DOI: 10.1111/cid.12784

WILEY

ORIGINAL ARTICLE

Clinical assessment of implant-supported full-arch immediate prostheses over 6 months of function

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Abstract

Objective: To assess the clinical outcomes of implant-supported full-arch immediate prosthesis over 6 months of functions and analyze the risk factors of prosthetic complications.

Materials and Methods: This retrospective cohort study included patients who were treated with implant-supported full-arch restoration under immediate loading protocol between April 2008 and June 2016, and who wore the immediate prosthesis for more than 6 months. Medical charts were reviewed for the patients' general information, implant information, prosthetic information, and details of any prosthetic complications. Prosthetic complications were classified as follows: class I, prosthesis loosening; class II, fewer than three artificial teeth fractured; class III, three or more artificial teeth fractured; and class IV, resin base fractures. A cox proportional hazards ratio model was adopted to analyze the potential risk factors for class IV complications.

Results: A total of 114 patients (mean age, 56.73 ± 10.19 years) and 144 prostheses were included. The average wearing time for the immediate prosthesis was 21.9 months, and 62 (54.39%) patients experienced prosthetic complications, 30 of whom suffered from complications more than once. The most common complications were class II complications (12.3%) during the first 6 months of functioning and class IV complications (28.1%) during the entire function period. Class II complications were more common in the anterior region, while class IV complications occurred more often in the posterior region. The multivariable Cox proportional hazards regression model showed that a prosthesis in the maxilla (HR = 3.37, P = .001) and fiber reinforcement (HR = 0.39, P = .021) were significantly related to class IV complications.

Conclusions: Implant-supported full-arch immediate prosthesis functioning over 6 months have a high prevalence of prosthetic complications. Fiber-reinforcement could reduce the prevalence of class IV complications when acrylic immediate prosthesis functioned longer than 6 months. Avoiding using the anterior teeth of the immediate prosthesis to tear pliable but strong food may prevent tooth fracture.

KEYWORDS

COX proportional hazards ratio model, full-arch, immediate prosthesis, prosthetic complication/technical complication

1 | INTRODUCTION

Immediate loading of the implant-supported full-arch prosthesis was first reported by Schnitman in the 1900s.[1,2] Later, improved protocols of fewer implants supporting the immediate prosthesis, proposed by Branemark et al.[3,4] and Malo et al.,[3] promoted the use of implant-supported full-arch immediate prosthesis in clinical practice. A number of clinical studies reported a 5-year implant survival rate greater than 95%, proving that immediate loading of the implant-supported full-arch prosthesis was a predictable option.[5-11]

The classical prosthetic protocol was to rehabilitate occlusion with acrylic resin immediate prosthesis in one or two visits to the dental clinic within 48 hours after surgery.[3,12] After 4 to 6 months, the provisional prosthesis would be replaced by metal-ceramic or metal-resin final prosthesis, which would require additional dental visits, more time and greater costs. The delivery of final prosthesis often varies and depends on the patients' desires; some patients opt to continue wearing the immediate prosthesis.[13]

Malo et al.[3,12] modified the classic prosthetic protocol in 2013, suggesting that a metal strip-reinforced acrylic prosthesis delivered immediately after surgery could be worn for a longer term as a low-cost final prosthesis. In 2005, Malo et al.[12] further suggested that an immediate accurately designed and supported all-acrylic prosthesis could be successful longer than only during the healing period. Numerous studies of immediate loading in the edentulous jaw emerging have been published, and the full-arch immediate prosthesis has gained popularity in daily practice, however, there have been few studies of the long-term function and complications of immediate prostheses.

Di et al.[14] reported that 60.9% Chinese patients who received immediate implant-supported full-arch prosthesis traveled a mean distance of 691 km for each dental visit, due to the vast territory and large population of China and the unbalanced distribution of well-equipped hospitals with well-trained clinicians. Most Chinese patients viewed their final prosthesis replacements unfavorably because of the frequent clinician visits and the peri-implant treatment cost, as well as the cost of the final prosthesis cost itself. Therefore, in China, it is of great clinical importance to assess the clinical outcome of immediate implant-supported full-arch prosthesis over 6 months of function and analyze the risk factors of prosthesis complications to find an effective, lower-cost, full-arch prosthetic protocol.

The first aim of this study is to assess the clinical outcome of 144 implant-supported full-arch immediate prostheses over 6 months of function by evaluating the prosthetic complications, to assess the feasibility of immediate prostheses functioning longer than the healing period, as Malo et al. proposed, in Chinese patients. The second aim of this study is to investigate the possible association between prosthetic complications and patient-related, prosthesis-related, or implant-related factors through multivariable regression to identify operative clinical measures that could decrease prosthetic complications, reduce the cost and time spent on prosthesis maintenance and repair, and eliminate patient discomfort caused by prosthetic complications of the immediate prosthesis.

2 | MATERIAL AND METHODS

This retrospective clinical study was conducted in the Department of Oral Implantology, Peking University School and Hospital of Stomatology, Beijing, China. Patient screening was performed between April 2008 and June 2016. Only patients who had been treated with the implant-supported immediately loaded fixed full-arch prosthesis and wore the prosthesis for more than 6 months were included. The study protocol was approved by the local ethics committee and the Beijing Health Bureau (No. 2008-9).

