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CLINICAL SCIENCE

Retrospective analysis of 26 complete-arch implant-supported monolithic zirconia prostheses with feldspathic porcelain veneering limited to the facial surface

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ABSTRACT

Statement of problem. Monolithic zirconia prostheses on teeth or implants have been proposed in recent years as a potential treatment. To date, limited data regarding the outcomes of these prostheses have been presented and are mainly based on limited sample size and short-term follow-up. Data on complete-arch monolithic zirconia prostheses are relatively scarce.

Purpose. The purpose of this retrospective study was to evaluate the clinical performances of 26 implant-supported, complete-arch, monolithic zirconia restorations with facial feldspathic porcelain veneers for the rehabilitation of completely edentulous patients.

Material and methods. All patients' charts from 2 private practices from 2010 to 2013 were reviewed. Patients rehabilitated with a complete-arch implant-supported monolithic zirconia prostheses were included in the study. Several parameters were recorded so as to evaluate the outcome of these rehabilitations: implant survival and success rates, prosthesis survival rate, interproximal bone loss, periimplant probing depth, and bleeding on probing. The number and type of prosthetic complications were also recorded. Data were analyzed with descriptive statistics.

Results. Eighteen patients were treated with a total of 26 complete-arch fixed prostheses. The mean follow-up time was 20.9 months (SD 13.6; range, 10 to 36 months). In total, 154 implants were placed supporting 309 retainers and pontics. The implant survival rate was 100% and the success rate was 94.8%. Mean bone loss was 0.66 mm (SD 0.59 mm). Mean probing depth was 3.4 mm (SD 0.92 mm). Bleeding on probing was positive in 19% of probing sites. The prosthesis survival rate was 100%.

Conclusions. The results of this retrospective evaluation showed that monolithic zirconia restorations with facial porcelain veneer provided satisfactory clinical performance and suggest that these rehabilitations are a viable treatment option for completely edentulous patients. (J Prosthet Dent 2015;■:■-■)

Complete-arch implant-supported monolithic zirconia rehabilitation with facial porcelain veneering could be a viable treatment for completely edentulous individuals.

Several restorative materials may be used to fabricate complete-arch implant-supported fixed prostheses. Metal ceramic restorations fabricated with a variety of alloys have been widely used and have demonstrated good outcomes.[1] Metal acrylic resin, implant-supported, complete fixed dental prostheses have also been suggested as an option for rehabilitating edentulous patients but have shown an increased incidence of mechanical complications when compared with other materials.[2,3]

Zirconia frameworks have become popular in prosthodontics in the last 15 years because of their mechanical properties and the possibility of being produced according to a digital work flow. These prostheses, when veneered with porcelain, have shown promising success rates.[4] Although these rehabilitations have been reported to be safe and effective, their use has also been associated with some complications, especially porcelain chipping.[5-9] Short-term clinical data suggest

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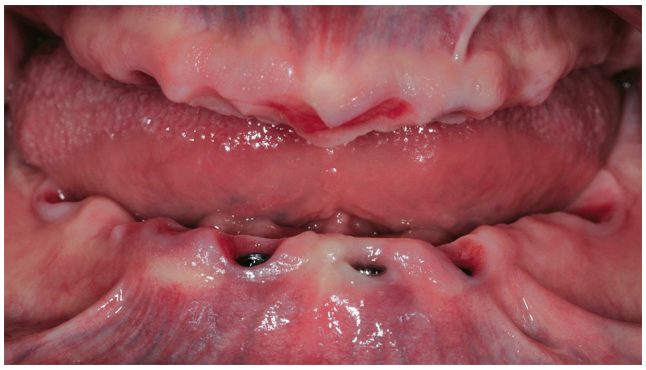

Figure 1. Frontal view after implant healing period.

