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Technical Complications and Prosthesis Survival Rates with Implant-Supported Fixed Complete Dental Prostheses: A Retrospective Study with 1- to 12-Year Follow-Up

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Abstract

Purpose: To report the rate of technical complications and prosthesis survival in a cohort of edentulous patients treated with implant-supported fixed complete dental prostheses (IFCDPs) after a mean observation period of at least 1 year.

Materials and Methods: The single-visit examination included clinical and radiographic assessment, occlusal analysis, photographs and questionnaire assessing patient satisfaction in a cohort of 52 patients rehabilitated with 71 IFCDPs (supported by 457 implants). The IFCDPs were assessed for technical complications, number of implants and cantilever extension, retention type and prosthetic material type. Comparison was made between ceramic IFCDPs (Group 1) and metal-resin IFCDPs (Group 2). Kaplan-Meier survival curve analysis was carried out for assessment of prosthesis survival and was done for both Groups 1 and 2 separately. The Cox proportional hazard model was used for survival analysis, adjusting for a number of potential confounders, to evaluate the association between prosthesis survival and several risk factors such as type of opposing occlusion, nightguard use, and presence of bruxism. Responses to patient satisfaction questions were compared with Fisher's exact test.

Results: Out of 71 edentulous arches (52 patients) restored with IFCDPs, 6 IFCDPs had failed, yielding a cumulative prosthesis survival rate of 91.6 % after a mean observation period of 5.2 years (range: 1-12 years) after definitive prosthesis insertion. Three IFCDPs were lost due to implant failures after 5.8 to 11 years of functional loading. Additionally, 3 metal-resin IFCDPs failed due to technical complications. Minor complications were the most frequent complications observed, namely wear of the prosthetic material (9.8% annual rate) being the most common, followed by decementation of cement-retained IFCDPs (2.9%), and loss of the screw access filing material of the screw-retained IFCDPs (2.7%). The most frequently observed major complication was fracture of the prosthetic material (1.9% annual rate), followed by fracture of occlusal screw (0.3%), and fracture of framework (0.3%). The annual rate of wear of prosthetic material was 7.3% for porcelain IFCDPs (n = 19/55) and 19.4% for metal-resin IFCDPs (n = 13/16), yielding a statistically significant difference between the 2 groups ($p = 0.01$).

Conclusions: After a mean exposure time of 5.2 years, 91.6% prosthesis survival rates were achieved (65 out of 71 IFCDPs). The most frequent minor technical complication was wear of the prosthetic material with estimated 5-year rate of 49.0%, while the most frequent major complication was fracture of the prosthetic material with estimated 5-year dental unit-based rate of 9.5%. The cumulative rates for "prosthesis free of minor complications" at 5- and 10-years were 60.5% (95% CI: 47.2-71.3%) and 8.9% (95% CI: 2.9-18.0%), respectively. The cumulative rates for "prosthesis free of major technical complications" at 5- and 10-years were 85.5% (95% CI: 73.0-92.5%) and

30.1% (95% CI: 12.0-50.6%), respectively. Presence of bruxism, and absence of a nightguard were associated with increased risk for chipping of the prosthetic material of the IFCDPs.

With substantial clinical and scientific evidence available, implant-supported fixed prostheses are a reliable treatment option for the replacement of missing teeth.[1-8] While many longitudinal studies have reported data on implant survival, data on implant complications are still sparse.[9-12] The main focus of previous longitudinal studies in the 1990s was the success of osseointegration and the survival of the implants, while other complications were rarely reported.[9,11]

With the more recent shift of focus on esthetics and patient-centered outcomes, more clinical studies started to include these variables, yet implant complications are still underreported.[6,10-13] Specifically, a systematic review by Papaspyridakos et al[10] revealed that biologic and technical complications routinely occur with implant-supported fixed complete dental prostheses (IFCDPs) for edentulous patients. Hence, the knowledge of incidence, types, and rates of complications with each treatment modality is necessary.[10-13]

Biologic and technical complications in implant dentistry do occur and are time dependent.[10,14] Technical complications after the definitive prosthesis insertion may lead to increased rates of repair and remakes, and the waste of chair side time and financial resources, and may even affect the patient's quality of life. Few studies have attempted to assess quantitatively the costs associated with IFCDPs and maintenance.[15] From the financial and effectiveness viewpoint, the patient and dentist preferences for specific treatment options should ideally rely on the longitudinal efficacy of the option coupled with the associated cost and maintenance.[10,16,17] From the viewpoint of outcome assessment, clinical outcomes of implant treatment require a time span of 5 years or more in order to draw meaningful conclusions.

