.1111/joor.12624
10. Ribeiro AB, Pita MS, Ribeiro AB, Garcia AR, Junqueira Zuim PR. Effect of short-term increase in occlusal vertical dimension on masticatory muscle electrical activities and pressure-to-pain threshold: A crossover

clinical study. *J Prosth Dent.* 2022;128:970-6. doi: 10.1016/j.prosdent.2021.01.023
11. Tanaka Y, Sato H, Toyoda H, Saito M, Maeda Y, Kang Y. The mechanism for regulating the isometric contraction of masseter muscles is involved in determining the vertical dimension of occlusion. *J Neurophysiol.* 2023;129:211-9. doi: 10.1152/jn.00301.2022
12. De Sousa Ervolino IC, Goiato MC, De Moraes Melo Neto CL, De Caxias FP, Da Silva EVF, Túrcio KHL, Dos Santos DM. Clinical reproducibility of different centric relation recording techniques in edentulous individuals: An observational cross-sectional study. *J Prosthodont.* 2023;32:497–504. doi: 10.1111/jopr.13635
13. Goodacre B, Goodacre C, Baba N. Using Intraoral Scanning to Capture Complete Denture Impressions, Tooth Positions, and Centric Relation Records. *Int J Prosthodont.* 2018;31:377-81. doi: 10.11607/ijp.5741
14. Nitecka-Buchta A, Proba T, Proba P, Stefański K, Baron S. Functional Assessment of the Stomatognathic System, after the Treatment of Edentulous Patients, with Different Methods of Establishing the Centric Relation. *Pain Res Manag.* 2018;2018:1-9. doi: 10.1155/2018/1572037
15. Goiato MC, dos Santos DM, Monteiro DR. Joint sounds in complete denture wearers. Literature review. *NY State Dent J.* 2010;76:46-9. PMID: 20359066.
16. Bilhan H, Geckili O, Ergin S, Erdogan O, Ates G. Evaluation of satisfaction and complications in patients with existing complete dentures. *J Oral Sci.* 2013;55:29-37. doi: 10.2334/josnusd.55.29
17. Yoshino N, Nozaki K, Maeda Y. The effect of denture installation at mandibular rest position on unsteady motion of the centre of pressure in postural sway. *J Oral Rehab.* 2016;43:528-33. doi: 10.1111/joor.12400
18. Huamani J, Watanabe R, Huamani J, Salcedo-Moncada D, Alvitez-Temoche D, Mayta-Tovalino F. Accuracy between functional swallowing and Knebelman craniometric method to measure occlusal vertical dimension in total denture wearers: A quasi-experimental study. *J Int Soc Prevent Communit Dent.* 2021;11:152. doi: 10.4103/jispcd.JISPCD_380_20
19. Sushma R, Roy M, Sanyal P, Joshi A, Vande A, Kore A. A clinical comparative study to assess the efficacy of a new centric registration technique with a conventional technique. *J Indian Prosthodont Soc.* 2019;19:290. doi: 10.4103/jips.jips_126_19
20. Aredes JE, Fassina NA, Macchi RL. Centric relation registration with intraoral central bearing on curved vs. flat plates with rim trays in edentulous patients. *Acta Odontol Latinoam.* 2021;34:35-42. doi: 10.54589/aol.34/1/035. PMID: 34137776.
21. Thakur M, Jain V, Parkash H, Kumar P. A Comparative Evaluation of Static and Functional Methods for Recording Centric Relation and Condylar Guidance: A Clinical Study. *J Indian Prosthodont Soc.* 2012;12:175-81. doi: 10.1007/s13191-012-0154-5
22. Marin DOM, Leite ARP, De Oliveira Junior NM, Compagnoni MA, Pero AC, Arioli Filho JN. Reestablishment of Occlusal Vertical Dimension in Complete Denture Wearing in Two Stages. *Case Rep Dent.* 2015;2015:1-5. doi: 10.1155/2015/762914
23. Alhajj MN, Khalifa N, Amran A. Eye-rima oris distance and its relation to the vertical dimension of occlusion measured by two methods: Anthropometric study in a sample of Yemeni dental students. *Eur J Dent.* 2016;10:29-33. doi: 10.4103/1305-7456.175689. PMID: 27011736.