2.1 | Patient selection

The patients were selected according to the following criteria.

Inclusion criteria

- Patients older than 18 years.
- Patients with edentulous or potential edentulous jaws.
- Implant-supported fixed full-arch prosthesis immediately loaded within 24 hours after implant placement.
- Immediate prosthesis in function over 6 months.

Exclusion criteria

- Incomplete patient data or failure to attend the scheduled appointments during the first 6 months after surgery
- General contraindications for oral surgery, such as a history of bisphosphonate therapy, current chemotherapy, or radiotherapy of the head and neck
- Pregnancy or lactation
- Severe parafunctional habits, such as heavy bruxism and clenching
- Lack of compliance with clinical examination

2.2 | Preoperative preparation

A thorough clinical examination of each patient was performed to assess the jaw size, intermaxillary relationship, vertical distance between the alveolar ridge and occlusal plane. Routine panoramic radiographs were taken to evaluate the vertical volume and quality of alveolar bones, related important anatomical structures (ie, mandibular nerve, mental foramen, and maxillary sinus). Cone beam computed tomography (CBCT) was obtained if any anatomical structures required further identification or assessment.

2.3 | Peri-operative medication

The patients took cefuroxime axetil tablets (500 mg) and tinidazole tablets (1000 mg) as a prophylactic measure 1 hour before surgery, and they continued to take cefuroxime axetil tablets 250 mg twice a day for 7 days and tinidazole tablets 500 mg daily for 5 days postoperatively. If the patients were allergic to cefuroxime axetil, they were prescribed roxithromycin instead. Chlorhexidine digluconate 0.2% mouthwash was prescribed to patients starting 30 minutes before surgery and continuing for 7 days following the surgery. Dexamethasone

tablets (3 mg twice a day for 2 days) were given postoperatively to relieve swelling and control inflammatory responses if the patients had no contraindications to cortisone medication.

Implant operation was performed with the patients under local anesthesia (4% Articaine chlorhydrate with 1 100 000 epinephrine tartrate) and conscious sedation with midazolam (10 mg, po., 30 minutes before surgery).

2.4 | Surgical protocol

For the edentulous patients, a crestal incision was made on the palatal side of the healed alveolar crest ensure that the implants could be surrounded by keratinized gingiva. Then, the full mucoperiosteal flaps were raised both buccally and lingually/palatally. For the potential edentulous patients, the remaining teeth were extracted in a minimally invasive manner, and then the extraction sockets were thoroughly debrided (ie, through curettage) to remove any granulation tissue remnants and were alternately rinsed with 3% H_2O_2 and 0.2% chlorhexidine. The alveolar ridge was trimmed using a rongeur to remove sharp alveolar crests or socket prominences, and further flattened. Excess alveolar bone was removed to obtain a favorable vertical distance of at least 12 mm, when necessary.

Implants were placed according to the manufacturer's guidelines, except that under preparation was routinely used to enhance the initial stability in patients with low bone density. A total of 4~6 implants were placed axially or distally tilted (30°~40° relative to the occlusal plane), according to the bone volume and length of the arch. The implant platform was positioned at the bone level, and straight abutments or angulated abutments (17° or 30°) were seated to achieve the common insertion path. The flaps were closed and sutured with a 4-0 absorbable suture (Vicryl, Johnson & Johnson, Livingston, UK).

The gaps between the implant and the socket and the residual sockets were filled with the mixture of bone substitutes (BioOss, Geistlish Co., Swiss) and autogenous bone chips harvested during alveolar crest trimming. If there was bone dehiscence around the implants, bone substitutes (BioOss) and autogenous bone chips were applied on the exposed implant surface and covered with a resorbable collagen membrane (BioGide, Geistlish Co., Swiss).

2.5 | Immediate prosthetic protocol

Open-tray multiunit impression transfer copings (Nobel Biocare, Gothenburg, Sweden) were fastened to the abutments with screws post-operatively and connected with self-curing composite resin materials (DMG, Hamburg, Germany). The pick-up technique was utilized to take impressions with silicone elastomeric material. Vertical dimensions were recorded, and bite registrations were taken after removing the impression transfer copings. With regard to the patients with malocclusions including crossbite and open bite, compensative restoration was adopted (ie, rectifying the malocclusion to the normal occlusion or edge-to-edge occlusion).

Immediate full-arch acrylic resin prostheses without metal frameworks were manufactured with heat-cured acrylic resin (Vertex RS, Dentimax, Zeist, the Netherlands) and acrylic resin artificial teeth (Heraeus Kulzer, Hanau, Germany) at the dental laboratory. The acrylic resin was PMMA-based, which was same as that documented by Malo et al.[15] The immediate prostheses were delivered to the patients approximately 6 hours after surgery. Provisional prostheses were composed of 10-12 units, depending on the emerging positions of the posterior implants, to guarantee a cantilever length of less than 8 mm. Carbon fibers were twisted and tightened between adjacent abutments in an "eight" pattern inside the resin base of immediate prosthesis because a 2013 in vitro study[16] showed that acrylic resin reinforcement with carbon fibers could increase anti-fracture strength.