However, data specifically related to technical implant complications encountered with IFCDPs for edentulous patients after an observation period of 5 years are limited.[3,6,8,10,15,18-21] To the authors' knowledge, this is the first study documenting the technical complication and prosthesis survival rates of full arch rehabilitation with moderately rough surface implants and IFCDPs by residents in a postgraduate prosthodontic clinic under supervision by experienced prosthodontists. The primary purpose of this retrospective clinical study was to report the technical complication and prosthesis survival rates with IFCDPs after a mean observation period of 5.2 years (range: 1-12 years). Secondary outcomes were the assessment of the patient satisfaction and the effect of risk factors on the incidence of the most common technical complications.

Materials and methods

This study's protocol was approved by the Tufts Health Sciences Campus Institutional Review Board (IRB approval # 11722). The recommendations for strengthening the reporting of observational studies in epidemiology (STROBE) were followed. All patients who had electronic records at the Department of Postgraduate Prosthodontics, Tufts University School of Dental Medicine (TUSDM) and had been rehabilitated with IFCDPs between January 1, 2005 and December 30, 2015 were screened.[20,21]

Inclusion criteria for this study comprised of patients 18 years or older; edentulous patients who had received rough surface dental implants; edentulous patients who had been rehabilitated with ceramic and MR IFCDPs in at least one dentulous jaw, with a minimum of 1 year under functional loading. Exclusion criteria included patients with less than 1 year since the insertion of the definitive IFCDP; patients with smooth (machined) surface implants; patients who do not wish to sign the informed consent form; and pregnant females. Patients that met the inclusion criteria were contacted and invited to participate in a comprehensive clinical and radiographic examination. All patients gave written informed consent after being informed in detail about the objectives of the investigation.[20,21] The informed consent document was written in accordance with the "Declaration of Helsinki".

A single-visit comprehensive examination was performed for all eligible patients that signed the informed consent and accepted participating in the study. At the examination visit, information was recorded for both biologic and prosthetic parameters and the former are reported separately in a previous publication.[20] This visit consisted of a medical and dental history review, intraoral photographs, radiographic and clinical examination.[20,21] In brief, the examination was carried out by 4 calibrated prosthodontists (PP, TBB, YJK, KER) and the following parameters were assessed: presence/absence of a IFCDP; location of edentulous jaw; number of replaced teeth and number of abutments; location of implants and number of prosthetic segments (if not 1-piece); prosthetic materials used to fabricate the prosthesis; type of retention (cement or screw); presence/absence of nightguard; presence/absence of bruxism; type of opposing dentition. The radiographic examination included digital panoramic and periapical radiographs of each implant with the long-cone technique.[20,21] The occlusal examination comprised the assessment of occlusal scheme (as either mutually protected occlusion with anterior guidance or group function). 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 single-visit examination, the IFCDPs were examined and assessed for encountered complications or failures.[20,21] Technical complications that had affected the implant-supported prostheses were divided into minor and major complications.[20,21] Minor complications were considered those that no treatment was needed or if chair side repair was feasible, e.g. chipping that could be only polished. The following were considered minor technical complications: wear of the prosthetic material; chipping of prosthetic material; loss of screw access material; loosening of an abutment/occlusal screw; and decementation (loss of retention of cement-retained IFCDPs). Major complications were those that needed additional laboratory and/or components costs.[20,21] The following were considered major technical complications: fracture of

Table 1 Descriptive overview of patients, location and material of IFCDP, and observation time

Patients	52
Female/male	21/31
Maxilla/mandible	38/33
Ceramic/metal-resin	55/16
Cemented/screw retained	36/35
Implants inserted	457
Implants mean observation time	7.5 years
Prostheses mean observation time	5.2 years

prosthetic material; fracture of framework; fracture of an abutment; fracture of an abutment/occlusal screw; fracture of an implant.

After completion of the comprehensive examination, the patients received a short questionnaire to evaluate their treatment satisfaction. The questionnaire was composed of 5 yes or no questions regarding satisfaction with esthetics, ability to chew, taste, speech, and general satisfaction.

