INPLASY

INPLASY2024120027

doi: 10.37766/inplasy2024.12.0027

Received: 8 December 2024

Published: 8 December 2024

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Impact of Shading on Zirconia: Structural, Optical, and Mechanical Property Alterations - A Systematic Review and Meta-Analysis

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ADMINISTRATIVE INFORMATION

Support - No financial support was received.

Review Stage at time of this submission - Piloting of the study selection process.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY2024120027

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 8 December 2024 and was last updated on 8 December 2024.

INTRODUCTION

Review question / Objective This systematic review and meta-analysis aims to assess how pre-sintering pigmentation (shading) impacts the structure, mechanical and optical properties of zirconia in dental restorations.

Rationale The use of monolithic zirconia has significantly increased due to its excellent mechanical properties and biocompatibility. To enhance zirconia's esthetics, shading techniques have been developed. However, concerns remain regarding the impact of these techniques on the material's mechanical and optical properties.

Condition being studied Pre-sintering pigmentation, applies metal oxide-based coloring liquids to green-stage zirconia. This method enables deeper pigment penetration, creating uniform coloration and customizable shades. However, this may alter zirconia's crystalline structure, translucency, mechanical properties, and bonding abilities, though evidence remains conflicting.

METHODS

Search strategy

Pubmed
color infiltration, stain, pigment, shade and zirconia

LILACS
Search : (color infiltration) OR (stain) OR (color) OR (colour) OR (pigment) OR (shade) AND (zirconia)

SCOPUS
Search : stain OR shade OR pigment AND sintering AND zirconia.

Participant or population Zirconia samples or prostheses of any shape or size, excluding glazed or stained zirconia without shading.

Intervention shading techniques such as brushing or dipping/immersion of green-stage zirconia before CAM or final sintering, regardless of immersion time or repetitions.

Comparator Non-shaded/white or precolored zirconia samples of identical shape and size.

Study designs to be included All studies except Conference abstracts, theses, books, and book chapters.

Eligibility criteria Only articles pertinent to the dental field were included.

Information sources In addition to the electronic databases, backward and forward citation analyses were performed, along with expert consultations and use of the "similar articles" feature in databases.

Main outcome(s) Primary outcomes were mechanical (e.g., flexural strength, hardness), optical (e.g., translucency, opalescence), and surface properties (e.g., micro-hardness, roughness).

Additional outcome(s) Secondary outcomes included bonding strength, structural properties (e.g., crystal phase, grain size), and color stability.

Data management Data management via Zotero, RevMan 5 and excel.

Quality assessment / Risk of bias analysis The risk of bias (RoB) was assessed for each study using the RoBDEMAT guideline [30]. Criteria included control group presence, random sample allocation, sample size justification, consistent experimental conditions, standardized testing and outcomes, appropriate statistical analysis, sample/material standardization, and operator blinding. Each criterion was graded as fully, partially, or not satisfied.

Strategy of data synthesis Overall intervention effects were calculated using RevMan 5 (The Cochrane Collaboration, Copenhagen, Denmark). For continuous outcomes, effects were measured using standardized mean differences. Meta-analyses, employing a random-effects model, were performed when at least two studies reported the same outcome, treating individual samples as the unit of analysis. Missing data were requested from investigators or sponsors. Heterogeneity was assessed with the I^2 statistic, and publication bias was evaluated via funnel plots.

Subgroup analysis Planned subgroup analyses included white and precolored controls.

Sensitivity analysis Sensitivity analysis was not conducted.

Language restriction Articles in English, German, French, Italian, Spanish, Portuguese, and Arabic were included.

Country(ies) involved France, Lebanon.

Keywords Color pigment solution, Flexural Strength, Mechanical Properties, Meta-Analysis, Optical Properties, Dental Protsthesis, Shading Techniques, Translucency, Zirconia.

Dissemination plans Publication in. peer-reviewed journal.

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