Outcomes of Immediate Function Implant Prosthetic Restorations with Mechanical Complications: A Retrospective Clinical Study with 5 Years of Follow-Up

Keywords

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ABSTRACT

Mechanical complications may have a significant impact on the outcome of implant-supported restorations; however, few studies address the topic. This study investigated the outcomes of implant supported restorations with mechanical complications. A total of 378 patients with 378 restorations supported by 1283 implants were included. Results demonstrated a prosthetic and implant cumulative survival rate at 5 years of 99.7% and 95.7%, respectively. Maxillary implants were a determinant for implant failure (hazard ratio= 6.7), while a reduced risk was registered for single tooth restorations (hazard ratio= 0.1) after adjusting for other variables of interest.

INTRODUCTION

Dental implants have become a favourable choice for oral rehabilitation, allowing the restoration of function without damaging adjacent teeth without prejudice of the long term outcome.[1,2] Nevertheless, clinical complications with implants and implant prostheses can occur, related to implant loss, bone loss, peri-implant soft tissue, mechanical and aesthetic/phonetic.[3] From the possible complications in implant dentistry, mechanical complications are one of the most prevalent,[3-7] and amongst these, the most common is veneer fracture.[3,4] Other mechanical complications may occur such as prosthetic screw loosening, prosthetic screw fracture, abutment screw loosening, abutment screw fracture, implant fractures, framework fracture, or loss of retention (for cemented prostheses).[8] Although most of these complications may not lead to implant/prosthetic failures, they may exert a significant negative impact on patient satisfaction. This negative impact was reflected on the significant amount of repair, maintenance, time, and cost to clinicians and patients.[9] According to the literature, potential risk indicators for the prevalence of mechanical complications include: bruxism, cantilever extensions, length of the reconstruction, and implant distribution.[7,10,11]

The effect of mechanical complications on implant success is subject to discussion: Some authors reported the absence of a direct impact on implant survival and success rates;[2] whereas other authors reported occlusal overload as a potential risk indicator for marginal bone loss[12-14] and implant failure.[14]

The aim of this study was to evaluate the outcome of implant supported fixed prosthetic restorations with mechanical complications.

MATERIAL AND METHODS

This article was written following the STROBE (strengthening the reporting of observational studies in epidemiology) guidelines.[15] This retrospective study was performed in a private clinic, Maló Clinic, Lisbon, Portugal, and was approved by an independent ethical committee (Ethical Committee for Health, Lisbon, Portugal; authorization no. 012/2010).

From an initial list of 1179 patients rehabilitated with dental implants in immediate function (implant, abutment and crown/prosthesis connection on the day of surgery), a list of patients with reported mechanical complications was retrieved for inclusion in this study: The sample included 378 patients (208 females and 170 males; average age= 53 years; range 18-81 years), whose fixed prosthetic rehabilitations supported by implants in immediate function were performed between December 1997 and April 2007. Patients in this report had at least one mechanical complication during the follow-up, ranging from loosening to fracture of prosthetic components (prosthetic screw, abutment or prosthesis).

The surgical and prosthetic protocols were adapted according to the type of rehabilitation: single tooth, partial rehabilitation or full-arch rehabilitation:[16-20]

A clinical examination with preoperative panoramic radiographs and computed tomography scans were used to plan the surgeries. Standard procedures were followed for insertion of the implants (Brånemark System® Mk II, Mk III, Mk IV, NobelReplace, and NobelSpeedy). Under-preparation was employed during implant site preparation; final implant insertion torque of at least 30 Ncm was required. The implant platform was positioned at bone level, and bicortical anchorage was established whenever possible. After closing and suturing the flap with 3-0 non-resorbable sutures, access to the abutments was opened by a soft tissue punch and impression copings were placed.

In case of total rehabilitation (All-on-four treatment concept, mandible, or maxilla), the anterior implants were placed in lateral or central incisor positions while the posterior implants typically emerged at the second premolar/first molar positions. The posterior implants were inserted just anterior to the foramina/anterior sinus wall and tilted distally between 30 and 45 degrees relative to the occlusal plane in the mandible and with 45 degrees of inclination following the anterior sinus wall in the maxilla.

