Five-Year Clinical Prospective Evaluation of Zirconia-Based Denzir 3-Unit FPDs

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Purpose: The aim of this prospective study was to evaluate the clinical performance of fully sintered hot isostatic pressed yttria-partially-stabilized zirconia (Denzir) 3-unit fixed partial dentures (FPDs). ***Materials and Methods:*** Nineteen 3-unit FPDs were placed in 18 patients. Ten FPDs were placed in the maxilla and 9 in the mandible. Two calibrated examiners evaluated the FPDs independently 1 week (baseline), 1 year, 3 years, and 5 years after placement using the California Dental Association quality evaluation system. ***Results:*** All FPDs were intact at the 5-year examination. One FPD lost retention after 12 months but remained intact; it was recemented and is still in function after 5 years. All FPDs were rated satisfactory over 5 years. No changes were seen in terms of color and anatomic form. The number of slightly rough or pitted occlusal surfaces increased approximately 30% over 5 years. Visible evidence of ditching along the margin increased over time, but only for those FPDs luted with zinc phosphate cement. ***Conclusion:*** The 5-year results indicate that yttria-partially-stabilized zirconia 3-unit FPDs with anatomically designed frameworks are promising prosthetic alternatives, even in the premolar and molar regions. However, for all-ceramic FPDs with more units in function, further studies are necessary. *Int J Prosthodont 2008;21:223–227.*

In recent years, the favorable mechanical properties of polycrystalline ceramics such as alumina and zirconia have made treatment with more extensive all-ceramic fixed partial dentures (FPDs) possible. The higher toughness of zirconia compared to alumina and other ceramics makes it a favorable choice as a core material. Zirconia is industrially sintered, resulting in blanks without porosities. Modern computer-aided design/computer-assisted manufacture (CAD/CAM) techniques enable the processing of these very hard materials, making it possible to successfully process cores for FPD frameworks. The majority of systems use partially sintered yttria-partially-stabilized zirconia blanks, a faster process that results in less wear compared to systems using fully sintered blanks.[1] The former process needs to compensate for the final sintering shrinkage by enlarging the original form before milling (20% to 25%), which is not needed for the fully sintered blanks. Regarding FPD reconstructions made of polycrystalline materials, few studies describe clinical long-term outcomes.[2–7] One concern about zirconia is its aging over time.[8–10] Another is the quality and longevity of the bond between the framework and the covering feldspar porcelain.[2,6,7] Those issues, among others, must be solved before more extensive use of this material can be recommended.

The aim of this prospective study was to evaluate the clinical performance of fully sintered, hot isostatic pressed yttria-partially-stabilized zirconia (Denzir, Cad.esthetics) 3-unit FPDs veneered with 2 different porcelain materials.

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Materials and Methods

Patient Selection

Patients in need of 3-unit FPDs were asked to participate in the study. They were informed about the purpose of the study, the clinical procedures, and the material used. Exclusion criteria included severe bruxism and/or periodontal disease. All participants had a complete dentition in the opposite arch occluding the ceramic FPD. Third molars, however, could be missing. All patients gave their written informed consent to participate in the study, which was approved by the Ethical Research Committee at Göteborg University, Sweden.

Clinical Procedures

The clinical treatment was performed by experienced clinicians who were either specialists in prosthetic dentistry or general practitioners at 2 centers in Sweden. One patient received 2 FPDs and all remaining patients received 1 FPD each. The tooth preparation procedure was performed in accordance with the manufacturer's guidelines. All abutment teeth had a chamfer preparation (90 to 120 degrees) without any undercuts and with a cervical preparation minimum depth of 1 mm, buccal/lingual/approximal reduction of 1 mm, and occlusal reduction of 1.5 mm.

Full-arch impressions were taken using a perforated metal stock tray and an A-silicone putty-soft and light-body material (President, Coltène). Impressions of the opposing arch were made with an irreversible hydrocolloid impression material. All patients were given a direct provisional FPD (Protemp, 3M ESPE) during the manufacturing period.

Before cementation, the abutment teeth were cleaned with 3% hydrogen peroxide and preconditioned according to the manufacturer's instruction. Ten FPDs were cemented with zinc phosphate cement (De Trey Zinc, Dentsply) and 9 were luted with resin cement (Panavia F, Kuraray).

