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Frequency and Type of Prosthetic Complications Associated with Interim, Immediately Loaded Full-Arch Prostheses: A 2-Year Retrospective Chart Review

Carl Drago, DDS, MS, FACP[1,2,3]

[1]Department of Dental Specialties, Gundersen Health System, LaCrosse, WI
[2]Department of General Dental Sciences, Marquette University School of Dentistry, Milwaukee, WI
[3]Eon Clinics, Waukesha WI

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Correspondence
Carl Drago, Gundersen Health System 1910 South Avenue, LaCrosse, WI 54601. E-mail: carl.drago@gmail.com

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Abstract

Purpose: The purpose of this report was to retrospectively evaluate implant and immediate full-arch prosthesis survival rates over a 24-month period; patients were consecutively treated with immediate occlusal loading. Dental arch, gender, and implant orientation (vertical vs. tilted) were also noted.
Materials and Methods: All Brånemark System implants (Nobel Active) and interim, all-acrylic resin prostheses placed in patients following an All-on-Four™ protocol, in a single private practice were assessed by retrospective patient chart review. The amount of space provided surgically for implant restorative components and prostheses was determined from measurements of the vertical heights of the interim prostheses in the right/left anterior and posterior segments. These measurements were made in the laboratory. Interim prosthetic repairs (type, frequency, length of time from insertion) were analyzed by type, arch, gender, and implant orientation. Implant survival and insertion torque values were also measured. Inclusion criteria consisted of all Brånemark System implants placed with the All-on-Four protocol from September 1, 2011, until August 31, 2013. Specific dietary instructions were given for the first 7 days immediately postoperatively and for the weeks prior to insertion of the definitive prostheses.
Results: One hundred twenty-nine patients, comprising 191 arches (766 implants) from September 1, 2011, until August 31, 2013, were included in the study. One patient experienced implant failure yielding an overall implant survival rate (SR) of 99.5% (762 of 766). Four hundred twenty-six of 430 maxillary implants and 336 of 336 mandibular implants survived for SRs of 99.1% and 100%, respectively. Regarding implant orientation, 415 of 417 tilted implants (SR 99.5%) and 343 of 345 (CSR 95.6%) vertical implants were noted to be clinically stable. Interim, all-acrylic resin prostheses were in place for a mean of 199.2 days; mandibular prostheses were in place for an average of 195.4 days; maxillary prostheses were in place for an average of 202.0 days. Thirty four of the 191 interim prostheses (17.8%) warranted at least one repair during the treatment period. The average overall implant insertion torque value was 60.74 Ncm; mandibular torque values averaged 63.08 Ncm; maxillary torque values averaged 59.00 Ncm.
Conclusions: The results from this study suggest that dental arch, gender, and implant orientation for implants placed and immediately restored with interim, all-acrylic resin, full-arch prostheses per the All-on-Four protocol did not have significant statistical or clinical effects on prosthetic complications of the interim prostheses or implant survival. Only one of the 129 patients experienced implant failures, indicating that the All-on-Four treatment protocol used in this study is a viable alternative to other protocols for rehabilitating edentulous patients.

In the 1960s, PI Brånemark at the University of Göteborg developed a new dental implant protocol. It was based on achieving direct bone/implant anchorage. Branemark et al termed this biologic phenomenon "osseointegration." Animal experiments indicated that direct contact between bone and endosseous implants could be established provided that precise surgical and

prosthetic guidelines were followed. This theory was documented by clinical reports published several years later.[1-3]

Animal and clinical trials with this implant protocol suggested that missing teeth could be replaced with titanium implants anchored in bone. Brånemark et al developed clinical procedures using screw-shaped, cylindrical, commercially pure titanium (cp Ti) implants, machined into 4 mm diameters and 10 mm lengths. Brånemark reported that unloaded healing periods of between 4 and 6 months were necessary for osseointegration to occur predictably. After healing, Brånemark et al identified that these dental implants were surrounded by compact bone.[1-3]