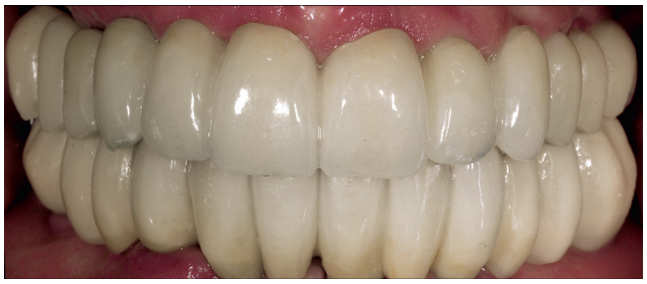

Figure 2. Frontal view with fixed complete-arch implant-supported interim prosthesis.

Figure 3. Phases of digital project. (Left) Scan of interim restorations after 6 months of use. (Right) Digital design of maxillary framework. Space for veneering porcelain was obtained by digital "carving" of interim restoration scan.

that zirconia fixed dental prostheses may serve as an alternative to metal ceramic in the anterior and posterior dentition.[10]

The use of monolithic zirconia restorations, potentially veneered with a limited amount of feldspathic porcelain in nonfunctional areas, have therefore been proposed because of the reduced incidence of fractures and lower cost.[11] Monolithic zirconia restorations seem to cause less wear of the opposing dentition than feldspathic porcelains and seem to have a better fit compared to porcelain-veneered zirconia prostheses.[12-14] The use of monolithic zirconia is increasing but is supported by only limited evidence.[15,16] The purpose of this clinical case series was to report on the outcome of complete-arch implant-supported monolithic zirconia prostheses with facial feldspathic porcelain veneers.

MATERIAL AND METHODS

All the records of edentulous patients treated in one or both arches in 2 private practices from 2010 to 2013 were reviewed. The study was conducted according to Italian laws and regulations. Patients rehabilitated with a complete-arch, single-piece, implant-supported monolithic zirconia restoration with facial porcelain veneers were selected.

Framework design inclusion criteria were the following: in the posterior areas (premolars and molars), the zirconia frameworks represented the entire restorations, with the exception of facial surfaces that were veneered with porcelain for esthetic purposes. In the anterior areas (incisors and canines), the zirconia frameworks were designed in 2 different ways: in 6 patients (11 prostheses), the palatal and lingual surfaces of the maxillary and mandibular frontal teeth were made of zirconia, while the incisal and facial aspects of the maxillary and mandibular teeth were veneered with porcelain; in 12 patients (15 prostheses), the zirconia frameworks were extended to the incisal part of the maxillary and mandibular incisors, and porcelain was only applied to the facial surfaces.

The prostheses were luted with an adhesive cement (Panavia F 2.0; Kuraray) to prefabricated titanium abutments in order to have a titanium-to-titanium connection at the implant level. All the frameworks were fabricated with computer-aided design/computer-aided manufacturing systems.

Patients who presented with total edentulism or with hopeless dentition in one or both arches were given clinical and radiographic examinations. Oral hygiene instructions were given, hopeless teeth were extracted, and scaling and root planing were carried out on the remaining teeth with good periodontal prognosis. If necessary, periodontal surgery was performed after scaling and root planing, and periodontal reevaluation was performed at 2 months to redetermine the prognosis of each individual tooth ahead of potential implant placement. At this stage, imaging of the available bone was performed with 3-dimensional (3D) systems, including computed tomography or cone beam computed tomography. Five to 7 implants were placed in each edentulous arch by experienced surgeons. The following implants were used: bone level or tissue level (SLActive; Institut Straumann AG) and bone level-type implants (Osseotite; Biomet 3i or Ti-Unite; Nobel Biocare).

