INPLASY

Porcelain-Fused-to-Metal and All-Ceramic Crowns and Fixed Dental Prostheses: A Systematic Review and Meta-Analysis

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Corresponding author:
Xiaodong Hu

hux_denti@163.com

Author Affiliation:
Shangyu People's Hospital of Shaoxing City.

Wang, JH; Guan, YY; Hu, XD.

ADMINISTRATIVE INFORMATION

Support - No support.

Review stage at the time of initial registration - Completed but not published.

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 11 November 2026 and was last updated on 11 November 2026.

INTRODUCTION

Review question / Objective Review question: In tooth-supported restorations, how do all-ceramic (AC) crowns and fixed dental prostheses (FDPs) compare with porcelain-fused-to-metal (PFM) restorations in laboratory fit measurements and clinical outcomes?

P (Population):

Clinical: Adults receiving tooth-supported single crowns or three-unit FDPs.

Laboratory: Extracted teeth, standardized tooth preparations, typodont teeth, or metal/resin dies used for fit assessment of fixed restorations. Implant-supported restorations were excluded.

I (Intervention):
All-ceramic restorations, including zirconia- and lithium-disilicate-based crowns and FDPs, evaluated at defined fabrication or cementation stages.

C (Comparator):
PFM or metal-ceramic restorations, assessed in direct head-to-head comparisons. Studies without a clinically or experimentally relevant PFM comparator were not included in comparative estimates.

O (Outcomes):

Laboratory fit outcomes: marginal gap, internal fit, cement-film thickness, and microleakage, interpreted separately by measurement domain, fabrication stage, and cementation condition.

Clinical outcomes: secondary caries and restoration-related technical complications, including veneering-ceramic chipping in veneered three-unit FDPs and mechanical events in

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monolithic single crowns. Survival and technical complications were treated as distinct constructs.

S (Study design):
Direct comparative in vitro laboratory studies and direct randomized clinical trials. Eligible randomized trials compared AC with PFM tooth-supported single crowns or three-unit FDPs and reported follow-up of at least 3 years. In vivo fit studies and ceramic studies without a PFM arm provided contextual evidence only and were not included in pooled comparative estimates. Laboratory studies used paired or parallel PFM-versus-AC assessments; coping-stage and completed-crown measurements were considered separately.

Condition being studied The condition being studied is the performance of tooth-supported fixed dental restorations used to restore damaged, weakened, or missing teeth. The clinical situation of interest is not a single systemic disease but a common prosthodontic treatment condition: adults who require single crowns or three-unit fixed dental prostheses (FDPs) and who may receive either porcelain-fused-to-metal (PFM) or all-ceramic (AC) restorations. PFM restorations have long been used because of their established mechanical performance, whereas AC systems, including zirconia- and lithium-disilicate-based materials, offer metal-free alternatives with different esthetic, strength, and fabrication characteristics. Contemporary zirconia includes 3Y-TZP, more translucent 4Y and 5Y compositions, and multilayer materials, so these ceramics should not be regarded as a single uniform material class.

The health-related problem being addressed is that the durability and biological behavior of these restorations depend on both material composition and restoration design. Marginal adaptation, internal fit, and cement-film thickness are laboratory-based indicators of how well a restoration seats on the prepared tooth. These measurements are influenced by tooth preparation, CAD/CAM or conventional fabrication, cement-space settings, seating pressure, luting-agent handling, and thermal or mechanical aging. They represent related but distinct constructs: a smaller marginal gap does not necessarily imply better internal fit, thinner cement film, or improved clinical outcome. Microleakage is a further laboratory indicator of interfacial sealing and may vary with cementation protocol and testing method.

Clinically, the condition of interest includes restoration-related technical complications and secondary caries. Veneering-ceramic chipping is particularly relevant to layered ceramic restorations, including veneered three-unit FDPs, because these restorations contain a veneer–core interface. Monolithic zirconia restorations lack this veneering interface and should be assessed for different mechanical failure modes. Secondary caries reflects a biological outcome that may be influenced by marginal contours, surface texture, plaque retention, and periodontal conditions, rather than by framework composition alone. Restoration survival and freedom from technical complications are therefore distinct outcomes.

