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Clinical and Technological Aspects of Applying Digital Technologies in the Manufacturing of Complete Removable Proteses

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Abstract: In modern orthopedic dentistry, there is an active implementation of digital technologies aimed at increasing the accuracy, functionality, and clinical effectiveness of fully removable prostheses. The purpose of this work is an analytical review of domestic and foreign scientific research devoted to the comparative assessment of analog and digital methods for manufacturing complete removable prostheses.

Keywords: Complete Removable Dentures, CAD/CAM, 3D Printing, PMMA, Digital Dentistry, Orthopedic Dentistry.

Introduction

Complete absence of teeth remains one of the urgent problems of orthopedic dentistry, significantly affecting the quality of life of patients, the functional state of the chewing apparatus, and the psycho-emotional status. Despite the development of implantological rehabilitation methods, complete removable prostheses continue to be widely used, especially in patients with medical contraindications, limited anatomical conditions, or economic factors. The analysis included publications from 2015-2025, indexed in the PubMed, Scopus, ScienceDirect, eLIBRARY databases, as well as materials from domestic sources. Three main prosthetic manufacturing technologies were considered: the traditional analog method, CAD/CAM milling from monolithic PMMA blocks, and additive 3D printing technologies using photopolymer and hybrid resins.

Comparative assessment was carried out according to the following criteria: accuracy of base fit, biocompatibility of materials, aesthetic characteristics, manufacturing speed, patient comfort, cost, and duration of the adaptation period. Literature analysis has shown that digital technologies, especially CAD/CAM milling, provide a more stable geometry of the structure, reduce the adaptation time of patients, and improve hygienic indicators compared to traditional methods. 3D printing demonstrates comparable accuracy and high manufacturing speed, but requires further study in terms of material durability.

The obtained data confirm the feasibility of introducing digital protocols into the clinical practice of orthopedic dentistry and justify the need for further research aimed at optimizing the technologies for manufacturing complete removable prostheses.

Traditional analog methods of making complete removable prostheses have demonstrated clinical reliability and predictability over decades. However, the multi-stage nature of the technological process, the polymerization shrinkage of acrylic materials, the porosity of the base, and the long adaptation period of patients limit the possibilities of improving the quality of orthopedic treatment.

In recent years, orthopedic dentistry has been undergoing an active digital transformation. The introduction of CAD/CAM technologies and additive production methods has opened up new prospects in the manufacture of removable prostheses, allowing for increased fit accuracy, reduced human intervention, and shortened clinical and laboratory stages. Milling from monolithic PMMA blocks ensures structural shape stability and improved hygienic properties, while 3D printing is characterized by high production speed and economic efficiency.

Despite the increasing number of studies devoted to digital technologies in orthopedic dentistry, data on the comparative effectiveness of various methods for manufacturing complete removable dentures remain fragmented and require systematization. In this regard, an analytical assessment of analog and digital technologies from the perspective of clinical and laboratory characteristics, patient adaptation, and the operational properties of dentures is a pressing task.

The purpose of this work is to conduct an analytical review of modern domestic and foreign research aimed at comparative assessment of traditional and digital technologies for making complete removable prostheses, with the aim of substantiating the most promising areas of their clinical application.

Materials and Methods

This work represents an analytical review of domestic and foreign research published between 2015 and 2025, dedicated to the technologies of making fully removable prostheses. Publications from PubMed, Scopus, eLIBRARY, ScienceDirect databases, as well as domestic sources, were included in the analysis.

The main focus was on three main methods:

- Analog technology (traditional acrylic casting),
- CAD/CAM milling from monolithic PMMA blocks,
- 3D printing using photopolymers and hybrid resins.

The following criteria were used for comparison: accuracy of fit, biocompatibility, aesthetics, manufacturing speed, patient comfort, cost, and adaptation duration.

Results and Discussion

The traditional methodology includes sequential clinical stages: anatomical and functional impressions, determination of occlusal relationships, tooth placement, and base pressing. Despite its long-term clinical reliability, this method is susceptible to polymerization shrinkage of up to 1.2%, which worsens adhesion and leads to base deformation [7]. Additionally, the material's high porosity contributes to microflora adhesion and accelerated wear.

Milling from solid PMMA blocks eliminates polymerization processes and ensures stable geometry. The surface of such dentures has less microscopic roughness, which reduces the adhesion of Candida albicans and improves hygienic indicators. Clinical studies have shown that the average adaptation period to dentures is 7-10 days, while with traditional methods, it reaches up to 21 days [8].

Furthermore, digital modeling allows for the precise restoration of interalveolar relationships and the creation of optimal occlusal contacts, minimizing the risk of traumatic occlusion.

3D printed prostheses

3D printing (additive technologies) is becoming increasingly in demand in orthopedic dentistry due to its high accuracy and cost-effectiveness. The use of new generation photopolymer and acrylic resins allows for obtaining biocompatible and aesthetically pleasing designs.

Studies have shown that in 3D printing, the base alignment accuracy is 0.05-0.1 mm, comparable to the milling results [9]. The advantage is the high production speed - the full cycle can take less than 24 hours. However, the limitation remains the relatively low strength of photopolymers during long-term operation and the possible color change when exposed to ultraviolet.

Table 1. Comparative characteristics of methods.

Parameter	Analog methods	CAD/CAM milling	3D printing
Accuracy of alignment	±0.8-1.2 mm	±0.05-0.1 mm	±0.05-0.1 mm
Surface roughness	High	Low	Average

Bioavailability	Average	High	High
Material porosity	Up to 3%	<0.5%	<1%
Manufacturing period	5-7 days	2-3 days	1 day
Adaptation period	14-21 days	7-10 days	10-12 days
Aesthetics and Color Stability	Moderate	High	Average
Cost	Low	Average	Low
Structure strength	Average	High	Moderate
Necessity of equipment	Minimum	High	High

The analysis results confirm that digital technologies significantly surpass traditional methods in a number of parameters: accuracy, aesthetics, stability, and reproducibility of results. CAD/CAM prostheses demonstrate the best accuracy and durability, while 3D printing provides high manufacturing speed and low cost, making it a promising direction for mass prosthetics.

Nevertheless, analog methods retain their clinical significance - especially in conditions where resources are limited or there is no access to digital equipment.

Modern trends are aimed at integrating hybrid approaches - combining digital design and traditional manual refinement, which allows achieving optimal balance between accuracy and patient's individual adaptation.

Conclusion

Modern methods of making fully removable prostheses demonstrate significant progress through the implementation of CAD/CAM and 3D technologies. These methods ensure higher quality, accuracy, and predictability of treatment, increasing patient comfort and satisfaction. In the near future, further improvement of digital technologies is expected - the integration of artificial intelligence, the improvement of polymer strength, and the development of new bioadaptive materials capable of ensuring the long-term stability of orthopedic structures.

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