Considering the immediate provisional prosthetic protocol, for single-tooth or partial rehabilitations, definitive abutments were inserted on the day of surgery and connected to provisional acrylic-resin crowns/prostheses. The occlusion was adjusted to eliminate direct contact to the prosthesis. For full-arch restorations, provisional acrylic-resin prostheses with titanium cylinders were manufactured at the prostheses laboratory and delivered on the day of surgery.

Regarding the definitive prosthetic protocol for partially edentulous patients, prosthetic restorations with full-ceramic crowns were connected after 4 to 6 months, and the occlusion scheme replicated where possible that of the natural dentition. For full-arch restorations and considering patient desires, metal-ceramic, metal acrylic, or acrylic resin prostheses were used to replace the provisional prostheses, at the earliest, 6 months post-surgery.

Patients were advised a soft food diet for the first 6 months post-surgically. All patients were included in a maintenance protocol and evaluated clinically at each planned follow-up visit (10 days, 2, 4, and 6 months, 1 year, and thereafter every 6 months).

The primary outcome measure was prosthetic and implant survival. Prosthetic survival was judged based on function: a prosthesis needed to be replaced due to loss of implant support was considered a failure. An implant was classified as surviving using the Malo survival criteria:[20] (1) it fulfilled its purported function as support for reconstruction; (2) it was stable when tested manually; (3) no signs of persistent infection observed; and (4) demonstrated a good aesthetic outcome of the rehabilitation. Implants that did not meet the survival criteria were classified as failures. The secondary outcome measures were the incidence of biological complications. The biological complications assessed were peri-implant pathology (presence of peri-implant pockets >4 mm assessed with a 0.25-Ncm calibrated plastic periodontal probe, with concurrent presence of bleeding on probing and marginal bone loss), suppuration, and fistulae formation.

The data concerning this study was retrieved from the patients' medical records by an outcome assessor blinded to the study objectives. The mechanical complications were evaluated on the provisional and definitive restorations. Concerning the provisional restorations, the type of mechanical complications considered were: prosthetic fractures, abutment fractures, abutment screw loosening, prosthetic screw fractures and prosthetic screw loosening. Regarding the definitive restorations, the type of mechanical complications considered were: prosthetic fractures, titanium cylinder fractures, crown fractures (ceramic fracture, ceramic chipping polished or repaired with composite resine, acrylic crown fracture), abutment fractures, abutment screw loosening, prosthetic screw fractures and prosthetic screw loosening. Descriptive and inferential statistics were used to analyse the variables of interest: Survival was analysed descriptively through life tables and computed using the Kaplan-Meier product limit estimator (considering the first implant failure in any given patient as censoring event), using the log rank test to evaluate the difference between survival curves in each variable.

Table 1. Distribution of the restorations with mechanical complications by type of rehabilitation and arch.

Site, type of restoration (provisional/definitive), and component	Single teeth: total (maxillary; mandibular)	Partial restoration: total (maxillary; mandibular)	Full-arch: total (maxillary; mandibular)	Total
Total restorations	95(88;7)[a]	33 (16;17)	250 (90;160)	378
Provisional restorations	72 (66;6)	21 (13;8)	160 (71;89)	253
Prostheses				
fractures	48 (43;5)	10 (7;3)	87 (52;35)	145
decementations	3 (3;0)	0	0	3
Abutments				
fractures	2 (2;0)	0	0	2
Loosenings	17 (17;0)	7 (6;1)	68 (27;41)	92
Prosthetic screws				
fractures	0	0	2 (1;1)	2
loosenings	11 (8;1)	5 (1;4)	23 (5;18)	39
Definitive restorations	26 (24;2)	12 (3;9)	91 (20;71)	129
Prostheses fractures	--	--	9 (1;8)[b]	9
Titanium cylinder fracture	--	--	2 (0;2)[c]	2
Crowns				
Ceramic fractures	12 (11;1)	2 (1;1)	18 (9;9)	32
Ceramic chipping	5 (4;1)	2 (1;1)	5 (3;2)	12
Acrylic crown fracture	--	--	27 (8;19)	27
Abutments				
fractures	0	0	1 (0;1)	1
loosenings	5 (4;1)	2 (0;2)	26 (0;26)	33
Prosthetic screws				
fractures	1 (1;0)	0	0	1

