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Full Zirconia Fixed Detachable Implant-Retained Restorations Manufactured from Monolithic Zirconia: Clinical Report after Two Years in Service

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Abstract

The most frequently encountered problem with fixed detachable dental prostheses is loosening or fracture of the prosthetic screws. Other problems include wear, separation or fracture of the resin teeth from the metal/acrylic prosthesis, chipping or fracture of porcelain from the metal/ceramic or zirconia/ceramic prosthesis, and fracture of the framework in some free-end prostheses. For this type of prosthesis it is necessary to place the implants in a position that enables occlusal or lingual access so as not to impair the esthetics. This clinical report describes the restoration of a patient with complete fixed detachable maxillary and mandibular prostheses made of monolithic zirconia with angled dental implants with buccal access. The prostheses were esthetically pleasing, and no clinical complications have been reported after 2 years.

Full-mouth reconstruction of a patient using dental implants is a challenge if there is vertical and horizontal bone resorption, since this includes the gingival area and restricts the position of the implants; however, hard- and soft-tissue grafting may allow the implants to be placed into the desired position. Although it is possible to regenerate lost tissues, an alternative is to use fixed detachable prostheses that restore the function and the esthetics of the gingiva and teeth. Various material combinations including metal/acrylic, metal/ceramic, and zirconia/ceramic have been used for constructing this type of restoration.[1-11]

Fixed detachable dental prostheses made of metal/acrylic may pose the following problems: loosening of the acrylic teeth, lack of natural color primarily in the prosthetic gingiva area, and wear of the occluding surfaces over time. Consequently replacement of teeth and maintenance of the prosthesis are required.[3-8] Prostheses made of metal/porcelain offer an excellent esthetic result; however, a major disadvantage of metal/porcelain prostheses is that the porcelain can break, endangering the entire restoration.[12-16] In zirconia/ceramic prostheses, ceramic chipping[17-19] or breakage of the zirconia framework can make the repair impossible.[20,21] Additionally, if the implant is in an angled position because of the anatomy of the bone, it may be necessary to use an angled abutment to avoid buccal access through the prosthesis in the esthetic area. Additionally, for patients with a high smile line, the treatment of the prosthetic gingiva with acrylic or ceramic is important.[22,23]

The zirconium oxide (yttrium-partially stabilized with tetragonal polycrystalline structure)[24] used to fabricate the prostheses described in this clinical report has been used successfully since the 1970s for orthopedic purposes.[25] It is made of raw mineral materials, such as chemically manufactured zirconium sand, partially stabilized with yttrium, and converted by mechanical procedures into zirconia blocks.[24-28] Zirconium is used in the manufacture of many types of dental restorations[26] and may be a more suitable prosthetic material due to its capability for limiting bacterial colonization,[27,28] and because it produces less wear to antagonistic teeth than does feldspathic dental porcelain.[29]

This clinical report describes a complete restoration using monolithic zirconia fixed detachable maxillary and mandibular prostheses. The incisal edges and occluding surfaces were made of monolithic zirconia (Prettau Zirconia, Zirkonzahn, Gais, Italy), to decrease the risk of chipping or fracture.

Clinical report

A 52 year old man presented to the Mediterranean Prosthodontic Institute (MPI) in Castellon, Spain with a request to have "fixed teeth." A comprehensive clinical and radiographic examination revealed advanced bone loss due to advanced periodontal disease (Fig 1). His general health was not impaired.

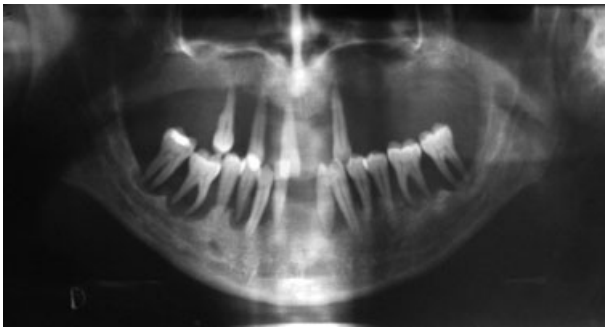

Figure 1 Residual dentition and bone loss due to advanced periodontal disease.

According to the Prosthodontic Diagnostic Index (PDI) for classification of partial edentulism, the patient was characterized as Class IV.[30] A panoramic radiograph was made, and the possibility of inserting dental implants in the remaining bone was considered, although not in the lower posterior region on both sides. A complete restoration of the entire mouth was planned by using fixed detachable prostheses supported by dental implants.

