



The Role of Calcium Phosphate Coatings in Promoting Osseointegration of Zirconia Implants: A Systematic Review

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BACKGROUND

Y-TZP has excellent mechanical properties and biocompatibility but low intrinsic bioactivity, which limits predictable osseointegration. Calcium phosphate (CaP) coatings are used to enhance the biological response of zirconia implants.

OBJECTIVE

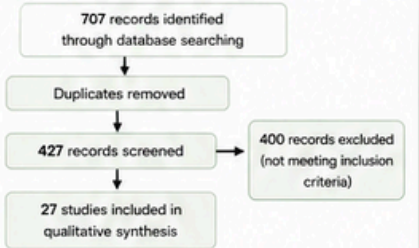
To evaluate the effects of CaP coatings on zirconia implant surfaces and identify factors influencing their clinical application.

MATERIALS & METHODS

- Systematic review following PRISMA guidelines
- Databases: PubMed, Scopus, Web of Science, Embase (July 2026)
- Inclusion: in vitro and in vivo studies comparing CaP-coated zirconia implants with controls
- Data extracted on coating type, deposition method, surface properties, and biological outcomes
- Search strategy:

("calcium phosphate" OR "tricalcium phosphate" OR TCP OR β -TCP) AND (zirconia OR zirconium) AND (implant OR implants)

STUDY SELECTION



RESULTS

CaP formulations	Deposition techniques	Study types	Key focus
• Hydroxyapatite (HA) • β-tricalcium phosphate (β-TCP) • Octacalcium phosphate (OCP) • Fluoridated hydroxyapatite (FHA) • Composite CaP coatings	• Biomimetic deposition • Sol-gel • Plasma spraying • RF magnetron sputtering • Electrophoretic deposition • Laser-assisted methods • Others	 In vitro  In vivo	• Surface characteristics • Cellular response • Osseointegration • Antibacterial activity

MAIN FINDINGS

CaP coatings improved surface properties	Enhanced biological performance
 Increased roughness  Improved wettability  Enhanced bioactivity	✓ Improved osteoblast adhesion and proliferation ✓ Increased differentiation and ALP activity ✓ Upregulated osteogenic gene expression ✓ Higher bone-to-implant contact

Multifunctional coatings show added benefits


Therapeutic ions (e.g., Sr, Mg, Zn)


Antimicrobial agents


Growth factors


Nanoparticles


Enhanced osteogenesis and antibacterial activity



KEY CHALLENGE

Considerable heterogeneity in coating composition, fabrication protocols, characterization, and biological evaluation limits comparison and prevents identification of the most effective coating strategy.

CONCLUSIONS



Calcium phosphate coatings improve the biological performance of zirconia implants by enhancing osseointegration. Future success depends on **standardized protocols, long-term coating stability, and well-designed translational studies** to achieve reproducible and clinically relevant surface engineering strategies.

