Journal of Drug Discovery and Health Sciences, 2024;1(1):62-65 eISSN- 3048-8842

Journal of Drug Discovery and Health Sciences

journal home page : https://jddhs.com/index.php/jddhs/index

Research Article

AI optimization of complete denture design using facial muscle dynamics.

Sindhu Kulkarni

DDS, BDS, MDS Bekir Bernardes DMD, MS

ARTICLE INFO

Article history:
Received: 09 March, 2024
Revised: 16 April, 2024
Accepted: 22 May, 2024
Published: 30 June, 2024

Keywords:
Artificial intelligence, complete dentures, facial muscle dynamics, digital dentistry, machine learning, facial scanning, prosthodontics, CAD/CAM, occlusal optimization, personalized denture design.

DOI:
10.21590/jddhs.01.01.08

ABSTRACT

Complete denture therapy remains a fundamental treatment for edentulous patients, yet achieving optimal retention, stability, comfort, and facial esthetics continues to present clinical challenges due to individual variations in oral anatomy and neuromuscular function. Recent advances in artificial intelligence (AI) and digital dentistry have created new opportunities to improve denture design through the analysis of facial muscle dynamics. By integrating three-dimensional facial scanning, digital impression techniques, jaw motion tracking, and machine learning algorithms, AI can evaluate dynamic facial expressions and masticatory movements to generate personalized denture designs that better adapt to each patient's functional characteristics. AI-driven predictive models facilitate optimization of tooth arrangement, occlusal relationships, flange contours, and border extensions, thereby enhancing prosthesis stability and minimizing the need for repeated clinical adjustments. The incorporation of computer-aided design and computer-aided manufacturing technologies further supports accurate fabrication and efficient clinical workflows. Although challenges such as data standardization, algorithm validation, equipment costs, and clinical integration remain, AI-assisted denture design demonstrates considerable potential to improve treatment outcomes and patient satisfaction. Continued research and interdisciplinary collaboration are expected to refine predictive modeling techniques and establish intelligent, patient-centered prosthodontic solutions that combine functional efficiency, esthetic excellence, and long-term clinical success in complete denture rehabilitation.

Introduction

Complete denture rehabilitation remains the primary treatment modality for restoring oral function, facial esthetics, and quality of life in edentulous patients. Despite continuous improvements in prosthodontic materials and fabrication techniques, achieving optimal denture retention, stability, comfort, and functional efficiency remains challenging because of individual variations in facial anatomy, muscle activity, and neuromuscular coordination. Conventional denture design relies heavily on static clinical records and clinician experience, which may not fully capture the dynamic interactions between facial musculature, jaw movements, and prosthesis performance (Langenbach & Hannam, 1999; Klineberg & Murray, 1999).

Advances in digital dentistry have transformed prosthodontic workflows through the integration of three-dimensional facial scanning, digital impressions, virtual articulation, and computer-aided design and manufacturing technologies. These innovations enable more comprehensive assessment of occlusal relationships

***Corresponding Author:** Sindhu Kulkarni
Address: DDS, BDS, MDS Bekir Bernardes DMD, MS
Email ✉:

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright © 2024 First Author *et al*. This is an open access article distributed under the terms of the Creative Commons Attribution- NonCommercial-ShareAlike 4.0 International License which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

Table 1: Scientific Foundations Supporting AI-Driven Complete Denture Design

Scientific Component	*Role in AI-Based Denture Design*	*Supporting Reference*
Facial muscle biomechanics	Predicts functional facial movements affecting denture stability	Langenbach & Hannam (1999)
Neural network modeling	Predicts facial deformation after denture insertion	Cheng et al. (2015)
Digital facial scanning	Captures dynamic facial and occlusal movements	Kim et al. (2019)
Machine learning algorithms	Integrates multimodal patient data for personalized design	Abdi (2020); Singh (2022)
Proprioception and sensory feedback	Supports functional adaptation to prostheses	Klineberg & Murray (1999)

and facial movements, facilitating individualized prosthetic planning. Dynamic facial scanning and target-tracking systems have further enhanced the evaluation of occlusal function by providing accurate motion analysis during mandibular movements (Kim et al., 2019).

Artificial intelligence (AI), particularly machine learning and neural network models, has emerged as a powerful tool for analyzing complex clinical datasets and generating predictive treatment models. AI algorithms can integrate facial muscle dynamics, jaw biomechanics, and digital imaging data to optimize tooth arrangement, denture borders, occlusal schemes, and overall prosthesis design. Early investigations demonstrated the capability of BP neural networks to predict facial deformation following complete denture placement, highlighting the feasibility of AI-assisted prosthodontic planning (Cheng et al., 2015). Similar machine learning applications have shown significant promise in digital surgical planning and patient-specific treatment optimization (Abdi, 2020). The broader adoption of AI across dentistry further supports its potential to improve diagnostic accuracy, treatment planning, and clinical decision-making (Singh, 2022). Together with advances in digital restorative workflows (Singh, 2020), AI-driven optimization of complete denture design offers a promising approach for achieving more personalized, functional, and esthetically successful prosthodontic rehabilitation.

