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CLINICAL RESEARCH

Complications and survival rates of 55 metal-ceramic implant-supported fixed complete-arch prostheses: A cohort study with mean 5-year follow-up

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ABSTRACT

Statement of problem. Long-term outcomes with metal-ceramic (MC) implant-supported fixed complete dental prostheses (IFCDPs) are scarce.

Purpose. The purpose of this retrospective study was to assess the rate of biologic and technical complications in a cohort of edentulous patients treated with MC IFCDPs by residents after a mean clinical follow-up of 5 years (range: 1 to 12 years).

Material and methods. Forty-one participants with 55 MC IFCDPs underwent a single-visit comprehensive examination that included a medical and dental history review and clinical and radiographic examinations. All supporting implants and prostheses were examined for biologic and technical complications. Life table analysis and Kaplan-Meier survival curves were calculated.

Results. Of 359 moderately rough surface dental implants, 2 had failed in 1 patient after 11 years of functional loading, yielding a cumulative implant survival rate of 99.4%. Owing to the implant failure, 1 of 55 edentulous arches restored with IFCDPs failed, yielding a cumulative prosthesis survival rate of 98.2% after mean observation period of 5.0 years. Soft tissue recession was the most frequent minor biologic complication (annual rate 7.8% at the prosthesis level) for both cement and screw-retained IFCDPs (group C and S), and peri-implantitis (annual rate 1.6% at the implant level) the most frequent major biologic complication. Wear of porcelain (annual rate 8.0% at the prosthesis level) was the most frequent minor technical complication for both groups, and fracture of porcelain (annual rate 0.8% at the dental-unit level) was the most frequent major technical complication. Minor complications were the most frequent in both the groups (cement and screw retained).

Conclusions. High implant and prosthesis survival rates (above 98%) were achieved, yet substantial complication rates were encountered. The most frequent major biologic complication was peri-implantitis, with a 5-year implant-based rate of 8% (95% confidence interval [CI]: 5.8-11.1), whereas the most frequent major complication was fracture of porcelain with a 5-year dental unit-based rate of 4%. The estimated cumulative rates for "prosthesis free of biologic complications" were 50.4% (95% CI: 36.4% to 63.0%) at 5 years and 10.1% (95% CI: 3.5% to 20.8%) at 10 years, whereas for "prosthesis free of technical complications," they were 56.4% (95% CI: 41.7% to 68.8%) at 5 years and 9.8% (95% CI: 3.2% to 21.0%) at 10 years. (J Prosthet Dent 2019;122:441-9)

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Clinical Implications

Rehabilitation with metal-ceramic implant-supported fixed complete dental prostheses yielded high implant and prosthesis survival rates (above 98%) after a mean 5-year follow-up. Although this represents a safe treatment modality, substantial complication rates were encountered. Porcelain chipping (minor) and porcelain fracture (major) are the most frequent complications. Clinicians should know the incidence to apply customized maintenance and recall protocols for patients as well as to inform them before beginning treatment.

Complete-arch fixed implant rehabilitation of edentulous patients represents an evidence-based treatment option.[1-12] The traditional implant-prosthodontic design reported from longitudinal studies published in the 1980s and 1990s included interforaminally placed implants and implant-supported fixed complete dental prostheses (IFCDPs) screw-retained on transmucosal (later replaced by multiunit) abutments.[2,11,12] The prosthetic materials for IFCDPs included gold, silver-palladium, cobalt-chromium, or titanium framework veneered with acrylic resin and supporting denture teeth. Studies focused mainly on implant and prosthesis survival, whereas complications were rarely reported.[13-16]

Complications in implant dentistry have been classified as biologic and technical and have been reported to occur frequently.[5,11,15] For edentulous patients, a systematic review by Papaspyridakos et al[15] reported that biologic and technical complications routinely occur with metal-resin IFCDPs. The 10-year estimated rate for prostheses free of complications was reported to be 8.6%. Besides the metal-resin prostheses, the use of metal-ceramic (MC) became popular in implant dentistry in the mid-1990s and early 2000s because MC prostheses were considered the gold standard in fixed prosthodontics.[17-20] Newer prosthetic materials such as monolithic zirconia were introduced in the 2010s and are gaining popularity because of their esthetic properties, ease of fabrication with a digital workflow, and the high cost of high noble alloys.[21-23] All new prosthetic materials used as alternatives to MC must demonstrate at least the same efficacy as MC in terms of chipping, fracture resistance, and marginal fit.[17,20] The MC design has been extensively examined, and good outcomes have been reported for partially edentulous patients rehabilitated with implant-supported fixed dental prostheses after up to 5 years of follow-up.[14] However, data related to complications with MC IFCDPs for edentulous patients after long-term follow-ups are limited.[4,14,15,18,19,24-33]

To the authors' knowledge, studies documenting the long-term outcomes of complete-arch rehabilitation with MC IFCDPs are lacking. The primary purpose of the present retrospective cohort study was to report the biologic and technical complication rates with MC IFCDPs after a mean observation period of 5.0 years (range: 1 to 12 years). Secondary outcomes were the assessment of the survival rates, patient satisfaction, effect of various risk factors, and type of retention on the incidence of the most frequent complications.