The treatment was divided into stages in order to control the patient's function and esthetic appearance. In the first stage, teeth were extracted without alveolectomy or ridge preservation. Insertion of the immediate interim complete denture was made, so as to restore the occlusal vertical dimension (OVD)[31] and to determine some aspects of the esthetics.

Eight maxillary and six mandibular fluoride-modified implant surfaces (OsseoSpeed, Astra Tech AB, Mölndal, Sweden) were placed in the 8th and 12th week, respectively (Fig 2, 3) (Table 1). A duplicate of the interim prosthesis was used as a surgical drilling template.

Insertion of straight healing abutments (Healing Abutment, Astra Tech AB) clearly showed the angulations of the implants and the future emergence profile in the buccal areas. After suturing, the interim complete dentures were adapted, and acrylic was reduced in the healing abutment areas so that the dentures did not touch the healing abutments during the osseointegration period. No soft liner was used.

Table 1 Implant distribution, diameters, and lengths

Implant distribution	Implant diameter (mm)	Implant length (mm)
3	3.5	11
4	3.5	11
5	4.5	11
7	4.0	8
9	4.5	11
11	4.5	9
12	4.5	13
14	4.5	11
22	4.5	11
23	3.5	11
24	3.5	11
26	3.5	11
27	3.5	11
28	4.5	9

After 8 weeks of osseointegration, the healing abutments were replaced by solid titanium abutments (3 mm high) for screw-retained restorations (20° UniAbutments, Astra Tech AB) in each implant site (Fig 4). An open tray definitive abutment level impression was made with a polysiloxane impression material (Coltoflax; Coltène/Whaledent AG, Altstätten, Switzerland). Closing copings (20° ProHeal Cap, Astra Tech AB) were placed on the abutments. Soft tissue was reproduced in the impression using vinylpolysiloxane (Gingifast Rigid; Zhermack, Rovigo, Italy), and maxillary and mandibular definitive casts were poured with type IV stone (T.C. 15; Techim Group, Milan, Italy).

The maxillary relation was taken with an arbitrary ear facebow (Denar Slidematic Facebow; Waterpik Technologies, Inc., Ft. Collins, CO). The infraorbital margin was used as a third point of reference. The OVD and an interocclusal centric relation were transferred to a semiadjustable articulator (Hanau Modular Articulator System 190; Waterpik Technologies, Inc.) using occlusal rims. Average setting of the condylar inclination on the articulator was 33° for the sagittal and 15° for the lateral condyle path inclination.[32] Afterward, a verification device was fabricated intraorally to evaluate the accuracy of the definitive cast. Impression copings were connected to the abutments and splinted to each other with acrylic resin (Duralay, Reliance, Dental Mfg. Co. Worth, IL). The verification jig was sectioned and reconnected, unscrewed, and transferred to the definitive cast. Passive fit of the index on the definitive cast was confirmed, and the accuracy of the definitive cast was verified.

Afterward, two fixed detachable interim maxillary and mandibular prostheses were manufactured in self-curing acrylic resin (Palapress Vario; Heraeus Kulzer, Hanau, Germany), using acrylic denture teeth, mold T46 for anterior and PU31 for posterior teeth (Vita MFT; VITA Zahnfabrik, Bad Säckingen, Germany), color A2 (VITAPAN classical shade guide; VITA Zahnfabrik). A metal framework and temporary cylinders (Temporary Cylinder, Uni 20°, Astra Tech AB) were built onto the lower fixed detachable prosthesis. This design was used to provide an increased resistance to deformation in the area of the free-end prostheses. The passive fit of the maxillary and mandibular fixed detachable interim prostheses on the abutments was evaluated in different ways. First, pressure was applied first on one end abutment and then on the other side[33] to look for movement of the prostheses. A visual check was then carried out, and fit was evaluated with an explorer.[34] Passivity was verified with an individual screw[35] in one of the end abutments. No movement of the restoration was noticed, and the restoration remained in its position at the opposite end abutment. The fit between the prostheses and all abutments was clinically verified in three dimensions, and was confirmed in two dimensions via periapical radiographs.[36]

Through these fixed detachable interim prostheses, the parameters of esthetics and function were determined (Fig 5). Analysis of the patient's smile showed that the commissural line was not parallel to the interpupillary line, and the lip showed some asymmetries when relaxed. Also, there were asymmetrical movements of the lips at different moments during smiling, making the analysis difficult. These modifications were made

