Section Editor
Clark M. Stanford, DDS, PhD, MHA
University of Iowa
Iowa City, Iowa, USA

David Chvartszaid, DDS, MSc (Prostho), MSc (Perio)
University of Toronto
Toronto, Canada

Thomas W. Oates, DMD, PhD
University of Maryland
Baltimore, Maryland, USA

Emad Estafanous, BDS, MSD
University of Illinois Chicago
Chicago, Illinois, USA

Jan-Eirik Ellingsen, DDS, PhD
University of Oslo
Oslo, Norway

Martin Osswald, BDS, MDent
University of Alberta
Edmonton, Canada

Clinical Performance of Dental Implants

Though comprehensive oral implant therapy can be a successful path, complications and possible persistent problems can also occur. Complications can be due to several factors that are either mechanical or biological. Complications also differ in nature, being either prosthetic failures or complications at the osseous level.

Bardis et al studied the performance of implants placed in the posterior edentulous area and concluded that there was a higher risk of peri-implantitis in patients who have apparent bruxism and poor oral hygiene. They also observed that older patients (≥ 60 years) had higher risks of mechanical complications, with this risk significantly increasing with the presence of bruxism, smoking, or periodontal disease. Bardis et al defined the success of implant treatment by the retention of all implant and prosthetic components without biological, mechanical, or technical complications. They also clearly pointed out the differences between the survival vs the success of an implant with good data; for example, in their study, the survival of an implant was 96.6%, while the success rate of implant treatment was 66.3%.

Berglundh et al studied peri-implantitis and placed a clinical practice guideline for the prevention of possible viable treatments to control existing peri-implant complications.

In part, the design of the prosthesis and the superstructures connected to the implant fixtures can affect the peri-implant soft and hard tissues. In a systematic review, Omeish et al evaluated the impact of bar designs in removable prosthetics on the peri-implant tissues. Despite bars sharing the stress across the implants, the biomechanical behavior can vary depending on the bar design parameters and the implant suprastructure. It was observed that there was better hygiene when the apical level of the bar was higher and further away from the mucosa (≥ 1 mm). Omeish et al also noted that the stress on the bone surrounding the implant fixtures was higher when the bar was higher. In cases where two implants were connected to a bar, the length of the distal extension played a great role in stress distribution. A 7-mm distal extension could present high strain, but the implant angulation also played a role. For example, 30-degree tilted implants with no distal extension had higher plaque index and gingival index than more vertically placed implants. In a four-implant scenario, 10-mm distal extensions did not affect distal bone loss or implant survival for milled bars. Also, round bars transferred less stress compared to rectangular and square bars, stiffer bars transferred more stress, and titanium and chrome cobalt bars had no influence on the stress in the bone surrounding the implants. In another scenario, one bar on four implants was more favorable than two separate bars on four implants. Multiunit abutments transferred less stress. In the case of four implants, 45-degree angled implants had higher stress compared to 30-degree and vertical fixtures, but the increase in the anterior-posterior spread provided better load distribution and less stress on the implants. Also, the presence of natural teeth in the opposing arch had favorable peri-implant health. The general conclusion of this study was that more information was needed to confirm these observations.

In the finite element study by Ye et al, the alveolar bone mass density affected the alveolar bone

resorption, with more favorable biomechanical outcomes in types I and II.

Addressing the mechanical failures in prosthetic restorations is very important, especially with the common use of all-ceramic restorations. Bömicke et al addressed the failure and initial damage of zirconia posterior cantilevered fixed partial dentures. Monolithic zirconia restorations performed better than partially or fully veneered zirconia restorations. The study also recommended further research on the different yttria content of the different generations of zirconia ceramic restorations. It was noted that all-ceramic restorations performed differently in implant-supported vs tooth-supported ceramic restorations. In tooth-supported ceramic restorations, the abutment tooth or teeth failed first, which was attributed to the different natures of teeth and implants, as well as the direction of force. It was recommended that oblique forces be avoided in cantilevered ceramic pontics.