After the passive fit of the immediate prosthesis was ensured, prosthetic screws were tightened with a torque of 15 Ncm. The centric and lateral contacts were checked with 40 μm articulating paper (Bausch Articulating Paper, Nashua, NH). Occlusion adjustments were made to achieve the following principles: (a) achieving maximum occlusal contact at the implant-supported area in centric relation, (b) multipoint contact during lateral and protrusive movements, and (c) eliminate occlusal contact at distal cantilever area, as much as possible.

A cold or room temperature soft diet for the first 24 hours after surgery was recommended, followed by a semisolid diet for the next 3 months. Sleep bruxism patients were instructed to wear occlusal splints at night.

2.6 | Follow-up pvaluation

Follow-up appointments were scheduled at 1 week, 1 month, 3 months, and 6 months after surgery. Occlusal stability and balanced contacts were checked at every follow-up visit. Replacement of the immediate prosthesis with a final prosthesis with titanium framework was suggested 6 months after surgery, while the actual delivery time of the final prosthesis depended on the patients' desires.

Clinical examinations were scheduled 1 year after surgery and at least one time annually thereafter, regardless of whether the immediate prosthesis was still in function. Patients were instructed to visit the doctor soon when there were signs of prosthesis problem, such as loosening or fracture.

2.7 | Data collection

The following variables were collected from medical charts: patient data (ie, gender, age), rehabilitated arch, presurgical jaw status (edentulous or potential edentulous), and opposing dentition (fixed dentition, such as natural dentition, fixed prostheses supported by implants or natural teeth), or removable prosthesis (arch rehabilitated with removable partial dentures or full removable dentures), implant and abutment data (implant number, location and size), and prosthetic data (fiber-reinforcement, prosthetic complication type and time, and the duration that the provisional prosthesis functioned).

Prosthetic complications were classified based on the time and cost of repair:

TABLE 1 Complications from immediate prosthesis in the first 6 months and the entire function period

Class of complication		First 6 months (patient/prosthesis)		Entire function period (patient/prosthesis)	
		No.	Percent (%)	No.	Percent (%)
Class I	Screw loosening	4/4	3.5/2.8	5/5	4.4/3.5
	Abutment loosening	8/8	7.0/5.6	18/18	15.8/12.5
	Total	12/12	10.5/8.3	23/23	20.2/16.0
Class II	Teeth fracture<3 teeth	14/16	12.3/11.1	29/31	25.4/21.5
Class III	Teeth fracture≥3 teeth	3/3	2.6/2.1	5/5	4.4/3.5
Class IV	Base fracture[a]	9/9	7.9/6.3	32/36	28.1/25.0
Total[b]		36/41	31.6/28.5	62/73	54.4/50.7

[a]Including base cracks that may potentially develop into a base fracture and had been repaired.
[b]some prostheses underwent different types of complications.

- Class I, screw loosening, abutment loosening.
- Class II, fracture of fewer than three artificial teeth.
- Class III, fracture of three or more artificial teeth.
- Class IV, a resin base fracture (including a base crack that might potentially develop into a base fracture and had been repaired).

Prostheses that did not require replacement of prosthetic accessories or adding of prosthetic materials during the entire function period (ie, prostheses free of complications or that only underwent class I complications, were defined as "prosthesis success").

2.8 | Statistical analysis

Statistical analysis was performed using SPSS version 22.0 (IBM, Germany). Descriptive statistics were computed for different kinds of prosthetic complications during the entire function period and in the first 6 months. Prosthesis success rates were calculated through Kaplan-Meier survival analysis, with patients as the statistical unit. For patients who received bimaxillary implant-supported full-arch immediate prostheses, the prosthesis with the prior prosthetic complication was included into the statistical analysis. If both prostheses were free of complications, the earlier treated arch was included in the analysis.

The Cox proportional hazards regression model was used to evaluate possible predictors of very severe complications. We used univariate analyses to identify covariates associated with complications: age, gender, rehabilitated arch, presurgical jaw status (edentulous or potential edentulous), type of opposing dentition (fixed dentition, or removable prosthesis), implant number, and fiber-reinforcement. A significance level of 0.20 was set for univariate analyses. Statistically relevant covariates ($P < .20$ in univariate analyses) and biologically relevant variables were then entered into a multivariate Cox proportional hazards regression model; regression coefficients were estimated with the corresponding SEs. The significance level for multivariate analyses was set at 0.05.

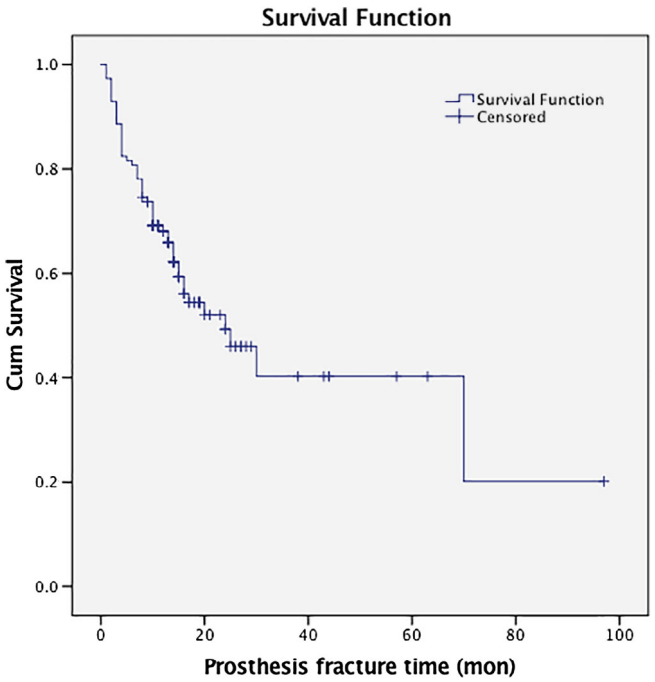

FIGURE 1 Graph of Kaplan-Meier cumulative success rate for immediate prostheses during the entire follw-up. The vertical axis shows the cumulative proportion of successful prostheses without repair