[a] One single tooth restoration failed in 1 patient.
[b] acrylic-resin prostheses
[c] titanium-acrylic resin prostheses

The determinants for implant failure were analysed with a multivariate Cox proportional hazards model. The effect of each possible explanatory variable was determined by the hazard ratio (HR) with 95% confidence intervals (95% CI). The covariates introduced in the univariate model were: type of rehabilitation (full-arch, partial, single tooth); rehabilitation site (maxilla; mandible); opposing dentition (implant supported prosthesis, fixed prosthesis over natural teeth, miscellaneous, natural teeth, removable prosthesis); age; gender (male, female), biological complications (present, absent), and smoking status (smoker, non-smoker). Covariates ($p<0.200$ in univariate analysis) were inserted in a multivariate Cox proportional hazards model to attempt to disclose significant effects of possible explanatory variables when controlled for the presence of other variables of interest. The level of significance considered was 5%. Statistics were performed using SPSS v.18.0 (IBM, Armonk, New York, USA).

RESULTS

There were 94 patients with a systemic compromised situation and 48 patients who were smokers. Thirty-two patients were lost to follow-up and 5 patients deceased due to unrelated causes with the implant treatment (total drop-out of 9.8%). Three-hundred-seventy-eight rehabilitations (195 in the maxilla and 183 in the mandible), distributed by 250 complete edentulous rehabilitations, 33 partial rehabilitations, 95 single teeth rehabilitations, and supported by a total of 1283 implants. The opposing dentition was implant supported fixed prosthesis (n=136), natural teeth (n=131), miscellaneous (n=68), removable prosthesis (n=37), or fixed prosthesis over natural teeth (n=6). The patients were followed up between 1 month and 163 months (average: 78 months). The average follow-up was 76 months for single teeth, 89 months for fixed partial prostheses, and 77 months for full-arch restorations.

The average follow-up time for the incidence of a mechanical complication in this cohort was 23 months (range: 1 month to 133 months). The types of mechanical complications were detailed in Table 1. The mechanical complications registered were related to the prosthetic screw (n=19 patients, 5%; loosening or fracture in the provisional or definitive restorations), the abutment (n=154, 40.8%; loosening or fracture in the provisional or definitive restorations), and prosthesis (n=231, 61.1%; acrylic fractures, titanium cylinder fractures, ceramic crown fractures or ceramic crown chipping in definitive restorations); with 24 patients experiencing more than one type of complication. The frequency of complications on the provisional restorations was almost 2 times higher when compared to the frequency of complications on the definitive restorations. The average number (standard deviation) of complications per patient during the follow up of the study was 4 (3.7). The distribution of mechanical complications by type of rehabilitation is illustrated on Table 1, with a higher incidence for full-arch rehabilitations (n=250; 66%), followed by single teeth rehabilitations (n=95; 25%), and partial rehabilitations (n= 33; 9%).

A total of 22/1283 implants failed in 16 patients, giving an overall survival rate of 95.7% after 5 years when using the patient as unit of analysis *(Table 2)*. There were no further implant failures for the remaining of the follow-up (up to 14 years). The implant failures meant a prosthetic failure in one patient with a single-tooth restoration (in the maxilla), rendering a 99.7% prosthetic survival.

Biological complications were registered in 82 patients (21.7% of the cohort), and 95 implants (7.4%; maxilla: 50/589 implants, 8.5%; mandible: 45/695 implants, 6.5%), ranging from peri-implant pathology (n=75) to suppuration (n=7 patients) *(Table 3)*.