At the beginning of the 1980s, Branemark et al recommended certain prerequisites that would help ensure osseointegration of dental implants.[4,5] These researchers identified biocompatibility, shape, surface treatments, state of the implant site, surgical technique at the time of the insertion, and loading applied after implant placement as extremely important for osseointegration of dental implants to predictably occur.[4,5]

The original treatment protocol included insertion of fixtures/implants into bone with a precise drilling sequence, placement of cover screws into the implants, and then suturing tissues over the implants and cover screws. The implants were not exposed to the oral environment. This surgical treatment was followed by a period of unloaded healing that varied from 3 to 6 months, depending on the jaw being treated. A second surgical procedure was needed to uncover the implants, with placement of transmucosal abutments. Peri-implant soft tissues would heal around the abutments prior to beginning the prosthetic portion of treatment. Patients with periodontally debilitated dentitions treated with this protocol would likely receive the definitive prostheses approximately 12 to 14 months after treatment commenced with extractions.

This treatment protocol was modified by leaving implants exposed to the oral cavity after implant placement by placing healing abutments on the implants immediately after surgical placement. This was termed a one-stage surgical protocol. One important benefit of this protocol when compared to the original two-stage protocol was the elimination of surgical procedures associated with uncovering implants; however, the initial one-stage protocol did not modify the healing times between implant placement and fabrication of the definitive prostheses. Further refinements in the one-stage protocol included decreased healing times for osseointegration and quicker initiation of prosthetic treatment.[6-8]

Immediate occlusal loading

Clinical reports began to appear in the dental literature regarding implant placement into edentulous jaws with immediate occlusal loading through full-arch prostheses.[9-11] Schnitman et al[9] reported on 10-year clinical results of ten edentulous patients treated with a combination of immediately loaded implants versus implants placed with a conventional, unloaded healing protocol. Of the 28 implants immediately loaded, four failed and yielded a cumulative survival rate (CSR) of 85.7%; all of the 35 conventionally loaded implants osseointegrated. Schnitman et al declared that immediate loading in edentulous mandibles was successful in the short term and could support full-arch interim prostheses; they considered the long-term prognosis to be guarded for implants placed distal to the anterior mandibular segment (mental foramen).These implants were machined cp Ti implants without enhanced surface treatments. Testori et al[10] published a report that included histologic findings associated with immediately loaded and unloaded mandibular implants. This patient report included the results associated with a patient who received 11 mandibular implants: six were immediately loaded; five were buried and healed without occlusal loading. Three implants were removed approximately 8 weeks post implant placement and loading. Testori et al reported that clinical and histologic osseointegration was achieved for both of the retrieved immediately loaded implants. They also reported that osteogenesis and bone remodeling on the implant surface were not impeded by immediate loading, as shown by histomorphometric evaluation, which revealed high levels of bone-to-implant contact ranging from 78% to 85%. Cooper et al[11] reported similar results of a clinical study where patients were followed for 6 to 18 months; 10 patients were treated with 54 mandibular implants immediately loaded with full-arch prostheses (5 or 6 implants were placed into each edentulous jaw). They reported that all implants were integrated, as determined by lack of clinical mobility and radiographic evidence of osseointegration. Long-term, more recent publications have established that, with specific clinical criteria, immediate occlusal loading of edentulous jaws with full-arch prostheses is a successful, viable clinical treatment.[12,13]

Prosthetic complications of interim immediate full-arch prostheses

Taylor published an early report (1998) on prosthodontic problems and limitations associated with osseointegration.[14] He concluded that, although dental implant therapy was successful as an alternative to conventional complete dentures for edentulous patients, implant prosthodontic therapy was not without its own set of risks. He stated that identifying and quantifying implant component fracture (abutment screws, retaining screws, prosthesis frameworks, veneers, opposing prostheses) and screw loosening in the dental literature, and frequency of prosthetic complications was difficult to obtain with enough certainty to make valid comparisons between studies because of incomplete reporting of results or confusing manipulation of numerical outcomes. He also advised that practitioners who treat patients with dental implants must be familiar with potential complications and must educate patients as to the risk of complications associated with implant therapy.