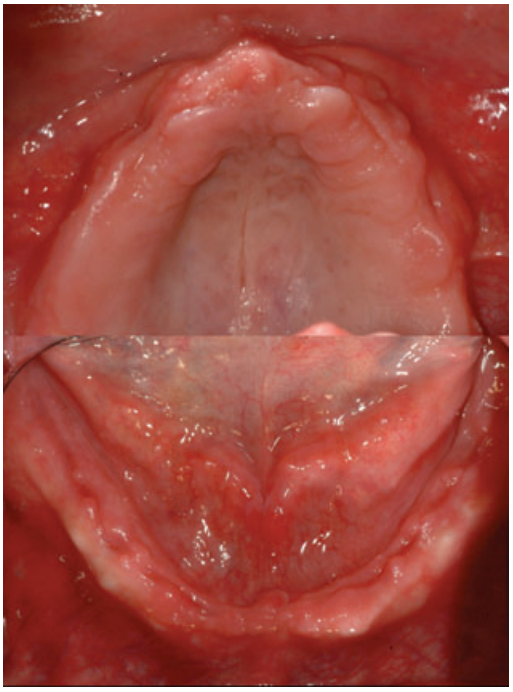

Figure 2 Twelve weeks after extractions.

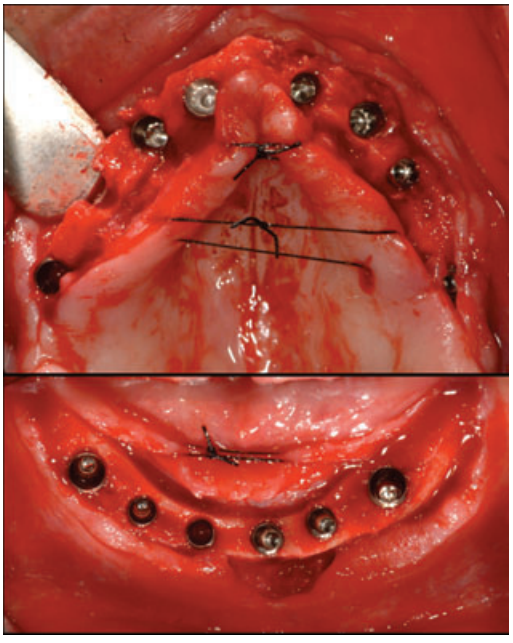

Figure 3 Implant placement in maxilla and mandible for conventional loading.

in the interim fixed detachable prostheses: the length of the maxillary central incisors was reduced intraorally using a high-speed diamond bur (Komet 5850.314.016; Komet USA LLC, Rock Hill, SC), and the patient's smile line was drawn in relation to the lower lip. The cervical contour of the maxillary anterior teeth was lengthened in an apical direction by adding

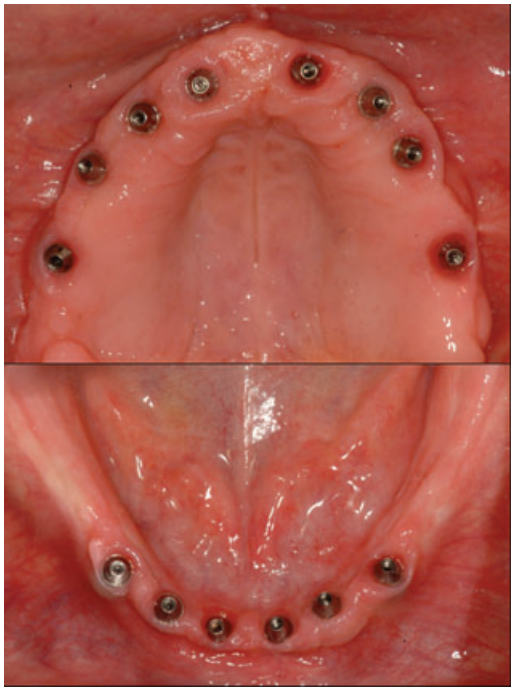

Figure 4 Solid titanium abutments for screw-retained fixed detachable restorations.

