Implant rehabilitation of edentulous jaws with predominantly monolithic zirconia compared to metal-acrylic prostheses: a 2-year retrospective clinical study

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Limited data are available on the clinical outcomes of patients with edentulism treated with predominantly monolithic zirconia fixed complete dentures (FCDs) compared to traditional restoration materials. The purpose of this study was to analyze the differences in terms of complications and failures of definitive full-arch implant rehabilitations made in metal-acrylic versus those made in monolithic zirconia with porcelain veneering limited to non-functional areas. This retrospective clinical study included 50 patients treated between January 2015 and December 2018, with 222 implants inserted in fifty edentulous jaws. All patients were treated with immediately loaded full-arch fixed prostheses (22 maxillary; 28 mandibular) each supported by four to six implants (two/four axial, two distally tilted). All 25 zirconia prostheses were predominantly monolithic with ceramic veneering limited to non-functional areas. The primary outcome measures were prosthetic success of the definitive restoration and implant survival. The secondary outcome measures were full mouth plaque score, full mouth bleeding score, peri-implant probing depths and peri-implant keratinized tissue. All implants and prostheses analyzed had a minimum of 2 years of follow-up. No chipping of the veneered facial porcelain or other technical complication was observed over the study period achieving a prosthesis survival and success rate of 100%. No implants were lost, achieving a 100% survival rate. Bleeding on probing was positive in 33% and 13% of probing sites for metal-acrylic prosthesis and zirconia prosthesis, respectively (p = 0.0445). Plaque index was positive in 76% and 53% of probing sites for metal-acrylic prosthesis and zirconia prosthesis, respectively (p = 0.0491). Mean probing depth was 1.74mm (SD 0.89mm) for the 106 implants supporting metal-acrylic prosthesis and 1.52mm (SD 0.63mm) for the 116 implants supporting zirconia prosthesis (p=0.0412). No other statistically significant differences were found between the two groups. The results of this retrospective evaluation showed that predominantly monolithic zirconia is a feasible alternative to the conventional metal framework acrylic for full arch implant-supported prosthesis. The restauration material did not influence the failure rate and complication risk of both prosthesis and implants.

Fixed complete dentures (FCDs) are a clinically proven treatment for edentulism (1-3) with an implant survival rate well above 90%. The long-term outcome of full-arch dental implants has been widely demonstrated. Clinical studies (4, 5) and systematic reviews (6) report an implant-survival rate of more than 90% after a follow-up period of at least 5 years. Nevertheless, a certain resonance should be also given to restorative material selection, manufacture and design of the supporting framework and handling of the veneering material in full-arch rehabilitations (7-10).

Key words: monolithic zirconia, metal-acrylic restorations, CAD-CAM, edentulism, fixed complete denture

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Many prosthetic designs and materials have been described (11, 12). FCDs are traditionally made of a metal framework with acrylic resin and denture teeth as veneering materials (13). These implant-supported hybrid prostheses (metal-acrylic resin) are associated with a high success rate (14). However, the high rate of prosthetic complications related to this kind of restoration has been reported over short- and long-term periods (15-17).

New ceramic materials, especially zirconia, have been recently introduced as an alternative to metal frameworks in full arch rehabilitations to improve the mechanical stability, biologic properties and aesthetic implications (18-21). This high-strength oxide ceramic presents a good dental and gingival aesthetics (22) due to its natural white color. The reduced plaque accumulation and favorable soft tissue response makes zirconia an excellent choice for implant-retained superstructures (23). In addition, the fabrication of zirconia restorations requires CAD/CAM technology that allows a better marginal fit and control of distortion which is introduced by conventional casting procedures (24, 25).

The combination between intraoral scanning and CAD/CAM procedures results in a fully digital workflow in which zirconia exhibits an excellent behavior being a high-quality core material (26).