For porcelain chipping and fracture, the California Dental Association rating system[22] for quality 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). For simplicity, the previous descriptions were replaced by the terms porcelain chipping (minor complication) and porcelain fracture (major complication), respectively.[8,11,21] Prosthesis survival was defined as prosthesis remaining in situ with or without modifications during the entire observation time.[7,11,12,20,21] Prosthesis failure was defined as an event leading to the loss of the prosthesis, the need to renew the entire implant-supported prosthesis (retread), multiple repeated fractures of the implant-supported prosthesis that affect function and esthetics, and the explanation/loss of implants leading to the loss of the implant-supported prosthesis.[1,8,11,12,20,21]

Descriptive statistics for patient follow-up time and patient satisfaction were calculated as was the cumulative incidence of technical complications. The Kaplan-Meier survival analysis was used for assessment of prosthesis survival. Two timelines were created: at 5 years and at 10 years. The definitive prosthesis insertion was the baseline time. The prostheses were further separated according to the type of material: Group 1 (G1) – ceramic; Group 2 (G2) – metal-resin (MR) prostheses. The Cox proportional hazard model was used for survival analysis, adjusting for a number of potential confounders, to evaluate the association between prosthesis survival and several risk factors such as type of opposing occlusion, nightguard use, and presence of bruxism. Responses to patient satisfaction questions were compared with Fisher's exact test. *p*-Values less than 0.05 were considered statistically significant. The statistical software SAS 9.4 (SAS Institute Inc, Cary, NC) and Stata 13.1 (StataCorp LLC, College Station, TX) were used in the analysis.

Results

Out of 90 eligible patients rehabilitated with 126 IFCDPs, a total of 52 patients (average age of 65.5-year-old; ranging from 39 to 88 years old) with 71 IFCDPs were included in this study. The convenience sample consisted of 21 females (average age of 64.6-year-old) and 31 male patients (average age of 66.1-year-old) (Table 1). These 52 patients had received 457 moderately rough surface dental implants (Nobel Biocare, Straumann, Biomet 3i). The mean follow-up time for the implants was 7.5 years, ranging from 2.7 years to 13 years. A total of 71 IFCDPs were evaluated; 38 in the maxilla and 33 in the mandible (19 edentulous maxillae, 14 edentulous mandibles, 19 both). Out of the 71 IFCDPs, 55 were ceramic and 16 were MR (Group 2). With respect to the type of retention, 36 IFCDPs were cement-retained and 35 were screw-retained. The opposing dentition was 40 IFCDPs, 16 mixed dentitions, 6 natural dentitions, 5 overdentures and 4 complete dentures. In regards to the occlusal scheme, 58 arches had anterior guidance (canine guidance), 12 group function, and 1 balanced occlusion. The mean follow-up time was 5.2 years.

The 5- and 10-year prosthesis failure rate was 2.0% (95% CI: 0.3-13.1%) and 18.7% (95% CI: 7.8-40.9%), respectively. A total of 6 IFCDPs were lost out of 71 in total. One cement-retained ceramic IFCDP was lost in Group 1 after 11 years under function due to implant failures, while 5 MR IFCDPs failed in Group 2 (three as a consequence of multiple fractures and two because of failure of the corresponding supporting implant) (Table 2). For Group 1 (ceramic), the 5- and 10-year prosthesis failure rate was 0% for 55 IFCDPs. One prosthesis failed after 11 years in function. For Group 2 (MR), the 5-year

Table 2 Overview of failures of the IFCDPs

Patient number	Gender	Arch	Material of IFCDP	Number of implants supporting prosthesis	Prosthesis delivery date	Date failure noted	Prosthesis follow-up (years)	Reason
4	M	Mx	PFM	6	Jan, 2005	Jan, 2016	11 years	Implant failure
19	F	Md	MR	6	April, 2010	Feb, 2016	5.8 years	Implant failure
21	M	Mx	MR	5	April, 2010	July, 2016	6.2 years	Multiple fractures
21	M	Md	MR	6	Dec, 2008	July, 2016	7.6 years	Multiple fractures
28	M	Md	MR	6	Feb, 2008	June, 2016	8.3 years	Implant failure
40	M	Md	MR	6	July, 2013	July, 2016	3 years	Multiple fractures

M = male, F = female, Mx = maxilla, Md = mandible, PFM = porcelain fused to metal, MR = metal-resin.

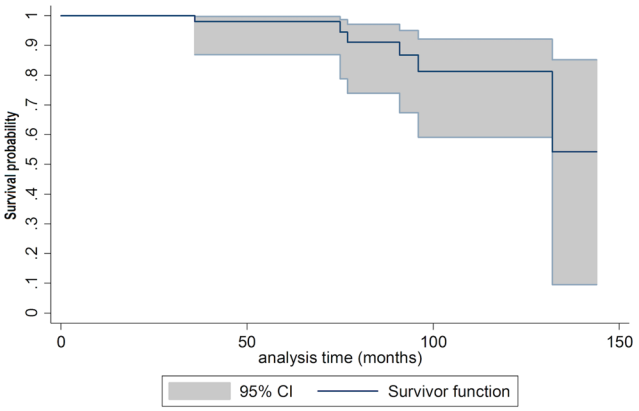

Figure 1 Kaplan-Meier curve for prosthesis survival.