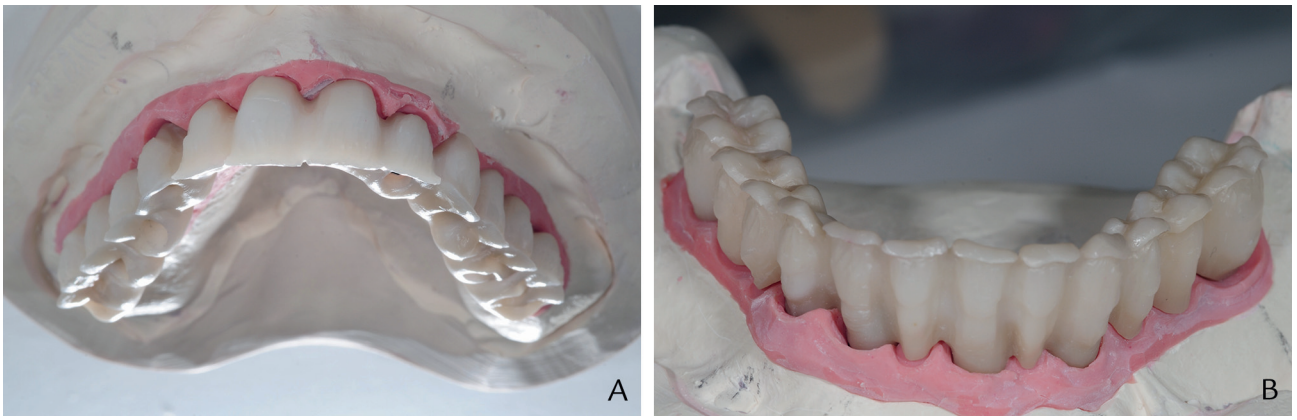

Figure 4. Zirconia framework after milling and sintering with zirconia protection of incisal edges. A, Maxillary arch. B, Mandibular arch.

After implant healing (Fig. 1), pickup impression copings were mounted and impressions were made with a polyether material (Impregum Penta; 3M ESPE) and custom impression trays (open tray technique). A facebow record was used to mount the maxillary cast in an articulator (SAM 3; Sam Präzisionstechnik GmbH), the occlusal vertical dimension was determined with esthetic and phonetic tests, and the mandibular cast was mounted with the maxillary cast.[17-22]

In all patients a fixed, interim, screw-retained prosthesis was fabricated, inserted by tightening the screws to 20 Ncm (Fig. 2), and used for at least 6 months. The occlusal scheme adopted for the interim and definitive restorations was based on a mutually protected articulation and group function without balancing contacts in the lateral movements. The interim restorations were used to provide the patient with a fixed rehabilitation that not only improved the esthetics and comfort during the prosthetic phases but were also used for diagnostic purposes. The 3D position of the teeth, occlusal vertical dimension, and occlusal wear of the prosthesis were monitored by the patient (subjective esthetic and phonetic evaluations) and clinician (visual examination of the prosthesis). Interim restoration fractures and significant wear or recurrent screw loosening were considered signs of incorrect functional articulation.

After the patient had uneventfully worn the interim prosthesis for at least 6 months, the definitive prostheses were fabricated with the following protocol: definitive impressions were made at the implant level with screw-retained implant transfers and a polyether material (Impregum Penta; 3M ESPE). Once the definitive cast had been fabricated, new transfers were screwed on the implant analogs and connected with acrylic resin (Pattern Resin; GC Corp). They were separated after setting with extra fine disks (Diamond Discs; Edenta AG) and then reconnected after 24 hours with the same acrylic resin to minimize resin distortion.[23] This index was then evaluated in the patient's mouth to verify the accuracy of the definitive cast. The vertical dimension, occlusal scheme, space for restorative materials, and tooth position information were maintained during the definitive prosthesis fabrication by using the cross-mounting technique as follows: a facebow record was made and the maxillary cast mounted on the articulator; then the mandibular cast was mounted using the patient's interim fixed prostheses and interocclusal registrations.[24]

The definitive cast with the screw-retained interim restoration was scanned with a 3D laboratory scanner (D700; Wieland Dental), titanium abutments for screw-retained prostheses (Institut Straumann AG) were secured to the implant analogs, and the cast with the mounted abutments was scanned again with the same 3D scanner. The 2 scans were digitally overlapped with laboratory software (Dental System; Wieland Dental), and the digital project of the zirconia framework was obtained from the scanned interim restoration through a limited digital cut-back procedure done to provide adequate space for the feldspathic veneering in the facial or incisal areas. In the posterior areas, the occlusal surfaces obtained by the scan of the interim restoration were not modified (Fig. 3).

