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Prospective evaluation of zirconia based tooth- and implant-supported fixed dental prostheses: 3-Year results

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ABSTRACT

Objectives: This prospective clinical study compared the performance of implant-retained (study group) and tooth-retained (control) zirconia based fixed dental prostheses (FDPs) with at least 4 units. The null-hypothesis stated that complication rates in both groups are equally distributed.
Methods: The study included patients in need of one 4- to 6-unit implant- or tooth-retained FDP each. All patients were examined 2 weeks after insertion (baseline) and then at 6 month intervals up to 3 years. At follow-up all restorations were examined for framework fracture, chipping, marginal integrity, surface roughness and biological complications. Kaplan–Meier estimation was used for data analysis.
Results: 20 patients received tooth-retained and 7 patients implant-retained FDPs. The study was halted early when differences in chipping rates reached a statistically significant level. One FDP in the study group was lost due to implant abutment failure. FDP related chipping rates were 71% in the study group (mean observation time 32 months) and 15% in the control (mean observation time 34 months). Unit (abutment crown/pontic) related chipping rates were 32% in the study group and 6% in the control. Chipping rates differed statistically significant (log-rank test, $p < .05$). However, all ceramic defects could be corrected by grinding and polishing. No framework fracture was detected.
Conclusions: Within the study limitations, survival rates seem satisfactorily in both implant- and tooth retained long-span zirconia based FDPs. However, implant-supported FDPs seem more susceptible to veneering ceramic chippings.
Clinical significance: The high chipping rates found in this study discourage the use of long-span implant-retained FDPs with zirconia frameworks.
The study was registered in ClinicalTrials.gov with the ID Number NCT02220764.

1. Introduction

In recent years all-ceramic fixed dental prostheses (FDPs) won popularity.[1] Due to improved mechanical properties,[2,3] their excellent biocompatibility[4,5] and aesthetics zirconia FDPs became promising alternatives to traditional porcelain fused to metal (PFM) FDPs.[6] Survival rates of zirconia based FDPs seem comparable to PFM FDPs.[7] Clinical studies proved a high fracture resistance of zirconia frameworks.[8,9] Yttria-tetragonal zirconia polycrystalline (Y-TZP) exhibits transformation toughening properties, increasing the fracture toughness

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and allowing its use for posterior tooth-retained and implant-retained FDPs. Although zirconia is a reliable core material, a number of clinical studies reported chipping of the veneering ceramic to be the most frequent complication.[8] Potential factors for these complications might have been an inappropriate framework design, mismatches in thermal expansion coefficients between zirconia and veneering ceramic or imperfect temperature control during firing. In implant-retained FDPs a systematic review reported incidences of chipping up to three times higher compared to tooth-retained FDPs.[9] This may be related to a reduced proprioception in implant-retained FDPs due to the lack of a periodontal ligament and a dental pulp. An intact proprioception seems essential for an optimal fine control of occlusal forces.[10,11] Furthermore dynamic load peaks in tooth-retained restoration may be absorbed by the periodontal ligament while osseointegrated implants show little shock absorbing capability. Thus higher peak forces must be expected in implant-retained prosthesis especially in patients with parafunctional habits.

Clinical studies show that 3-unit zirconia based FPDs perform well[12] but survival rates decrease with increasing FDP span-width.[13,14] However, the literature is lacking prospective studies comparing the performance of tooth- and implant-retained long-span zirconia FDPs. The objective of this clinical study was to investigate failure and complication rates of zirconia FDPs with at least 4 units and dental implants serving as abutments (study group) and tooth-retained FDPs as control. As a null-hypothesis it was stated that failure and complication rates are equally distributed in both groups.

2. Materials and methods

This prospective study was conducted in accordance with the Declaration of Helsinki (1964, revised in Venice 1983), approved by the local ethics committee (EK 1012008) and registered in ClinicalTrials.gov with the ID Number NCT02220764.

2.1. *Patient recruitment*

Patients in need for 4-to 6-unit tooth or implant supported FDPs were invited to participate in the study. Informed written consent was obtained from all patients prior to registration. All patients were informed implicitly about their right to withdraw from the study at any time. Exclusion criteria from the study were as follows:

- Addiction to alcohol or drugs.
- Severe craniomandibular disorders.
- Severe systematic diseases.
- Patients unable or unwilling to sign the informed consent form.

All treatments were carried out at the Department of Prosthetic Dentistry.

2.2. *Tooth-retained FDPs*

Abutment teeth criteria were as follows: vital dental pulp or successful root canal treatment, absence of periodontal inflammation, pocket depth <5 mm, tooth mobility <2 and furcation involvement <2. Where needed pretreatment comprised periodontal and endodontic treatment.

Tooth colour was chosen using the VITA Shade guide (VITA Zahnfabrik, Bad Säckigen, Germany) before tooth preparation. Abutment teeth were prepared following manufacturer's instructions: occlusal reduction of 1.5–2 mm, circular reduction of 0.8–1 mm and deep chamfer preparation. Preparation margins were located paragingivally or up to 0.5 mm subgingivally. Temporary FDPs were fabricated from autopolymerizing acrylic resin (Luxatemp, DMG, Hamburg, Germany) and cemented utilizing eugenol-free provisional cement (Temp Bond NE, Kerr, USA).

Impression was made with stainless steel stock trays using double-mix technique and vinyl polysiloxane impression material (Honigum, heavy-body and light-body, DMG, Hamburg). Generally impression of the opposing dentition was made with alginate.

2.3. *Implant-retained FDPs*

After prosthetic planning cylindrical dental implants with an internal abutment connection (Wi.tal Implants, Wieland Dental GmbH, Pforzheim, Germany) were placed using guide splints. All implants were placed by a well experienced oral surgeon following the manufacturer's instructions. Prosthetic therapy was accomplished after a healing period of 4–6 months. Impressions were taken with polyether (Impregum, 3 M Espe, Germany) using custom trays from light-curing resin (Palatray, Heraeus Kulzer, Hanau, Germany) and pick-up technique.

All laboratory procedures were carried out at a dental laboratory that had been authorized by Wieland Dental GmbH, Pforzheim, Germany. Individual zirconia implant abutments (Wi.tal Implants, Wieland Dental GmbH) were fabricated with a cervical shoulder depth of 1.2 mm. All zirconia abutments were then bonded to titanium bases with Panavia 21 (Kuraray Co, Kurashiki, Japan).

All zirconia FDP frameworks were designed using the software package DentalDesigner ^{TM} (Wieland Dental GmbH). Frameworks had a minimum thickness of 0.5 mm and a connector cross-section size of 3 mm × 3 mm minimum. Frameworks were milled from pre-sintered blanks (Zenotec Zr Bridge, Wieland Dental GmbH) and sintered. All frameworks were checked intraorally for their accuracy of fit. Crown margins were inspected with a dental explorer and the internal fit was evaluated with a silicone disclosing agent (Fit Checker, GC America Inc.). In cases of misfit new impressions were taken and frameworks remade. After try-in the frameworks were veneered with layering porcelain. Prior to insertion all FDPs were checked intraorally for marginal integrity. Proximal and occlusal contacts were evaluated with articulation foil (Accufilm, Parkell, Inc. Edgewood, NY, USA) in static and dynamic occlusion and adjusted adequately with porcelain polishing kit (CeramiPro Dialite, Brasseler, USA). Implant abutment screws were tightened with a torque of 35 Ncm. All FDPs were cemented with glass ionomer cement (Ketac^{TM} cem, 3 M Espe, Germany).

All patients were examined 2 weeks after insertion (baseline) and then at 6 month intervals up to 3 years. The