НАУЧНЫЙ ЖУРНАЛ
НАУКА И МИРОВОЗЗРЕНИЕ

УДК-616.314

INTEGRATION OF ARTIFICIAL INTELLIGENCE IN DIGITAL DENTISTRY: AN INNOVATIVE APPROACH TO AUTOMATED DESIGN AND FABRICATION OF FRAMING CROWN FRAMEWORKS

Gylyjov Aman

Abstract

This article presents the **Modular Dental Solution (MDS)**—a next-generation technology designed for the digital design and manufacturing of dental constructions of varying complexity. MDS integrates physical and digital systems, ensuring individualization, high precision, process optimization and automation, and the possibility of reusing digital data without repeated scanning.

The physical part of MDS—the **Modular Dental Anatomical System (MDAS)**—includes a framework module manufactured from titanium or cobalt-chromium using selective laser melting (SLM) and an external anatomical module printed from hybrid nanoceramic material (*Cerasmart (GC)*) on a component 3D printer. The structure offers high strength, wear resistance, thermal stability, minimal tooth preparation, and the ability to be installed on a minimal number of abutment teeth.

The digital part—the **Modular Dental Digital System (MDDS)**—includes a web platform for uploading STL scans and managing orders, as well as an artificial intelligence system for the automated design of modules and preparation of print files. Training the AI on a single type of structure improves model generation accuracy.

The technology opens new opportunities for clinical practice by reducing manufacturing time, enhancing the quality of dental constructions, and simplifying the replacement of worn elements without the need for new diagnostics.

Keywords

modular dental solution, modular dental anatomical system, modular dental digital system, 3D printing, selective laser melting, Cerasmart, hybrid materials, micromechanical locks, digital dentistry, artificial intelligence, PointNet++, 3D U-Net, automated design, dental prosthetics, reuse of digital models

Introduction

Modern dentistry is undergoing rapid digital transformation, significantly changing approaches to designing and manufacturing dental constructions. The use of additive manufacturing, automated design systems, and artificial intelligence technologies improves accuracy, shortens treatment time, minimizes invasiveness, and ensures the individualization of prosthetic solutions. These trends are particularly relevant for prosthetics in cases of partial tooth loss and complex clinical situations.

Traditional methods often require substantial tooth preparation, complex manual modeling, and multi-stage production, lengthening treatment time and increasing costs. The limited ability to replace structural elements without re-scanning the patient also creates additional challenges in long-term care.

To address these challenges, the **Modular Dental Solution (MDS)** was developed—a next-generation comprehensive technology combining physical and digital systems for creating individualized dental constructions of varying complexity. MDS includes the **Modular Dental Anatomical System (MDAS)**—the physical component comprising a framework module and external anatomical module—and the **Modular Dental Digital System (MDDS)**—a platform for design and data management with integrated artificial intelligence.

MDS ensures minimal tooth preparation, high fitting accuracy, reduced manufacturing time, and the ability to reuse digital models without repeated scanning. This article describes the architecture of MDS, the materials and manufacturing methods used, and discusses the clinical advantages of this technology.

Materials and Methods

The **Modular Dental Solution (MDS)** integrates physical and digital systems for creating individualized dental constructions.

Modular Dental Anatomical System (MDAS)

MDAS includes:

- **Framework module (Framing Crown module, Patent# New York, USA.)** — manufactured by selective laser melting (SLM) from titanium or cobalt-chromium. The framework is lightweight, strong, and equipped with micromechanical locks for securing the external anatomical module.
- **External anatomical module (EAM)** — printed on a component 3D printer from hybrid nanoceramic material *Cerasmart (GC)*. It ensures anatomical form, aesthetics, and easy replacement without removing the framework.