Many studies providing ceramic veneered zirconia restorations have shown promising short-term clinical results with a prosthetic survival rate of almost 99% (27-29). In a prospective study by Mendez Caramês, out of the total 77 restorations, only one framework fracture was observed during the follow-up period, resulting in a survival rate of 98.7% for the zirconia framework veneered with feldspathic porcelain (30). Nevertheless, one of the most frequently reported complications of these prostheses is chipping, due to the dissimilar framework-veneering interface (31). In a recent systematic review, short-term results from a combined 223 patients with 285 one-piece zirconia FCDs showed a mean failure rate of 1.4% due to fracture of the zirconia framework and a 14.7% of minor complications exclusive to fracture of veneered porcelain (31). The same results are confirmed by Sailer (32) and Pieralli (33). In the first systematic review by Sailer (32) et al. the comparison between metal-ceramic and zirconia-ceramic for multiple-unit fixed dental prostheses resulted in a cumulative 5-year ceramic fracture or chipping of 11.6% for the first group and 50% for the second group. In the other review by Pieralli (33), chipping of the veneering ceramic was frequent, resulting in estimated 5-year complication rated of 22.8% for partial fixed dental prostheses and 34.8% for full-arch fixed dental prostheses. To minimize these complications, monolithic zirconia was developed and introduced (34). Being monolithic, its constituent does not present dissimilar interfaces. This allows to almost avoid any fracture and/or chipping events since it represents a greater bulk of material that improves the structural properties (35).

In a recent systematic review by Abdulmajeed, monolithic zirconia in complete-arch implant-supported fixed dental prostheses was evaluated (36). It resulted that only nine studies with a mean follow-up of at least 1 year were included in the review due to lack on the long-term outcome (36).
All the analyzed reviews suggest the need for more long-term studies on all-ceramic complete-arch fixed implant prostheses focusing especially on monolithic zirconia. In fact, there is lack of published RCTs comparing various restorative materials (37).

The aim of the present short-term study is to report the clinical performance of predominantly monolithic zirconia used for full-arch rehabilitations compared to the conventional cast metal-acrylic prostheses. Fixed complete dentures supported by 4 to 6 implants were retrospectively followed up for 2 years.

MATERIALS AND METHODS

Patient selection

This study was conducted in accordance with the tenets of the Declaration of Helsinki and followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies (http://www.strobe-statement.org). This single-centre retrospective study was performed at the Department of Dentistry, IRCCS San Raffaele Hospital, Milan, Italy. All the records of single arch edentulous patients treated from January 2015 to December 2018 were reviewed. The principles were in accordance with Helsinki Declaration

and Italian Law.

Patients rehabilitated with four to six implants supporting an immediate loading metal-acrylic or monolithic zirconia prosthesis according to the all-on-four technique were selected.

Inclusion criteria:
- age > 18 years
- total or partially edentulous in one arch
- adequate bone volume (divisions A, B or C based on the Misch classification of bone available (38)
- appropriate bone density (class D1, D2 or D3 based on the Misch classification (39)
- implant occlusal loading with a provisional prosthesis of at least 4 months

Exclusion criteria:
- severe immunodeficiency with a high recurrence of opportunistic infections
- uncontrolled diabetes
- severe malocclusion
- severe parafunction (bruxism)
- inadequate bone volume (division D based on the Misch classification (38)
- inadequate bone density (class D4 based on the Misch classification (39)
- disorders for which surgical procedures were contraindicated
- lack of collaboration
- lack of oral hygiene
- patients receiving bone grafts
- patients participating in other clinical studies that could affect either the design of the prosthesis or the follow-up protocol
- patients with distal cantilever more than 10mm
- heavy smokers (>10 cigarettes per day).

Pre-treatment

All diagnoses were made clinically and radiographically. All patients gave their written informed consent for immediate implant loading and professional oral hygiene was provided before surgery. The local ethical committee approved the study. Conventional impressions were taken for study casts and provisional prostheses; to assess bone volume (according to Cawood and Howell classification (40)) and bone density in each patient, the diagnosis was conducted as first level with panoramic radiography and at second level with cone beam computed tomography (CBCT).

Surgical procedure

All surgeries were performed by a single experienced surgeon. On the day of surgery, implants were positioned after antibiotic prophylaxis with 2 g amoxicillin and clavulanic acid (Augmentin, GlaxoSmithKline, Brussels, Belgium), which was administered 1 hour prior to surgical incision. After preparation of the patient, a povidone and chlorhexidine rinses were performed (41, 42). Implant surgery was performed under local anaesthesia (optocain 20 mg/mL with adrenaline 1:80,000; Molteni Dental, Firenze, Italy).

