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# Methods for Determining The Central Jaw Ratio During Total Denture Replacement on Dental Implants

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**Abstract:** Determining the centric relation of the jaws (CRJ) is one of the key stages in the orthopedic treatment of patients with complete edentulism, especially when replacing prostheses. The distribution of masticatory load, implant stability, functional integration of prostheses, and the health of the temporomandibular joint (TMJ) all depend on the accuracy of CRJ registration. This article presents an analytical review of methods for determining CRJ, ranging from traditional mechanical and anatomical-physiological approaches to modern digital and axiographic technologies. The operating principles of electronic systems for recording mandibular movements (ARCUSdigma, Zebris, Cadiax), the features of the virtual articulator, and the effectiveness of integrating digital data into the prosthesis design process using CAD/CAM systems are discussed. A comparative analysis of the accuracy, reproducibility, and clinical applicability of various methods for implant-supported total prosthetics was conducted.

**Keywords:** Centric Relation, Dental Implants, Axiography, Virtual Articulator, Digital Prosthodontics, Orthopedic Dentistry, Functional Diagnostics

## Introduction

Determining the central jaw ratio (CSR) is one of the fundamental problems of orthopedic dentistry and gnathology. CSF reflects the most stable position of joint heads in joint pits with minimal masticatory muscle tone, ensuring the physiological balance of the dentofacial system [1,2].

With full prosthetics using dental implants, the importance of accurately recording CSF increases significantly. Unlike natural teeth, implants do not have periodontal receptors, which precludes physiological feedback and makes the accuracy of mechanical fixation a key factor in the durability of the structure [3]. The slightest deviation leads to uneven distribution of chewing load, overloading of individual support elements, micro-movements, and gradual resorption of the marginal bone [4,5].

In recent decades, with the development of digital technologies, new approaches have emerged to determining the maxillary sinus: electronic axiography, virtual articulators, intraoral scanners, as well as lower jaw movement analysis systems (KaVo ARCUSdigma II, Zebris JMA, Cadiax Compact, Prosystom Axiograph Life Package). These methods allow for recording motion dynamics in three planes with an accuracy of up to tenths of a millimeter, ensuring high reproducibility and objectivity [6,7,8].

The aim of the study is to conduct a clinical and analytical review of modern methods for determining the central ratio of the maxillae during complete prosthetics with implants, and to identify their advantages, limitations, and prospects for application in digital orthopedic practice.

## Methodology

A systematic analysis of domestic and foreign publications for 2000-2025 was conducted, which were included in the PubMed, Scopus, Web of Science, eLibrary.ru, and ResearchGate databases. The study included original clinical articles, reviews, experimental works, dissertation research, and guidelines on digital prosthetics.

Inclusion criteria: availability of a description of the SSC registration methodology; use in full removable prosthetics or prosthetics based on implants; assessment of accuracy, reproducibility, or biomechanical consequences; publication in English or Russian; biomechanical consequences; publication in English or Russian.

## Results and Discussion

Biomechanical foundations of the central ratio. Central ratio is the position of the mandible in which the heads of the temporomandibular joints are in an anterior-upper position relative to the articular fossae with an even distribution of intra-articular pressure [9,10,11,12]. This position is considered stable and physiological, regardless of the presence of teeth.

According to Slavicek and Buman, it is precisely the central ratio that serves as the only reproducible guide for constructing an occlusion in complete adentia. In the absence of tooth rows, periodontal reflexes do not participate in lower jaw positioning, and the stabilizing function passes to the muscles and joint complex. Errors in determining the central ratio can lead to chronic overload, CNS dysfunction, micromovements of implants, and loss of bone tissue around them [13,14].

***Classic anatomical and physiological methods***

Traditional methods include the methods of Pfennig, Gizi, Gottfried, Gerber, and Schiller. They are based on determining the central ratio by the splitting of movements, using Gothic arcs, or by the position of physiological rest.

Advantages: simplicity, accessibility, low cost.

Disadvantages: high subjectivity, dependence on the doctor's experience, and inability to accurately record in patients with impaired neuromuscular coordination [15,16,17].

The research of Gizi and Gerber laid the foundation for modern gnatographic approaches. However, even if the methodology is followed, the error may reach ±1.5 mm in the horizontal plane and ±0.7 mm in the vertical plane, which is unacceptable during implantation [18,19].