The population of interest includes adults receiving tooth-supported single crowns or three-unit FDPs, and laboratory studies using extracted teeth, standardized preparations, typodont teeth, or metal/resin dies. Implant-supported restorations are excluded. The comparison is between AC and PFM restorations in direct head-to-head laboratory or randomized clinical assessments. The outcomes include marginal gap, internal fit, cement-film thickness, microleakage, secondary caries, and material-specific technical complications such as veneer chipping. Thus, the condition being studied encompasses the dimensional fit, interfacial sealing, biological complications, and technical durability of PFM versus AC tooth-supported crowns and FDPs.

METHODS

Participant or population Adults receiving tooth-supported single crowns or three-unit fixed dental prostheses.

Intervention Not applicable.

Comparator Not applicable.

Study designs to be included Direct comparative in vitro laboratory studies employing paired or parallel designs for PFM-versus-AC assessments at defined fabrication or cementation stages; and randomized clinical trials (RCTs) with ≥3 years of follow-up that directly randomize participants to AC or PFM tooth-supported single crowns or three-unit FDPs. In vivo fit studies were included only as contextual evidence and were not pooled. Studies without a PFM comparator, implant-supported restorations, and non-randomized clinical designs were excluded from the comparative synthesis.

Eligibility criteria Eligibility criteria
In vitro studies
Specimens included extracted teeth, standardized tooth preparations, typodont teeth, or metal/resin

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dies used for laboratory assessment of fixed restoration fit.
Comparisons included paired or parallel assessment of a PFM or metal–ceramic restoration and an AC restoration at a defined fabrication or cementation stage. Coping-stage comparisons were considered separately from completed crown measurements.
Marginal gap was the distance measured at the restoration margin, reported in micrometers (μm). Results were interpreted by fabrication stage and measurement method.
Internal fit was defined as the space between the prepared tooth and the inner restoration surface, assessed at defined internal measurement sites.
Cement-film thickness was the measured thickness of a luting-cement layer or replica film between the restoration and prepared tooth.
Microleakage was defined as the penetration observed in laboratory tests, usually assessed using dye penetration and reported on study-specific ordinal scales.

The direct PFM-versus-AC synthesis excluded implant-supported restorations and studies without a clinically or experimentally relevant material comparison.

Clinical randomized clinical trials
The population was adults receiving tooth-supported single crowns or three-unit FDPs.
The intervention and comparator were AC and PFM restorations, evaluated in a direct randomized clinical comparison.
Clinical endpoints were secondary caries and restoration-related technical complications at the reported follow-up. Veneering ceramic chipping was examined for veneered FDPs. Mechanical events in monolithic single crowns were interpreted separately because the restoration architecture differs.
Follow-up was ≥3 years.
Studies of ceramic designs without a PFM comparator were considered only as contextual clinical evidence and were not included in relative-effect calculations.

Information sources Web of Science Core Collection, PubMed, Scopus, Embase, and Scientific Electronic Library Online (SciELO) were searched from January 1, 2000, to August 31, 2025. The final search was conducted on August 31, 2025. Records were exported before deduplication and managed in EndNote 20 (Clarivate, Philadelphia, PA, USA). Reference lists of relevant publications were also checked. Searches specifically targeting unpublished gray literature were not undertaken.

Main outcome(s) The descriptive effect for continuous fit-related measurements was the study-level mean difference (MD = AC − PFM), expressed in micrometers. Negative values indicate a smaller measured gap or film thickness with the AC restoration, without implying equivalence of the underlying measurement domains.
Marginal gap, internal fit, and cement-film thickness were reported separately. Laboratory and in vivo fit measurements were also distinguished, and coping-stage values were identified explicitly.
Microleakage findings were described by cementation protocol and assessment method because the reported ordinal scores were not directly comparable.

Clinical secondary caries was summarized as events per trial arm. Studies with no events in either arm were presented descriptively rather than assigned a comparative relative effect. For veneered three-unit FDP chipping, risk ratios (RRs) were calculated as the AC event risk divided by the PFM event risk; a continuity correction of 0.5 was applied for a zero-event arm. Monolithic single crowns were presented as a separate clinical subgroup.