In edentulous mandibles, a crestal incision with bilateral releasing incisions was made from the first molar region to the contralateral side. Sub periosteal dissection was performed on the lingual and vestibular surfaces; a full- thickness buccal flap was raised, exposing the buccal bone wall and allowing detection of the mental foramina. In edentulous maxillae, a crestal incision was performed on the alveolar crest from the pterygomaxillary region to the contralateral side with bilateral releasing incisions; a mucoperiosteal buccal flap was elevated, exposing the vestibular bony wall. Residual hopeless teeth were automatically extracted before implants insertion to preserve the alveolar ridge.

The two posterior implants were placed bilaterally immediately anterior to the mental foramina in edentulous mandibles; following the anterior sinus wall in edentulous maxillae, the implants were distally tilted at approximately 30 to 45 degrees relative to the occlusal plane, emerging at the second premolar position to shorten the cantilever length and maintain a large inter-implant distance (3). The two to four anterior implants always followed the jaw anatomy in direction. Bone density was assessed by CBCT as previous described, during the early phase of drilling by the clinician's experience and sensation and scored in accordance with the Lekholm and Zarb classification (43).

The diameter of the final drill was chosen based on bone quality to optimize implant stability. The insertion of the implants followed standard procedures, although under-preparation was used in soft bone to achieve an insertion torque ranging between 30 and 40 N·cm before final seating of the implant, thereby obtaining

high primary stability and immediate function. A manual wrench was also used when incomplete seating of the implant occurred. The implant neck was aimed to be positioned at bone level, and bicortical anchorage was established whenever possible (3).

Surgical placement of the implants always aimed to achieve ideal prosthetically driven implant positioning; therefore, to allow optimal prosthetic screw access and placement of holes in an occlusal or lingual location, angulated abutments for anterior implants were set at 17 degrees, and those for posterior implants were set at 30 degrees to compensate for the lack of parallelism between implants. Flap adaptation and suturing were performed with 4-0 non-resorbable suture (Vicryl; Ethicon, Johnson & Johnson, New Brunswick, NJ, USA).

After surgery, a Low-level-laser Therapy Protocol with a 645 nm Diode Laser was performed to reduce tissue inflammation and to improve the tissue healing phase (Diode Laser, 645 nm, 0,6 Watt) (EGG Laser, DMT, Lissone, Italy) (44,45,46).

Post-surgical instructions

After surgery, mouth rinsing with a chlorhexidine digluconate-containing solution (0.12% or 0.2%), twice per day for 10 days, was prescribed in addition to the recommended standard post-surgical medication: amoxicillin and clavulanic acid (Augmentin, GlaxoSmithKline) 1 g, two times per day for 7 days after surgery, and non-steroidal anti-inflammatory drugs (ibuprofen 600 mg, Brufen, Abbott Laboratories, Chicago, IL, USA) as needed. All patients were instructed to avoid brushing and any trauma to the surgical site, and were recommended to follow a soft diet (avoiding bread and meat) for 2 months. One week after implant placement, sutures were removed.

Prosthetic protocol

According to the direct provisionalization technique (47), the interim restorations were properly intraorally relined with autopolymerizing polyurethane resin (Voco, Fort Mill, SC, USA) including the straight titanium cylinders screwed to the angulated abutments (47-49). The vertical dimension was established and corrected using facial reference marks recorded prior to surgery.

No more than 3 hours after surgery, provisional complete-arch all-acrylic resin prostheses were delivered to all patients based on preliminary impressions and diagnostic set up. On this screw-retained prosthesis, only 10 teeth were mounted, no cantilevers were used (3). An interocclusal registration was then performed using the prefabricated prosthesis, and panoramic radiographs were obtained. The torque for tightening the prosthetic screws was 20 N. Screw access holes were covered with provisional resin (Fermit, Ivoclar Vivadent, Naturno, Bolzano, Italy).

Following the immediate provisional prosthetic protocol (47), centric and lateral contacts were limited to the intercanine area and modified where needed using an articulating paper (40 μm Bausch Articulating Paper, Nashua, NH, USA). Passive fitting was also checked. After the post-surgical visit, occlusal balancing was made and after 3 months, a control recording was made to verify functional adaptation (50).