The transition to functional gnathology has increased the accuracy of registration. Modern articulators (Artex, Denar, SAM, KaVo PROTAR) mimic real movements of the lower jaw based on individual parameters.According to Korda M. (2018), the use of a facial arc and an individually tuned articulator reduces the risk of occlusive errors during prosthesis manufacturing by 30-35%. The gnathological approach ensures the alignment of the occlusal plane with anatomical landmarks (Kampfer's plane, interorbital line) and minimizes the risk of discrepancies between jaw positions in the articulator and in the oral cavity.

However, even with a gnathological approach, the human factor remains, limiting reproduction, especially in cases of complete adentia [20,21,22].

Electronic axiography and motion recording of the lower jaw

Electronic axiography is a method of three-dimensional recording of the movement trajectory of joint heads using ultrasonic or optical sensors.

The most common are the following systems:

• KaVo ARCUSdigma II (Germany) - ultrasonic recording, accuracy up to 0.1 mm;
• Zebris JMA (Germany) - optical system with infrared sensors;
• Gamma Cadiax Compact (Austria) - mechanical-optical system;
• Prosystom Axiograph Life (Russia) - a domestic development compatible with CAD/CAM.

According to O. Schefer (Schaefer O., 2021), the average error of SSI registration using ARCUSdigma is 0.18 ± 0.04 mm, which is an order of magnitude higher than the accuracy of traditional methods. ± 0.04 mm, which is an order of magnitude higher than the accuracy of traditional methods.

Axiography allows for the collection of the following data:

• Angles of the joint pathways (sagittal and Bennett);
• Symmetry and synchrony of movements;
• Laterotrusion and protrusion amplitude;
• Identify functional disorders of the temporomandibular joint before prosthetics.

These parameters are integrated into the KaVo KiD or Zebris WinJAW software, after which they are exported to the CAD/CAM system (Exocad, 3Shape). This ensures the perfect reproduction of functional movements in the virtual articulator and allows for the formation of individual occlusion [23,24].

Digital and Virtual Methods

Modern CAD/CAM technologies allow for the complete elimination of the subjective factor. The central ratio of the jaws is determined using:

• Intraoral scanners (3Shape TRIOS, Medit i700);
• Occlusion analysis systems (T-Scan III, Tekscan Inc.);
• Virtual articulators (3Shape, Exocad, dentalcad).

The axiography and scanning data are integrated into a single virtual model. A doctor and a technician can work synchronously in a digital environment, modeling occlusive contacts in the position of the central jaw relationship.

Research by Kim Y. (Kim Y., 2022) and Rozov R. (Rozov R., 2023) showed that using a digital axiograph in combination with CAD/CAM reduces the frequency of clinical corrections for prostheses by 40%, improves the uniformity of occlusive contacts by 25%, and reduces treatment time by an average of 30%.

Thus, the digital determination of the central jaw ratio is the most accurate, objective, and reproducible method in modern orthopedic dentistry, especially for complete prosthetics based on implants.

Modern approaches to determining the central ratio during implant prosthetics reflect the transition from empirical to objectively measurable technologies. Axiographic systems allow for the modeling of real kinematic jaw parameters, while integration with CAD/CAM allows for the creation of fully individualized orthopedic structures[25,26].

Recent studies confirm that the use of axiography in combination with a digital articulator increases the accuracy of recording the central ratio, reduces the risk of functional overload, and extends the service life of prostheses and implants.

However, the high cost of equipment, the need for training, and the complexity of data analysis limit the widespread implementation of these technologies, especially in developing countries. The development of machine learning-based automated software systems capable of predicting individual parameters of the central ratio based on axiography and MRI data of the temporomandibular joint remains a promising direction.

**Conclusion**

Determining the central ratio of the jaws during complete prosthetics with implants is a critical stage that determines the success of orthopedic treatment. Traditional methods, despite their simplicity, do not provide the necessary accuracy and reproducibility. Electronic axiography and digital methods allow for the objectification of the registration process and the integration of the obtained data into the digital modeling of prostheses.

The joint use of axiography and CAD/CAM is currently the "gold standard" in digital orthopedics. This approach ensures physiologically justified lower jaw position, even distribution of chewing load, and long-term stability of implants.

The prospects for further research are linked to the implementation of artificial intelligence technologies and the automatic verification of axiographic data to optimize the CS determination process and reduce clinical time.

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