Malo et al reported on the results of a retrospective clinical study that included 30 patients followed for at least 2 years.[15] One hundred twenty mandibular implants were placed anterior to the mental foramen. All of the patients had four implants placed into each edentulous jaw and were immediately reconstructed with full-arch, acrylic resin prostheses. Four of the immediately loaded implants failed prior to the 6-month follow-up appointments. Malo et al reported that nine (30%) of the immediate acrylic resin prostheses in the experimental group (greater than four implants placed [rescue implants]) fractured and were repaired; they reported no prosthesis fractures in the

immediate loading group. The authors modified the prosthetic protocol by reinforcing the acrylic resin prostheses with metal; they reported that this eliminated the prosthetic fractures.

In an extensive literature review, Aglietta et al assessed survival rates of short-span, implant-supported cantilever fixed dental prostheses (ICFDPs) and the incidence of technical and biologic complications after an observation period of at least 5 years.[16] No differentiations were described relative to all-acrylic resin prostheses versus definitive metal framework supported prostheses. Aglietta et al concluded that ICFDPs represented a predictable and reliable treatment for replacement of posterior missing teeth in partially edentulous patients. The most frequent technical complications reported included veneer fractures, followed by screw loosening and loss of retention.

The purpose of this retrospective analysis was to identify prosthodontic complications associated with immediate, full-arch, acrylic resin prostheses for patients treated in one private practice over a 2-year period.

Materials and methods

This was a retrospective chart review, and the patients were not identifiable to the researcher. The institutional review board stated that approval was not necessary. One hundred twenty nine consecutively treated patients included in this study were treated in one urban, private practice setting from September 1, 2011, to August 31, 2013. All patients received full-arch, screw-retained, acrylic resin prostheses, which were immediately loaded (191 total arches; 110 maxillary, 81 mandibular). Twelve patients were already edentulous; 117 patients presented with periodontally debilitated dentitions, the teeth were extracted, and implants were placed and loaded with full-arch prostheses on the same day. All patients were treated with one specific implant type (NobelActive™; Nobel Biocare, Yorba Linda, CA). Seven hundred sixty six implants were placed (430 maxillary; 336 mandibular). In order to be immediately loaded, implants had to achieve insertion torque values of at least 35 Ncm (all implants were immediately loaded). One of two oral/maxillofacial surgeons (Diplomates, American Board of Oral and Maxillofacial Surgery) placed the implants with one specific implant surgical protocol; the author and one dental laboratory technician were responsible for fabrication of the interim prostheses. Vertical heights of the interim prostheses were measured prior to insertion of the interim prostheses; measurements were made of the denture bases from the incisal embrasures between the central and lateral incisors to the peripheral edges of the prostheses directly opposite the incisal embrasures, as well as from the occlusal embrasures between the first molars and second premolars to the peripheral edges of the prostheses directly opposite the occlusal embrasures (Figs 1–4). Cantilever lengths of the distal extensions of the prostheses were not measured.

Patients treated with only full-arch, mandibular prostheses waited at least 3 months prior to abutment level impressions for fabrication of the definitive mandibular prostheses; patients treated with full-arch maxillary prostheses waited at least 4 months prior to abutment level impressions. If both jaws were treated, patients waited at least 4 months prior to abutment level impressions for the definitive prostheses. At the abutment impression appointment, all abutment screws were torqued to the manufacturer's recommended levels (15 Ncm for angled abutments; 35 Ncm for straight abutments) with a torque controller. Lack of implant mobility/tenderness was the clinical sign used to determine clinical osseointegration. One patient lost all four of the maxillary implants. These were subsequently replaced and were successful.

Specific dietary instructions were given to all patients and their drivers immediately prior to discharge on the operative

Figure 1 Laboratory illustration of the vertical measurement of an interim maxillary prosthesis between the central and lateral incisors and the height of the denture base.