Survival curves were generated from the survival estimates performed through Kaplan-Meier survival *(Figures 1 to 3)* for the variables analysed through univariate Cox regression: dental implants inserted in female or male patients (95.6% and 95.7%, p=0.927), dental implants inserted in healthy and systemic compromised patients (both with 95.7%, p=0.994), dental implants inserted in non-smoking and smoking patients (96.3% and 91.2%, p=0.115), dental implants inserted in the mandible or maxilla (98.3% and 93.1%, p=0.013), dental implants inserted for full-arch, partial or single tooth reconstructions (93.9%, 100% and 98.8%, p=0.058), dental implants with differing opposing dentitions (implant supported fixed prosthesis: 94.8%; Miscellaneous: 97.0%; natural teeth: 96.1%; removable prosthesis: 94.4%), dental implants inserted in patients with absence or presence of biological complications (96.0% and 94.6%, p=0.651).

Concerning the multivariate Cox regression analysis, the determinant of implant failure was implant insertion in the maxilla (HR=6.7) while the risk of implant failure was reduced in single tooth reconstructions (HR=0.1) when using full-arch reconstructions as reference, with significant effects registered at the univariate level that remained significant after adjusting for the other variables of interest *(Tables 4 and 5)*.

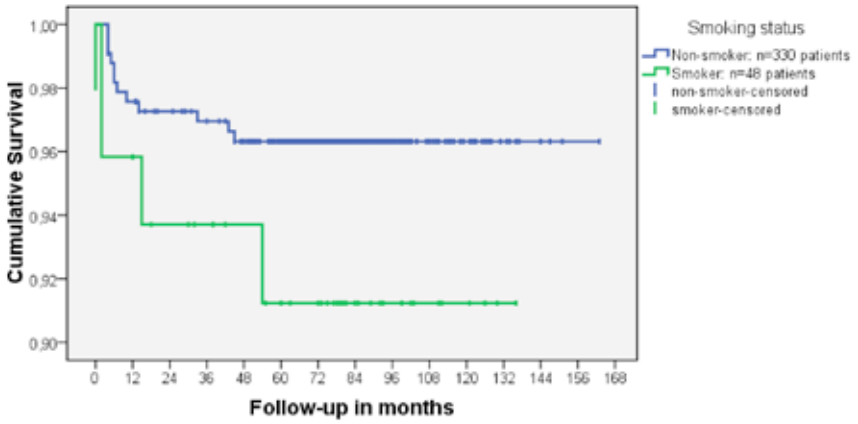

Figure 1: Kaplan-Meier survival curves for dental implants inserted in non-smoking and smoking patients. P=0.130, hazard ratio=2.41, 95% confidence interval= 0.78-7.48.

Table 2. Implant life table distributed per type of rehabilitation using the patient as unit of analysis (first implant failure censored).

Duration	Overall					Single teeth					Fixed partial rehabilitations					Full-arch rehabilitations				
	Total	Failed	LFU	FUI	CSR%	Total	Failed	LFU	FUI	CSR%	Total	Failed	LFU	FUI	CSR%	Total	Failed	LFU	FUI	CSR%
Placement	378	10	1	0	97.4	95	0	0	0	100	33	0	0	0	100	250	10	1	0	96.0
1 year	367	2	7	0	96.8	95	0	2	0	100	33	0	0	0	100	239	2	6	0	95.2
2 years	357	1	7	0	96.5	93	0	1	0	100	33	0	1	0	100	231	1	4	0	94.8
3 years	350	3	8	2	96.0	92	0	5	1	100	32	0	1	0	100	226	2	3	1	93.9
4 years	338	1	7	19	95.7	87	1	3	12	98.8	31	0	1	0	100	220	0	3	7	93.9
5 years	312	0	2	70	95.7	72	0	0	17	98.8	30	0	0	7	100	210	0	4	46	93.9
6 years	238	0	2	81	95.7	55	0	0	23	98.8	23	0	0	8	100	160	0	2	50	93.9
7 years	155	0	2	67	95.7	32	0	2	13	98.8	15	0	0	5	100	108	0	1	49	93.9
8 years	85	0	0	43	95.7	17	0	0	5	98.8	10	0	0	1	100	58	0	0	37	93.9
9 years	42	0	0	13	95.7	12	0	0	4	98.8	9	0	0	2	100	21	0	0	7	93.9
10 years	29	0	0	18	95.7	8	0	0	4	98.8	7	0	0	3	100	14	0	0	11	93.9