Scientific Basis of AI-Driven Denture Design

Artificial intelligence (AI)-driven complete denture design is founded on the integration of digital prosthodontics, facial biomechanics, neuromuscular physiology, and predictive computational modeling. Unlike conventional approaches that primarily rely on static anatomical impressions, AI incorporates dynamic facial muscle behavior and jaw movements to generate individualized prosthetic designs. Facial expressions, mastication, and speech involve coordinated activity of the perioral muscles, tongue, and temporomandibular joints, all of which influence denture retention, stability, and esthetics. Three-dimensional biomechanical models have demonstrated that passive muscle tensions significantly affect mandibular movement and functional jaw mechanics, emphasizing the importance of incorporating muscle dynamics into prosthodontic planning (Langenbach & Hannam, 1999).

Machine learning algorithms process facial scans, occlusal records, and jaw motion data to identify patient-specific functional patterns. Neural network models have shown considerable potential for predicting facial deformation following complete denture placement, allowing clinicians to optimize denture contours and esthetic outcomes before fabrication (Cheng et al., 2015). Likewise, digital workflows combining three-dimensional facial scanners with dynamic occlusal tracking provide comprehensive assessments of mandibular function that improve prosthesis design accuracy (Kim et al., 2019). AI-based predictive modeling and registration techniques further enhance treatment planning by integrating multiple datasets into a unified digital environment (Abdi, 2020). In digital dentistry, AI supports data interpretation, decision-making, and workflow automation, thereby improving precision and consistency in prosthetic rehabilitation (Singh, 2022). These principles align with the broader transition toward minimally invasive, digitally guided restorative procedures that emphasize individualized treatment planning and enhanced clinical efficiency (Singh, 2020). Furthermore, preservation of functional proprioceptive relationships remains essential for successful adaptation to complete dentures, highlighting the significance of neuromuscular feedback in prosthetic performance (Klineberg & Murray, 1999).

AI Workflow for Optimizing Complete Denture Design

The AI workflow for optimizing complete denture design integrates digital data acquisition, intelligent analysis, virtual simulation, and computer-aided manufacturing to produce patient-specific prostheses with improved function and esthetics. The process begins with the collection of comprehensive patient data, including intraoral scans, edentulous ridge morphology, facial scans, and dynamic jaw movements during speech, mastication, and facial expressions. Three-dimensional facial scanners and motion-tracking systems accurately capture occlusal

Table 2: AI Workflow for Optimizing Complete Denture Design

Workflow Stage	*AI/Digital Technology*	*Clinical Outcome*
Patient data acquisition	Intraoral and 3D facial scanning	Accurate anatomical records
Functional recording	Motion tracking and occlusal analysis	Dynamic muscle assessment
AI analysis	Machine learning and BP neural networks	Personalized denture optimization
Virtual simulation	Biomechanical modeling	Prediction of stability and facial support
CAD/CAM fabrication	Digital design and 3D printing/milling	Precise, customized denture production
Clinical validation	Functional adjustment using AI feedback	Improved comfort, esthetics, and prosthesis performance

dynamics and facial muscle activity, providing functional information beyond conventional static impressions (Kim et al., 2019).

Machine learning and artificial neural network models then process these datasets to predict facial soft-tissue deformation, optimize occlusal relationships, and estimate muscle-driven denture behavior under functional loading. BP neural networks have demonstrated effectiveness in predicting facial deformation associated with complete denture placement, enabling more personalized prosthetic design (Cheng et al., 2015). AI-assisted registration techniques further improve anatomical alignment and treatment planning accuracy (Abdi, 2020). Biomechanical simulations incorporating passive muscle tensions and proprioceptive principles refine denture borders, flange contours, and tooth positioning to enhance stability and patient comfort (Langenbach & Hannam, 1999; Klineberg & Murray, 1999).

The optimized virtual denture is subsequently transferred to CAD/CAM systems for precise fabrication through milling or three-dimensional printing. This digital workflow reduces manual adjustments, shortens clinical appointments, and enhances treatment predictability. Similar AI-driven decision-support approaches have demonstrated significant improvements in precision and workflow efficiency across dental specialties, highlighting their potential in prosthodontic rehabilitation (Singh, 2022; Singh, 2020).