MATERIAL AND METHODS

Strengthening the Report of Observational Studies in Epidemiology (STROBE), guidelines from the EQUATOR website were followed for this observational retrospective cohort study, which was approved by the Tufts Health Sciences Campus Institutional Review Board (IRB approval #11722). The authors screened the electronic records of all patients who had been rehabilitated with IFCDPs from January 1, 2005, to December 30, 2015, in the Postgraduate Prosthodontics clinic of Tufts University School of Dental Medicine in Boston, Mass, United States. All patients were enrolled in a structured maintenance care program (recare) at the aforementioned clinic of the Tufts University School of Dental Medicine after the definitive prosthesis insertion and were seen at 6-month intervals. Compliance was not mandatory and was at each patient's discretion.

Inclusion criteria in this retrospective examination included patients aged at least 18 years; edentulous with moderately rough surface dental implants; rehabilitated with IFCDPs by prosthodontic residents in at least 1 edentulous jaw; with IFCDPs fabricated in MC material; and with the IFCDP in service for at least 1 year. Patients who had received the definitive IFCDP within less than 1 year, patients with smooth surface implants, pregnant women, and patients who did not wish to sign the informed consent form were excluded.[5,11]

Patients who met the inclusion criteria were contacted and invited to participate in a single comprehensive examination.[5,11] All participants signed an informed written consent that was in accordance with the Declaration of Helsinki. The examination consisted of a medical and dental history review, intraoral photographs, and a radiographic and clinical examination, which included the evaluation of the oral cavity and soft and hard tissues according to the standard of care procedures.[5,11]

Three prosthodontists (P.P., T.B.B., K.E.R.) conducted the clinical examination, in which implant and prosthesis parameters were evaluated. The implant parameters were presence or absence of peri-implant suppuration, modified Plaque Index at 6 sites around the implants, and probing depths at the identical 6 sites of each implant by using a probe (Probe UNC 15; Hu-Friedy) to the nearest

millimeter.[5,11] One periodontist (Z.S.N.) assisted in all assessments of biologic implant parameters. The prosthesis parameters were the presence/absence of IFCDP, location of the edentulous jaw, prosthetic materials used to fabricate the prosthesis, type of retention (cement or screw), presence of cantilever extension, and type of opposing dentition. Occlusal analysis comprised the assessment of the occlusal scheme and the presence of wear. The opposing dentition was categorized according to the presence of naturally restored or unrestored teeth, implant-supported prostheses, overdenture, complete denture, or removable partial denture.

During the clinical examination, all supporting implants and prostheses were examined for any potential complications. For descriptive purposes, the encountered complications were divided into minor and major complications.[11] Minor complications were considered those for which chairside correction was feasible without affecting the function of the prosthesis. Major complications were those that needed additional treatment and costs. Minor biologic complications included soft tissue recession and/or dehiscence, tissue inflammation under the fixed prosthesis, peri-implant mucositis, and hypertrophy or hyperplasia of soft tissues. Peri-implantitis and late implant failure were considered as major biologic complications. Minor technical complications included wear of porcelain, chipping of porcelain, loss of screw access filling, loosening of an abutment or occlusal screw, and decementation (for cement-retained IFCDPs). Major technical complications included fracture of porcelain, fracture of framework, fracture of an abutment and/or abutment or occlusal screw, and fracture of an implant.

The radiographic examination consisted of digital panoramic and periapical radiographs of each implant made with the long-cone technique. An examiner not involved in the patient treatment (T.B.B.) compared the radiographs made at the time of the prosthesis insertion with the ones at the examination visit.[5,11] For calibration, the known thread pitch and diameter of each implant were used to measure the distance from the implant platform to the first visible bone-implant contact (DIB) and was measured in millimeters at the mesial and distal aspects of each implant. For each implant, one DIB value was calculated based on the average of the mesial and distal values obtained. The decision to average the mesial and distal bone remodeling was taken based on the previous literature and on the characteristics of the edentulous jaw, which commonly appears flat.[5-10]

In the present investigation, the authors defined implant survival as implant remaining in situ and supporting a functional prosthesis during the entire observation time.[9,10,13,16] Implant failure was defined as an event leading to the loss of the implant or the need to remove the implant.[9,10,13,16] Peri-implantitis was defined as the radiographic DIB adjacent to an implant exceeding 2 mm after the first year of functional loading, or exceeding 0.2 mm for each following year, combined with profuse bleeding and suppuration on probing.[13,15]

Table 1. Descriptive analysis of patient demographics

Patients	41
Prosthesis	55
Female/male	19/22
Maxilla/mandible	32/23
Cement-retained/screw-retained IFCDPs	36/19
Implants inserted	359
Implants supporting cement/screw-retained IFCDPs	243/116
Implants mean observation time	7.5 y
Prostheses mean observation	5.0 y

IFCDP, implant-supported fixed complete dental prostheses.