Similar results were observed in a study by Larsson et al, which investigated 358 cases of implant-supported single crowns over a span of 10 years. Bruxism was observed to be a direct cause for implant failures, implant fractures, marginal bone loss, prosthesis failure, and mechanical complications. Also, men had more implant failures than women. Larsson et al attributed this to increased occlusal forces in men. The most common observed mechanical complications were crown and screw looseness, with a greater risk in external connection implants. The second most commonly observed mechanical failure was ceramic veneering failure and full monolithic zirconia crown chipping, which was in agreement with the findings of Pjetursson et al regarding multiunit fixed implant restorations. In Zumstein et al, more implant failures were in narrow- or reduced-diameter implants placed in the molar area, with an implant survival rate of only 80%. The clinical performance of the life of an oral implant needs very careful planning, as the outcomes can vary between different patients and different clinical scenarios

Emad Estafanous, BDS, MSD
Clark M. Stanford, DDS, PhD, MHA

Bardis D, Agop-Forna D, Pelekanos S, et al. Assessment of various risk factors for biological and mechanical/technical complications in fixed implant prosthetic therapy: A retrospective study. Diagnostics (Basel) 2023;13:2341.

The goal of this research was to determine the influence of several factors on biological and technical implant complications in posterior fixed implant prosthetic therapy. Materials and methods: The study group consisted of 67 edentulous patients (mean age: 63.88 ± 11.709 years; 20 men, 47 women) with implant prosthetic therapy for posterior edentulism. A total of 76 implant-supported fixed partial dentures and 178 implants were assessed using clinical and paraclinical assessments. Risk factors for biological complications (peri-implantitis) and technical complications were determined by using the Pearson chi-squared test and multivariate analysis. Implant success (the absence of biological and mechanical/technical complications) was 66.30%. The prevalence of biological complications was 13.5%. The prevalence of technical complications was 28.70%. Variables that were associated with a higher risk of peri-implantitis were poor oral hygiene and bruxism. In univariate analysis, poor oral hygiene increased the risk of peri-implantitis by 5.778 times and bruxism by 5.875 times. Variables that were associated with a higher risk of mechanical/technical complications were age group > 60 years, smoking, a history of periodontal disease, and bruxism. In univariate analysis, the risk of technical complications increased by 4.14 times for patients in the age group > 60 years (vs age group 40–60 years) and by 20.5 times for patients with bruxism. Bruxism and smoking were significant predictors of mechanical/technical complications in the multivariate model. In univariate models, patients with poor oral hygiene and bruxism had an increased risk of peri-implantitis. In multivariate models, we did not identify significant predictors of peri-implantitis. Age group > 60 yrs, smoking, history of periodontal disease, bone grafting, and bruxism were risk factors for the increase in the mechanical/technical complication rate. In the multivariate model, smoking and bruxism were significant predictors of the mechanical/technical complications.

Correspondence to: doriana.agop-forna@umflasi.ro

Berglundh T, Mombelli A, Schwarz F, Derks J. Etiology, pathogenesis, and treatment of peri-implantitis: A European perspective. Periodontol 2000 2024. Online ahead of print.

Peri-implantitis is a plaque-associated pathological condition that occurrs in tissues around dental implants. It is characterized by inflammation in the peri-implant mucosa and progressive loss of supporting bone. Over the last 30 years, peri-implantitis has become a major disease burden in dentistry. An understanding of the diagnosis, etiology and pathogenesis, epidemiology, and treatment of peri-implantitis must be a central component in undergraduate and postgraduate training programs in dentistry. In view of the strong role of

European research in periodontology and implant dentistry, the focus of this review was to address peri-implantitis from a European perspective. One component of the work was to summarize new and reliable data on patients with dental implants to underpin the relevance of peri-implantitis from a population perspective. The nature of the peri-implantitis lesion was evaluated through results presented in preclinical models and evaluations of human biopsy material together with an appraisal of the microbiological characteristics. An overview of strategies and outcomes presented in clinical studies on nonsurgical and surgical treatment of peri-implantitis is discussed, with a particular focus on end points of therapy and recommendations presented in the S3 level Clinical Practice Guideline for the prevention and treatment of peri-implant diseases.
Correspondence to: tord.berglundh@odontologi.gu.se

Omeish N, Bessou L, Carra M-C, Tavernier B, Porporatti AL. Effect of bar designs on peri-implant tissues health in implant-supported removable prostheses: A systematic review. BMC Oral Health 2024;24:138.