LFU: Lost to follow-up; FUI: Follow-up incomplete; CSR%: Cumulative survival rate in percentage

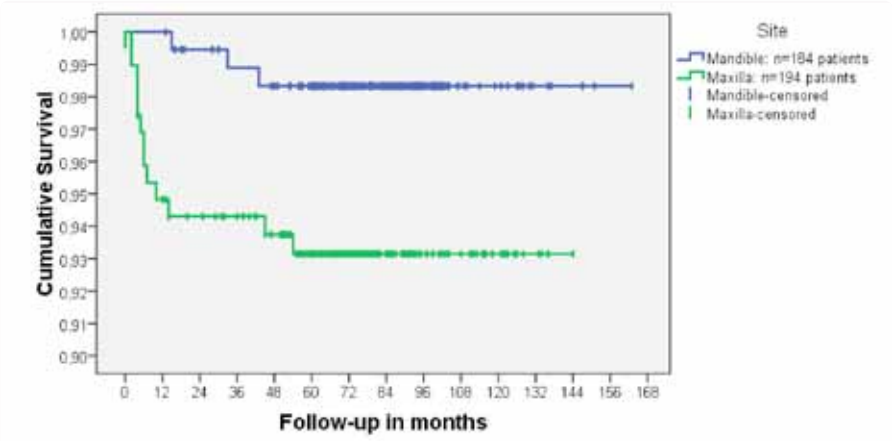

Figure 2: Kaplan-Meier survival curves for dental implants inserted in the mandible and maxilla. P=0.013, hazard ratio=4.32, 95% confidence interval= 1.23-15.15.

Table 3. Descriptive statistics (total n = 378 patients).

Factor	N	Percentage
Demographic variables		
Age	52.9 ± 11.4 (range: 18- 81)	
Gender		
Female	208	55.0%
Male	170	45.0%
Implant site		
Mandible	184	48.7%
Maxilla	194	51.3%
Smoking habits		
Non-smoker	330	87.3%
Smoker	48	12.7%
Type of reconstruction		
Single teeth	95	25.1%
Partial	33	8.7%
Full-arch	250	66.1%
Opposing Dentition		
Implant supported fixed prosthesis	136	36.0%
Fixed prosthesis over natural teeth	6	1.6%
Miscellaneous	68	18.0%
Natural teeth	131	34.7%
Removable prosthesis	37	9.8%
Incidence of biological complications		
Absence	296	78.3%
Presence	82	21.7%

Table 4. Univariate analysis of risk factors for implant failure with Cox proportional hazards (n = 378 patients).

Factor	Hazard Ratio	95% confidence interval	p-value
Demographic variables			
Age	1.04	(0.99, 1.09)	0.06
Gender			
Female	1.0		
Male	0.95	(0.36, 2.56)	0.93
Implant site			
Mandible	1.0		
Maxilla	4.32	(1.23, 15.15)	0.02
Smoking habits			
Non-smoker	1.0		
Smoker	2.41	(0.78, 7.48)	0.13
Systemic condition			
Healthy	1.0		
Systemic compromised	1.0	(0.32, 3.11)	0.99
Type of reconstruction			0.23
Full-arch	1.0		
Partial	0.0		
Single teeth	0.17	(0.02, 1.30)	0.09
Opposing Dentition			0.95
Implant supported fixed prosthesis	1.0		
Fixed prosthesis over natural teeth	0.0		0.98
Miscellaneous	0.56	(0.12, 2.71)	0.47
Natural teeth	0.73	(0.23, 2.29)	0.58
Removable prosthesis	1.04	(0.22, 5.02)	0.96
Incidence of biological complications*			
Absence	1.0		
Presence	1.29	(0.42, 4.03)	0.651

* The variable "Incidence of biological complications" was recoded for effects of causality, including as "presence" of biological complications, only the number of patients with biological complications before implant failure (n=76).