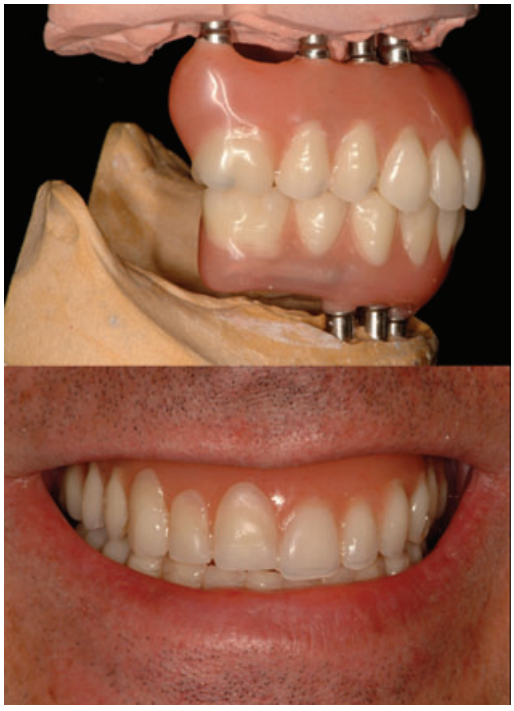

Figure 5 Fixed detachable interim prosthesis for determination of standard esthetic parameters.

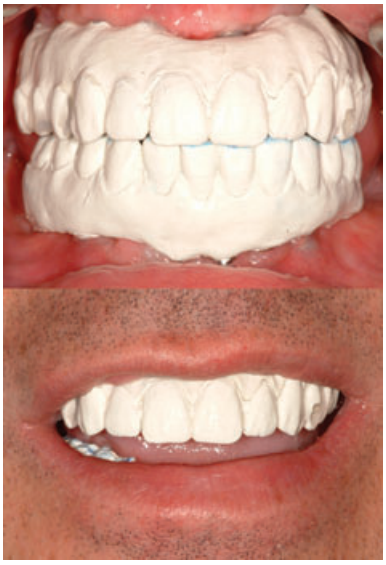

Figure 6 White resin frame to evaluate the final esthetics and occlusion intraorally.

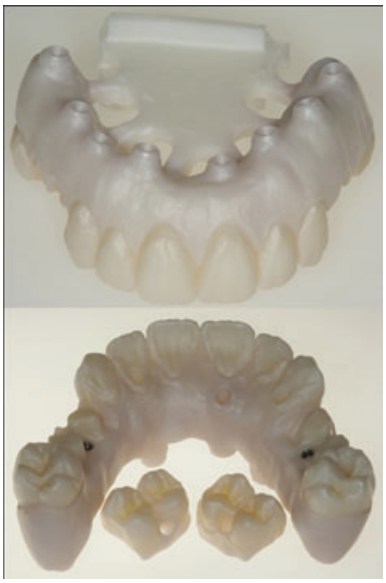

Figure 7 Full zirconia prosthesis from a monolithic zirconia before being colored.

light-cured composites (Z100 Restorative, 3M ESPE, St. Paul, MN), to compensate for the incisal reduction and to reduce the gingival area visible when smiling (Fig 5).

When all esthetic and functional parameters for the patient were satisfied, maxillary and mandibular impressions of the prostheses were made with irreversible hydrocolloid (Cavex CA37; Cavex, Haarlem, The Netherlands), and poured with type III stone (Elite model; Zhermack), copying the interim fixed detachable prostheses. Afterward, the patient's fixed detachable interim prostheses were removed, and the maxillary prosthesis was screwed into the previously articulated definitive cast. Afterward, the cast of the mandibular interim prosthesis

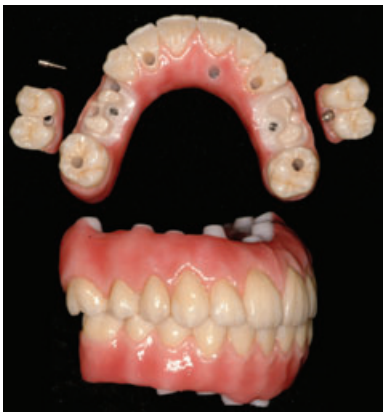

Figure 8 Prostheses in full zirconia after being colored.

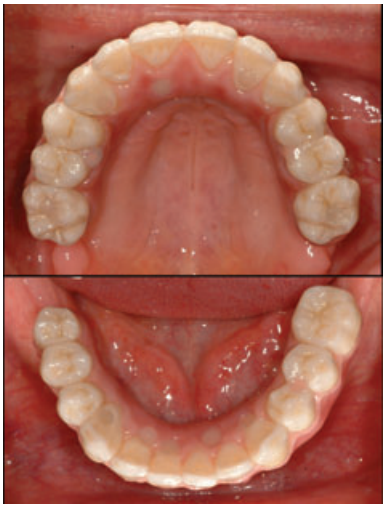

Figure 10 Restorations screwed into the abutments. Note the full-zirconia occlusal surface and no evidence of chipping after more than 2 years.

