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INPLASY

Tactile Perception of Materials Used for the Production of 3D-Printed Typodont Teeth in Dental Education: A Systematic Review

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ADMINISTRATIVE INFORMATION

Support - University of Birmingham employs primary reviewer as a PhD student (funded by the university of Birmingham as a part-time student and full time member of clinical staff). No additional funding has been sought.

Review Stage at time of this submission - The review has not yet started.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY202520062

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 11 February 2025 and was last updated on 11 February 2025.

INTRODUCTION

Review question / Objective Primary aim: To evaluate the tactile perception of materials used to produce 3D-printed in comparison to human teeth and traditional typodont materials.

PICOS =
Participants:
Inclusion: Studies involving dental students (UG and PG), dental educators, qualified dentists or dental focused researchers using or evaluating 3D-printed typodont teeth.
Exclusion: Studies not involving dental participants or unrelated to dental education.
Interventions:
Inclusion: Studies that disclose and/or evaluate the materials used in the production of 3D-printed typodonts
Exclusion: Studies that do not disclose materials or production methods of 3D printed typodonts
Comparators:
Human teeth
Traditional typodont models
Virtual simulators
Outcomes:
Inclusion: Studies reporting on:
•Tactile perception of typodont teeth: feedback realism, fidelity and forces during operative procedures (quantified if available).
• Perceptions of dental students and educations regarding the materials, educational benefits (eg skill acquisition, satisfaction)
Exclusion:
• Studies not addressing at least one of the above outcomes.
• Study Design:
Inclusion: Original research articles, experimental studies, observational studies, qualitative studies, and case series.

Exclusion: Review articles, editorials, letters, and non-research-based reports.

Rationale A more realistic training experience leads to:
- Fewer procedural errors, reducing risks such as over-drilling, inadequate restorations, or improper force application.
- Improved treatment outcomes, as dentists who train with realistic models develop better tactile sensitivity, leading to more precise and patient-safe procedures.
- Higher clinical competency, ensuring that new dentists transition into practice with refined skills, reducing the need for corrective treatments and improving long-term oral health outcomes.

Condition being studied Advances in 3D printing technology have significantly transformed educational tools in healthcare. Once such tool is a typodont, or simulation tooth, which is essential for training dental students operative procedures. Traditional typodont teeth are primarily manufactured through injection moulding using monoblock plastics. However, newer 3D-printed models offer enhanced benefits such the ability to customise to specific clinical scenarios and local production in educational settings.
Previous studies have primarily focused on the applications of 3D printing in the context of typodonts, evaluating their educational benefits and durability in comparison to traditional models and extracted human teeth, and did not follow systematic review protocols (Dobroś, Hajto-Bryk et al. 2023) (Fayyaz, Ali et al. 2024) . The current proposed systematic review diverges from these earlier investigations by focusing on new objectives—specifically evaluating the tactile perception of 3D-printed typodont teeth and following systematic review protocols. Understanding these aspects is crucial for assessing the overall value of 3D-printed typodonts in dental education, particularly in terms of their impact on delivering clinical care, educational outcomes, production costs, material sustainability, and anatomical realism.

METHODS

Search strategy
o PubMed, Scopus, Embase, Web of Science, CINAHL Complete, IEEE Explore and Cochrane Library.
o (3D-printed OR 3D printing OR additive manufacturing OR 3D printed OR three dimensional OR 3D printed teeth OR 3D printed tooth) AND (typodont teeth OR simulation teeth OR teeth OR simulation OR commercial models) AND (dental education OR dental students OR training OR dental OR teaching) AND (fidelity OR tactile OR feel).

Participant or population Inclusion: Studies involving dental students (UG and PG), dental educators, qualified dentists or dental focused researchers using or evaluating 3D-printed typodont teeth. There are no restrictions on age range, gender, ethnicity and health status of any participants.
Exclusion: Studies not involving dental focused participants or unrelated to dental education.

Intervention Inclusion: Studies that disclose and/or evaluate the materials used in the production of 3D-printed typodonts.
Exclusion: Studies that do not disclose materials or production methods of 3D printed typodonts**.**

Comparator
Human teeth
Traditional typodont models
Virtual simulators**.**

Study designs to be included Inclusion: Original research articles, experimental studies, observational studies, qualitative studies, and case series.Exclusion: Review articles, editorials, letters, and non-research-based reports.

Eligibility criteria All within the PICO framework and above sections.

Information sources
• Databases :
o PubMed, Scopus, Embase, Web of Science, CINAHL Complete, IEEE Explore and Cochrane Library.
• Supplementary Searches:
o Grey literature via Google Scholar.
o Citation tracking from relevant studies.
o Contacting authors for unpublished data if necessary.
o Hand-searching reference lists of relevant articles returned from existing searches.

Main outcome(s) This systematic review will provide comprehensive evidence on the tactile perception of materials used in 3D-printed typodont teeth compared to traditional and human alternatives. It will offer insights for educators, researchers, and manufacturers into the broader implications of adopting 3D printing in dental education. The primary outcome of this review is to identify 3D-printed training materials models that best replicate the feel of real teeth, the review

ensures that future dentists develop the necessary manual skills for precise and effective treatment.

Additional outcome(s)
• To explore how these materials are perceived by dental students and educators.
• To identify potential barriers to the widespread adoption of 3D printed typodont teeth.
• To assess any additional educational benefits of these models as reported in the literature.

Data management Data will be extracted using a standardised data extraction form using MS Forms which will then be exported into MS Excel for analysis. Evernote will be used to keep meticulous record of inclusions and exclusions.

Quality assessment / Risk of bias analysis a. For experimental and observational studies, the Cochrane Risk of Bias Tool (RoB 2) will be used for randomized studies, and the ROBINS-I (Risk Of Bias In Non-randomised Studies - of Interventions) tool will be used for non-randomised studies.
b. For qualitative studies, the CASP (Critical Appraisal Skills Programme) tool will be employed to assess methodological rigor, trustworthiness, and transferability of findings.
c. For case series, the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Series will be used to evaluate aspects such as clarity of inclusion criteria, methods of data collection, and validity of outcomes.

Strategy of data synthesis Criteria for Synthesis: Outcomes will be synthesised if at least three studies report on comparable measures with similar methodologies.
Quantitative Synthesis: Meta-analysis may be performed for the primary outcome, tactile perception, if sufficient homogeneity exists across included studies. Random-effects models will combine effect measures such as mean differences or standard mean differences. Heterogeneity will be assessed using the I^2 statistic, with sensitivity analyses to explore the impact of studies at high risk of bias. Subgroup analyses will focus on factors such as material types or study designs.

Subgroup analysis Qualitative Synthesis: For descriptive outcomes related to tactile perception and material selection, thematic analysis will identify key patterns. A narrative synthesis will integrate findings across study types, grouped by outcome and methodological characteristics.

Reviewers and Discrepancy Resolution: Two reviewers will independently conduct data synthesis. Disagreements will be resolved through discussion or a third reviewer if necessary.

Interpretation: Findings will be framed in the context of clinical and educational relevance, emphasising their implications for improving tactile training and material selection in dental education.

Sensitivity analysis Tools and Software: Statistical analyses will use RevMan or R; thematic analysis will use NVivo. Forest and funnel plots will visualise results where applicable.

Language restriction English.

Country(ies) involved UK.

Keywords 3D printing; typodont; dental simulation; dental education.

Dissemination plans Publish in peer-reviewed dental education or materials journal.

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