The zirconia frameworks were then fabricated from the CAD files (Fig. 4) and milled from disks of yttrium-stabilized zirconia (Sagemax Zr; Sagemax Bioceramics Inc) obtained from powder by cold isostatic pressing (Tosoh Corporation). The Sheffield test was used during clinical evaluation to evaluate the passivity of the frameworks, and intraoral periapical radiographs were also made.[25] Once the passivity of the zirconia frameworks was established, the occlusal contacts were evaluated to maintain the same mutually protected occlusal scheme. Feldspathic porcelain (E-max Ceram; Ivoclar Vivadent AG) was then veneered onto the frameworks, and the prostheses were cemented to the titanium abutments with resin cement (Panavia F; Kuraray). All prostheses were fabricated by the same laboratory (Apulia Digital Lab, Bari, Italy) and according to a

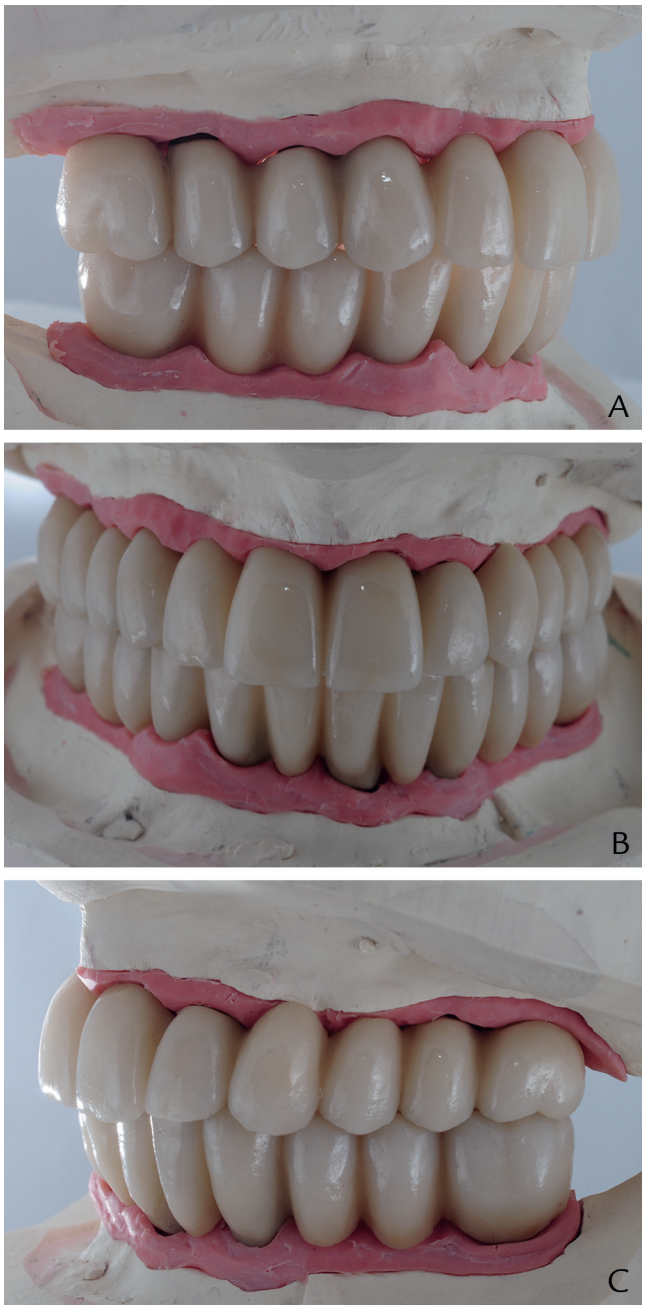

Figure 5. A-C, Representative zirconia prostheses on definitive cast after porcelain veneering.