Different characteristics of bars (cross-sectional shape, diameter, distal extension, etc) lead to different biomechanical behavior (retention and stress) regarding implants and peri-implant tissues. The purpose of this review was to evaluate the impact of implant-supported removable prosthesis bar designs in a fully edentulous arch (in the maxilla and/or mandible) with four implants or more on the peri-implant soft and hard tissues. Two reviewers searched for observational studies, RCTs, and in vitro studies that were published on five main databases and three grey literature sources, without restrictions, in November 2023. Of the 3,049 selected articles, 4 met the inclusion criteria. Four RCTs evaluated peri-implant health tissues in fully edentulous arches that had four or six implants rehabilitated with implant bar overdentures. One prospective study with 5 years of follow-up evaluated the success/survival rate of implants and implant bar overdentures. Overall, 261 subjects with 1,176 implants were enrolled in our systematic review. The overdenture survival rate was 100%. There was a trend that plaque indices and gingival indices were low in all of the studies; however, no statistical analysis was done due to the lack of information. Due to the lack of information in the included studies, we cannot confirm if bar characteristics affect the peri-implant tissues health.
Correspondence to: Nadine.omeish@gmail.com

Ye Z, Ye H, Wu Y, et al. Effect of bone mass density and alveolar bone resorption on stress in implant restoration of free-end edentulous posterior mandible: Finite element analysis of double-factor sensitivity. Ann Anat 2024:253:152210.

Osseous condition of the mandible was regarded as a key factor that influenced implant stability in the early stage. Finite element analysis was used to assess the effect of bone mass density and alveolar bone resorption (double factors) on stress in a four-unit implant restoration of a free-end edentulous posterior mandible. A 3D finite element model was constructed for a single-sided free-end edentulous mandible (from mandibular first premolar to mandibular second molar) containing threaded dental implants. Mandible sensitivity modes were constructed with different alveolar bone resorption levels for normal conditions, as well as mild, moderate, and severe periodontitis. Based on the mass density of cancellous bone for four types of bones as the sensitivity parameter, two implant design modes were constructed: Model A (four-unit fixed bridge supported by three implants; implant positions: 34, 36, and 37) and model B: 34 × 36, 37 (34 × 36: three-unit fixed bridge supported by two implants, implant positions: 34 and 36; 37: a single-implant crown). A total of 32 sensitivity-based finite element models, grouped in two groups, were constructed. Stress distribution and maximum von Mises stress on cortical bone and cancellous bone around the implant, as well as on the surface of implant, were investigated by using ABAQUS when vertical and 45-degree oblique loading were applied, respectively. When vertical loading was applied to the implant, maximum von Mises stress on the cortical bone around the implant was assessed to be 4.726 to 13.15 MPa and 6.254 MPa to 13.79 MPa for groups A and B, respectively; maximum stress on the cancellous bone around the implant was 2.641 MPa to 3.773 MPa and 2.864 MPa to 4.605 MPa, respectively; maximum stress on the surface of implant was 14.7 MPa to 21.17 MPa and 21.64 MPa to 30.70 MPa, respectively. When 45-degree oblique loading was applied to the implant restoration, maximum von Mises stress on the cortical bone around the implant was assessed to be 42.08 MPa to 92.71 MPa and 50.84 MPa to 102.5 MPa for groups A and B, respectively; maximum stress on the cancellous bone around the implant was 4.88 MPa to 25.95 MPa and 5.227 MPa to 28.43 MPa, respectively; maximum stress on the surface of implant was 77.91 MPa to 124.8 MPa and 109.2 MPa to 150.7 MPa, respectively. Stress peak on the cortical bone and on cancellous bone around the implant increased and decreased, respectively, with the decrease in bone mass density. Stress peak on alveolar bone increased with alveolar bone resorption when oblique loading was applied. Both alveolar bone resorption and bone mass density (double factors) are critical to implant restoration. Bone mass density may exhibit a more pronounced impact than alveolar bone resorption. From the biomechanical perspective, types I and II bones are preferred for implant

restoration, while implantation should be considered carefully in the case of type III bone, or those with less bone mass density accompanied by moderate to severe alveolar bone loss. Splinted crown restoration is biomechanically superior to single crown restoration.
Correspondence to: biomech@163.com

Bömicke W, Boisserée P, Rammelsberg P, Stefan Rues. Initial damage and failure load of zirconia-ceramic and metal-ceramic posterior cantilever fixed partial dentures. Clin Oral Investig 2024;28:94.