Prosthesis survival was defined as an MC prosthesis remaining in situ with or without modifications during the entire observation time.[9,10,13,16] A prosthesis failure was defined as an event leading to the loss of the prosthesis, multiple repeated fractures of the implant-supported prosthesis that affect function and esthetics, and the explantation or loss of implants leading to the loss of the implant-supported prosthesis.[1,9,10,13,16] The California Dental Association rating system for quality (CDA 1977) was used to characterize the ceramic failures as either acceptable (surface is deficient but can be polished) or unacceptable (surface is fractured and restoration must be repaired or replaced).[17,20] For simplicity, the previous descriptions were replaced by the terms porcelain chipping (considered as minor complication) and porcelain fracture (considered as major complication), respectively.[9,10,16]

Descriptive statistics (mean and standard deviation) for patient follow-up time were used. The actual annual incidence and the estimated 5- and 10-year biologic and technical complications were computed along with 95% confidence intervals (CIs). Actual annual complication rates were compared between the cement-retained and screw-retained groups. The Kaplan-Meier curve was used to assess prosthesis survival. Survival analysis was used to evaluate the association between prosthesis survival and its risk factors under study (type of occlusion, night guard use, and bruxism). The life table analysis was used to assess implant and prosthesis survival. The definitive prosthesis insertion date was the baseline time (α=.05). A statistical software package (SAS v9.3; SAS Institute Inc) was used.

RESULTS

Forty-one participants (average age of 65.8 years; ranging from 39 to 88 years) who were treated with a total of 359 moderately rough surface dental implants (Nobel Biocare, Straumann, Biomet 3i) and rehabilitated with 55 MC IFCDPs were included in the investigation. Table 1 summarizes the participant demographics. The opposing dentition comprised 28 IFCDPs, 17 mixed

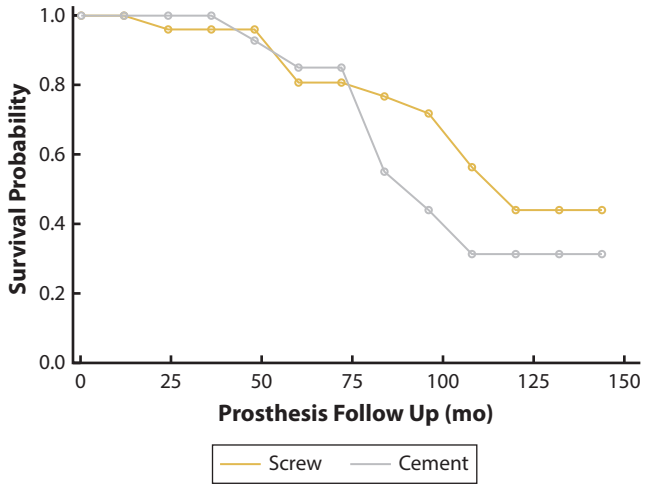

Figure 1. Kaplan-Meier curve for peri-implantitis between group C (cement-retained) and group S (screw-retained). Survival curve for peri-implantitis higher in screw-retained group than in cement-retained group after about 6 years.

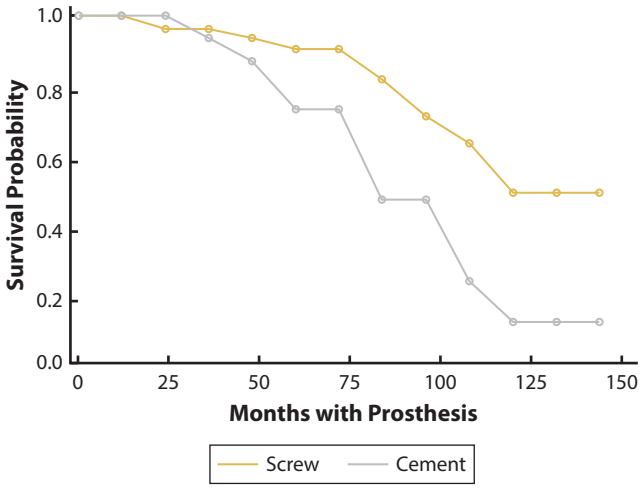

Figure 2. Kaplan-Meier curve for fracture of porcelain between group C (cement-retained) and group S (screw-retained). Survival curve for fracture of porcelain higher in screw-retained group than in cement-retained group after about 3 years.