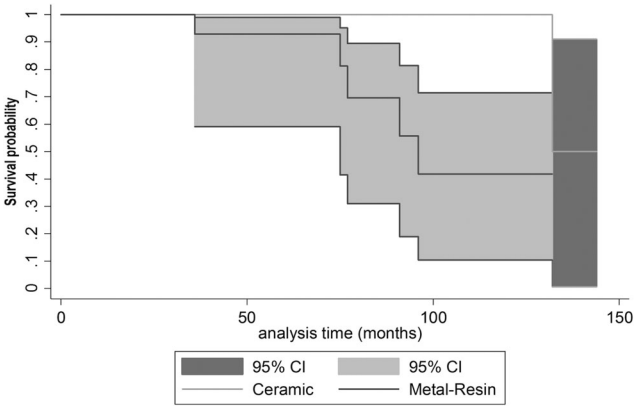

Figure 2 Kaplan-Meier curve for prosthesis survival between Group 1 (ceramic) and Group 2 (metal-resin).

prosthesis failure rate was 7.1% (95% CI: 1.0-40.9%) and 10-year was 58.2% (95% CI: 28.5-89.6%) for 16 metal-resin IFCDPs. Out of 457 in total, only 6 implants failed during the follow-up time of 1-12 years yielding a 10-year implant failure rate of 3.0% (95% CI: 1.2-4.7%).

Kaplan-Meier survival curve analysis was carried out with the prosthesis insertion as baseline (Fig 1). Additionally, Kaplan-Meier survival curve analysis was done for both Groups 1 and 2 separately (Fig 2), so as to show the prostheses distribution over time.

A total of 274 technical complications were registered, affecting 57 IFCDPs (80.3% or n = 57/71), with an average of 4.8 complications per prosthesis (minimum of 1, maximum of 21) (Table 3). Consequently, 14 prostheses were free of complications (19.7% or n = 14/71). The cumulative rates for "prosthesis free of complications" at 5- and 10-years were 58.28% (95% CI: 45.3-69.2%) and 8.2% (95% CI: 2.8-17.4%), respectively.

Technical complications were further divided into minor and major. Minor complications happened in 35 prostheses (49.3% or n = 35/71) 185 times, with an average of 5.3 complications per prosthesis (minimum of 1, maximum of 10). Thirty-six prostheses (50.7% or n = 36/71) were free of minor complications. The cumulative rates for "prosthesis free of minor complications" at 5- and 10-years were 60.5% (95% CI: 47.2-71.3%) and 8.9% (95% CI: 2.9-18.0%), respectively. The most frequently observed minor technical complication was wear of the prosthetic material (9.8%), as described in Tables 3 and 4.

Major technical complications occurred in 22 prostheses (31% or n = 22/71) 89 times, with an average of 4 complications per prosthesis (minimum of 1, maximum of 15). Prostheses with more than 5 major complications failed due to multiple fractures of the prosthetic material (n = 3/71).

Forty-nine prostheses (69% or n = 49/71) were free of major technical complications. The cumulative rate for "prosthesis free of major technical complications" at 5-year was 85.5% (95% CI: 73.0-92.5%) and at 10-year was 30.1% (95% CI: 12.0-50.6%). The most frequently observed major technical complication was fracture of the prosthetic material (1.9%), as shown in Table 3.

From 1 to 12 years of prosthesis follow-up, 42 IFCDPs (n = 42/55) in Group 1 (ceramic) and 15 IFCDPs (n = 15/16) in Group 2 (MR) showed at least one technical complication, resulting in 76.4% complication rate in Group 1 and 93.7% in Group 2, respectively. A total of 177 technical complications were registered in Group 1, however, since decementation could only happen in a cement-retained type of IFCDPs and no comparison would be possible with Group 2, this complication was excluded from the comparison. So, a total of 154 complications were registered in Group 1, with an average of 3.7 complications per prosthesis (minimum of 1, maximum of 15), as showed in Table 4.