After a healing period of 4 months, open tray impressions were taken for the realization of the definitive prosthesis. Integral pick-up impression copings were screwed over the fixtures and splinted together using orthodontic wire and composite resin, that has been gradually polymerized in order to reduce and avoid its shrinkage. The impression material used for all patients was gypsum (Éclair Class II, Ultima, Angers, FRANCE). After obtaining the impression, it was necessary to attach the implant analogs to the copings and then realize a stone model to replicate the exact position of the implant in the cast.

Monolithic zirconia restaurations

Once the definitive cast had been fabricated, a 3D laboratory scanner (Optical scanner S600 ARTI, Zirkonzahn) was used to obtain the virtual model of the considered jaw and begin the CAD-CAM procedure. The stone cast model of the opposing arch was scanned with the same procedure. In addition, the virtual model of the temporary prosthesis, attached to implant analogs, was extraorally acquired through the same laboratory scanner. Subsequently, the scans have been digitally overlapped with a laboratory software (ImplantPlanner, Zirkonzahn) for each patient. The resulting 3D scans were then exported in the standard tessellation format (.stl).

Once the virtual model is created with the dental implant in position, virtual digital creation of the zirconia frameworks from the scanned interim restoration can be designed through the CAD software (Exocad software,

Darmstadt, Germany). A limited digital cut-back procedure was done to provide adequate space for the feldspathic veneering in the facial areas. The definitive restoration is ready to be milled from monolithic zirconia. The milling (CAM) process of the zirconium oxide blank (Prettau Zirconia, Zirkonzahn) was carried out on the basis of this computer designed project (CAD data) using standardized fabrication protocols recommended by the manufacturer (Zirkonzahn). The CAD/CAM system was CAD/CAM 5-Tech, Zirkonzahn.

To finalize the rehabilitation after milling, the monolithic zirconia prosthesis underwent the sintering process. The resulting monolithic zirconia full-arch fixed rehabilitation was then hand veneered with a reduced amount of feldspathic porcelain (ICE Zirkon Ceramics, Zirkonzahn) limited to nonfunctional facial areas of the prosthesis. For this reason, the restoration is considered mainly monolithic. The prostheses were luted with adhesive cement (Panavia F 2.0; Kuraray) to prefabricated titanium abutments in order to have a titanium-to-titanium connection at the implant-level.

Metal-acrylic restorations

After realization of the stone model, the technician followed the conventional procedures for the fabrication of a metal framework up to the completion of the try-in of the tooth setup (51). A wax pattern was made on the stone model to reproduce the design of the final Co-Cr framework obtained through the traditional lost-wax casting technique. Thereafter, the metal framework was refined and polished by the technician, and after clinical try-in, the prostheses were completed by curing acrylic resin and composite teeth (Ivoclar Vivadent) to the metal frame, following standard procedures (51) used for conventional cast fixed full-arch prostheses. The prostheses, set up for the esthetic trial placement, were fabricated based on the provisional prosthesis, but refined in esthetics, function and in relation to soft tissue.

Both metal-acrylic and monolithic zirconia definitive prostheses were finally positioned and screwed onto dental implants. Sheffield test was carried out to check the precision of framework. The marginal fit of final prosthetic frameworks screwed onto the implants was checked by intraoral digital radiographic examination in both groups. Articulating paper (Bausch Articulating Paper, Nashua, NH, USA) was used to check the occlusion and adjust it, if necessary. In particular, static occlusion consisted of central contacts established on all masticatory units and dynamic occlusion included canine/premolar guidance, regardless of the opposite arch settings. Screw access holes were covered with temporary resin (Fermit, Ivoclar Vivadent, Naturno, Bolzano, Italy).

Primary outcome measures:

- Prosthetic success: defined as absence of failure and occurrence of technical complications. Failure consisted in fracture of any part of the full-arch prosthesis resulting in the need for a complete refabrication of the prosthesis. Technical complication is defined as an unanticipated event that affected any or all of the full-arch prosthesis and required maintenance services but without replacement with a new prosthesis.
- Implant survival: defined as presence of implant stability, absence of radiolucent zone around the implants, no mucosal suppuration or bleeding and no pain. Implant success was defined as implant survival plus marginal bone loss of less than 1.5mm after 1 year of loading and no more than 0.2mm loss between each follow-up appointment after the first year of function. The stability of each individual implant was assessed manually after 6 months and then annually from insertion by tightening the abutment screws with the removed prostheses.
- Peri-implant marginal bone levels: bone level measurements were performed on the mesial and distal aspect of each implant, using the implant-abutment junction as reference point (52); these were made perpendicular to the long axis of the implant with the long-cone parallel technique using an occlusal custom template to measure the marginal bone level. The difference in bone level was measured radiographically through custom software (DIGORA 2.5, Soredex, Tuusula, Finland). To adjust the dimensional distortion and enlargement on the radiographs, the software was calibrated for each image using the known implant diameter at the most coronal portion of the neck of the implant. The linear distance between the most coronal point of bone-to-implant contact and the coronal margin of the implant collar was measured to the nearest 0.01 mm at both the mesial and distal sides, and then averaged.