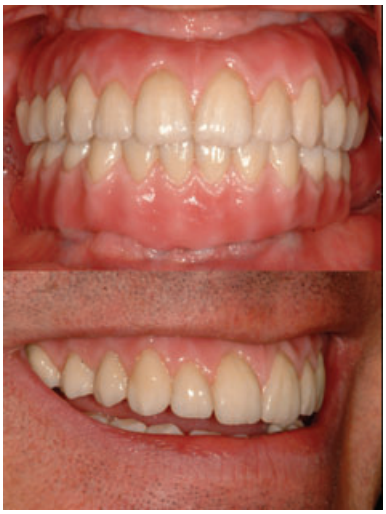

Figure 12 Esthetics and function were restored with the full-zirconia restorations.

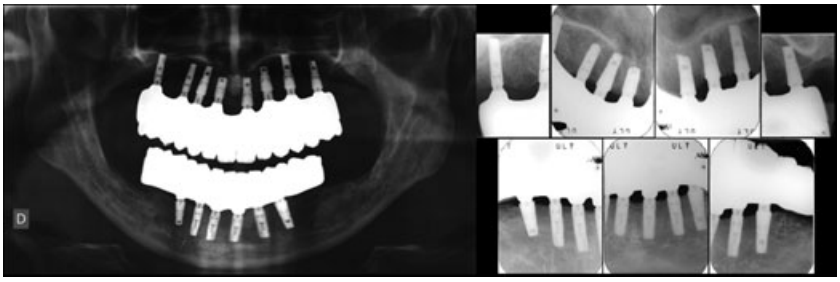

Figure 9 Initial X-ray of the full-zirconia fixed detachable restorations. Note the marginal bone at the level of the implants and the fit of the restorations.

was articulated at the same OVD against the maxillary definitive cast and interim prosthesis. Then, the maxillary cast was articulated against the previously mounted mandibular cast. By this method of cross-mounted casts, the dental technician manufactured the maxillary fixed detachable white resin prosthesis (Frame, Zirkonzahn) by using the mandibular cast as an antagonist to control the occlusal plane, the midline, and the smile line. As soon as the two prostheses made of white resin (Frame) were manufactured, they were screwed in the patient's mouth to evaluate occlusion and esthetics (Fig 6). The passive fit of the maxillary and mandibular white resin prostheses (Frame) on the abutments was evaluated in the same way as for the interim prostheses. No adjustments to the white resin prostheses were required.

The white acrylic prostheses were copied into full zirconia prostheses (Prettau, Zirkonzahn) from a 40 mm high block of zirconium oxide (Ytrium-partially stabilized with tetragonal polycrystalline structure) (Prettau Zirconia 16er XH40, Zirkonzahn) using a copy-milling unit (Zirkograph 025 ECO, Zirkonzahn) (Fig 7). The milled units were colored as appropriate for teeth and gingiva (Color Liquid, Zirkonzahn). The gingival color was selected for the patient by means of a color guide for the pink-colored ceramic (Ceramic Tissue, Zirkonzahn). Finally the prostheses were dried and then sintered (Fig 8).

The passive fit of the maxillary and mandibular restorations on the abutments was evaluated in the same way as for the interim fixed detachable prostheses and white resin prostheses (Frame), and the fit was confirmed in two dimensions via periapical radiographs (Fig 9). The lower fixed detachable prosthesis was screwed and tightened with a 15 Ncm torque. In the maxilla, first the macro structure was screwed, and then the substructures were screwed with 15 Ncm torque (Fig 10). Afterward, the access holes were covered with gutta-percha (Gutta Percha; Henry Schein, Inc, Melville, NY) and light-cured composite (Z100 Restorative).

The initial periapical radiograph (Fig 9) shows the fitting of the fixed detachable restorations on the abutments and the bone at the level of the implants. After 2 years, the periapical radiograph showed no changes to the bone level (Fig 11) when compared with the initial periapical radiographs. The soft tissue remained stable, with no inflammation or bleeding in any region. There was no presence of tartar. No change could be seen in the restorations, with no fractures within the occlusal or incisal areas or any wear. The patient reported no problems (Fig 12). The prosthesis made of monolithic zirconia improved the patient's oral function and esthetic appearance.