Table 2. Life table on implant level

Year Interval	No. of Implants	No. of Failures	Survival Rate (%)	Cumulative Survival Rate (%)
0-1	359	0	100.0	100.0
1-2	332	0	100.0	100.0
2-3	278	0	100.0	100.0
3-4	249	0	100.0	100.0
4-5	221	0	100.0	100.0
5-6	155	0	100.0	100.0
6-7	127	0	100.0	100.0
7-8	105	0	100.0	100.0
8-9	74	0	100.0	100.0
9-10	19	0	100.0	100.0
10+	19	2	89.5	99.4

Table 3. Life table on prosthesis level

Year Interval	No. of Prosthesis	No. of Failures	Survival Rate (%)	Cumulative Survival Rate (%)
0-1	55	0	100.0	100.0
1-2	50	0	100.0	100.0
2-3	41	0	100.0	100.0
3-4	37	0	100.0	100.0
4-5	33	0	100.0	100.0
5-6	24	0	100.0	100.0
6-7	20	0	100.0	100.0
7-8	17	0	100.0	100.0
8-9	11	0	100.0	100.0
9-10	3	0	100.0	100.0
10 +	3	1	66.7	98.2

dentitions, 6 natural dentitions, 2 overdentures, and 2 complete dentures. With regard to the occlusal scheme, 47 arches presented with anterior guidance (canine guidance), 5 arches with group function, and 3 with balanced occlusion. The mean prosthesis exposure time was 5.0 years.

Of 359 moderately rough surface implants, two failed after prosthesis insertion in a single participant after 11 years in function, resulting in an implant survival rate of 99.4%. Both failed implants were placed in a male patient in the anterior area of the maxilla, had received a delayed loading time, and were supporting a cement-retained MC IFCDP. The prosthesis survival was affected by the 2 implant failures, and the patient's cement-retained MC IFCDP had to be replaced with an overdenture. Hence, only 1 IFCDP was lost out of a total of 55.

The cumulative prosthesis survival rate was 98.2% (n survived/n total=54/55 IFCDPs) after a mean follow-up of 5.0 years (range: 1-12 years). Kaplan-Meier analysis showed the overall survival rate was 100% at 5 years of follow-up and 92.9% at 10 years, as shown in Figures 1, 2. Life table implant and prosthesis survival analysis can be seen in Tables 2 and 3.

All 55 IFCDPs showed at least 1 complication, either biologic or technical. The cumulative rates for "prosthesis free of biologic complications" at 5 years were 50.4% (95% CI: 36.4% to 63.0%) and 10.1% (95% CI: 3.5% to 20.8%) at 10 years. The cumulative rates for "prosthesis free of technical complications" at 5 years were 56.4% (95% CI: 41.7% to 68.8%) and 9.8% (95% CI: 3.2% to 21.0%) at 10 years (Tables 4 and 5).

Table 4 summarizes the findings on biologic complications. Most biologic complications were minor complications (83.3% or n implant with minor complication/n total implant=155/186), affecting 45 prostheses (293 implants), whereas major biologic complications (16.7% or n implant with biologic complication/n total implant=31/186) occurred in 13 prostheses (31 implants).

Table 4. Overview of biologic complications with MC IFCDPs

	No. of Prostheses Affected	No. of Implants Affected	No. and Percentage of Complications	Exposure Time (y)	Estimated 1-y Complication Rate (95% CI)	Estimated 5-y Complication Rate (95% CI)	Estimated 10-y Complication Rate (95% CI)
Minor complications	45	293	155 (83.3)	–	–	–	–
Soft tissue recession and/or dehiscence	35	228	118 (63.4)	1507.5	7.8 (6.5-9.3)	39.0 (33.5-48.0)	78.0 (67.2-90.9)
Inflammation under fixed prosthesis	16	112	16 (8.6)	1655	1.0 (0.6-1.5)	5.0 (3.2-7.2)	10.0 (6.6-13.4)
Peri-implant mucositis	14	100	14 (7.5)	1670	0.8 (0.5-1.4)	4.0 (2.7-6.7)	8.0 (5.5.0-13.1)
Hypertrophy/ hyperplasia of soft tissue	7	53	7 (3.8)	1728.8	0.4 (0.2-0.8)	2.0 (1.1-3.8)	4.0 (2.6-7.8)
Major complications	13	31	31 (16.7)	–	–	–	–
Peri-implantitis	12	29	29 (15.6)	1758.8	1.6 (1.1-2.3)	8.0 (5.8-11.1)	16.0 (11.9-21.8)
Implant failure	1	2	2 (1.1)	1792.5	0.1 (0.02-0.4)	0.5 (0.1-1.9)	1.0 (0.2-3.8)
Total	49	301	186 (100)	–	–	–	–

CI, confidence interval; MC IFCDP, metal-ceramic implant-supported fixed complete dental prosthesis.