24. Goldstein G, Goodacre C, MacGregor K. Occlusal Vertical Dimension: Best Evidence Consensus Statement. *J Prosthodont.* 2021;30:12-9. doi: 10.1111/jopr.13315
25. Nagpal A, Parkash H, Bhargava A, Chittaranjan B. Reliability of Different Facial Measurements for Determination of Vertical Dimension of Occlusion in Edentulous Using Accepted Facial Dimensions Recorded from Dentulous Subjects. *J Indian Prosthodont Soc.* 2014;14:233-42. doi: 10.1007/s13191-013-0315-1
26. Pereira De Caxias F, Leal Túrcio KH, De Moraes Melo Neto CL, Florencio De Athayde FR, Coelho Goiato M, Micheline Dos Santos D. Effects of rehabilitation with complete dentures on bite force and electromyography of jaw and neck muscles and the correlation with occlusal vertical dimension. *Clin Oral Invest.* 2021;25:4691-8. doi: 10.1007/s00784-021-03783-1
27. Shen Y-F, Wei M-C, Li H-P, Pan Y-H, Hong H-H, Chen C-C, Kuo S-B, Ho C-Y, Chang C-T, Huang Y-F. Vertical dimension of occlusion related to mandibular movement during swallowing. *Biomedical J.* 2021;44:217-22. doi: 10.1016/j.bj.2019.12.006
28. Vinnakota D, Kamatham R. Estimation of occlusal vertical dimension using cephalometric angular reconstruction. *Indian J Dent Res.* 2021;32:31. doi: 10.4103/ijdr.IJDR_783_18
29. Jodeh DS, Kuykendall LV, Ford JM, Ruso S, Decker SJ, Rottgers SA. Adding Depth to Cephalometric Analysis: Comparing Two- and Three-Dimensional Angular Cephalometric Measurements. *J Craniofac Surg.* 2019;30:1568-71. doi: 10.1097/SCS.0000000000005555
30. Dervis E. The influence of the accuracy of the intermaxillary relations on the use of complete dentures: a clinical evaluation. *J Oral Rehab.* 2004;31:35-41. doi: 10.1046/j.0305-182X.2003.01214.x
31. Chou T-M, Moore DJ, Young L, Glaros AG. A diagnostic craniometric method for determining occlusal vertical dimension. *J Prosthet Dent.* 1994;71:568-74. doi: 10.1016/0022-3913(94)90439-1
32. Ayuso-Montero R, Mariano-Hernandez Y, Khoury-Ribas L, Rovira-Lastra B, Willaert E, Martinez-Gomis J. Reliability and Validity of T-scan and 3D Intraoral Scanning for Measuring the Occlusal Contact Area. *J Prosthodont.* 2020;29:19-25. doi: 10.1111/jopr.13096
33. Abutayyem H, M Annamma L, Desai VB, Alam MK. Evaluation of occlusal bite force distribution by T-Scan in orthodontic patients with different occlusal characteristics: a cross sectional-observational study. *BMC Oral Health.* 2023;23:888. doi: 10.1186/s12903-023-03544-4
34. Jauregi M, Amezua X, Iturrate M, Solaberrieta E. Improving the precision of recordings acquired with digital occlusal analyzers: A dental technique. *J Prosth Dent.* 2023;S0022391323005036. doi: 10.1016/j.prosdent.2023.08.001
35. Throckmorton GS, Rasmussen J, Caloss R. Calibration of T-Scan ® sensors for recording bite forces in denture patients. *J Oral Rehab.* 2009;36:636-43. doi: 10.1111/j.1365-2842.2009.01978.x
36. Peroz S, Peroz I, Beuer F, Von Stein-Lausnitz M, Sterzenbach G. Digital versus conventional complete dentures: A randomized, controlled, double-blinded crossover trial. *J Prosth Dent.* 2022;S0022391322002839. doi: 10.1016/j.prosdent.2022.04.023
37. Rovira-Lastra B, Khoury-Ribas L, Flores-Orozco E-I, Ayuso-Montero R, Chaurasia A, Martinez-Gomis J. Accuracy of digital and conventional systems in locating occlusal contacts: A clinical study. *J Prosth Dent.* 2023;S002239132300481X. doi: 10.1016/j.prosdent.2023.06.036
38. Araújo M, Martins M, Soares A, Carvalho L, Gomes V, E Ferreira E, Miranda Cota L, Senna M, Ferreira R. Relationship Between Quality of Complete Dentures and User Satisfaction at 1 and 5 Years Postinsertion. *Int J Prosthodont.* 2018;31:271-9. doi: 10.11607/ijp.5477