The most frequent complication was wear of the prosthetic material (7.3%), affecting 34.6% of the IFCDPs (n = 19/55). While in Group 2, a total of 97 complications were encountered, with an average of 6.5 complications per prosthesis (minimum of 1, maximum of 21). The most frequently observed complication was also wear of the prosthetic material, however with a statistically significant higher rate (19.4%) ($p < 0.05$), affecting 81.3% of the IFCDPs (n = 13/16). The risk of wear of the prosthetic material was 0.4 lower in Group 1 compared with Group 2 (Hazard Ratio 95% CI: 0.2-0.9) (Table 5).

A total of 121 minor complications were registered in Group 1, affecting 38.2% of the IFCDPs (n = 21/55), with an average of 5.8 complications per IFCDP (minimum of 1, maximum of 9). A total of 41 minor complications were observed in Group 2, affecting 87.5% of the IFCDPs (n = 14/16), with an average of 2.9 complications per IFCDP (minimum of 1, maximum of 10).

The minor complication most frequently registered in Group 1 was wear of the prosthetic material (7.3%), followed by porcelain chipping (2.5%), and loss of screw access filing material (1.3%). While in Group 2 wear of the prosthetic material (19.4%) was the most frequently observed minor complication, followed by loss of screw access filing material (4.6%), and loosening of a screw (0.6%) (Table 4). Chipping of the prosthetic material was significantly more frequently observed in Group 1 (2.5%) compared with Group 2 (0.3%) ($p < 0.05$). The risk of chipping was 4.7 times higher in Group 1 compared with Group 2 (hazard ratio 95% CI: 1.12-19.77%) (Table 5).

In Group 1, a total of 33 major technical complications affecting 21.8% of the IFCDPs (n = 12/55), with an average of 2.7 complications per prosthesis (minimum of 1, maximum of 7) were observed. While in Group 2, 56 major complications

Table 3 Overview of technical complications in IFCDPs

	Total no. of prostheses, teeth, implants in the study	No. of prostheses with complications	No. of complications	Complication percentage	Complication rate (%) (Prostheses level)	Exposure time (y)	Annual complication rates (95%CI)*	Estimated 5-year complication rate (95% CI)	Estimated 10-year complication rate (95% CI)
Minor Complications		**35**	**185**	**67.5**	**77.5**				
Wear of the prosthetic material	**71 prostheses**	32	32	11.7	46.5	328	**9.8** (6.8-13.6)	**49.0** (36.2-68.4)	**98.0** (70.3-133.6)
Decementation (loss of retention)	**36 prostheses**	10	23	8.4	27.8	340	**2.9** (1.6-5.5)	**14.7** (8.0-27.5)	**29.4** (1.1-55.0)
Loss of screw access filing	**214 implants**	14	30	10.9	42.9	1112	**2.7** (1.9-3.8)	**13.5** (10.7-17.9)	**27.0** (21.2-36.1)
Chipping of prosthetic material	**869 teeth**	31	87	31.7	43.7	4411	**2.0** (1.6-2.4)	**10.0** (9.1-11.2)	**20.0** (18.2-22.9)
Loosening of a screw	**457 implants**	5	10	3.6	7.0	2366	**0.4** (0.2-0.7)	**2.0** (1.1-3.3)	**4.0** (3.1-5.9)
Loosening of an abutment screw	**457 implants**	2	3	1.1	2.8	2376	**0.1** (0.03-0.3)	**0.5** (0.2-1.4)	**1.0** (0.4-2.6)
Major Complications		**22**	**89**	**32.5**	**31**				
Fracture of the prosthetic material	**869 teeth**	20	82	29.9	28.2	4418	**1.9** (1.5-2.3)	**9.5** (8.6-11.1)	**19.0** (16.7-21.6)
Fracture of a screw	**457 implants**	2	6	2.2	2.8	2371	**0.3** (0.1-0.5)	**1.5** (0.6-2.4)	**3.0** (1.7-4.6)
Fracture of framework	**71 prostheses**	1	1	0.4	1.4	368	**0.3** (0.01-1.3)	**1.5** (0.1-6.3)	**3.0** (0.2-11.6)
Fracture of an abutment	**457 implants**	0	0	0	0	0	0	0	0
Fracture of an implant	**457 implants**	0	0	0	0	0	0	0	0
Total		**57**	**274**	**100**	**80.3**				

CI = confidence intervals.