Table 5. Overview of technical complications with MC IFCDPs

	Total No. of Prostheses, Teeth, Implants in Study	No. of Prostheses With Complications	No. and Percentage of Complications	Complication Rate (%) (Prosthesis Level)	Exposure Time (y)	Estimated 1-y Complication Rate (95% CI)	Estimated 5-y Complication Rate (95% CI)	Estimated 10-y Complication Rate (95% CI)
Minor complications		41	148 (81.8)	74.5	–	–	–	–
Wear of porcelain	55 prostheses	20	20 (11.0)	36.4	250	8.0 (5.0-12.1)	40.0 (26.2-58.8)	80.0 (53.3-120.2)
Decementation (loss of retention)	36 prostheses	10	23 (12.7)	18.2	340	6.8 (4.4-10.0)	34.0 (23.3-48.5)	68.0 (46.6-98.5)
Chipping of porcelain	673 teeth	29	84 (46.4)	52.7	3260	2.6 (2.1-3.2)	13.0 (11.1-15.2)	26.0 (23.2-30.9)
Loss of screw access filling	116 implants	7	10 (5.5)	12.7	567.5	1.8 (0.9-3.1)	9.0 (5.7-13.9)	18 (11.2-31.1)
Loosening of a screw (abutment screw or prosthetic screw)	359 implants	4	7 (3.9)	7.3	1786.25	0.4 (0.2-0.8)	2.0 (1.1-3.3)	4.0 (3.1-6.8)
Loosening of a custom abutment	359 implants	2	4 (2.2)	3.6	1790	0.2 (0.1-0.5)	1.0 (0.6-2.4)	2.0 (1.2-4.7)
Major complications		12	33 (18.2)	21.8	–	–	–	–
Fracture of porcelain	673 teeth	9	26 (16.0)	16.4	3332.5	0.8 (0.5-1.1)	4.0 (2.8-5.1)	8.0 (5.7-10.6)
Fracture of a screw	359 implants	2	6 (3.3)	3.6	1787.5	0.3 (0.1-0.7)	1.5 (0.6-3.3)	3.0 (1.4-6.6)
Fracture of framework	55 prostheses	1	1 (0.6)	1.8	273.7	0.4 (0.02-1.8)	2.0 (0.1-8.3)	4.0 (0.2-16.6)
Fracture of an abutment	359 implants	0	0	0	0	0	0	0
Fracture of an implant	359 implants	0	0	0	0	0	0	0
Total		53	181 (100)	96.4	–	–	–	–

CI, confidence intervals; MC IFCDP, metal-ceramic implant-supported fixed complete dental prosthesis.

Soft tissue recession was the most frequent biologic complication (minor complication), followed by peri-implantitis (major complication) (Table 4).

Peri-implantitis was encountered around 29 implants (8.1% of total implants) supporting 12 IFCDPs (21.8% of total IFCDPs), with an average bone loss of 3.5 mm (minimum of 2.1 mm, maximum of 7.0 mm). Of the 29 implants, 10 (2.8% or n implant with bone loss/n total implant=10/359) presented advanced bone loss equal to or greater than half of the implant length and were considered failing implants. The average bone loss of the 19 remaining implants with peri-implantitis was 2.8 mm. The average bone loss around the 359 implants was 0.7 mm (0.6 to 0.8 mm). It was 0.6 mm (0.4 to 0.7 mm) for implants that were under functional load for less than 5 years and 0.8 mm (0.6 to 1.0 mm) for implants that were in function for more than 5 years.

Table 5 summarizes the findings on technical complications. The most frequently encountered technical complications were minor ones such as wear of porcelain, followed by decementation of cement-retained IFCDP and chipping of porcelain (Table 5). Minor complications occurred in 41 prostheses (74.5% or minor complications/n total implant=41/55) for a total of 148 times, with an average of 3.6 complications per prosthesis (minimum of 1, maximum of 9). Major technical complications occurred in 12 prostheses (21.8% n major technical/n total=12/55) for a total of 33 times, with an average of 2.8 complications per prosthesis (minimum of 1, maximum of 7). The most