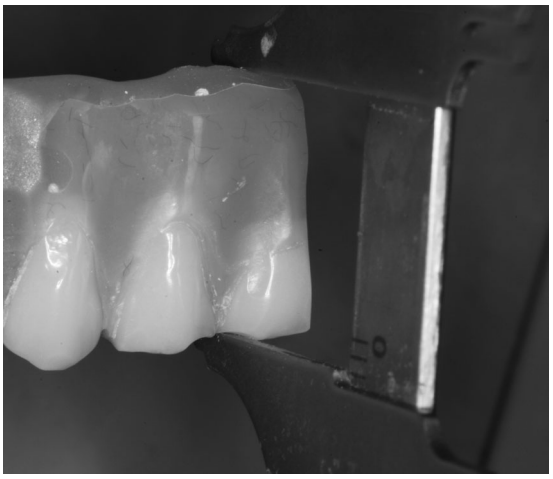

Figure 2 Laboratory illustration of the vertical measurement of an interim maxillary prosthesis between the second premolar and first molar and the height of the denture base.

Figure 3 Laboratory illustration of the vertical measurement of an interim mandibular prosthesis between the central and lateral incisors and the height of the denture base.

Figure 4 Laboratory illustration of the vertical measurement of an interim mandibular prosthesis between the second premolar and first molar and the height of the denture base.

days; the first set of instructions included foods in liquid form such as protein shakes with milk, broth, yogurt, and high-calorie milkshakes. Chewing any type of food was to be avoided. Patients were instructed to avoid fruits with seeds so as to avoid seeds being displaced into the surgical wounds. The dietary instructions from the first week postoperatively until insertion of the definitive prostheses included foods that could be cut with a fork such as stroganoff, lasagna, pasta, fish, chicken, ground beef, and cooked vegetables. Foods to be avoided included anything hard such as nuts and fresh vegetables; also patients were instructed to avoid using the anterior teeth for biting into subway-type sandwiches and hot dogs.

Table 1 Implant insertion torque values (Ncm)

	Mean	SD	Q1	Median	Q3	N
Overall	60.74	13.43	50.00	70.00	70.00	767
Mandibular	63.08	12.07	60.00	70.00	70.00	326
Maxillary	59.00	14.12	50.00	70.00	70.00	441

Table 2 Number of days interim prostheses were in function

	Mean	SD	Q1	Median	Q3
Days interim prostheses were in function	199.23	104.49	156	170.00	190.00

The number of days patients used the interim prostheses from initial placement on the day of surgery to the day definitive prostheses were inserted was calculated from reviewing patient charts. The average number of days per patient was tabulated and compared statistically.

All prosthetic repairs were included in the data, including interim prosthesis (denture base) fracture, denture tooth debonding/delamination, denture tooth fracture, prosthetic and/or abutment screw loosening. All repairs were accomplished in the laboratory on master casts generated from abutment impressions at the time of implant placement.

Results

There were 129 patients (average age was 57 years, SD = 12) included in the study: 53% were female; 90% were nonsmokers. One hundred ninety-one prostheses were placed. Forty-eight percent of patients had prostheses placed in both jaws; 37% in the maxilla only; and 15% in the mandible only. One maxillary prosthesis failed secondary to total implant failure; this patient was noncompliant regarding diet, hygiene, and recall appointments. All prostheses, except two, were supported by four implants placed corresponding to approximate teeth numbers 4, 7, 10, and 13 in the maxilla and 20, 23, 26, and 29 in the mandible. In this study, four implants out of 766 failed prior to construction of the definitive prostheses (CSR 99.5%). These implants were noted to have macroscopic mobility at the time the interim prosthesis was removed (approximately 4 months postimplant placement and immediate occlusal loading with the interim prosthesis). Four hundred twenty-six of 430 maxillary implants and 336 of 336 mandibular implants survived for CSRs of 99.1% and 100%, respectively. Regarding implant orientation, 415 of 417 tilted implants (SR 99.5%) and 343 of 345 (CSR 95.6%) vertical implants were noted to be clinically stable. The average overall implant insertion torque value was 60.74 Ncm; mandibular 63.08 Ncm; maxillary 59.00 Ncm (Table 1). The average number of days the interim prostheses were used in both jaws was 199.23 days (Tables 2 and 3).