Table 4 Technical complications in IFCDPs—comparison between the groups

	Group 1						Group 2					
	Total no. of prostheses, teeth and implants in Group 1	No. of prosth. with complications	No. of events	Complication percentage	Exposure time (year)	Actual annual complication rate (95% CI)	Total no. of prostheses, teeth and implants in Group 2	No. of prosth. with complications	No. of events	Complication percentage	Exposure time (year)	Actual annual complication rate (95% CI)
Minor Complications		**21**	**121**	**78.6**				**14**	**41**	**42.3**		
Wear of the prosthetic material	55 prostheses	19	19	12.3	261	**7.3** (4.5-11.2)	16 prostheses	13	13	13.4	67	**19.4** (10.8-32.4)
Chipping of prosthetic material	673 teeth	29	84	54.5	3395	**2.5** (2.0-3.0)	196 teeth	2	3	3.1	1021	**0.3** (0.1-0.8)
Loss of screw access filing	116 implants	6	8	5.2	603	**1.3** (0.6-2.5)	98 implants	8	22	22.7	482	**4.6** (2.9-6.8)
Loosening of a screw	359 implants	4	7	4.5	1860	**0.4** (0.2-0.7)	98 implants	1	3	3.1	507	**0.6** (0.2-1.6)
Loosening of an abutment screw	359 implants	2	3	1.9	1866	**0.2** (0.04-0.4)	98 implants	0	0	0	510	0
Major Complications		**12**	**33**	**21.4**				**10**	**56**	**57.7**		
Fracture of prosthetic material	673 teeth	10	26	16.9	3471	**0.7** (0.5-1.1)	196 teeth	10	56	57.7	948	**5.9** (4.5-7.6)
Fracture of framework	55 prostheses	1	1	0.6	285	**0.4** (0.02-1.7)	16 prostheses	0	0	0	83	0
Fracture of a screw	359 implants	2	6	3.9	1869	**0.3** (0.1-0.7)	98 implants	0	0	0	510	0
Fracture of an abutment	359 implants	0	0	0	1869	0	98 implants	0	0	0	510	0
Fracture of an implant	359 implants	0	0	0	1869	0	98 implants	0	0	0	510	0
Total		**42**	**154**	**100**				**15**	**97**	**100**		

CI = confidence intervals.

Table 5 Risk factors—hazard ratio 95% confidence interval

	Porcelain vs metal-resin*	Nightguard	Bruxism
Minor complications			
Wear of the prosthetic material	0.4(0.2-0.9)**	0.9(0.2-3.7)	0.6(0.2-1.9)
Chipping of prosthetic material	4.7(1.12-19.77)**	4.4(1.1-17.8)**	0.1(0.03-0.5)**
Loss of screw access filing	0.8(0.03-0.9)**	0.5(0.02-10.4)	5.9(0.7-47.1)
Loosening of an abutment	NA	NA	NA
Loosening of a screw	1.7(0.01-68.23)	NA	NA
Loss of retention	NA	NA	NA
Major complications			
Fracture of prosthetic material	0.2(0.04-0.95)**	0.15(0.02-1.05)	1.07(0.20-5.67)
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

*Adjusted for night guard use, bruxism, and opposing dentition.

**p value <0.05.

NA = not applicable.

were registered, affecting 62.5% of the IFCDPs (n = 10/16), with an average of 5.6 complications per prosthesis (minimum of 1, maximum of 15). As Table 4 shows, the most frequently observed major technical complication was fracture of the prosthetic material in both groups (Group 1 = 0.7%, Group 2 = 5.9%), and it was also the only major complication observed in Group 2 (metal-resin), showing a statistically significant difference between the groups ($p < 0.05$), where the risk of fracture was 0.2 lower in Group 1 compared with Group 2 (Hazard Ratio 95% CI: 0.04-0.95). At a prosthesis level, statistically significant fewer major technical complications occurred in Group 1 (21.8%) than in Group 2 (62.5%) ($p = 0.004$).

More than 94% of the patients, in general, were satisfied with their IFCDPs. The ability to taste the food was the category that showed the highest number of patients satisfied (98.1%). On the other hand, the ability to chew showed the lowest number (88.5%) (Table 6). The statistical comparison of patient satisfaction between the two groups showed that more patients were satisfied with their ability to chew in Group 1 (95.1%) than in Group 2 (63.6%) ($p = 0.01$). Also, more patients were satisfied in general with their treatment in Group 1 (100%) than in Group 2 (72.7%) ($p = 0.007$).