TABLE 2 Time of the first class II, class III, or class IV complication after immediate prosthesis delivery

Time after delivery of immediate prosthesis	Prostheses entered the time interval	Prostheses encountered class II, class III, or class IV complications
0-3 mo	114	13
3-6 mo	101	9
6-9 mo	92	7
9-12 mo	82	7
1-2 y	61	13
2-3 y	15	2
3-4 y	7	0
4-5 y	4	1
5-6 y	2	0
7-9 y	1	0

3 | RESULTS

A total of 114 consecutive patients (72 males and 42 females, mean age 56.7 ± 10.2 years, ranging from 31.4 to 86.4 years) were included in the study, 30 of whom were treated bimaxillary. In total, 61 maxillary and 83 mandibular arches were rehabilitated. A total of 119 prostheses were supported by 4 implants, 5 prostheses were supported by 5 implants, and 18 prostheses were supported by 6 implants. The other two prostheses were three implants.

The function time of the immediate prosthesis ranged from 7.3 to 100.2 months, and the median time was 12.7 months. A total of 15 prostheses had been in function for more than 3 years, and 6 prostheses functioned for more than 5 years. A total of 11 patients still wore immediate prostheses by the end of our observation, despite having been warned that provisional prostheses are not intended for long-term use. The other patients opted to replace the immediate prosthesis with the final metal-acrylic prosthesis, the function time of which ranged from 7.3 to 62.4 months.

Table 1 shows the prevalence of different classes of complication in the first 6 months and the entire function period. A total of 41 prostheses (28.5%) experienced complications before 6 months in 36 patients (31.6%), and 62 patients (54.39%) encountered complications during the entire function period. Figure 1 shows the cumulative prosthesis success curve. The 6-month cumulative prosthesis success rate was 81%. A total of 48 immediate prostheses were successful after 1 year of function (ie, free from class II, III, IV complications). Seven immediate prostheses and two immediate prostheses remained successful after 3 years and 5 years of function, respectively, as shown in Table 2.

In the first 6 months, class II complications (12.3%) were the most common complications. During the entire function period, class IV complications (28.1%) became were the most frequent complications, followed by class II complications (25.4%). The number of class II, class III, and class IV complications were calculated at the patient level and are listed in Table 3. Four patients experienced complications more than five times; they were all males and were treated bimaxillary.

During the entire function period, 62 class IV complications occurred in 32 patients. A total of 44 class IV complications occurred repeatedly in 14 patients, and 16 times the fractures were at the same position where the previous fracture occurred. A total of 23 times, class IV complications occurred in the anterior region, while the other 39 times were in the posterior region. No statistically significant differences were observed between the patients who experienced a one-time class IV complication and patients with multiple class IV complications at the first occurrence time, in terms of patient age at surgery, gender, rehabilitated arch, fiber-reinforcement, and opposing jaw (Table 4).

As for class II and class III complications, 64 teeth fractures occurred in 33 patients, 12 of which were fractures at the same sites that had been repaired. Figure 2 shows the teeth sites and times of teeth fracture. The anterior teeth suffered significantly more teeth fractures than the posterior teeth (number of fractures per anterior tooth: 5.4 ± 2.8, number of fractures per posterior tooth: 1.6 ± 1.1, $P = .001$).

The Cox proportional hazards regression model was used to evaluate the association between class IV complication and several possible risk indicators on the patient level. Variables included in the multivariate model were selected based on biological importance (gender) or statistical significance in the univariate analyses ($P < .20$) (Table 5). The multivariable Cox proportional hazards regression model showed that prosthesis in the maxilla (HR = 3.37) remained as a statistically significant risk factor for class IV complication ($P = .001$), while fiber reinforcement (HR = 0.39) was a protective factor of base fracture ($P = .021$), after controlling for age, gender, opposing dentition, and the number of implants (Table 6).