Table 3 Number of days interim prostheses were in function per jaw

	Mean	SD	Q1	Median	Q3
Mandible	195.44	114.43	154.00	169.00	181.00
Maxilla	202.01	96.98	158.00	172.50	196.00

Table 4 Mean vertical lengths of the interim prostheses (anterior and posterior) (mm)

Embrasure locations	Mean	SD	N
2/3	12.8	–	1
3/4	12.45	1.93	105
7/8	13.35	2.09	105
9/10	15.47	1.95	105
13/14	12.96	1.96	105
19/20	13.18	1.98	83
23/24	15.79	1.98	83
25/26	15.62	2.01	83
29/30	13.16	2.08	83
30/31	10.70	–	1

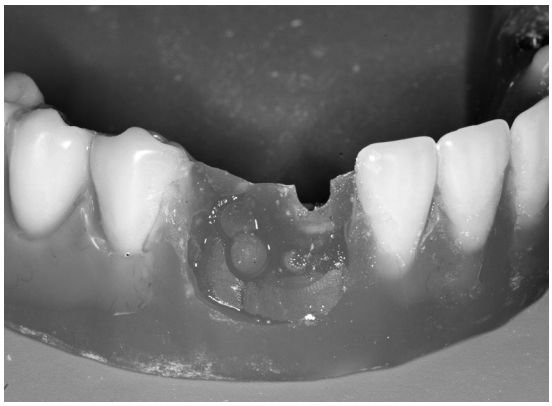

Figure 5 Representative illustration of a denture tooth repair required for a maxillary interim prosthesis (adhesive failure).

The average vertical height in the anterior segments for maxillary prostheses was 15.4 mm; the average vertical height in the anterior segments for mandibular prostheses was 15.71 mm. The average vertical height in the posterior segments for maxillary prostheses was 12.74 mm; the average vertical height in the posterior segments for the mandibular prostheses was 12.35 mm (Table 4).

Thirty-four of the 191 prostheses (17.8%) required repair. Eight of the 34 (23.5%) required denture tooth replacement due to denture tooth fracture (Fig 5); 24 (70.6%) required denture base repairs (Fig 6); two of the 34 (5.9%) warranted both types of repairs. One maxillary prosthesis required two separate repairs. In this instance, the initial denture base repair occurred at day 32 post-implant placement/occlusal loading; the second denture base repair occurred at day 65. One mandibular prosthesis required two denture base repairs (day 168, day 171; Tables 5 and 6).

Figure 6 Representative illustration of a denture base repair required for a maxillary prosthesis.

Table 5 Prosthetic repair/complication rates

	All		Jaw with prosthesis			
			Mandible		Maxilla	
	N	%	N	%	N	%
None	157	82.20	64	33.51	93	48.69
Repair	34	17.80	17	8.90	17	8.90
All	191	100.00	81	42.41	110	57.59

Table 6 Prosthetic repairs by type (denture base fracture; tooth fracture/debonding)

	All		Jaw with prosthesis			
			Mandible		Maxilla	
	N	%	N	%	N	%
Denture Base	24	70.59	11	64.71	13	76.47
Tooth	8	23.53	5	29.41	3	17.65
Both	2	5.88	1	5.88	1	5.88
All	34	100.00	17	100.00	17	100.00

Discussion

Immediate loading with full-arch, interim, all-acrylic resin prostheses has become a viable treatment alternative for patients with advanced periodontal disease and/or who are already edentulous and unable to manage complete dentures.[9-12] Various protocols regarding immediate occlusal loading have been established regarding surgical and prosthetic treatment modalities.[17,18] Regardless of the protocol selected, long-term prosthetic and surgical success is dependent on meticulous performance of the many steps involved in performing these treatments.

