INPLASY

Optimizing Milling Path Strategies in Dental CAD/CAM: A Systematic Review

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ADMINISTRATIVE INFORMATION

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Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 18 May 2025 and was last updated on 18 May 2025.

INTRODUCTION

Review question / Objective What are the most effective milling path strategies and parameter combinations for optimizing surface quality, tool wear, and energy efficiency in dental CAD/CAM systems?

Rationale Dental CAD/CAM machining is essential for the precise fabrication of prosthetic restorations. However, milling trajectories remain under-optimized, affecting tool longevity, surface quality, and energy use. This review aims to identify the best practices and strategies for efficient toolpath planning.

Condition being studied Optimization of dental CAD/CAM milling strategies to enhance prosthetic quality, minimize tool degradation, and reduce energy consumption.

METHODS

Search strategy Databases: PubMed, Scopus, ScienceDirect

Timeframe: 2014–2025

Keywords: “milling strategy”, “toolpath”, “CAD/CAM”, “CNC”, “dental”, “prosthetic”

Language restriction: English onlyOptimization of dental CAD/CAM milling strategies to enhance prosthetic quality, minimize tool degradation, and reduce energy consumption.

Participant or population Experimental studies on dental materials machined using CAD/CAM or CNC platforms with documented toolpath strategies and performance metrics.

Intervention Evaluation of various milling path strategies (e.g., adaptive offset, zigzag, spiral, tilt-optimized) and associated cutting parameters.

Comparator Comparison between different toolpath strategies and cutting parameter sets across materials and machine setups.

Study designs to be included Quantitative experimental studies assessing milling strategy performance in dental CAD/CAM contexts.

Eligibility criteria Inclusion: Experimental studies on toolpath optimization for dental materials via CNC/CAD-CAM systems

Exclusion: Reviews, opinion papers, studies without experimental toolpath assessment.

Information sources PubMed, Scopus, ScienceDirect, manual reference checking of included studies.

Main outcome(s) Surface roughness (Ra); Tool wear (VB); Material removal rate (MRR); Energy consumption.

Additional outcome(s) Machining time; Tool lifespan; Cutting force and vibration control**.**

Data management Data extracted in Excel; two reviewers cross-checked entries independently.

Quality assessment / Risk of bias analysis Critical appraisal using an adapted JBI checklist for experimental studies (9 criteria scored +, –, ?).

Strategy of data synthesis Descriptive and narrative synthesis. Quantitative comparison of strategies where appropriate. No meta-analysis planned.

Subgroup analysis Yes. Subgroup analyses will be performed based on:

Type of material (e.g., zirconia, titanium, aluminum alloys, Inconel)

Toolpath strategy (e.g., adaptive offset, zigzag, spiral, tilt-optimized)

Machine configuration (3-axis vs. 5-axis CNC systems)

Use of optimization models (e.g., Taguchi, RSM, NSGA-II)

These subgroups allow comparison of strategy effectiveness and identify material-specific best practices.Data visualized through comparative tables, radar charts, histograms, and JBI heatmaps. Follows PRISMA flow structure.

Sensitivity analysis Yes. Sensitivity analysis will be conducted to assess the robustness of the findings:

Studies with a JBI score <6/9 will be analyzed separately to evaluate potential bias impact.

Findings will be compared with and without inclusion of lower-quality studies.

Influence of lack of control group, non-repetition, or missing instrument validation (criteria Q4, Q5, Q8) will be discussed.

Language restriction English.

Country(ies) involved Morocco.

Keywords CAD/CAM, toolpath, milling strategy, CNC, prosthetic dentistry, energy efficiency, surface roughness.

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