Intelligent Construction and Biomechanical Optimization of Post Space for Maxillary Anterior Teeth Restoration

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Abstract

Background: Trauma to maxillary anterior teeth frequently results in crown-root fractures. Post-core crown restoration serves as the primary treatment following root canal therapy. Conventional post space preparation is associated with insufficient cutting accuracy, high operator dependence, poor repeatability, and uncontrollable biomechanical performance, which may lead to complications such as post loosening, root fracture, and root perforation. *Objective*: To address these clinical challenges, this study established a digitally intelligent design and biomechanical optimization system for post space preparation. *Methods*: CBCT data were collected from 50 patients with traumatized maxillary anterior teeth. The nnU-Net framework was applied to achieve pixel-level segmentation of dental hard tissues and root canals, with automatic extraction of anatomical parameters. Optimal post space parameters were output and a guiding model was generated via Abaqus finite element analysis, XGBoost machine learning, and genetic algorithm-based multi-objective optimization. *Results*: The segmentation accuracy of dental anatomical structures exceeded 96.2%. After optimization, the maximum dentin stress was reduced by 25.7%, the stress distribution peak coefficient decreased by 25.8%, and the amount of preserved tooth tissue increased by 15.6%. *Conclusions*: Driven by anatomy and mechanics, this study enables personalized and precise design of post space and optimizes the mechanical distribution of the post space. It is expected to further improve the safety and long-term outcomes of anterior teeth post-core crown restoration, providing an AI-enhanced novel approach for digital post crown restoration in dentistry.

Keywords

Post Crown Restoration, Post Space, Intelligent Design, Biomechanical Optimization, Machine Learning