4 | DISCUSSION

A number of previous studies have reported that implant-supported full-arch immediate rehabilitation would be replaced by final prosthesis with metal or zirconia framework after 3-6 month provisional function of the immediate prosthesis.[6,8,14,17-21] Prostheses with metal or zirconia frames have greater strength and are considered to increase the prosthesis success rate.[22,23] However, if the oral function was remarkably improved by immediate prosthesis, the replacement with final prosthesis on time was unfavorable for those Chinese patients considering frequently visiting a clinician and the peri-treatment cost besides final prosthesis cost itself.[14] Malo et al.[3,12] proposed that accurately designed

TABLE 3 Number of class II, class III, and class IV complications per patient

Times of complications	Class II complications (no. of patients/%)	Class III complications (no. of patients/%)	Class IV complications (no. of patients/%)	Overall Complications (no. of patients/%)
0	85/74.6	109/95.6	82/71.9	62/54.4
1	16/14	4/3.5	18/15.8	26/22.8
2	4/3.5	1/0.9	7/6.1	7/6.1
3	5/4.4	0/0	3/2.6	6/5.3
4	2/1.8	0/0	1/0.9	6/5.3
5	1/0.9	0/0	2/1.8	3/2.6
6	1/0.9	0/0	1/0.9	1/0.9
7	0/0	0/0	0/0	1/0.9
8	0/0	0/0	0/0	2/1.8

TABLE 4 Comparison of patients with one-time class IV complication and multitime class IV complications in the first occurrence time, patient age at surgery, gender, rehabilitated arch, fiber-reinforcement, and opposing jaw

Times of class IV complication	No. of patients	First fracture time (months)		Age at surgery		Gender			Rehabilitated arch			Fiber reinforcement			Opposing arch		
		Mean ± SD	*P*	Mean ± SD	*P*	Male	Female	*P*	Maxilla	Mandible	*P*	Presence	Absence	*P*	Fixed dentition	Removable Prosthesis	*P*
Multitimes	14	11.42 ± 14.99	.73	56.65 ± 8.68	.80	7	7	.14	6	8	.69	4	10	.70	11	3	1.00
One-time	18	12.90 ± 6.10	…	57.55 ± 10.84	…	14	4	…	9	9	…	4	14		15	3	…

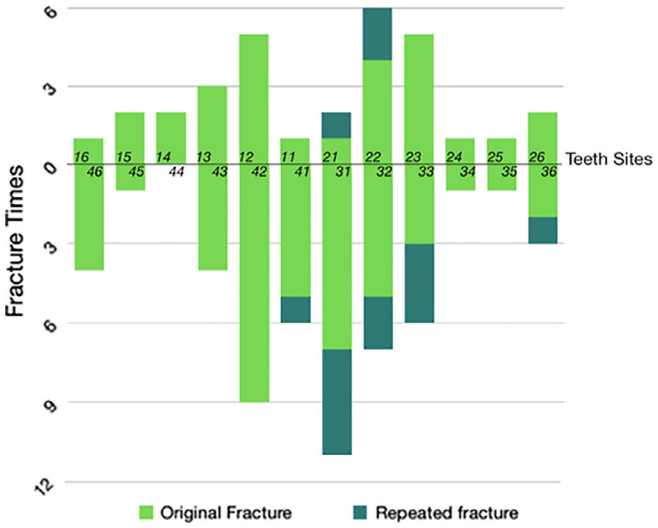

FIGURE 2 Distribution and frequency of teeth fracture

and supported all-acrylic prosthesis could be successful for long-term use, however, there are few studies of the long-term function of immediate prostheses. In China, it is important to explore an effective and low-cost prosthetic protocol and its indications.

The most common prosthetic complications in this study were class II complications (12.3%) and class IV complications (28.1%) during the first 6 months of function and the entire function period, respectively, both prosthetic fractures. This result aligns with the results of previous studies, in which immediate prostheses only functioned during the healing period.[6,18,19,24-27] In the first 6 months, the prevalence of class II complications, class III complications, and class IV complications added up to 19%. Drago et al.[25] reported that 17.8% of immediate prostheses fractured in 129 patients after a mean wearing time of 6.63 months, which was comparable to our results. As the function time lengthened, the prevalence of class IV complications increased. By the end of the observation period (mean function time of immediate prosthesis: 22 months), the prevalence of class II complications, class III complications, and class IV complications were 25%, 4%, and 28%, respectively.

Our study first documented the distribution difference between base fracture and artificial teeth fracture. Base fractures occurred more frequently in the posterior region, while the anterior teeth fractured more times than posterior teeth. Base fracture and teeth fracture were commonly counted as the same type of complication in previous studies.[24] In our study, teeth fractures and base fractures were classified as different complications and analyzed independently. The results showed that they differed in position distribution. In natural dentition, the posterior teeth bear more masticating force than the anterior teeth. Research has indicated that premolars were the main force-borne sites in the implant-supported full-arch prosthesis, and the prostheses were more likely to fracture in this area,[28] which explains our observation that base fractures occurred more often in the posterior region. Conversely, artificial teeth fracture occurred more frequently in the anterior teeth. Chinese dietary habits may contribute to anterior teeth fractur, because Chinese are accustomed to tearing and cutting their food with

TABLE 5 Univariate analysis of variables associated with class IV complications using the cox proportional hazards regression model

Variables	β	SE	*P*	Hazard ratio	95% CI	
					Lower limit	Upper limit
Age at surgery	0.023	0.017	.178	1.024	0.989	1.059
Gender (male)	−0.375	0.380	.324	0.687	0.326	1.448
Rehabilitated arch (maxilla)	1.151	0.365	.002	3.161	1.545	6.464
Presurgery jaw status (potential edentulous)	0.127	0.409	.756	1.135	0.509	2.529
Fiber reinforcement (presence)	−0.881	0.412	.032	0.414	0.185	0.928
Opposing dentition (fixed dentition)	0.734	0.454	.106	2.084	0.856	5.074
No. of implants	−0.402	0.313	.199	0.669	0.362	1.235

their anterior teeth instead of cutting food with table knives, which may yield unfavorable lateral force and thus increase the risk of teeth fracture. This effect will be amplified when diets are pliable but strong, including foods such as meat or pancakes. Unlike the anterior teeth, the posterior teeth primarily bear axial force during mastication, which is much safer than lateral force when considering teeth fracture. Therefore, reinforcement of acrylic resin base strength in posterior region by carbon fiber is effective to prevent base fracture, and oral health instructions on the avoidance of using the anterior teeth to tear solid food are necessary, as the teeth are commercially artificial teeth, and fewer measures can be taken clinically to increase the strength of the teeth.