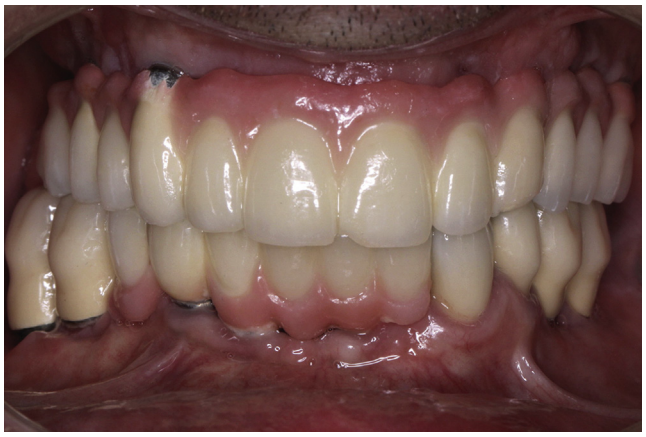

Figure 3. Multiple porcelain veneer chippings and fractures in one-piece maxillary metal-ceramic IFCDP. IFCDP, implant-supported fixed complete dental prosthesis.

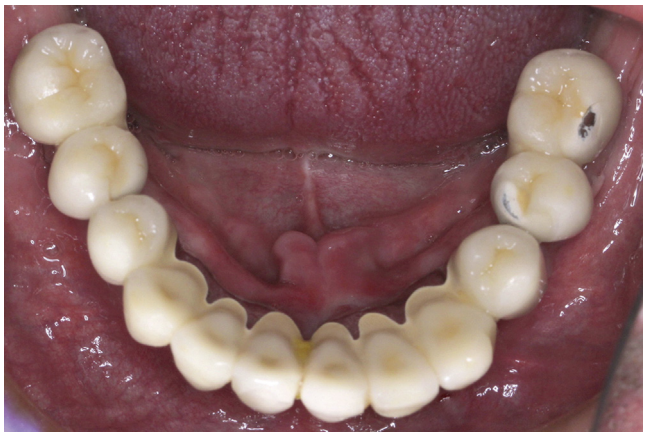

Figure 4. Wear and porcelain veneer chippings and fractures in one-piece mandibular metal-ceramic IFCDP. IFCDP, implant-supported fixed complete dental prosthesis.

Table 6. Overall hazard ratio and 95% confidence intervals of biologic complications

	Cement vs. Screw HR (95% CI)*
Minor complications	
Inflammation under fixed prosthesis	1.13 (0.34-3.74)
Soft tissue recession and/or dehiscence	0.73 (0.35-1.53)
Hypertrophy/hyperplasia of soft tissue	2.21 (0.22-22.39)
Peri-implant mucositis	1.43 (0.38-5.36)
Major complications	
Peri-implantitis	0.97 (0.24-3.95)
Late implant failure	NA

CI, confidence interval; HR, hazard ratio; NA, not applicable. *P* value<.05. *Adjusted for plaque.

Table 7. Overall hazard ratio and 95% confidence intervals of technical complications

	Cement vs. Screw HR (95% CI)[a]	Night Guard HR (95% CI)	Bruxism HR (95% CI)
Minor complications			
Wear of porcelain	7.8 (1.01-60.0)[b]	3.1 (0.5-18.3)	5.0 (1.1-10)[b]
Chipping of porcelain	2.3 (0.9-6.4)	4.1 (0.97-17.7)	10 (1.7-25)[b]
Loss of screw access filling	NA	NA	NA
Loosening of an abutment	0.32 (0.01-6.01)	NA	NA
Loosening of a screw	NA	NA	NA
Loss of retention	NA	NA	NA
Major complications			
Fracture of porcelain	NA	NA	0.14 (0.01-1.38)
Fracture of framework	NA	NA	NA
Fracture of an abutment	NA	NA	NA
Fracture of a screw	NA	NA	NA
Fracture of an implant	NA	NA	NA

CI, confidence intervals; HR, hazard ratio; NA, not applicable. [a]Adjusted for night guard use, bruxism, and opposing dentition. [b]*P* value<.05.

frequently observed major technical complication was fracture of porcelain, followed by fracture of the framework and fracture of an occlusal screw, as shown in Table 5. Clinical complications such as wear of porcelain and facture of porcelain are illustrated in Figures 3, 4.

No statistical significance was found when the cement-retained IFCDPs (group C) were compared with the screw-retained IFCDPs (group S). The most frequent biologic complication encountered in both the groups was soft tissue recession (minor complication), with an annual rate of 7.5% (95% CI: 5.9% to 9.4%) in group C and 8.4% (95% CI: 6.1% to 11.3%) in group S, followed by peri-implantitis (major complication), with an annual rate of 1.5% (95% CI: 0.9% to 1.3%) in group C and 1.9% (95% CI: 1.0% to 3.4%) in group S. The most frequent technical complication in both the groups was wear of porcelain, with an annual complication rate of 11.4% (95% CI: 6.9% to 17.7%) in group C and 2.2% (95% CI: 0.4% to 7.1%) in group S. The second most frequent technical complication was chipping of porcelain, 3.6% (95% CI: 2.9% to 4.5%) at the dental-unit level in group C and 0.6% (95% CI: 0.3% to 1.2%) in group S, followed by fracture of porcelain, 1.1% (95% CI: 0.8% to 1.7%) at the dental-unit level in group C and 0.08% (95% CI: 0.004% to 0.4%) in group S.

