Comparative evaluation of traditional and digital methods for recording centric occlusion in prosthodontics

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Abstract: The accurate determination of centric occlusion is a fundamental prerequisite for the success of prosthodontic treatment. This article presents a comparative analysis of traditional clinical methods and emerging digital techniques used to register centric occlusion. Traditional methods, such as wax occlusion rims, bite registration pastes, and intraoral records, remain widely applied but are limited by operator dependence and reduced reproducibility. Digital technologies, including intraoral scanners and computerized jaw tracking systems, provide objective and reproducible measurements with enhanced diagnostic precision. The study analyzes the strengths and limitations of each approach and underscores the potential of combining conventional clinical experience with digital innovations to achieve optimal treatment outcomes in prosthodontics.

Keywords: centric occlusion, prosthodontics, digital dentistry, occlusal registration, clinical methods

Introduction

The accurate determination and registration of centric occlusion (CO) represent a fundamental stage in prosthodontic rehabilitation, since even minor errors in recording mandibular position may lead to occlusal disharmony, temporomandibular joint dysfunction, impaired masticatory efficiency, and reduced patient satisfaction. For decades, clinical practice has relied on conventional methods - wax registrations, functional techniques, and instrumental approaches - to establish the relationship between the maxilla and mandible. These methods, although widely used, are associated with operator dependence, limited reproducibility, and insufficient objectivity, which collectively restrict the reliability of treatment outcomes.

The rapid advancement of digital technologies has significantly transformed dental practice, including the field of occlusal analysis and registration. Intraoral scanning, computer-assisted design/manufacturing (CAD/CAM), T-Scan systems for occlusal force analysis, and virtual articulators provide clinicians with new opportunities to achieve a higher degree of accuracy, reproducibility, and efficiency. Digital systems also allow for dynamic visualization of occlusal contacts, arch relationships, and functional movements, thereby facilitating comprehensive diagnosis and individualized treatment planning.

However, the implementation of digital technologies does not fully eliminate the relevance of traditional approaches. In many clinical situations, wax or functional registrations remain indispensable, particularly in resource-limited settings or when managing patients who cannot tolerate digital procedures. Therefore, the contemporary trend is not the complete replacement of

conventional methods, but rather their integration with modern digital workflows to optimize clinical outcomes.

The present study analyzes the current methods of recording and fixing centric occlusion, highlighting their advantages and limitations, and emphasizing the clinical significance of digital technologies as a progressive step in the modernization of prosthodontic practice.

Materials and Methods

Traditional Methods of Recording Centric Occlusion

Conventional techniques remain the cornerstone of clinical prosthodontics, as they provide an accessible and cost-effective means of recording mandibular position. Among these, the wax registration method is the most widespread. This approach involves the use of softened wax sheets placed between the occlusal surfaces of the teeth, after which the patient is guided to close in the desired position. The wax then cools and hardens, fixing the interocclusal relationship. While widely applied, this method is highly dependent on operator skill and patient cooperation. Moreover, the material itself is prone to deformation during removal, cooling, and storage, which may compromise accuracy.

Functional methods are based on guiding the mandible into centric occlusion through repeated closure movements and controlled neuromuscular positioning. Techniques such as swallowing, phonetic tests, or chewing simulation are used to capture the physiologically determined position of the mandible. These methods can provide valuable insight into dynamic function and neuromuscular coordination. However, they often lack reproducibility and objectivity, since subtle variations in mandibular trajectory or operator guidance can significantly affect the registration.

Instrumental methods, including mechanical articulators and face-bow transfers, are designed to replicate the spatial relationships between the maxilla and mandible outside the oral cavity. These devices facilitate the analysis of occlusal contacts, mandibular movements, and articulatory dynamics. Despite their importance in complex restorative cases, their use requires significant clinical experience and involves multiple stages of laboratory transfer, each of which may introduce potential error.

Overall, traditional methods continue to play an important role in clinical practice. Nevertheless, their inherent limitations - subjectivity, susceptibility to material distortion, and operator dependence - highlight the necessity for modern technological integration to improve accuracy and reproducibility in prosthodontic rehabilitation.

Digital Methods of Recording Centric Occlusion

Recent advances in digital dentistry have significantly transformed the registration of mandibular position, offering greater accuracy, reproducibility, and clinical efficiency compared with traditional approaches. Intraoral scanning systems, which rely on optical acquisition of dental surfaces, allow precise three-dimensional reproduction of occlusal contacts. These scans can be directly integrated into computer-aided design and manufacturing (CAD/CAM) workflows, reducing the risk of material distortion and eliminating the need for multiple laboratory transfers.

One of the most widely used technologies is the T-Scan system, which provides dynamic registration of occlusal contacts with temporal and force distribution analysis. Unlike static methods, T-Scan captures the sequence of contact events during closure, enabling clinicians to evaluate occlusal balance and identify premature contacts or excessive load distribution. Such data are particularly valuable in prosthodontic rehabilitation, implantology, and occlusion-related pathology, where precise adjustment of occlusal forces is critical for long-term treatment success.