We have added twisted carbon fibers inside the resin base of immediate prosthesis since 2013, when Li et al.'s in vitro study[16] showed that resin reinforcement with carbon fibers could increase the anti-fracture strength in a three-point loading test. During the mastication process, denture base materials bear complex stress, including compressive stress, tensile stress, and shear stress.[29] In the three-point loading test, the force placed on the specimen was unidirectional, whereas the denture base in the mouth bore multidirectional stresses. The multivariable Cox proportional hazards regression model showed that fiber reinforcement (HR = 0.39) was a protective factor of base fracture(*P* = .021) after controlling for age, gender, opposing dentition, and the number of implants, indicating that carbon fiber reinforcement may be effective in decreasing class IV complications. Some studies have utilized cast or milled metal framework/bar to reinforce the acrylic resin immediate restorations, and the prevalence of prosthesis fracture ranged from 7.8% to 12.5%.[30-34] A pilot study by Crespi et al.[35] reported immediate prosthesis with CAD/CAM resin framework (Resin IVOCRON, Ivoclar Vivadent)functioning, and the prevalence of prosthesis fracture was 8.3% after 3 years of function. Both the traditional metal and CAD/CAM resin framework yielded lower prosthesis fracture prevalence. However, these materials and techniques require extra time and cost, which leads to a greater financial burden for the patient and makes it difficult to finish the immediate prosthesis within 24 hours. In comparison, carbon fiber reinforcement is a low-cost method and easy to operate. It is a more economical and pragmatic method for immediate prosthesis reinforcement. The result of our study showed: that carbon fiber reinforcement could decrease the class IV complication rate. The class IV complication rates were 34.6% (18/52) and 54.8% (34/62) in prostheses with or without carbon fiber reinforcement, respectively. However, carbon fiber reinforcement could not eliminate class IV complications.

The multivariable Cox proportional hazards regression model in our study also showed that prostheses in the maxilla (HR = 3.37) remained as a statistically significant risk factor for Class IV complications (*P* = .001). Cercadillo-Ibarguren et al.[24] also observed a higher percentage of fractures in maxillary restorations. A possible explanation could be the greater leverage on some maxillary restorations due to centripetal resorption.

Bruxism may attribute to prosthetic complications because of overloading. Zhou et al.[36] demonstrated that the prevalence of prosthetic complications and implant failure in patients with bruxism was higher than that in patients without bruxism. In the present study, patients with suspicious bruxism were treated with occlusal splints, excluding the effect of bruxism on prosthetic complications, theoretically. Although some patients were found to have bruxism after implant placement and immediate loading, the diagnosis largely depends on the history of dentition abrasion. The follow-up time of this study was limited, and the impact of bruxism on complications of the immediate prosthesis could not be analyzed.

TABLE 6 Multivariate analysis of the variables associated with class IV complications using the cox proportional hazards regression model adjusted for age, gender, opposing dentition, and number of implants

Variables	β	SE	*P*	Hazard ratio	95% CI	
					Lower limit	Upper limit
Rehabilitated arch (maxilla)	1.214	0.369	.001	3.366	1.633	6.936
Fiber reinforcement (presence)	−0.951	0.412	.021	0.386	0.172	0.865

The mean function time of immediate prostheses was 21.9 months in this study. In total, 86% of the patients in this study postponed their replacement appointments for final prostheses because of remarkably improved function with provisional prosthesis or for economic reasons. Only 14% of the patients delayed the replacement of the final restoration due to the inconvenience of keeping an appointment, such as staying abroad. The results reflected the social demands and positive practical significance in exploring cost-effective and predictable prosthetic protocols.

The results of this study showed that acrylic resin immediate prostheses had a high fracture rate (54.4%) if they functioned for over 6 months, although fiber-reinforced acrylic resin prosthesis could improve the strength of prosthesis so that they function for a longer period. Therefore, it is recommended to replace the immediate prosthesis with a final prosthesis with metal/ceramic framework after the healing period to reduce the time and cost spent on prosthesis repair, as well as to eliminate patient discomfort. However, 48 immediate prostheses and 7 immediate prostheses continued to demonstrate prosthesis success (ie, free of class II, III, and IV complications) after 1 year of function and 3 years of function, respectively. This study design is retrospective. Clinical data, such as mastication habits and dietary habits, could not be obtained. The impact of this information on the complications of the prostheses cannot be assessed. Therefore, further prospective studies with larger sample sizes and more comprehensive clinical information are necessary to analyze the risk factors of the prosthetic complications and to identify the possible indications for long-term function with immediate prosthesis.