The aim of this study was to compare failure load and initial damage in monolithic, partially veneered, and completely veneered (translucent) zirconia cantilevered fixed partial dentures (CFPDs), as well as completely veneered metal-ceramic CFPDs under different support and loading configurations. Eight test groups with anatomically congruent CFPDs (n = 8/group) were fabricated, differing in CFPD material/support structure/loading direction (load applied via steel ball [Ø 6 mm] 3 mm from the distal end of the pontic for axial loading with a two-point contact on the inner cusp ridges of the buccal and oral cusps, and 1.3 mm below the oral cusp tip for 30-degree oblique loading): (1) monolithic zirconia/CoCr abutment teeth/axial, (2) monolithic zirconia/CoCr abutment teeth/oblique, (3) partially veneered zirconia/CoCr abutment teeth/axial, (4) partially veneered zirconia/CoCr abutment teeth/oblique, (5) completely veneered zirconia/CoCr abutment teeth/axial, (6) completely veneered CoCr/CoCr abutment teeth/axial (control group), (7) partially veneered zirconia/implants/axial, and (8) partially veneered zirconia/natural teeth/axial. Restorations were artificially aged before failure testing. Statistical analysis was conducted using one-way ANOVA and Tukey post hoc tests. Mean failure loads ranged from 392 N (group 8) to 1,181 N (group 1). Axially loaded monolithic zirconia CFPDs (group 1) and controls (group 6) showed significantly higher failure loads. Oblique loading significantly reduced failure loads for monolithic zirconia CFPDs (group 2). Initial damage was observed in all groups except the monolithic zirconia groups, and fractography revealed design flaws (sharp edges at the occlusal boundary of the veneering window) in partially veneered zirconia CFPDs. Monolithic zirconia CFPDs might be a viable alternative to completely veneered CoCr CFPDs in terms of fracture load. However, oblique loading of monolithic zirconia CFPDs should be avoided in clinical scenarios. Design improvements are required for partially veneered zirconia CFPDs to enhance their load-bearing capacity. Monolithic zirconia may represent a viable all-ceramic alternative to the established metal-ceramic option for CFPD fabrication. However, in daily clinical practice, careful occlusal adjustment and regular monitoring should ensure that oblique loading of the cantilever is avoided.
Correspondence to: Wolfgang.boemickee@med.uni-heidelberg.de

Larsson A, Manuh J, Chrcanovic BR. Risk factors associated with failure and technical complications of implant-supported single crowns: A retrospective study. Medicina (Kaunas) 2023;59:1603.

Implant-supported single crowns have become a routine approach for the replacement of missing single teeth, being considered one of the most common methods of rehabilitation when the adjacent teeth are healthy. The present retrospective study aimed to investigate the risk factors possibly associated with the failure and technical complications of implant-supported single crowns and their supporting implants. Patients treated at one faculty (2009 to 2019) were considered for inclusion. Complications investigated included ceramic fracture/chipping, crown loss of retention/mobility, crown failure/fracture, loosening/loss/fracture of prosthetic screw, and implant failure/fracture. Any condition/situation that led to the removal/replacement of crowns (implant failure not included) was considered prosthesis failure. Univariate/multivariate Cox regression models were used to evaluate the associations between clinical covariates and failure. A total of 278 patients (358 crowns) were included. Mean ± SD follow-up was 56.5 ± 29.7 months. Seven implants (after a mean of 76.5 ± 43.7 months) and 20 crowns (21.3 ± 23.5 months) failed. The cumulative survival rate (CSR) for crowns was 93.5% after 5 years, remaining at 92.2% between 6 and 11 years. The most common reasons for crown failure were porcelain large fracture (n = 6), crown repeatedly loose (n = 6), and porcelain chipping (n = 5). Men and probable bruxism were identified in the Cox regression model as being associated with crown failure. The most common observed technical complications were mobility of the crown and chipping of the ceramic material, with the latter being observed even in crowns manufactured of monolithic zirconia. Cases with at least one technical complication (not considering loss of screw hole sealing) were more common among probable bruxers than in nonbruxers ($P = .002$). Cases of ceramic chipping were more common among bruxers than in nonbruxers ($P = .014$, log-rank test). Probable bruxism and patient sex (men) were factors associated with a higher risk of failure of implant-supported single crowns.
Correspondence to: agyemangjustice8@gmail.com

Pjetursson BE, Sailer I, Merino-Higuera E, Spies BC, Burkhardt F, Karasan D. Systematic review evaluating the influence of the prosthetic material and prosthetic design on the clinical outcomes of implant-supported multi-unit fixed dental prosthesis in the posterior area. Clin Oral Implants Res 2023:34(suppl 26):86–103.