Laboratory Procedures

The FPD frameworks were manufactured with the Cad.esthetic CAD/CAM system (Cad.esthetics) using a prefabricated noncolored, solid block of fully sintered, hot isostatic pressed yttria-partially-stabilized zirconia ceramic. The material was sintered at a temperature $<$ 1,500°C to increase the density of the material and then heated to 1,400°C to 1,500°C under pressure $>$ 1,000 bar in an inert atmosphere. The frameworks were manufactured with an anatomic form and a minimum wall thickness of 0.5 mm. For optimal esthetics, they were veneered with either feldspar porcelain (Vita Veneering Ceramic D, Vita Zahnfabrik) or a glass-ceramic (IPS Empress, Ivoclar Vivadent). The type of veneering material was blinded to the treating clinician and evaluators. The dimension of the cross sections of the connecting areas between the abutments and pontic was 3 $\times$ 3 mm. All FPDs were manufactured by the same dental technician.

Evaluation Procedures

The 19 FPDs were examined 1 week (baseline), 1 year, 3 years, and 5 years after completing treatment. Complications such as chipping or fracture of the veneering material or framework fractures that had appeared between the baseline examination and the reexaminations were registered, along with the subjective opinion of each patient. Margin index in accordance with Silness,[11] secondary caries, loss of vitality, and periapical lesions were monitored for the abutment teeth. Plaque and bleeding indices in accordance with Lenox and Kopczyk[12] were monitored at the abutment teeth and contralateral teeth. Radiographs and clinical photographs were taken.

The authors examined all restorations in accordance with the California Dental Association's (CDA) system for quality assessment of dental care,[13] focusing on surface and color, anatomic form, and margin integrity.

Results

Eighteen patients—12 women with a mean age of 58 years (range: 48 to 84 years) and 6 men with a mean age of 60 years (range: 55 to 69 years)—received 19 FPDs (Table 1). All FPDs had full occlusal contact with teeth in the opposite arch. All patients attended all examinations. Patient satisfaction was overall very positive regarding both function and esthetics at all examinations. After 5 years, the survival rate was 100%, and all FPDs were intact (Fig 1). One complication was registered at the 1-year examination. One FPD (Fig 1) lost retention after 12 months. This FPD had been luted with Panavia F. No signs of fractures or surface defects were seen, internally or externally, and the FPD was recemented with the same resin cement. No further complications of this FPD were registered.

No significant difference was seen between abutment teeth and corresponding contralateral teeth regarding plaque and bleeding on probing. The plaque and bleeding indices were 15% and 5%, respectively, for abutment teeth and contralateral teeth at all 4 examinations. Margin index revealed that the majority of the buccal and lingual/palatal margins were placed at the margin or supragingivally. Approximal margins were placed subgingivally in 5% of the abutments. No caries was registered over time.

Table 1 Distribution of the FPDs, Nonvital Abutments (†), Abutments with Posts and Cores (‡), and Empress (*) and Vita (**) Veneering Material

FPD no.																
1			*	X												
2					*	X										
3					*	X										
4					*	X										
5							*	X								
6											*	X				
7											*	X	†			
8												**	X			
9												**	X	‡		
10													*	X	‡	
	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
Tooth no.																
	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
11		*	X													
12		**	X													
13		**	X													
14		*‡	X	†												
15			*‡	X												
16											**	X	‡			
17												**	X			
18													**	X		
19													*	X		

Fig 1 Clinical view of a posterior mandibular Denzir FPD after 5 years in service.

Table 2 Deviations (%) from a CDA Rating of Excellent Over 5 Years of Follow-up

	Abutment 1	Abutment 2	Pontic
SMM			
Baseline	16	16	16
1 y	16	16	16
3 y	16	16	16
5 y	21	26	26
SRO			
Baseline	16	5	0
1 y	21	5	0
3 y	26	21	16
5 y	37	32	32
SOCO			
Baseline	10	5	0
1 y	10	5	0
3 y	10	5	0
5 y	10	5	0
SCR/SDIS			
Baseline	5/0	5/0	–
1 y	5/0	10/0	–
3 y	5/0	26/0	–
5 y	5/16	26/5	–

SMM = slight mismatch between the restoration and tooth structure within the normal range of tooth color, shade, and/or translucency; SRO = surface of restoration is slightly rough or pitted but can be polished; SOCO = restoration is slightly overcontoured; SCR = visible evidence of ditching along the margin; SDIS = discoloration of the margin between the restoration and the tooth structure.