1-piece, screw-retained design (Fig. 5).[26-35] During delivery (Figs. 6, 7), the prosthetic screws were tightened to 20 Ncm, and the screw channels were filled with an interim resin material (Telio Cs Inlay; Ivoclar Vivadent AG); 1 month after delivery, the patients were recalled, and the prostheses were inspected to visualize eventual porcelain and/or framework cracks or chippings. After reevaluating the occlusion, the prosthetic screws were tightened to 35 Ncm and their access holes filled with polytetrafluoroethylene tape (800 Golden Band; AW

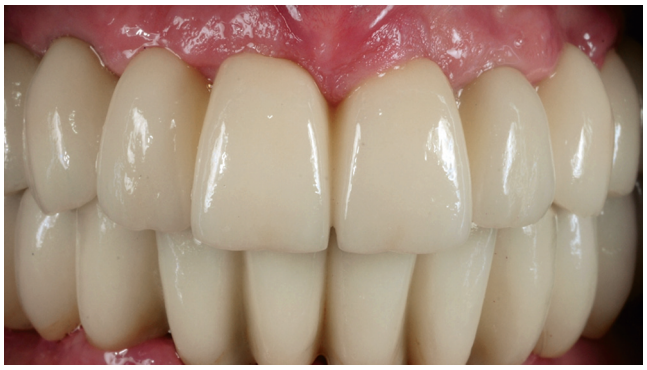

Figure 6. Frontal view of representative prostheses.

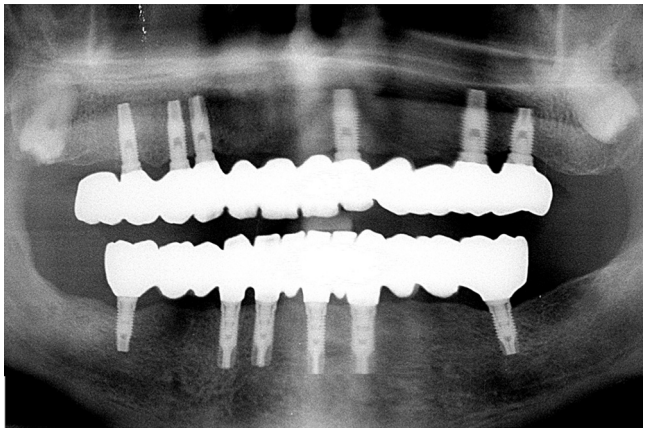

Figure 7. Representative panoramic radiograph of prostheses.

Chesterton Co); they were then sealed with composite resin (Tetric EvoCeram Bulk Fill; Ivoclar Vivadent AG).

The patients were recalled every 6 months for hygiene and clinical examinations, and periapical radiographs were made once a year to monitor crestal bone levels. Implant success rates were evaluated according to the criteria of Buser et al[36]: absence of persistent subjective complaints (pain, foreign body sensation, and/or dysesthesia), absence of periimplant infection with suppuration, absence of mobility, and absence of continuous radiolucency around the implant. In addition to the aforementioned criteria, implants were considered to survive if they showed crestal bone resorption less than 2 mm, with a probing depth less than 5 mm and with no bleeding on probing. Interproximal bone loss was measured on follow-up periapical radiographs relative to the implant platform and calculated from baseline, which was considered as the time of definitive prosthesis delivery. Periimplant probing depth and bleeding on probing, the survival rate of the prosthesis, and the number and type of prosthetic complications were also recorded at the follow-up visit and reported with descriptive statistics.