Discussion

There have been previous reports on the use of fixed detachable prostheses made of metal/acrylic, metal/ceramic, or zirconia/ceramic. In studies of hybrid prostheses using frameworks of various materials, several different complications arose. In 1999, Bergendal et al compared titanium frameworks and gold alloys over 5 years,[3] and reported slightly more fractures of Ti frameworks than gold alloy frameworks and more fractures of artificial teeth in the Ti frameworks. Most fractures were related to the welding joints at the distal abutments. In 2000, Örtorp et al reported no mechanical complications except for some fractures of the resin facing[4] in a 1 year prospective study. In 2003, Duncan et al, in another prospective study regarding a clinical test over a period of 36 months, reported that 68% of patients provided with fixed detachable prostheses had complications.[5] For the majority of patients, this concerned fracture of the resin teeth. This occurred more frequently in the anterior than posterior area and with a greater frequency after 1 year of use.

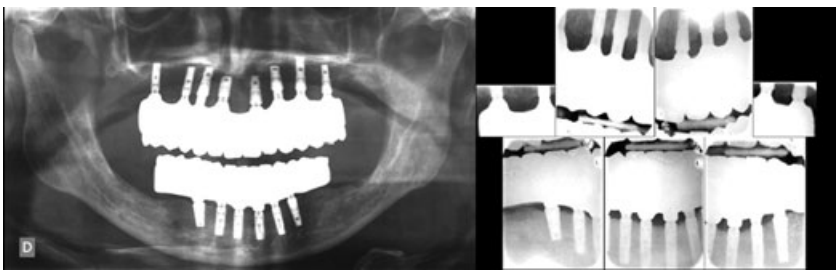

Figure 11 Radiographic control after 2 years in use showing stable marginal bone at the level of the implants.

In 2009, Örtorp and Jemt conducted a comparative follow-up study on a supervised period of 15 years, in which laser-welded Ti frameworks were compared with gold alloy frameworks.[6] In that study, the fracture of the resin or acrylic teeth and the inflammation of the soft tissue were the most common complications with hybrid prostheses fabricated with Ti frameworks. Fractures in the Ti framework were detected in 15.5% of the patients. More fractures were detected in Ti frameworks than in gold alloy frameworks.[6]

The most common complication with metal/acrylic restorations is the need to replace the acrylic resin prosthetic teeth due to wear or fracture of the acrylic teeth. Fracture of the resin tooth is due to different factors, including poor bonding of the tooth to the acrylic resin, trauma, and insufficient support from the framework. Resin tooth wear could be a result of increased occlusal forces using fixed prostheses, or in some cases, due to parafunctional activities.[7,8] In ceramometal restorations, the chipping or fracture of the ceramic is due to different factors: impact and fatigue load, occlusal forces, differences in thermal expansion coefficients, low-elastic modulus of the metal, improper design, microdefects, and trauma.[13-16]

Some clinical reports on the use of porcelain-veneered zirconia prostheses reported fractures in veneering porcelain[9,17,18] and in all-ceramic cantilever FPDs.[20,21] In a 2008 review, Denry and Kelly found 15 major studies of zirconia prostheses where fractures were uncommon, but chipping with the porcelain veneer was present in all studies.[26] The difference in the coefficients of thermal expansion that may produce residual stresses during the fabrication of all-ceramic crowns and fixed partial dentures (FPDs), and the interface between the veneering porcelain and the zirconia substructure are the origin of the chipping in these type of restorations.[17,18]

There are only a few reports on hybrid prosthetic restorations with zirconia frameworks. Those regarding FPDs have shown that fracture of the porcelain facing is caused by the strain in the framework, since most of the breakages arose in the interface between the framework and porcelain layer.[37,38] In a 2007 prospective clinical cohort study, Sailer et al reported a 97.8% success rate of zirconia frameworks, and chipping of the veneering ceramic in 15.2% after 5 years of clinical observation.[39] Moreover, there are some positive reports concerning cases with zirconia frameworks on natural teeth[40] and others concerning hybrid prostheses on implants using zirconia frameworks without any complication during a monitoring period of 6 months.[10,11] Long-term studies must be carried out using zircoina/ceramic implant-supported, full-arch fixed restorations.

As far as this author's knowledge, no clinical report has yet been published on a monolithic zirconia complete fixed detachable restoration. In the future, long-term studies must be carried out using this type of restoration, to compare this kind of material with the materials existing on the market, and to determine the advantages discussed in this clinical report.

Acknowledgments

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