The CDA rating of satisfactory was given for 100% of the FPDs at all examinations. Deviations from the range of excellent are presented in Table 2. Only slight mismatch between the restoration and tooth structure within the normal range of tooth color was seen. No differences of registered surface roughness were seen between FPDs veneered with Empress (4 FPDs) or Vita D (3 FPDs). Regarding anatomic form, slightly overcontoured restorations were seen in 5% to 10% of cases. Visible evidence of ditching along the margin was registered in 5% of the mesial abutments. No changes were seen over time. For the distal abutment, an increasing amount of ditching was registered from baseline (5%) to the 5-year examination (26%). Ditching was only registered for FPDs luted with zinc phosphate cement. At the 5-year examination, discoloration of the margins was registered in 16% of mesial abutments and 5% of distal abutments.

Discussion

A small number of short-term studies concerning glass-reinforced or glass-ceramic FPDs have reported failure rates from 6.7% to 50%.[14–19] The main reasons reported were framework fractures in the connector area, and so far, failures have been more frequently reported for FPDs in the posterior area. For FPDs with a framework based on zirconia, the reported survival rates are as high as 100% after 3 years in service.[2–6] In a 5-year follow-up study of 3- and 4-unit posterior fixed partial dentures, the success rate of the zirconia frameworks was 97.8% but the survival rate was 73.9% because of other complications, mainly secondary caries and chipping of the veneering ceramic.[7] In the present study, the 5-year survival rate of 3-unit FPDs fabricated from fully sintered hot isostatic pressed yttria-partially-stabilized zirconia was 100%.

Several in vitro studies have focused on the critical stress distribution pattern in ceramic materials.[20,21] Brittle materials need dimensions that minimize tensile stresses, and therefore the recommended dimensions for connectors in glass-ceramics and glass-reinforced alumina FPDs have been overdimensioned compared to metal-reinforced FPDs. This was verified in studies where connector fractures were related to connector dimensions not meeting the manufacturer's specification.[22] Because of the mechanical properties of zirconia and the results from clinical studies, it seems that the connector dimension can be similar that used for metal-reinforced FPDs.[2–6]

Concern has been raised regarding the risk of an insufficient bond of veneering ceramics to the zirconia framework, and chipping of the material has been reported to take place in 13% to 32% of zirconia FPDs.[2,3,5–7] This is in contrast to the results of present study, in which no material-related failures appeared during the 5-year observation period. When comparing 2 different ceramic systems, Denzir and In-Ceram Zirconia, Larsson et al[3] found significantly higher levels of chipping fractures for implant-retained Denzir FPDs. The Denzir material/processing system was the same as that used in present study, but a different result was seen for the veneering porcelain. Consequently, the results are conflicting. One explanation could be the different abutment support. It has been reported that more porcelain fractures occur for implant-supported FPDs.[23] However, in the study of Larsson et al,[3] the abutment support was the same regardless of the ceramic system. Another possible explanation is differences in the laboratory and technical handling of the material. In the study by Larsson et al, 2 dental technicians made the veneering porcelain, 1 for each ceramic system. In the present study, 1 dental technician performed all laboratory work, and no chipping or debonding was seen. Further, in present study the frameworks were anatomically designed to provide solid support to the veneering material, which is likely of equal importance to the handling of and type of veneering material.

Patient satisfaction was positive overall. Small deviations regarding color, surface texture, and anatomic form were observed from baseline to the 5-year examination, but all were within the range of satisfactory. This is in agreement with the results of other studies concerning all-ceramic FPDs.[2–7,14,16–19,22] Furthermore, no difference in surface texture or color appearance between the 2 veneering materials was seen, and no effect on 5-year survival was registered.

Clinical long-term success of all-ceramic FPDs can be influenced by marginal discrepancies. In the present study, abutments luted with zinc phosphate cement showed increasing ditching from baseline (5%) to the 3-year examination (26%). This is in agreement with the study by Albert and El-Mowafy,[24] in which zinc phosphate cement resulted in the highest percentage of extensive microleakage. Compared to other studies, the frequency of ditching was small and appeared after a longer time in service.[2,5,7,19] Discoloration of the margins was registered in 16% of FPDs after 5 years. This is far less compared to other studies, where discoloration of resin cement margins in up to 50% of all-ceramic FPDs has been reported.[5]

The preliminary results of the present 5-year study of 3-unit Denzir FPDs in the lateral segments seem promising. However, it should be emphasized that they were limited to 3 units. Furthermore, it must be emphasized that there was a controlled patient selection and the treating clinicians and technicians were experienced. The results are promising, but only time will tell about the long-term success.

Conclusion

Within the limitations of the present prospective study, the 5-year results indicate that yttria-partially-stabilized zirconia (Denzir) 3-unit FPDs with anatomically designed frameworks are promising prosthetic alternatives, even in the premolar and molar regions. However, for all-ceramic FPDs with more units in function, further studies are necessary.

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