Digital face-bow transfers and virtual articulators further enhance the accuracy of intermaxillary records. By integrating cone-beam computed tomography (CBCT) data with intraoral

scans, clinicians can replicate the anatomical and functional relationships of the maxilla and mandible in a virtual environment. This digital simulation allows for predictive modeling of mandibular movements, occlusal stability, and prosthetic fit prior to clinical implementation.

The integration of artificial intelligence (AI) into digital occlusal analysis has introduced new opportunities for automated error detection, predictive diagnostics, and individualized treatment planning. AI-driven software can process large datasets of occlusal recordings, identifying subtle patterns of dysfunction that may not be visible through conventional evaluation.

Despite these advantages, digital systems are associated with high equipment costs, the need for specialized training, and reliance on software accuracy. Nevertheless, the objectivity, reproducibility, and data integration they provide make digital technologies an essential component of contemporary prosthodontics. Their use not only enhances diagnostic precision but also contributes to more predictable clinical outcomes, ultimately improving the quality of patient care.

Comparative Analysis of Traditional and Digital Methods

The transition from conventional to digital techniques in recording centric occlusion reflects broader trends in dentistry toward precision and evidence-based practice. Traditional wax registration, while historically widespread, is characterized by subjectivity and variability. Its accuracy is often limited by material properties such as polymerization shrinkage, susceptibility to deformation during removal, and dimensional instability over time. Furthermore, interpretation of occlusal contacts in static conditions does not account for the dynamic nature of mandibular function, frequently leading to clinical adjustments during prosthetic delivery.

Digital methods address many of these limitations by introducing standardized, quantifiable, and reproducible measurements. Intraoral scanning and T-Scan technology eliminate distortions associated with impression and cast manipulation. Virtual articulators and CBCT integration provide functional simulations that are unattainable through purely mechanical devices. These innovations allow clinicians to predict potential occlusal interferences and plan restorative or prosthetic treatment with greater precision.

However, digital techniques do not completely replace conventional methods. In certain clinical settings - particularly where access to advanced equipment is limited or financial constraints exist - traditional approaches remain practical. Moreover, digital systems require substantial investment, regular software updates, and clinician training, which may restrict their widespread implementation.

The most effective strategy in contemporary prosthodontics may lie in combining both modalities. Conventional techniques provide an accessible foundation, while digital systems refine and validate records with enhanced precision. This hybrid model allows practitioners to maximize diagnostic reliability while adapting to the practical realities of different clinical environments.

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Discussion and Clinical Implications

The choice between traditional and digital methods for recording centric occlusion has direct implications for diagnostic accuracy, treatment planning, and long-term prosthetic success. Errors in occlusal registration remain one of the primary causes of prosthesis failure, postoperative discomfort, and temporomandibular joint dysfunction. Therefore, reliable assessment of occlusal relationships is fundamental to restorative and prosthodontic practice.

Digital technologies represent a paradigm shift by enabling clinicians to visualize occlusal contacts in real time, quantify force distribution, and simulate mandibular dynamics under functional loading. Such precision facilitates individualized treatment planning, particularly in complex rehabilitation cases, where even minimal discrepancies can compromise prosthetic stability. Importantly, digital systems also contribute to improved patient communication, as visual data allow patients to better understand the rationale for treatment interventions.

Nevertheless, the transition to digital workflows must be approached critically. Overreliance on technology without clinical judgment risks misinterpretation of data. Traditional clinical skills - palpation, tactile feedback, and functional analysis - remain essential for validating digital findings. Furthermore, limited accessibility in certain regions underscores the continued relevance of conventional methods, which, when applied correctly, still yield clinically acceptable outcomes.

The integration of traditional and digital approaches should therefore be viewed not as a replacement but as a complementary process. By combining the strengths of both systems, clinicians can achieve higher diagnostic accuracy, optimize occlusal rehabilitation strategies, and ultimately improve patient satisfaction and quality of life.

Conclusion

The comparative analysis of traditional and digital methods for recording centric occlusion demonstrates that both approaches maintain clinical value, though with differing strengths and limitations. Traditional techniques, while time-tested and accessible, are subject to operator variability and lack quantitative precision. Digital technologies, on the other hand, provide objective measurements, dynamic visualization, and reproducibility, thereby enhancing diagnostic accuracy and facilitating individualized prosthodontic treatment.

The evidence suggests that the optimal strategy lies in the integration of conventional clinical expertise with advanced digital tools. Such a hybrid approach ensures both accuracy and accessibility, reduces the likelihood of occlusal errors, and promotes long-term functional stability of prosthetic restorations. Future research should focus on refining digital protocols, expanding accessibility, and validating their clinical efficacy across diverse patient populations.

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