Table 1. Prostheses provided

Patient No.	Treated Arches	No. of Implants	Incisal Margin Anterior Teeth	Opposing Arch	No. of Prosthetic Elements	Cantilever	Cantilever Elements	Prosthetic Complications
1	Both	6 Maxillary, 7 mandibular	Ceramic	Monolithic zirconia	14+14	Y	both mandibular second molars	N
2	Maxillary	6 maxillary	Zirconia	Natural teeth+monolithic zirconia FPD	12	N		Minor chipping maxillary left canine
3	Both	5 maxillary, 7 mandibular	Ceramic	Monolithic zirconia	12+13	Y	both maxillary first molars	N
4	Maxillary	7 maxillary	Zirconia	Natural teeth	12	N		N
5	Both	6 maxillary, 6 mandibular	Zirconia	Monolithic zirconia	12+12	Y	maxillary right first molar	N
6	Both	6 sup, 6 mandibular	Zirconia	Monolithic zirconia	12+12	N		N
7	Maxillary	6 maxillary	Zirconia	Natural teeth	10	N		N
8	Maxillary	6 maxillary	Zirconia	Natural teeth+monolithic zirconia FPD	12	N		N
9	Maxillary	6 maxillary	Zirconia	Natural teeth	12	N		N
10	Maxillary	5 maxillary	Zirconia	Natural teeth	10	Y		N
11	Both	6 maxillary, 6 mandibular	Ceramic	Monolithic zirconia	12+12	N		N
12	Maxillary	5 maxillary	Ceramic	Natural teeth	12	N		N
13	Both	6 maxillary, 6 mandibular	Ceramic	Monolithic zirconia	11+13	Y	mandibular left second molar	Minor chipping, maxillary right central incisor
14	Maxillary	6 maxillary	Zirconia	Natural teeth+PFM FPD	12	N		N
15	Both	5 maxillary, 7 mandibular	Ceramic	Monolithic zirconia	10+12	Y	both mandibular first molars	Minor chipping maxillary left lateral incisor
16	Maxillary	6 maxillary	Zirconia	Natural teeth	12	N		N
17	Mandibular	4 mandibular	Zirconia	PFM	10	Y	both mandibular first molars	N
18	Both	6 maxillary, 6 mandibular	Zirconia	Monolithic zirconia	12+12	N		N
Total								
18 Patients	26 arches treated	154 implants	11 ceramic 15 zirconia		299 elements		10 cantilever units	3 minor porcelain chippings

PFM, porcelain fused to metal; FPD, fixed partial denture.

RESULTS

Eighteen patients were treated for a total of 26 complete-arch fixed prostheses, with 9 of them receiving maxillary prostheses, 1 of them receiving a mandibular prosthesis, and 8 of them receiving prostheses in both arches. The mean follow-up time was 20.9 months (SD, 13.6; range, 10 to 72 months).

A total of 154 implants were placed supporting 26 restorations with 309 prosthetically replaced teeth, such as pontics and retainers. In 6 out of 26 prostheses, distal cantilever extensions were included either unilaterally or bilaterally for a total of 10 pontics, with no more than 1 pontic for each cantilever.

Table 1 describes the implants and the restorations. Eleven prostheses were designed so as to have veneered porcelain on the incisal margins of the anterior teeth and 15 with zirconia incisal margins; consequently, 243 retainers and pontics presented with porcelain veneered on the facial aspect, but not on the occlusal or incisal area, while 66 units (all in the anterior areas) had porcelain veneered on the facial and incisal aspects.

Table 2. Descriptive statistics of measured parameters

Characteristic	Crestal Bone Resorption	Probing Depth	Bleeding on Probing	
Mean	0.66	3.40		
SD	0.59	0.92	Present	19%
Median	0.5	3	Absent	81%
95% confidence interval	0.59-0.72	3.3-3.5		
Min	0	2		
Max	2.5	7		

No implants were lost, achieving a 100% survival rate; crestal bone loss was, on average, 0.66 mm (SD 0.59 mm). Eight out of 154 implants showed more than 2 mm of crestal bone resorption, more than 5 mm probing depth, and bleeding on probing and were considered to be surviving, thus leading to a 94.8% implant success rate. Probing depth showed a mean value of 3.4 mm (SD 0.92 mm), and bleeding on probing was positive in only 19% of probing sites (Table 2). Three porcelain veneered teeth had minor cohesive

chipping of the veneering porcelain in 3 different prostheses, while no frameworks exhibited fracture of the zirconia structure.

