IJCNP, Volume 4, Issue 02, 2026 ISSN: 2995-536X
https://medicaljournals.eu/index.php/IJCNP

INTERNATIONAL JOURNAL OF COGNITIVE NEUROSCIENCE AND PSYCHOLOGY

# CLINICAL PERFORMANCE OF CAD/CAM-FABRICATED PROSTHESES IN FULL-ARCH REHABILITATION

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**Abstract:** Full-arch rehabilitation presents complex challenges in prosthodontics, requiring accurate fit, optimal occlusion, and long-term stability. CAD/CAM technology has revolutionized full-arch prosthesis fabrication, enabling precise digital design, standardized milling, and improved material properties. This study evaluates the clinical performance of CAD/CAM-fabricated full-arch prostheses over a five-year period, assessing prosthetic fit, marginal adaptation, occlusal stability, complication rates, patient satisfaction, and peri-implant tissue health. Fifty patients received full-arch implant-supported prostheses fabricated via CAD/CAM techniques, with restorations made from zirconia, titanium frameworks, and hybrid ceramic materials. Clinical and radiographic evaluations were conducted at baseline, 6 months, 1 year, 3 years, and 5 years. Results demonstrated excellent marginal fit, minimal mechanical complications, high patient satisfaction, and stable peri-implant tissue health. CAD/CAM-fabricated prostheses exhibited lower incidence of framework fractures and screw loosening compared to conventional techniques. These findings suggest that digital workflows significantly enhance prosthesis predictability, longevity, and clinical outcomes in full-arch rehabilitation.

**Keywords**: CAD/CAM prostheses, Full-arch rehabilitation, Digital dentistry, Implant-supported prostheses, Marginal fit, Occlusal stability, Zirconia frameworks, Hybrid ceramics, Peri-implant tissue health, Clinical outcomes, Prosthodontics

**Introduction:** Full-arch implant-supported prostheses are a cornerstone of contemporary rehabilitation for edentulous patients. Conventional fabrication methods, including lost-wax casting and manual waxing, often introduce errors in marginal adaptation, occlusal contacts, and framework fit. Digital workflows using CAD/CAM technology allow precise scanning, virtual articulation, and milling from high-strength materials such as zirconia and titanium, reducing human error and enhancing reproducibility. Clinical success of full-arch prostheses relies on prosthetic fit, accurate occlusion, framework rigidity, and soft tissue management. Poorly fitting prostheses can cause peri-implantitis, marginal bone loss, screw loosening, and fracture of restorative materials. While numerous studies have evaluated single-unit CAD/CAM restorations, data on full-arch digital prostheses remain limited. This study aims to comprehensively evaluate the long-term clinical performance, complications, and patient-centered outcomes of CAD/CAM-fabricated full-arch implant-supported prostheses in edentulous patients, providing evidence for optimized digital prosthodontic protocols.

**Materials and Methods:** Fifty edentulous patients aged 45–75 years received 200 implants for full-arch rehabilitation in maxilla and mandible. Digital impressions were obtained using intraoral scanners and processed in CAD software for framework design. Frameworks were fabricated via CAM milling in zirconia, titanium, or hybrid ceramic materials. Screw-retained and cement-retained designs were evaluated. Prosthetic margins, occlusal schemes, and emergence profiles were digitally planned to optimize peri-implant tissue health. Clinical parameters recorded included probing depth, bleeding on probing, plaque index, mucosal recession, occlusal contacts, framework passivity, marginal adaptation, and prosthetic complications. Radiographic evaluation of crestal bone levels was performed using periapical and panoramic radiographs. Finite element analysis was used to assess stress distribution of

different framework designs. Follow-ups were conducted at 6 months, 1 year, 3 years, and 5 years. Statistical analysis included Kaplan–Meier survival estimates, paired t-tests, and multivariate regression to correlate prosthetic variables with clinical outcomes. Ethical approval was obtained and patients provided informed consent.

**Materials:** 1. Titanium implants with internal connection and SLA surface treatment, sterilized and stored in protective packaging. 2. CAD/CAM zirconia frameworks with high fracture toughness and translucency, stored in temperature-controlled containers. 3. Titanium frameworks for screw-retained prostheses, pre-milled and packaged to prevent contamination. 4. Hybrid ceramic blocks for digital milling, combining resin matrix with ceramic filler, stored in light-protected containers. 5. Screw-retained abutments, precisely machined, sterilized, and stored dry. 6. Cement-retained abutments compatible with resin-modified glass ionomer cements, stored in manufacturer-recommended conditions. 7. Resin-based provisional materials for temporization, stored in sealed syringes to prevent premature polymerization. 8. Intraoral scanners with high resolution and accuracy, calibrated before each use. 9. Torque-controlled drivers for precise abutment placement, sterilized and stored in dry conditions. 10. Surgical guides fabricated via 3D printing for accurate implant placement, sterilized and stored in protective packaging. 11. Low-viscosity resin cements for cement-retained prostheses, stored in light-protected syringes. 12. Radiographic positioning devices and standardized holders to ensure reproducible imaging, stored in protective cases.

**Results:** At five-year follow-up, prosthetic survival rate was 98% with minimal framework fractures. Marginal adaptation showed a mean gap of 45 ± 12 μm, indicating excellent fit. Screw-retained prostheses demonstrated fewer complications compared to cement-retained designs. Mechanical complications included minor screw loosening in 6% of cases and veneer chipping in 4%. No catastrophic framework failures were observed. Clinical parameters revealed stable peri-implant soft tissues, mean probing depth of 2.7 ± 0.5 mm, bleeding on probing 12%, and minimal crestal bone loss of 0.6 ± 0.3 mm. Patient satisfaction assessed via standardized questionnaires showed 92% reported excellent function, aesthetics, and comfort. Finite element analysis demonstrated uniform stress distribution in both zirconia and titanium frameworks, with hybrid ceramics exhibiting slightly higher stress concentrations at occlusal contacts but within safe limits.

**Discussion:** CAD/CAM-fabricated full-arch prostheses provide superior clinical performance compared to conventional techniques, mainly due to enhanced marginal fit, framework passivity, and material precision. Digital planning allows controlled emergence profiles, optimized occlusal schemes, and uniform framework thickness, reducing mechanical complications. Screw-retained prostheses reduce risks of cement-induced peri-implant disease, while cement-retained designs offer improved aesthetics in select cases with meticulous cement control. Material selection, including high-strength zirconia and hybrid ceramics, impacts long-term wear resistance and stress distribution. Clinical outcomes corroborate that digital workflows improve peri-implant tissue stability, patient satisfaction, and prosthesis longevity, confirming CAD/CAM as a reliable approach for full-arch rehabilitation.

**Conclusion:** CAD/CAM-fabricated full-arch prostheses demonstrate excellent clinical performance over a five-year period, with high survival rates, stable peri-implant tissue health, minimal mechanical complications, and high patient satisfaction. Screw-retained designs provide predictable outcomes with fewer biological complications, while material selection and digital design significantly influence prosthetic longevity and biomechanical behavior. Digital workflows enhance reproducibility, accuracy, and clinical efficiency, establishing CAD/CAM technology as the preferred method for full-arch rehabilitation in edentulous patients. Continuous monitoring and integration of emerging materials and software updates are essential to maintain long-term prosthetic success.

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