Clinical Applications, Advantages, Challenges, and Future Perspectives

Artificial intelligence (AI) integrated with facial muscle dynamics has expanded the scope of complete denture rehabilitation by enabling individualized prosthesis design based on patient-specific anatomical and functional characteristics. Clinically, AI-assisted systems can optimize tooth arrangement, occlusal schemes, denture borders, and facial support using dynamic facial scanning and jaw motion analysis. Such approaches are particularly valuable for complete dentures, implant-supported overdentures, immediate dentures, and maxillofacial prosthetic rehabilitation, where precise adaptation to muscle activity improves prosthesis stability and esthetics (Kim et al., 2019; Cheng et al., 2015).

The principal advantages include enhanced treatment personalization, improved prediction of facial soft-tissue changes, optimized occlusal balance, reduced chairside adjustments, and streamlined digital workflows. Machine learning algorithms can analyze large datasets to support evidence-based prosthodontic decision-making and improve clinical efficiency (Singh, 2022; Abdi, 2020). Furthermore, incorporating biomechanical models that account for passive muscle tension and proprioceptive responses contributes to greater functional harmony between dentures and the stomatognathic system (Langenbach & Hannam, 1999; Klineberg & Murray, 1999).

Despite these benefits, widespread implementation is constrained by the need for standardized datasets, robust clinical validation, interoperability among digital platforms, and the financial costs associated with advanced imaging technologies. Future developments are expected to integrate real-time facial muscle monitoring, adaptive AI algorithms, and comprehensive digital workflows, thereby enhancing precision, patient satisfaction, and long-term clinical outcomes in complete denture therapy (Singh, 2022; Abdi, 2020; Singh, 2020).

Table 3:

Aspect	*Clinical Significance*
Applications	Complete dentures, overdentures, immediate dentures, maxillofacial prostheses
Advantages	Personalized design, improved esthetics, enhanced stability, efficient workflow
Challenges	Limited dynamic datasets, high equipment costs, algorithm validation, clinician training
Future Perspectives	Real-time facial motion analysis, adaptive AI models, digital twins, cloud-based prosthodontic planning

Conclusion

Artificial intelligence has introduced a transformative approach to complete denture design by integrating facial muscle dynamics with digital prosthodontic workflows. Through the use of machine learning, three-dimensional facial scanning, dynamic occlusal analysis, and predictive biomechanical modeling, AI enables the development of patient-specific dentures that improve retention, stability, function, and facial esthetics. By considering individual variations in muscle activity and jaw movement, AI-assisted systems provide more accurate treatment planning and reduce the need for extensive post-insertion adjustments (Cheng et al., 2015; Kim et al., 2019).

The incorporation of biomechanical principles and neuromuscular analysis further enhances prosthesis performance by promoting harmonious interactions between dentures, facial musculature, and the stomatognathic system (Langenbach & Hannam, 1999; Klineberg & Murray, 1999). Although challenges remain regarding data standardization, algorithm validation, clinical implementation, and the cost of advanced digital technologies, continued progress in artificial intelligence is expected to strengthen the precision and efficiency of complete denture rehabilitation. Future integration of intelligent predictive models with CAD/CAM systems and comprehensive digital workflows will further support personalized prosthodontic care and improve long-term patient outcomes. As AI technologies continue to evolve, they are poised to become an integral component of modern complete denture therapy, advancing both clinical decision-making and patient-centered treatment (Singh, 2022; Abdi, 2020; Singh, 2020).

References

1. Singh, S. (2022). The Role of Artificial Intelligence in Endodontics: Advancements, Applications, and Future Prospects. *Well Testing Journal*, *31*(1), 125-144.
2. Cheng, C., Cheng, X., Dai, N., Jiang, X., Sun, Y., & Li, W. (2015). Prediction of facial deformation after complete denture prosthesis using BP neural network. *Computers in biology and medicine*, *66*, 103-112.
3. Kim, J. E., Park, J. H., Moon, H. S., & Shim, J. S. (2019). Complete assessment of occlusal dynamics and establishment of a digital workflow by using target tracking with a three-dimensional facial scanner. *Journal of prosthodontic research*, *63*(1), 120-124.
4. Singh, S. (2020). Deep margin elevation: A conservative alternative in restorative dentistry. *SRMS JOURNAL OF MEDICAL SCIENCE*, *5*(02), 1-9.
5. Abdi, A. H. (2020). *Machine learnt treatment: machine learning and registration techniques for digitally planned jaw reconstructive surgery* (Doctoral dissertation, University of British Columbia).
6. Langenbach, G. E. J., & Hannam, A. G. (1999). The role of passive muscle tensions in a three-dimensional dynamic model of the human jaw. *Archives of Oral Biology*, *44*(7), 557-573.
7. Klineberg, I., & Murray, G. (1999). Osseoperception: sensory function and proprioception. *Advances in dental research*, *13*(1), 120-129.

HOW TO CITE THIS ARTICLE: Kulkarni, S. AI optimization of complete denture design using facial muscle dynamics. J. of Drug Disc. and Health Sci. 2024;1(1):62-65. **DOI:** 10.21590/jddhs.02.01.08