Immediate occlusal loading complications may be divided into two basic genres: surgical and prosthetic. The surgical protocol used in this study included average implant insertion

torque values of at least 60.74 Ncm (Table 1). Patient compliance is an essential part of short- and long-term treatment success. The dietary suggestions for the immediate and long-term postoperative healing periods were identified in the Materials and Methods section. In this study, only one set of four immediately loaded maxillary implants failed. This was discovered at the time the interim prostheses were removed in anticipation of abutment impressions for the definitive prostheses. This particular patient admitted to ignoring the soft diet recommendations and eating raw vegetables and nuts from approximately the fourth week postoperatively. The prosthesis was not mobile and did not "feel" any different to the patient. The mobile implants were removed, and the osteotomies were grafted with particulate bone. During this next phase of treatment, this patient was treated with a maxillary complete denture that included temporary tissue conditioner liners, which were replaced every 5 to 6 weeks. Osseous healing occurred uneventfully over the next 4 months; another set of four implants were placed and immediately loaded. These implants stabilized over time. The overall CSR for the implants placed in this study was 99.5%. These results are significantly higher than other reports for immediate occlusal loading.[9-11]

Prosthetic complications, depending on the type and when they occurred, may have a negative impact on implant survival as well as patient confidence in the procedures being accomplished. Prosthetic complication rates in this study were significantly less than the complication rates reported by Malo et al regarding prosthetic complications associated with interim, full-arch, acrylic resin prostheses placed into immediate function.[15] Prosthetic complications as described in this study could have occurred secondary to lack of vertical restorative space, excessive length of cantilevered segments, inadequate thickness of the denture base, tooth flexure secondary to excessive resin removal in setting/processing the denture teeth to the denture bases. The anterior/posterior spread associated with dental implant placement may be implicated in prosthetic complications; this will be the topic of another research article.

This study also described the amount of time patients used the interim, full-arch, acrylic resin prostheses. The author used the manufacturer's recommendation regarding osseointegration periods: 4 months for maxillary implants; 3 months for mandibular implants prior to proceeding with impressions for the definitive prostheses. The definitive prostheses were generally inserted within 2 months of the definitive impressions.

The protocol the author used in this study required surgeons to provide approximately 12 to 15 mm of space for fabrication of interim prostheses. The author termed this "restorative space." This space was measured intra-operatively after tooth extractions and horizontal reduction of the residual alveolar ridge. This was measured from the occlusal (horizontal) surface of the edentulous ridge to the approximate height of the maxillary central incisal edge and the occlusal surfaces of the molar teeth in the surgical guide or immediate prosthesis (Fig 7). Adequate restorative space was considered to be essential to fabricate interim prostheses that would be strong enough to withstand the masticatory forces associated with the recommended soft diet and parafunctional habits, if any, as well as provide enough space for fabrication of the definitive prostheses with CAD/CAM frameworks, denture bases, and teeth.

Figure 7 Clinical image of a periodontal probe that measured the restorative space between the crest of an edentulous maxillary ridge and the occlusal surface of the maxillary interim prosthesis prior to implant placement.

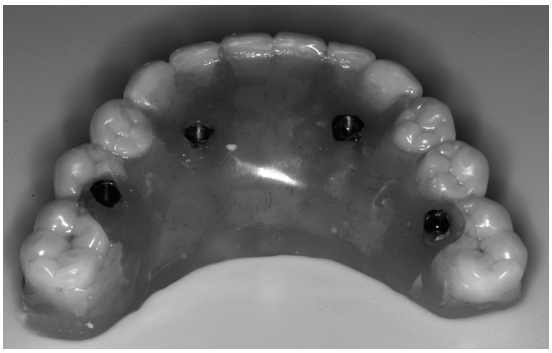

Figure 8 Laboratory occlusal image of a typical mandibular interim prosthesis.

The interim acrylic resin prostheses were also designed with minimal posterior cantilevered segments (Fig 8).

Conclusions

The results of this retrospective chart review indicated that immediate occlusal loading with 191 full-arch acrylic resin prostheses was successful and predictable. The patients in this study were restored using four implants in each jaw to support full-arch interim prostheses. Patient compliance regarding diet, hygiene, and recall appointments was essential to treatment success, as the only failure involved a noncompliant patient. Successful prosthetic treatment for the interim prostheses was also dependent on minimal posterior cantilevered segments, adequate restorative space and strong acrylic resin prostheses. Additional long-term studies are needed regarding long-term treatment success that would also include definitive, full-arch prostheses.

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