Porcelain veneering material, presence of bruxism, and absence of a nightguard were associated with increased risk for chipping of the prosthetic material of the IFCDPs ($p < 0.05$). The risk of chipping was 4.6 times higher in the ceramic type of IFCDPs compared with the MR type of prosthesis (Hazard Ratio 95% CI: 1.12-19.77). The risk of chipping was 4.4 higher in patients, who did not use a nightguard compared with those who used it (hazard ratio 95% CI: 1.1-17.8). Additionally, the risk of this complication was lower in patients diagnosed without bruxism in relation to those who were diagnosed with bruxism (Hazard Ratio 95% CI: 0.03-0.5) (Table 5).

Table 6 Patient satisfaction

	General	Group 1 (%)	Group 2 (%)
Esthetics	92.3	95.1	81.8
Ability to chew	88.5	95.1*	63.6*
Ability to taste	98.1	100	90.9
Ability to speak	92.3	95.1	81.8
General	94.2	100+	72.7+

*Statistically significant different ($p = 0.01$).

+Statistically significant different ($p = 0.007$).

Discussion

The objective of this retrospective study was to report the technical complication and prosthesis survival rates with IFCDPs for edentulous patients after mean exposure time of 5.2 years (range: 1-12 years). The findings of this study show a high cumulative implant and prosthesis survival rates of 98.7% and 91.7% after a mean observation period of 5.2 years (range 1-12 years), respectively. Out of 71 IFCDPs (supported by 457 rough surface) 6 failed, yielding a cumulative 10-year survival rate of 91.7%. The IFCDP survival is directly related to implant survival. Out of the 6 IFCDP failures, 3 were attributed to late implant failures in 3 patients (2 implant failures each) and affected the IFCDP survival. These 3 patients had to be switched to overdentures from the previously IFCDPs. The remaining 3 IFCDP failures were observed in Group 2 (metal-resin) and were due to technical complications and prosthetic material failure.

The implant and prosthesis survival rates reported in this study are in accordance with the findings of systematic reviews that demonstrated that treatment with maxillary and mandibular IFCDPs yields high implant and prosthesis survival rates, namely more than 96% after 10 years.[8,23] The slightly lower prosthesis survival rate of 91.6% in this study was mainly due to late implant failures after 5 years, which necessitated the removal of the involved IFCDPs and patients to be switched to overdentures. The 3 IFCDPs that had to be replaced with overdentures were structurally sound.

In this study, out of the 6 IFCDP failures (6/71), 3 were attributed to late implant failures in 3 patients (2 implant failures each) and affected the IFCDP survival. As mentioned above, these 3 patients had to be switched to overdentures

from the previously made IFCDPs. The remaining implants in these 3 patients were sound and were used to support the overdentures. The prosthesis design may have had an adverse effect on cleansability and implant survival for 1 patient (2 implant failures), since a ridge-lap, cement-retained IFCDP had been inserted. Ridge laps are contra-indicated, especially when combined with cement retention. The inappropriate prosthetic design may potentially be one of the reasons for these 2 implant failures.[20] The remaining 3 IFCDP failures were observed in the MR group (Group 2) and were due to technical complications and prosthetic material failure. These findings are similar to the ones reported previously in literature, where out of 108 MR IFCDPs 7 were converted into implant overdentures and 2 were converted into complete dentures because of late implant failures.[10] In regards to biologic complications and peri-implantitis, a 5-year implant-based peri-implantitis rate of 10% (95% CI: 8.9-11.5) and a 10-year implant-based rate of 20% (95% CI: 16.9-24.9) was reported in a separate publication on the same patient cohort.[20] Overall, 10.1% of the 457 implants supporting the 71 IFCDPs exhibited signs of peri-implantitis.[20] Additionally, the 5- and 10-year cumulative rates for "prostheses free of biologic complications" were 52.5% (95% CI: 39.9-63.7%) and 8.1% (95% CI: 2.8-17.2%), respectively. This highlights the importance of appropriate prosthetic design for cleansability and regular maintenance through recalls.[20,21]

In regards to complications, the most frequent minor technical complication was wear of the prosthetic material (9.8), while the most frequent major technical complication was fracture of the prosthetic material (1.9%). These findings are in accordance with the complication rates reported in the literature. All prosthetic materials are subject to time-dependent wear and a variety of factors are affecting it. Papaspyridakos et al[10] reported that the most frequent technical complication reported with metal-resin IFCDPs was prosthetic material chipping/fracture. Technical complications after the definitive prosthesis placement may result in an increased number of repairs and maintenance sessions.[10] MR IFCDPs exhibited more wear of the prosthetic material than the ceramic type IFCDPs (7.3%), yielding a statistically significant difference associated with the percentage of wear between the 2 groups. This is in accordance with what is reported in the literature regarding acrylic teeth and wear. Another study assessed 205 edentulous arches restored with MR IFCDPs and reported that the replacement of denture teeth (retread) occurred after an average of 7.8 years.[14] It has to be mentioned that there are more variables that may affect prosthesis integrity and survival such as opposing dentition, occlusal schemes, and anterior-posterior implant spread.[23] In the present investigation, these data were recorded but not further analyzed. Rather, the effect of bruxism, the absence of a nightguard and porcelain veneering material were analyzed and eventually associated with increased risk for chipping of the prosthetic material of the IFCDPs.