The objectives of the study were to assess the survival, failure, and technical complication rates of implant-supported fixed dental prosthesis (iFDPs) with pontic or splinted crown (iSpC) designs in the posterior area and compare the influence of prosthetic materials and prosthetic design on the outcomes. Electronic and manual searches were performed to identify randomized, prospective, and retrospective clinical trials with a follow-up time of ≥ 12 months, evaluating the clinical outcomes of posterior iFDPs with pontics or iSpCs. Survival and complication rates were analyzed using robust Poisson regression models. Thirty-two studies reporting on 42 study arms were included in the present systematic review. The meta-analysis of the included studies indicated estimated 3-year survival rates of 98.3% (95% CI: 95.6% to 99.3%) for porcelain-fused-to-metal (PFM) iFDPs, 97.5% (95% CI: 95.5% to 98.7%) for veneered zirconia (Zr) iFDPs with pontics, 98.9% (95% CI: 96.8% to 99.6%) for monolithic or microveneered zirconia iFDPs with pontics, and 97.0% (95% CI: 84.8% to 99.9%) for lithium disilicate iFDPs with pontics. The survival rates for different material combination showed no statistically significant differences. Veneered restorations, overall, showed significantly ($P < .01$) higher ceramic fracture and chipping rates compared with monolithic restorations. Furthermore, there was no significant difference in survival rates (98.3% [95% CI: 95.6% to 99.3%] vs 99.1% [95% CI: 97.6% to 99.7%]) and overall complication rates between PFM iFDPs with pontics and PFM iSpCs. Based on the data identified by this systematic review, PFM, veneered Zr, and monolithic Zr iFDPs with pontics and iSpCs showed similarly high short-term survival rates in the posterior area. Veneered restorations exhibit ceramic chipping more often than monolithic restorations, with the highest fracture rate reported for veneered Zr iFDPs.

Correspondence to : bep@hi.is

Zumstein K, Waller T, Hämmerle CHF, Jung RE, Benic G, Mühlemann S. Clinical performance of monolithic zirconia crowns on titanium-zirconium reduced-diameter implants in the molar area: Interim data at three years of a randomized controlled trial. Clin Oral Implants Res 2023;34:1354–1362.

The aim of the present study was (i) to evaluate the clinical performance of reduced-diameter implants placed in the molar area and (ii) to test whether monolithic zirconia implant-supported crowns lead to similar clinical outcomes compared to porcelain-fused-to-metal crowns. A total of 76 patients needing a single implant crown in the posterior region were recruited. All patients received a titanium-zirconium reduced-diameter implant (Straumann Roxolid, Tissue Level, Standard Plus, diameter 3.3 mm, regular neck) and were randomly allocated to receive either a (1) monolithic zirconia crown (test) or (2) porcelain-fused-to-metal crown (control). Implant survival, prosthetic outcomes, and patient-reported outcomes were assessed at crown delivery and after 3 years of follow-up. Marginal bone levels (MBL) as well as clinical parameters including probing depth (PD), bleeding on probing (BOP), and plaque levels (PCR) were also recorded. A total of 59 patients were available at the 3-year follow-up; 32 patients with a monolithic zirconia crown (test) and 27 patients with a porcelain-fused-to-metal crown (control). 14 implants (11 implant fractures/3 aseptic losses) were lost leading to an estimated implant survival rate of 80% ± 5.1% (95% CI: 70.8% to 90.8%). Prosthetic complications were limited to the control group and involved minor chipping. This type of reduced-diameter implant to support single-implant molar crowns in the molar area cannot be recommended. Monolithic zirconia crowns appear to be a viable option in the posterior region, showing similar prosthetic outcomes to porcelain-fused-to-metal crowns.

Correspondence to: katrin.zumstein@zzm.uzh.ch