5 | CONCLUSION

Implant-supported full-arch immediate prosthesis functioning over 6 months have a high prevalence of prosthetic complication, with moderate complications and very severe complications as the most common complication in the first 6 months and the entire function period, respectively. Fiber-reinforced acrylic immediate prosthesis may function better during the healing period, with fewer base fractures. Oral health instructions on the avoidance of using the anterior teeth of the immediate prosthesis to tear solid food could prevent teeth fracture.

CONFLICT OF INTEREST

This study was funded by Capital's Funds for Health Improvement and Research (2018-2-4102). The authors report no conflicts of interest related to this study.

REFERENCES

1. Schnitman PA, Wohrle PS, Rubenstein JE. Immediate fixed interim prostheses supported by two-stage threaded implants: methodology and results. *J Oral Implantol*. 1990;16(2):96-105.
2. Schnitman PA, Wohrle PS, Rubenstein JE, DaSilva JD, Wang NH. Ten-year results for Branemark implants immediately loaded with fixed prostheses at implant placement. *Int J Oral Maxillofac Implants*. 1997;12(4):495-503.
3. Malo P, Rangert B, Nobre M. "All-on-four" immediate-function concept with Branemark system implants for completely edentulous mandibles: a retrospective clinical study. *Clin Implant Dent Relat Res*. 2003;5(1):2-9.
4. Branemark PI, Engstrand P, Ohrnell LO, et al. Branemark Novum: a new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study. *Clin Implant Dent Relat Res*. 1999;1(1):2-16.
5. Testori T, Galli F, Fumagalli L, et al. Assessment of long-term survival of immediately loaded tilted implants supporting a maxillary full-arch fixed prosthesis. *Int J Oral Maxillofac Implants*. 2017;32(4):904-911.
6. Lopes A, Malo P, de Araujo Nobre M, Sanchez-Fernandez E, Gravito I. The NobelGuide(R) all-on-4(R) treatment concept for rehabilitation of edentulous jaws: a retrospective report on the 7-years clinical and 5-years radiographic outcomes. *Clin Implant Dent Relat Res*. 2017;19(2):233-244.
7. Cassetta M. Immediate loading of implants inserted in edentulous arches using multiple mucosa-supported stereolithographic surgical templates: a 10-year prospective cohort study. *Int J Oral Maxillofac Surg*. 2016;45(4):526-534.
8. Tallarico M, Meloni SM, Canullo L, Caneva M, Polizzi G. Five-year results of a randomized controlled trial comparing patients rehabilitated with immediately loaded maxillary cross-arch fixed dental prosthesis supported by four or six implants placed using guided surgery. *Clin Implant Dent Relat Res*. 2016;18(5):965-972.
9. Shigehara S, Ohba S, Nakashima K, Takanashi Y, Asahina I. Immediate loading of dental implants inserted in edentulous maxillas and mandibles: 5-year results of a clinical study. *J Oral Implantol*. 2015;41(6):701-705.
10. Vandeweghe S, Ferreira D, Vermeersch L, Marien M, De Bruyn H. Long-term retrospective follow-up of turned and moderately rough implants in the edentulous jaw. *Clin Oral Implants Res*. 2016;27(4):421-426.
11. Malo P, de Araujo Nobre M, Lopes A, Ferro A, Gravito I. All-on-4(R) treatment concept for the rehabilitation of the completely edentulous mandible: a 7-year clinical and 5-year radiographic retrospective case series with risk assessment for implant failure and marginal bone level. *Clin Implant Dent Relat Res*. 2015;17(Suppl 2):e531-e541.
12. Malo P, Rangert B, Nobre M. All-on-4 immediate-function concept with Branemark system implants for completely edentulous maxillae: a 1-year retrospective clinical study. *Clin Implant Dent Relat Res*. 2005;7(Suppl 1):S88-S94.
13. Lopes A, Malo P, de Araujo Nobre M, Sanchez-Fernandez E. The NobelGuide(R) all-on-4(R) treatment concept for rehabilitation of edentulous jaws: a prospective report on medium- and long-term outcomes. *Clin Implant Dent Relat Res*. 2015;17(Suppl 2):e406-e416.
14. Di P, Lin Y, Li JH, et al. The all-on-four implant therapy protocol in the management of edentulous Chinese patients. *Int J Prosthodont*. 2013;26(6):509-516.
15. Malo P, Nobre M, Lopes A. Immediate loading of 'All-on-4′ maxillary prostheses using trans-sinus tilted implants without sinus bone grafting: a retrospective study reporting the 3-year outcome. *Eur J Oral Implantol*. 2013;6(3):273-283.
16. Li BB, Xu JB, Cui HY, Lin Y, Di P. In vitro evaluation of the flexural properties of all-on-four provisional fixed denture base resin partially reinforced with fibers. *Dent Mater J*. 2016;35(2):264-269.
17. Francetti L, Corbella S, Taschieri S, Cavalli N, Del Fabbro M. Medium- and long-term complications in full-arch rehabilitations supported by upright and tilted implants. *Clin Implant Dent Relat Res*. 2015;17(4):758-764.
18. Hinze M, Thalmair T, Bolz W, Wachtel H. Immediate loading of fixed provisional prostheses using four implants for the rehabilitation of