To the authors' knowledge, this is the first study that attempts to report separately and compare complications encountered between these 2 groups (ceramic type vs MR). However, the number of IFCDPs in Group 1 (55) was 3.5 times more than Group 2 (16), and this represents one of the limitations of this study since the size of the two groups was disproportionate, and the comparative analysis should be read with caution. The preponderance of literature reporting on longitudinal follow-ups includes MR IFCDPs.[3,9] The longitudinal effectiveness of the MR IFCDPs against maxillary complete dentures has been demonstrated in the literature, with considerably high rates of technical complications like wear and chipping encountered as a result of material fatigue and stress.[14] Studies have also reported on the incidence of complications with ceramic type IFCDPs.[6,19,25-30] While no studies have been identified directly comparing intra-group ceramic IFCDPs to MR IFCDPs, it must be mentioned that there is paucity of reports on complications with ceramic IFCDPs for edentulous jaws with observation periods of at least 5 years conversely with the MR design.[8]

This study reports data on patient-centered outcomes. The patients' high satisfaction rate in this study demonstrates that treating the edentulous predicament with osseointegrated implants is an effective treatment modality. Satisfaction was greater among patients restored with ceramic type versus MR IFCDPs and it can be hypothesized that the wear of the prosthetic material especially observed in the MR group or the reduced proprioception in completely edentulous patients could have played a role.[6,14,30]

Strong points of this retrospective study include the long-term follow-up of up to 12 years and the relatively large cohort of edentulous patients, whereas limitations pertain to the retrospective design. The retrospective design is inherently associated with sampling bias because it depends on acquired data from files and records that have been registered by various clinicians. However, even though retrospective studies rank below RCTs and prospective clinical trials in the hierarchy of evidence, long-term retrospective studies with mean follow-ups of >5 years can offer significant clinical information.[3] Not being able to remove the IFCDPs at the examination visit is an additional limitation of this study. Additionally, it was not possible to record the preoperative condition of the patients prior to implant placement, which represents an additional limitation.

The clinical implications of the present retrospective study pertain to the high implant survival rates achieved during full arch rehabilitation with IFCDPs after a long-term follow-up. However, only 58.28% of the IFCDPs were free of complications at 5-years and this indicates a very high maintenance load for either form of prosthesis at face value. At the 5-year landmark and when broken down to *minor* and *major* complications, cumulative rate for "prosthesis free of minor complications" was 60.5% (95% CI: 47.2-71.3%) and cumulative rate for "prosthesis free of major technical complications" at 5-year was 85.5% (95% CI: 73.0-92.5%). This might be manageable in an institutional setting but could be a high financial liability in a private practice setting. More studies are necessary to ascertain the financial burden of prosthetic maintenance of full-arch implant rehabilitation. The patients should also be informed that they have to adhere to frequent maintenance that also carries a cost. While 40 out of the 71 IFCDPS were followed for more than 5 years, significantly more wear and prosthesis failures were found in the MR group. The initial lower cost of metal-resin IFCDP may be outweighed by the significantly more maintenance burden in the longitudinal follow-up.

Conclusions

Under the limitations of this retrospective study, the most frequent *minor* technical complication was wear of the prosthetic material, whereas the most frequent *major* complication was fracture of the prosthetic material. Significantly more wear was observed in the MR IFCDPs compared with the ceramic type IFCDPs. The porcelain material, the presence of bruxism, and the absence of nightguard were associated with increased risk for chipping of the prosthetic material of the IFCDPs. Significantly more patients were satisfied in general with their treatment with ceramic IFCDPs than with MR IFCDPs. The cumulative rates for "prosthesis free of minor complications" at 5- and 10-years were 60.5% (95% CI: 47.2-71.3%) and 8.9% (95% CI: 2.9-18.0%), respectively. The cumulative rates for "prosthesis free of major technical complications" at 5- and 10-years were 85.5% (95% CI: 73.0-92.5%) and 30.1% (95% CI: 12.0-50.6%), respectively.

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