Secondary outcome measures:

- Full mouth plaque score (FMPS) calculated by dividing plaque presenting sites for all sites around implants (6 points per element) and expressed in percentage.
- Full mouth bleeding score (FMBS) calculated by dividing bleeding sites for all sites around implants (6 points per element) and expressed in percentage.
- Pocket probing depth (PPD) of implants supporting full-arch prostheses, expressed as a mean of all sites probed (6 points per element).
- Peri-implant keratinized tissue (KT) of each implant measured with a periodontal probe from free gingival margin to the mucogingival junction and expressed as a mean.

All outcomes are referred to the definitive restoration, inserted 4 months after surgery.

Follow-up

Follow-up visits that included clinical and radiological examination were performed at 4, 6, 12 and 24 months after implant placement. Appointments with a dental hygienist were also scheduled every 6 months during the follow-up. The maintenance protocol was conducted according to Jepsen et al. (53). As reinforcement for the home oral hygiene, patients were instructed on the proper use of aids such as interproximal brush, mono tuft toothbrush, and Super floss. Moreover, patients occasionally failed to visit the hygienist, but were always recalled for another appointment.

Radiographic examination

Radiographic evaluation was performed using panoramic radiographs obtained immediately after surgery and at each follow-up visit. The marginal fit precision of final prosthetic frameworks of both groups, screw-retained onto the implants, was checked by intraoral digital radiographic examination (DIGORA 2.5 software Soredex, Tuusula, Finland) immediately after placement.

Statistical analysis

A dedicated software (SPSS 11.5.0, IBM, Armonk, NY, USA) was used for all statistical analysis. Measurements of probing pocket depth (PPD) and peri-implant keratinized tissue (KT) are reported as mean ± standard deviation (SD). Full mouth plaque score (FMPS) and full mouth bleeding score (FMBS) are reported as percentages. Comparisons between zirconia and metal-acrylic supporting implants were made regarding PPD, FMPS, FMBS and differences in KT. Student's t tests were applied at a significance level of $P < 0.05$.

RESULTS

Data related to a total of 50 full arch prosthesis were analyzed in this study over the 2-year evaluation period. Fifty patients (31 men, 19 women, average age 64.8) were included in the present sample. All patients had only a single jaw rehabilitated. Of the 222 implants, 104 were placed in the maxilla and

Table I. *Diameters and lengths of implants placed in the maxilla and mandible.*

	Zirconia prosthesis	Metal-acrylic prosthesis	TOTAL
	9	13	22
	3	1	4
	13	11	24
	0	0	0
	25	25	50

118 were placed in the mandible. The majority of the implants (160) were 3.8mm in diameter, followed by 3.3mm implants (62) as shown in table I.

Thirty-nine patients were rehabilitated through four implants (156 implants, 39 full-arch prostheses) and eleven patients through six implants (66 implants, 11 full-arch prostheses), therefore 122 implants were placed axially and 100 were placed tilted to avoid anatomical structures. The prosthetic material of the full-arch prosthesis was metal-acrylic with denture teeth for 25 patients and predominantly monolithic zirconia for the others. The opposing dentitions (table II) were implant-supported prosthesis (22 patients), natural teeth (4 patients), or a combination of both (24 patients). No chipping of the veneered facial porcelain or other technical complication was observed over the 2-year study period achieving a prosthesis success rate of 100%. No implants were lost, achieving a 100% survival rate.