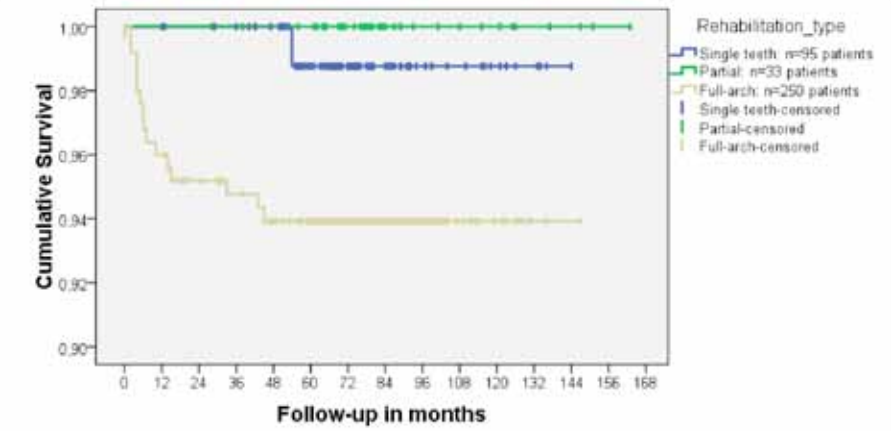

Figure 3: Kaplan-Meier survival curves for dental implants inserted in full-arch, partial and single tooth reconstructions. P=0.09, hazard ratio=0.17, 95% confidence interval= 0.02-1.30.

Table 5. Multivariate Cox regression model for risk factors for implant failure (total n = 378 patients).

Factor	Hazard Ratio	95% confidence interval	p-value
Age	1.03	(0.98, 1.09)	0.203
Implant site			
Mandible	1.0		
Maxilla	6.74	(1.87, 24.25)	0.004
Smoking habits			
Non-smoker	1.0		
Smoker	2.24	(0.67, 7.45)	0.190
Type of reconstruction			0.112
Full-arch	1.0		
Partial	0.0		0.982
Single teeth	0.11	(0.01, 0.87)	0.036

Implant site and single tooth reconstructions (concerning their difference to full-arch reconstructions) remained significant after adjusting for the other variables of interest.

DISCUSSION

The survival outcome registered in this study on a population of patients with mechanical complications was comparable to the results of previous systematic reviews on dental implant rehabilitations: Pjetursson *et al.*[21] reported estimated survival rates for implant-supported fixed dental prostheses of 95.6% after 5 years and 93.1% after 10 years; Jung *et al.*[21] reported survival rates for single teeth restorations of 97.2% at 5 years and 95.2% at 10 years; and Pjetursson *et al.*[23] reported estimated survival rates for fixed partial prostheses of 95.4% at 5 years and 92.8% at 10 years. Furthermore, a recent systematic review of the literature investigating the influence of bruxism on dental implants concluded that bruxism was related to a higher incidence of mechanical complications, but not to implant failures.[11] The results of our study comply with this conclusion, as the implant and prosthetic survival rates were high in a population of patients with mechanical complications. Despite the high survival rates for implants supporting restorations with mechanical complications, the results of this study should be interpreted with caution given the performance in a controlled environment. On the clinical setting, in a less controlled environment and with poor experience/competence operators, a substantial number of complications may occur with a potentially significant worse prognosis.

The risk indicator for implant failure in our study was implant insertion in the maxilla. In a recent systematic review, Strub *et al.*[24] indicated that while immediate loading of oral implants in the mandible revealed encouraging and predictable results, further multicenter randomized controlled clinical trials with sufficient statistical power were needed to examine the outcome of immediately loaded implants in the maxilla. This may be related primarily with bone quality, and in particular, the effect of overloading on poor bone quality, as evaluated in recent systematic reviews: Marquezan *et al.*[25] investigated the influence of bone mineral density on what is considered one of the most important aspects for successful immediate loading (the implants' primary stability), having established a positive association between implant primary stability and bone mineral density of the receptor site.