Tables 6 and 7 summarize the overall hazard ratio for complications and show significant (95% CI: 1.1-10) risk 5 times higher for wear of porcelain and significant risk 10 times higher for chipping of porcelain in patients with bruxism (self-reported or diagnosed by signs of wear) (Table 7).

DISCUSSION

The objective of the present retrospective study was to report the complication and survival rates of MC IFCDPs for completely edentulous patients after a mean exposure time of 5.0 years (range: 1-12 years). To the authors' knowledge, this is the first study documenting the long-term outcomes, specifically with MC IFCDPs inserted in a postgraduate prosthodontic clinic by residents under clinical supervision by experienced prosthodontists.

The findings of the present study show a high cumulative implant survival (99.4%) and prosthesis survival rate (98.2%) after a mean observation period of 5.0 years (range: 1-12 years) and are in accordance with those of previous studies.[10,31]

The most frequent major biologic complication was peri-implantitis, with an annual rate of 1.5% (95% CI: 0.9% to 1.3%) in group C and 1.9% (95% CI: 1.0% to 3.4%) in group S. As a time-dependent disease, the implant-based peri-implantitis prevalence of 8.07% and the subject-based peri-implantitis prevalence of 21.81% reported in the present study seem consistent with those reported in the study by Lee et al[32] who reported an implant-based peri-implantitis prevalence of 9.25% (95% CI: 7.57% to 10.93%) and subject-based peri-implantitis prevalence of 19.83% (95% CI: 15.38% to 24.27%). In the present investigation, a 5-year estimated implant-based peri-implantitis rate of 8.0% (95% CI: 5.8-11.1) and a 10-year implant-based peri-implantitis rate of 16.0% (95% CI: 11.9-21.8) were found.

A comment must be made regarding the soft tissue recession complication. Although empirically very frequently encountered, peri-implant soft tissue recession is often underreported in the literature for IFCDPs. In the present study, it was recorded, but the baseline situation after definitive prosthesis insertion could not be recorded. As a result, comparisons between insertion and follow-up could not be made, and only the incidence of soft tissue recession was reported.

In regard to technical complications, fracture of porcelain (annual rate 0.8% at the dental-unit level) was the most frequent major technical complication. However, a direct comparison could not be made as the systematic review reported on metal-resin IFCDPs and there are few longitudinal reports on complications with MC IFCDPs. A systematic review on prosthodontic complications with IFCDPs including MC prostheses reported that MC IFCDP cumulative complication rates for porcelain fractures (at the prosthesis level) were 22.1% at 5 years and 39.3% at 10 years.[30] No data were reported at the dental-unit level, whereas the included studies consistently underreported other types of prosthodontic complications.[30] The present retrospective investigation reported an estimated 5-year porcelain fracture rate (at the dental-unit level) of 4.0% (95% CI: 2.8-5.1) and a 10-year rate of 8.0% (95% CI: 5.7-10.6). In addition, an estimated 5-year porcelain chipping rate (at the dental-unit level) of 13.0% (95% CI: 11.1-15.2) and a 10-year rate of 26.0% (95% CI: 23.2-30.9) were reported. At the prosthesis level, 16.4% of the 55 MC IFCDPs encountered porcelain fractures, and 52.7% of the 55 MC IFCDPs encountered porcelain chipping.

More biologic complications were encountered in the cement-retained group, and 1 IFCDP failed due to 2 implant failures in that group. Prosthesis contours, avoidance of ridge laps, and meticulous removal of excess cement are critical when the clinician designs a cement-retained IFCDP. Screw retention seems a more favorable option for complete-arch implant rehabilitation due to its inherent retrievability.