Bleeding on probing (BOP) was positive in 70 sites for metal-acrylic prosthesis and 30 for zirconia prosthesis leading to a FMBS of respectively 33% and 13% (table III). The difference was statistically significant ($p = 0.0445$). Plaque index (PI) was

Table II. *Status of the opposite jaw at the time of implant placement.*

	Implant diameter	Number of implants placed		
		11mm	13mm	15mm
Maxilla				
Axial (n=60)	3.8mm	12	26	0
	3.3mm	8	14	0
Tilted (n=44)	3.8mm	0	20	24
	3.3mm	0	0	0
Mandible				
Axial (n=62)	3.8mm	8	24	6
	3.3mm	2	18	4
Tilted (n=56)	3.8mm	0	22	18
	3.3mm	0	6	10

Table III. *FMBS and FMPS of implants supporting full-arch prosthesis.*

Periodontal Index	Zirconia prosthesis	Metal-acrylic prosthesis
Full-mouth bleeding score (FMBS)	13%	33%
Full-mouth plaque score (FMPS)	53%	76%

positive in 161 sites for metal-acrylic prosthesis and 123 for zirconia prosthesis leading to a FMPS of respectively 76% and 53% (table III). Again, the difference was statistically significant (p = 0.0491).

Probing depth (PPD) showed a mean value of 1.74mm (SD 0.89mm) for the 106 implants supporting metal-acrylic prosthesis and 1.52mm (SD 0.63mm) for the 116 implants supporting zirconia prosthesis resulting in a statistically significant difference (p=0.0412) (table IV).

No other significant differences were found between the two groups (Table V). In fact, the amount of keratinized tissue (KT) was similar between implants of metal-acrylic and zirconia prosthesis (p=0.1454). The prostheses in metal-acrylic group were fabricated with a framework of Cr-Co alloy and acrylic artificial teeth. All zirconia prostheses were bonded to prefabricated or custom metal cylinders (indirect interface) differently from the first-generation design of direct zirconia interface.

DISCUSSION

The current study shows the results obtained with predominantly monolithic zirconia used for fixed complete implant-supported dentures. It has some limitations because of its retrospective design but the presence of a control group (metal-acrylic full-arch prosthesis) allowed a comparison between materials. The surgical protocol adopted in this study, widely described, allows to simplify and shorten the implants rehabilitation for both patient and clinician (54). Patients experience a more comfortable post-surgical period since they wear a fixed prosthesis from the day of the surgery (54).

The most recent literature confirms the same survival and implant success rate also in patients with systemic diseases (HIV, HCV, SJOGREN) (55-58). Cattoni et al. in 2020 also evaluated a possible neuro-cognitive measure of how self-perception can change as a significant consequence of aesthetic prosthetic rehabilitation (59).

Table IV. *PPD of implants supporting full-arch prosthesis (mean ± standard deviation in mm).*

Framework material	Number of implants	Periodontal pocket depth (PPD) mean
Zirconia prosthesis	Axial (n=66)	1.40 ± 0.62
	Tilted (n=50)	1.63 ± 0.64
	Total (n=116)	1.52 ± 0.63
Metal-acrylic prosthesis	Axial (n=56)	1.73 ± 0.92
	Tilted (n=50)	1.74 ± 0.85
	Total (n=106)	1.74 ± 0.89

Table V. *KT around implants supporting full-arch prosthesis (mean ± standard deviation in mm).*

		Zirconia prosthesis	Metal-acrylic prosthesis
Peri-implant keratinized tissue (KT)	Axial	1.04 ± 0.71	1.07 ± 0.7
	Tilted	0.86 ± 0.78	1.18 ± 0.9
	Total	0.95 ± 0.74	1.12 ± 0.8

Choosing the right material is considered a determinant factor for the rehabilitation of the edentulous arch through dental implants (60). Factors as production and manipulation of the prosthetic material, the supporting framework and the veneering material should be evaluated (61, 62). Before the surgical and prosthetic treatment, especially in the pandemic actual situation, it is necessary, however, to evaluate the tissue healing and the inflammatory state of the oral cavity (63-65).