Another systematic review conducted by Sun *et al.*[26] investigated the influence of various factors on the long-term failure of dental implants with ≤ 10mm of length and concluded that most failures could be attributed to poor bone quality in the maxilla. Goiato *et al.*[27] in a systematic review investigating the longevity of dental implants on type IV bone, including 19 studies with 3937 patients and 12465 implants, reported an influence of bone density on the survival outcome, with 97.6%, 96.2%, 96.5%, for type I to type II bone, respectively, and 88.8% for type IV bone. Furthermore, He *et al.*[28] in an 8-year retrospective study of 2684 implants set to explore the influence of local bone density on implants cumulative survival rates registered the lowest survival rate for implants inserted on type IV bone (92.25%), compared to 100%, 98.18% and 96.83% for types I to III, respectively.

The risk of implant failure was reduced in single tooth reconstructions when using full-arch reconstructions as reference. A previous systematic review registered a higher survival rate for single tooth reconstructions when compared to fixed dental prosthesis after 10 years of follow-up, nevertheless the low number of studies used for that comparison and the admittedly lack of proper randomized controlled trials published. Biomechanically, single tooth reconstructions benefit from the presence of adjacent teeth, while full-arch reconstructions depend on the distribution of load for all the implants to reduce load from the posterior implants and remain stable. In the presence of conditions favoring improper occlusal stress with a high probability for the incidence of mechanical complications, such as in the population of this study, the stability of full-arch reconstructions will be more difficult to achieve, a situation that secondarily associated with bone characteristics can cause bone loss around implants and earlier failure.[13,29] In our study, implant failure occurred in more patients on the posterior maxilla (n=9 patients) than the overall sum of the remaining areas of rehabilitation (anterior maxilla: 4 patients; posterior mandible: 1 patient; anterior mandible: 2 patients; one patient with implant failures in both anterior and posterior mandible).

The incidence of biological complications is within the results achieved in other studies, with 21.7% of patients experiencing biological complications, and a majority of patients (19.8%) experiencing peri-implant pathology. Previous reports range the prevalence of peri-implant pathology between 5% and 56%, depending on the definition and criteria used to classify peri-implant pathology.[30-35] Nonetheless, the impact of these biological complications on the hazard ratio of implant failure was non-significant when analyzed in the Cox proportional hazards model. Given that peri-implant pathology is considered the major cause for late implant failure[36] and dependent on follow-up time (exposure time)[37] a possible explanation for this non-significant effect could be that the patients were not exposed long enough, and that longer follow-ups will be needed to fully understand the impact of this variable on implant survival.

The limitations of this study include being performed in a single centre, the lack of a control group and the absence of controlling the HR results for the loss of natural dentition history. Future research should focus on the effect of mechanical complications on implant survival and the implication in the soft tissue outcome at 10 years of follow-up.

CONCLUSIONS

The overall survival rate of 95.7% after 5 years of follow-up indicates that the long-term outcome of prosthetic rehabilitations with mechanical complications is high. The determinant of implant failure in the sample of patients with mechanical complications was the insertion of implants in the maxilla, while the risk of implant failure was reduced for single tooth reconstructions when considering full-arch reconstructions as reference.

MANUFACTURERS' DETAILS

The dental implants, titanium cylinders and ceramics used were from the Nobel Biocare system, Gothenburg, Sweden.

Implant-supported fixed prosthesis with a titanium framework and all ceramic crowns (Procera forte scanner, Procera and NobelProcera titanium framework, NobelProcera NobelRondo ceramics) from Nobel Biocare, Gothenburg, Sweden.

Metal acrylic-resin implant-supported fixed prosthesis with a titanium framework (NobelProcera titanium framework, Nobel Biocare AB) and acrylic-resin prosthetic teeth (Mondial teeth crowns, Heraeus Kulzer GmbH, Hanau, Germany).

High-density acrylic-resin (PalaXpress Ultra) prosthesis with titanium cylinders (nobel Biocare AB) and acrylic-resin prosthetic teeth (Mondial teeth, Heraeus Kulzer GmbH, Hanau, Germany).

The plastic periodontal probe (click-probe) used was from Hawe-Neos, Bioggio, Switzerland.

CONFLICTS OF INTEREST

Professor Maló is currently a consultant for Nobel Biocare.

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