Quality assessment / Risk of bias analysis Laboratory studies were evaluated using the 12-item QUIN instrument16. Each item was scored 0, 1, or 2, and the total was interpreted as a proportion of the applicable maximum score; results are provided at study and item level.
Direct randomized clinical comparisons were assessed using the Cochrane risk-of-bias tool (RoB 2) across randomization, deviations from intended interventions, missing outcome data, outcome measurement, and selection of the reported result. Overall judgments were assigned for the specified clinical outcome.

Strategy of data synthesis Pooled RRs for the veneered-FDP comparison were estimated using an inverse-variance random-effects approach with the DerSimonian–Laird moment estimator of between-study variance. Ninety-five percent confidence intervals (CIs) were calculated on the log-risk-ratio scale using a normal approximation. Statistical analyses were performed using R, version 4.6.1 (R Foundation for Statistical Computing, Vienna, Austria), and graphical displays were prepared using Matplotlib, version 3.10.8 (Matplotlib Development Team; https://matplotlib.org). Statistical heterogeneity was summarized using the I^2 statistic. The analysis unit

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for clinical binary outcomes was the randomized restoration as reported in each trial.

The suitability of meta-regression was assessed according to the number of independent studies, comparability of outcome definitions, and variation in candidate moderators. Following the methodological guidance in the Cochrane Handbook, a minimum of 10 independent studies per candidate moderator was considered a conservative practical criterion for meta-regression. This threshold was treated as a general methodological recommendation rather than an absolute requirement. In the present review, only seven independent laboratory studies were available, and marginal gap, internal fit, and cement-film thickness represented distinct measurement constructs. No individual outcome domain therefore contained sufficient independent studies to support reliable meta-regression. Accordingly, no inferential meta-regression was performed. Potential variation related to cementation conditions, fabrication stages, and aging was examined descriptively alongside the study characteristics. Within-study manufacturing-stage observations were presented in their original sequence.

The robustness of the pooled FDP chipping estimate was explored by omitting one publication at a time. Formal tests for small-study effects were not used for the small number of directly comparable trials.

Subgroup analysis No formal inferential subgroup analyses were performed because the number of directly comparable studies and clinical events was small. Evidence was stratified descriptively by evidence stream (laboratory vs clinical), restoration type (posterior single crowns vs three-unit FDPs), AC configuration (veneered FDPs vs monolithic zirconia single crowns), and, for laboratory data, by measurement domain (marginal gap, internal fit, cement-film thickness, microleakage), fabrication stage (coping, completed crown, cementation, thermomechanical aging), and setting (in vitro vs in vivo). Secondary caries and veneer chipping were summarized separately. The monolithic single-crown trial was presented as a separate clinical subgroup and was not pooled with veneered FDPs. Leave-one-publication-out analysis, not subgroup analysis, was used to explore the robustness of the pooled FDP chipping estimate.

Sensitivity analysis In four randomized comparisons, secondary caries was absent in both material groups during the reported follow-up, although these data did not permit a comparative effect estimate. For veneered three-unit FDPs, the AC group had a higher observed frequency of veneering-ceramic chipping than PFM, but the pooled estimate remained imprecise (RR = 2.45, 95% CI, 0.83–7.18). Monolithic zirconia crowns should be distinguished from veneered FDPs because their mechanical failure modes are different. The three-study sensitivity analysis supported a similar directional estimate while retaining broad confidence limits.

Country(ies) involved China.

Keywords Porcelain-fused-to-metal, all-ceramic, zirconia, dental crowns, fixed dental prostheses,marginal fit,veneering ceramic chipping veneering ceramic chipping, secondary caries,systematic review.

Contributions of each author

Author 1 - Jiahui Wang - Conceptualization, Methodology, Writing – original draft,Writing – review & editing
Email: wjh_2025hospi@petalmail.com
Author 2 - Yingying Guan - Data curation, Resources, Visualization, Writing – original draft,Writing – review &editing
Email: guanyy2025@petalmail.com
Author 3 - Xiaodong Hu - Formal analysis, Supervision, Writing – original draft,Writing – review & editing
Email: hux_denti@163.com

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