Both kinds of prosthetic materials gave optimal results when applied to full-arch rehabilitations (7). In particular, Malò (66) achieved a 100% survival rate in full-arch prostheses using reinforced composite resin and Tischler (28) achieved a 99.4% cumulative survival rate in full-arch prosthesis using predominantly monolithic zirconia over a 4-year period. Nevertheless, clinical data comparing the two materials are lacking. In a recent RCT study (37), Merli et al. compared ceramic vs composite veneering of full arch implant-supported zirconium frameworks reporting no difference between the two treatments in terms of complications, reduction of FMBS, patient preference and satisfaction. However, the comparison was limited to the same kind of zirconium framework. In order to compare restorations made with different framework materials, the present study evaluated various factors that can influence the clinical outcome of full-arch implant-supported prosthesis.

Despite the statistically significant differences concerning FMPS (p=0.0491), FMBS (p=0.0445) and PPD (p=0.0412) found between the two groups, implant survival rate seems not to be affected. As reported in literature, the prosthetic material does not influence implant stability and function (9-10). A recent study by Brignardello-Petersen showed a high survival of implants and fixed complete dentures after 3 years, regardless of material used to fabricate the implant-supported fixed complete dentures (69). Moreover, the mentioned differences did not influence the prosthetic survival and success rate of full-arch implant-supported prosthesis.

With the advent of CAD/CAM protocols, milled zirconia frameworks became quite popular in implant prosthodontics (11). Some authors noted a relative inaccuracy of metal frameworks fitting due to unprecise clinical or laboratory casting techniques (11). In the present study, even if the passive fit of the framework was not investigated primarily, no differences were found between CAD/CAM zirconia framework and metal framework in relation to implant and prosthetic survival. Prosthetic complications reported when speaking about full-arch implant-supported prosthesis are well known and include chipping of veneering material, prosthetic screw loosening or fracture, loss of retention, framework fracture and loss of access hole filling (32). Fracture or wear of the reconstruction materials were considered predictable risks when using resin-based supra-structure materials (5). In the present study the acrylic resin used as supra-structure wasn't affected by any of the cited complications probably thanks to the decennial experience of the team in full-arch rehabilitations.

In the last decade, many authors showed satisfactory treatment outcomes in the short-term for zirconia (26). In particular, the last studies focused on monolithic zirconia since the weak point of these rehabilitation appears to be the ceramic veneering. Being mostly monolithic, it is possible to restrict the veneering to nonfunctional area (26). This modification drastically reduced the incidence of ceramic chipping. In the current study, thanks to the limited veneering, it was achieved a 0% chipping rate reflecting the result obtained by Venezia in a recent retrospective study (27).

Even if the modern technologies would allow a fully digital workflow (70), the authors preferred a combined approach for the zirconia rehabilitation (23). This approach involved taking analogic impressions instead of using an optical scanner. The stone models are then digitalized through a laboratory scanner for zirconia rehabilitations as suggested by many authors (23). This method was chosen to standardize the clinical and laboratory procedures as much as possible.

In addition, the presence of a well-harmonized interface between soft tissues and implant abutments is necessary for the long-term survival of the implant and a successful prosthodontic treatment (71). Many authors compared different abutment

materials (72) but scarce data are provided on mucosal surfaces of the FCSs. From the current study, monolithic zirconia prosthesis showed a reduced plaque accumulation in comparison to metal-acrylic prosthesis. This result is consistent with published literature (73), especially with a recent RCT by Kanao in which resin surfaces obtained the worst result in terms of plaque accumulation (71). These findings may explain the other results of the present study, in fact, it is well known how plaque accumulation led to inflammation and tissue bleeding resulting in a greater PPD and FMBS for implants supporting metal-acrylic prosthesis compared to zirconia (74). Moreover, these results couldn't be explained by a difference in the width of the peri-implant keratinized mucosa as suggested by Schrott (75) since it resulted similar in both groups (p= 0.1454). Thus, oral hygiene must be considered when choosing a prosthesis material. To conclude, despite the present study showed stackable results between the two groups, further studies are necessary to confirm these promising data. An investigation regarding patient preference and satisfaction between the two restauration materials is missing. OHIP-21 and VAS questionnaires could be useful tools to perform this comparison.

Within the limitations of this short-term retrospective study, it can be concluded that predominantly monolithic zirconia is a feasible alternative to the conventional metal framework acrylic veneer in the realization of full arch implant-supported prosthesis. The rehabilitations with only facial porcelain veneering showed minimal biologic and mechanical complications demonstrating a 100% survival rate. Additional RCTs and long-term studies with at least 5 years of prospective follow-up are needed to validate these results.

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