DIGITAL TOOTH COLOR MODELING BEFORE AND AFTER WHITENING: CLINICAL CAPABILITIES AND LIMITATIONS

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Relevance. Predicting and monitoring changes in tooth color during whitening procedures remains a significant challenge in contemporary dentistry. Visual shade assessment methods are often limited by subjective perception, lighting conditions, and individual clinician variability. Digital tooth color modeling technologies offer a more precise and objective measurement, enabling clinicians to anticipate whitening outcomes, enhance treatment planning, and improve patient understanding and satisfaction. However, the accuracy and reliability of these methods depend on the type of discoloration, enamel structure, and software capabilities, necessitating a comprehensive evaluation of their clinical potential and limitations.

Objective. The aim of this study was to evaluate the clinical capabilities of digital tooth color modeling for predicting and monitoring whitening outcomes, to identify factors affecting measurement accuracy, and to determine practical limitations of the method across different forms of dental discoloration.

Materials and Methods. The study included 60 patients aged 18–50 years presenting with various forms of dental discoloration: superficial stains caused by exogenous factors, endogenous color changes, and mixed forms of discoloration.

Patients were divided into three groups according to the whitening method applied:

1. In-office whitening using high-concentration peroxide systems (35–40% H_2O_2);
2. At-home whitening with individualized trays and low-concentration gels (10–16% carbamide peroxide);
3. Combined methods, including localized microabrasion prior to application of whitening systems.

Digital tooth color assessment was performed using photometric and spectrophotometric scanners, D-scanning of the dental arch, and subsequent software-based shade modeling. Results were compared with visual assessments using the VITA Classical and 3D-Master scales. Analyses included predictive accuracy of shade changes before and after whitening, stability of results at 1 and 3 months, concordance between digital and clinical measurements, and identification of sources of error and method limitations.

Results. Digital modeling enabled prediction of tooth shade changes with an accuracy of 1–2 shades on the VITA scale.

1. In the in-office whitening group (n=20), the mean lightening was 3–5 shades**,** with digital predictions matching clinical visual assessment in 85% of cases. Limitations were noted in teeth with endogenous discoloration and areas of high enamel translucency.
2. In the at-home whitening group (n=20)**,** the mean lightening was 2–3 shades**,** with digital modeling providing stable predictions, especially for superficial stains, showing 90% concordance with visual assessment.
3. In the combined group (n=20)**,** mean lightening was 3–4 shades**;** the digital model effectively predicted outcomes in areas subjected to prior microabrasion, though minor discrepancies occurred in regions with enamel defects.

It was observed that the accuracy of digital modeling decreased in cases of complex endogenous discoloration, localized spots or mottling, and defects in enamel transparency and surface texture. Nevertheless, the technology enabled objective tracking of the whitening process, visualization of predicted outcomes for patients, and optimization of subsequent treatment planning.

Conclusion. Digital tooth color modeling is an effective tool for planning and monitoring whitening procedures, enhancing objectivity and standardization of outcome assessment. To achieve maximal accuracy, digital data should be used in conjunction with clinical visual evaluation, particularly for complex or localized color changes. The technology allows for reliable prediction of whitening effects, minimizes subjective errors, and increases patient satisfaction with aesthetic treatment outcomes.

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