To the authors' knowledge, this is the first study to report complications encountered with MC IFCDPs provided by prosthodontic residents. In regard to MC IFCDPs, few longitudinal studies exist, and porcelain fracture has been reported to be the most common technical complication.[30] Conversely, the preponderance of literature reporting on longitudinal follow-ups includes metal-resin IFCDPs.[2,15] While traditional metal frameworks veneered with acrylic resin have been replaced by titanium bars veneered with durable monolithic polymethyl methacrylate (PMMA) teeth, newer prosthodontic concepts have emerged to reduce the number of technical complications encountered. The use of titanium frameworks with individual abutment preparations and cemented single crowns, as well as the use of monolithic zirconia with partial or no facial veneering, is gaining popularity.[6,21-23,33]

The advantages of the present study include the long-term follow-up of up to 12 years, although limitations pertain to the retrospective design. The retrospective design is inherently associated with sampling bias because it depends on acquired data from records that have been registered by various clinicians. However, long-term retrospective studies can offer significant clinically relevant information.[12] Another limitation of the present study is that the IFCDPs were not removed. Therefore, probing around the implants and accurately recording the modified Sulcus Bleeding Index (mSBI) and Pocket Depth (PD) indices was not possible. In addition, the preoperative condition of all patients before implant placement could not be recorded. Recall compliance was at the discretion of the patient, and not all patients had been enrolled in the prosthodontic recall system, which represents an additional limitation and risk factor for complications. Another limitation pertains to the convenience sample of patients used in the present study, which may not have enough power to find significant differences in the subgroup analysis. Finally, the cohort size of this study fell to 17 IFCDPs beyond a follow-up of 7 years, making it harder to draw solid conclusions on longitudinal effectiveness.

Porcelain chipping (minor) and porcelain fracture (major) were frequent with MC IFCDPs, and patients should be made aware of the incidence.[30] Clinicians should know the incidence to apply a customized maintenance and recall protocol for patients.[34] The reported estimated 5- and 10-year porcelain fracture and porcelain chipping rates (at the dental-unit level) in the present study were high, and although these rates of complication might be manageable in a university setting, they could be a financial burden in a private

practice setting. More studies are necessary to ascertain the financial burden of prosthetic maintenance of complete-arch implant rehabilitation. New prosthetic materials such as monolithic zirconia and the implementation of a digital workflow in complete-arch implant rehabilitation seem promising but require additional clinical research.[6,21-23,33]

CONCLUSIONS

Within the limitations of this retrospective study, the following conclusions were drawn:

1. After a mean exposure time of 5.0 years (range: 1-12 years), a high implant survival rate of 99.4% and prosthesis survival rate of 98.2% were recorded.
2. The cumulative rates for "prosthesis free of minor biologic complications" were 51.9% at 5 years (95% CI: 37.7% to 64.4%) and 10.4% at 10 years (95% CI: 3.6% to 21.3%). The cumulative rate for "prosthesis free of major biologic complications" was 85.9% at 5 years (95% CI: 71.2% to 93.4%) and was 54.7% at 10 years (95% CI: 31.9% to 72.6%).
3. The cumulative rates for "prosthesis free of minor technical complications" were 58.0% at 5 years (95% CI: 43.2% to 70.2%) and 10.1% at 10 years (95% CI: 3.2% to 21.5%). The cumulative rate for "prosthesis free of major technical complications" was 90.4% at 5 years (95% CI: 76.3% to 96.3%) and 49.1% at 10 years (95% CI: 26.6% to 68.2%).
4. The most frequent minor biologic complication was soft tissue recession (annual rate 7.8% at the implant level). The most frequently observed major biologic complication was peri-implantitis (annual rate 1.6% at the implant level).
5. The most frequent minor technical complication was wear of porcelain (annual rate 8.0%), whereas the most frequent major complication was fracture of porcelain (annual rate 0.8% at the dental-unit level).
6. Regarding cement- versus screw-retained IFCDPs, no statistically significant difference was found in the frequency of complications with either retention type.
7. The porcelain material, the presence of bruxism, and the absence of night guard were associated with an increased risk for chipping of porcelain in MC IFCDPs.

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Noteworthy Abstracts of the Current Literature

The role of implant-tooth distance on marginal bone levels and esthetics

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Purpose. The peri-implant bone and mucosa architecture contribute to the health and esthetics of single-tooth dental implants. The implant-tooth distance (ITD) has been regarded as a key determinant of their outcomes. This study was conducted to determine the relationship between ITD and peri-implant bone, mucosa, and pink esthetic scores (PES) for anterior single-tooth implants.

Material and methods. For 44 dental implants with a micro-thread conical abutment interface design placed in 38 participants, periapical radiographs and photographs were evaluated at 1 and 4 years to assess interproximal bone levels and PES.

Results. Mean mesial and distal marginal bone level change over 4 years was 0.20 ±1.00 mm and 0.20 ±0.74 mm, respectively. In this cohort there was no relationship between ITD and interproximal bone changes or papilla fill at 4 years; however, marginal bonechanges influenced PES score-the smaller the ITD, the lower the PES ($P<.001$). Alone, ITD did not influence marginal bone levels or papilla in this cohort.

Conclusions. These results imply a complex relationship between ITD, marginal bone levels, and PES scores for single-tooth implants.