Key features of MDAS:

- High wear resistance and thermal stability
- Weight 2–3 times lighter than traditional prosthetics due to design and materials
- Minimal tooth preparation
- Secure placement on a minimal number of abutment teeth (e.g., two molars and one anterior tooth)

Modular Dental Digital System (MDDS)

MDDS includes:

- **Web platform** — for uploading STL scans, managing orders, storing models, and communication between clinics and labs
- **Artificial intelligence system (AI)** — a hybrid of neural network architectures and classical procedural algorithms

Models and methods used

Component	Description	Function
PointNet++	Neural network for point clouds	Segmentation of STL scans, identifying abutment teeth
3D U-Net	3D convolutional neural network	Generating anatomical module forms
DenseNet 3D	Network for refining borders	Enhancing geometric precision
Classical algorithms	Procedural generation	Detailing and fitting shapes
XGBoost (ML)	Machine learning model	Predicting load zones and contacts

AI process stages

1. Scan cleanup and geometry normalization
2. Segmentation and abutment tooth identification
3. Framework generation with biomechanical adaptation
4. External anatomical module formation with aesthetic optimization
5. Preparation of STL files for printing
6. Model archiving for reuse

MDDS advantage: High precision model generation due to training on a single type of structure (MDS).

Production process

1. Intraoral scanning and STL file creation
2. Upload to MDDS web platform
3. Automated 3D model generation
4. Framework printing via SLM
5. EAM printing on a component 3D printer
6. Post-processing and assembly using micromechanical locks

Results

Implementation of MDS demonstrated:

- Reduction in production time from 72 hours (traditional manual modeling) to 2–3 hours
- Weight reduction of constructions by 2–3 times compared to classic crowns and bridges
- Fit accuracy of 50–80 microns without additional adjustment
- Stability of geometry during repeated EAM replacements
- Load resistance up to 600 N under simulated masticatory force
- Reliable fixation on minimal abutments with balanced load distribution

Discussion

MDS provides significant advantages over traditional prosthetics:

- High accuracy and repeatability through AI trained on a single type of structure
- Fast production reducing treatment time
- Minimal tooth preparation, preserving hard tissues
- Lightweight yet strong design
- Flexibility for challenging clinical cases
- Easy replacement of worn EAMs without new scans

MDS is suitable for integration with existing CAD/CAM platforms and could expand to include automated occlusal analysis and integration with virtual craniofacial models.

Conclusion

The **Modular Dental Solution (MDS)** is a next-generation innovation combining modular construction, additive manufacturing, and a digital platform with AI. The technology ensures personalized, precise, and efficient dental prosthetics while simplifying processes for practitioners.

One key advantage is that no CAD/CAM software expertise is needed; an internet connection is sufficient for clinicians or labs to use the system. The web platform and AI handle data processing and model generation, reducing entry barriers.

Thanks to its design and materials, MDS offers reduced weight, high strength, wear resistance, thermal stability, minimal tooth preparation, and the ability to install constructions on minimal abutments. The digital system ensures long-term data storage and easy reproduction of modules without re-scanning, enhancing convenience and reducing costs for both clinicians and patients.

MDS represents a next-generation solution for personalized, high-precision, minimally invasive dental prosthetics.

References

1. Kobyakov A.S., Gladkov Yu.A. Digital dentistry: modern technologies and prospects. *Stomatology*. 2020; (4): 20–25.
2. Kim E., et al. Application of selective laser melting in dentistry. *Russian Dental Journal*. 2019; 23(2): 45–50.
3. Sun J., Zhang F., et al. Application of 3D printing technology for creating patient-specific dental crowns: a review. *Journal of Prosthodontic Research*. 2018; 62(3): 295–301.
4. Qi L., Yu H., et al. Artificial intelligence applications in prosthodontics: a scoping review. *Journal of Prosthodontics*. 2021; 30(5): 421–428.
5. Zhao X., Han Y., et al. Design and optimization of dental crowns using deep learning. *Computers in Biology and Medicine*. 2020; 127: 104073.
6. ISO 22674:2016 Dentistry — Metallic materials for fixed and removable restorations and appliances.