The porcelain chippings were located on a maxillary central incisor, a maxillary lateral incisor and a maxillary canine in 3 different patients, but because of their limited extension, they did not affect the esthetic and functional outcome of the rehabilitations. All 3 porcelain fractures occurred in frameworks with veneered porcelain on the incisal margins and were treated by intraoral adjustment and polishing with low-speed porcelain polishing rotary instruments (prosthesis survival rate was 100%).

DISCUSSION

The current study reported the results obtained with monolithic zirconia with facial porcelain veneer used for 1-piece, complete-arch restorations. It has some limitations because of its retrospective design and because of the absence of a control group.

The authors' choice of screw-retained prostheses was based on the desire to avoid cementation because it has been demonstrated that cement remnants may be difficult to remove and that they could lead to mucositis and periimplantitis.[26-28] In addition, screw-retained prostheses are more easily retrievable than cemented ones, and this may be an advantage in the treatment of eventual mechanical and biological complications. Indeed, the European Association of Osseointegration consensus statement recommends screw-retained frameworks in extensive implant-supported reconstructions.[29]

Implant survival and success rate demonstrated excellent results while the incidence of biological and prosthetic complications was low and consistent with published literature.[30-32] The 1-piece, complete-arch design of the prostheses, with the distribution of occlusal forces on several implants and the passivation of the frameworks obtained by luting them onto prefabricated titanium abutments, probably contributed to the absence of screw loosening during the follow-up period.

Two different designs were used by the authors: some patients were treated with porcelain veneer of the incisal margin in the anterior teeth, while the most recent patients received a monolithic zirconia incisal margin, with veneering limited to nonfunctional areas. The design with a veneered incisal margin was used because of the supposedly better esthetic outcome of veneered porcelain when compared with zirconia. The veneered porcelain, however, represented the weak point of the system, which is consistent with published evidence of relatively frequent chipping in porcelain fused to zirconia restorations.[5-9] In 3 out of 11 prostheses with porcelain on the incisal margins, minor chippings were found, with a prevalence of 27% of the prostheses and 4.5% of the teeth with veneered porcelain on the incisal margins. Although these complications were easily treated because of the small extent of the fractures, this was the main reason the authors used a prosthesis design with zirconia incisal margins in subsequent prostheses. No porcelain fractures were found in any of the 15 prostheses fabricated with this modified design.

Another issue relates to the use of 1-piece frameworks rather than a segmented approach. Although there is no definitive evidence for the superiority of one particular design, some authors suggest that a segmented, multiple-piece framework might be used for its ease of retrievability and repair,[33] even if this design usually requires the placement of an increased number of implants. In the present case series, the 1-piece design was used because in most patients 5 or 6 implants were used to support the complete-arch prostheses.

In a few patients (6 prostheses), cantilever pontics were used, as no evidence exists regarding the detrimental effect of a distal cantilever in implant-supported restorations if its extension is limited.[34,35] Moreover, the use of monolithic zirconia frameworks with facial porcelain veneering allows the connectors between the prosthetic elements to be more robust than in situations with completely veneered porcelain, thus increasing the resistance of the frameworks to occlusal loading, especially in the cantilever sites.

In the present study, 8 patients received 2 monolithic zirconia restorations with facial porcelain veneering in both jaws, and 10 patients received the restoration in a single jaw, with natural teeth in the opposing jaw. A different neuromuscular perception during function could be expected in these 2 situations, and although no significant difference in any of the measured parameters was found, this issue should be investigated in further studies.

CONCLUSIONS

In this retrospective evaluation, monolithic zirconia restorations with facial porcelain veneering provided satisfactory clinical results. The rehabilitations with incisal protection in the anterior areas showed the best results with minimal biologic and mechanical complications.

Further studies are needed to validate these promising results.

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