the edentulous arch: a prospective clinical study. *Int J Oral Maxillofac Implants*. 2010;25(5):1011-1018.
19. Krennmair S, Seemann R, Weinlander M, Krennmair G, Piehslinger E. Immediately loaded distally cantilevered fixed mandibular prostheses supported by four implants placed in both in fresh extraction and healed sites: 2-year results from a prospective study. *Eur J Oral Implantol*. 2014;7(2):173-184.
20. Agliardi E, Panigatti S, Clerico M, Villa C, Malo P. Immediate rehabilitation of the edentulous jaws with full fixed prostheses supported by four implants: interim results of a single cohort prospective study. *Clin Oral Implants Res*. 2010;21(5):459-465.
21. Grandi T, Guazzi P, Samarani R, Grandi G. Immediate loading of four (all-on-4) post-extractive implants supporting mandibular cross-arch fixed prostheses: 18-month follow-up from a multicentre prospective cohort study. *Eur J Oral Implantol*. 2012;5(3):277-285.
22. Stegaroiu R, Khraisat A, Nomura S, Miyakawa O. Influence of superstructure materials on strain around an implant under 2 loading conditions: a technical investigation. *Int J Oral Maxillofac Implants*. 2004;19(5):735-742.
23. Mendez Carames JM, Sola Pereira da Mata AD, da Silva Marques DN, de Oliveira Francisco HC. Ceramic-veneered zirconia frameworks in full-arch implant rehabilitations: a 6-month to 5-year retrospective cohort study. *Int J Oral Maxillofac Implants*. 2016;31(6):1407-1414.
24. Cercadillo-Ibarguren I, Sanchez-Torres A, Figueiredo R, Valmaseda-Castellon E. Early complications of immediate loading in edentulous full-arch restorations: a retrospective analysis of 88 cases. *Int J Oral Maxillofac Implants*. 2017;32:1116-1122. https://doi.org/10.11607/jomi.5496.
25. Drago C. Frequency and type of prosthetic complications associated with interim, immediately loaded full-arch prostheses: a 2-year retrospective chart review. *J Prosthodont*. 2016;25(6):433-439.
26. Francetti L, Agliardi E, Testori T, Romeo D, Taschieri S, Del Fabbro M. Immediate rehabilitation of the mandible with fixed full prosthesis supported by axial and tilted implants: interim results of a single cohort prospective study. *Clin Implant Dent Relat Res*. 2008;10(4):255-263.
27. Pomares C. A retrospective study of edentulous patients rehabilitated according to the 'all-on-four' or the 'all-on-six' immediate function concept using flapless computer-guided implant surgery. *Eur J Oral Implantol*. 2010;3(2):155-163.
28. Ma FF, Lin Y, Di P, Li JH, Cui HY, Sun F. All-on-4 occlusion study: using T-scan occlusal analysis system. *Zhonghua Kou Qiang Yi Xue Za Zhi = Zhonghua Kouqiang Yixue Zazhi = Chinese J Stomatol*. 2016;51(9):517-520.
29. John J, Gangadhar SA, Shah I. Flexural strength of heat-polymerized polymethyl methacrylate denture resin reinforced with glass, aramid, or nylon fibers. *J Prosthet Dent*. 2001;86(4):424-427.
30. Sannino G. All-on-4 concept: a 3-dimensional finite element analysis. *J Oral Implantol*. 2015;41(2):163-171.
31. Capelli M, Zuffetti F, Del Fabbro M, Testori T. Immediate rehabilitation of the completely edentulous jaw with fixed prostheses supported by either upright or tilted implants: a multicenter clinical study. *Int J Oral Maxillofac Implants*. 2007;22(4):639-644.
32. Mozzati M, Arata V, Gallesio G, Mussano F, Carossa S. Immediate postextractive dental implant placement with immediate loading on four implants for mandibular-full-arch rehabilitation: a retrospective analysis. *Clin Implant Dent Relat Res*. 2013;15(3):332-340.
33. Pieri F, Aldini NN, Fini M, Corinaldesi G. Immediate occlusal loading of immediately placed implants supporting fixed restorations in completely edentulous arches: a 1-year prospective pilot study. *J Periodontol*. 2009;80(3):411-421.
34. Tallarico M, Canullo L, Pisano M, Penarrocha-Oltra D, Penarrocha-Diago M, Meloni SM. An up to 7-year retrospective analysis of biologic and technical complication with the all-on-4 concept. *J Oral Implantol*. 2016;42(3):265-271.
35. Crespi R, Vinci R, Cappare P, Romanos GE, Gherlone E. A clinical study of edentulous patients rehabilitated according to the "all on four" immediate function protocol. *Int J Oral Maxillofac Implants*. 2012;27(2):428-434.
36. Zhou Y, Gao J, Luo L, Wang Y. Does bruxism contribute to dental implant failure? A systematic review and meta-analysis. *Clin Implant Dent Relat Res*. 2016;18(2):410-420.

How to cite this article: Shen H, Di P, Luo J, Lin Y. Clinical assessment of implant-supported full-arch immediate prostheses over 6 months of function. *Clin Implant Dent Relat Res*. 2019;21:473–481. https://doi.org/10.1111/cid.12784