

Article

Immediate Loading of Fixed Prosthesis in Fully Edentulous Jaws: A 7-Year Follow-Up from a Single-Cohort Retrospective Study

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Abstract: The aim of this retrospective single-cohort study was to evaluate the clinical outcome of four-to-five implants immediately restored with metal-resin screw-retained cross-arch fixed prostheses in edentulous jaws 10 years after loading. One-hundred-and-four consecutive patients received four to five implants placed with a torque superior 35 Ncm. One-hundred-and-twenty-seven metal-resin screw-retained fixed prostheses (59 mandibular and 68 maxillary) were to be delivered within 3 days. Outcome measures, evaluated by the treating clinician, were: prosthesis and implant failures, prosthetic modifications, peri-implant mucositis, and biological and prosthetic complications. A total of 549 implants were placed. Twenty-one implants failed in 14 patients and 102 prostheses were remade, at least once, in 81 patients: 2 due to implant failures and 33 because of fractures of the prostheses. In particular, 25 original metal-resin prostheses had to be remade because of fractures versus only eight of the replacement monolithic metal-resin prostheses. All patients were wearing fixed prostheses at the end of the follow-up. Thirty-six biological complications occurred in 22 patients. Eighty-six prosthetic complications occurred in 42 patients. In conclusion, immediately loaded cross-arch prostheses supported by four-to-five immediately placed implants are a viable therapeutic option if robust prostheses are made.

Keywords: dental implants; immediate loading; fully edentulous jaws



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1. Introduction

Four implants are often placed to support fixed cross-arch prosthesis [1,2]. While it may be difficult to place more than four implants between the mental foramina without risking compromise to oral hygiene procedures, more implants can be placed distal to the mental foramina if there is sufficient bone height above the mandibular canal. In the upper jaw, the number of implants to be inserted may be limited by large pneumatized maxillary sinuses and by reduced bone volumes [3,4]. The reduction of tissue volumes, hard and soft, can be treated with regenerative techniques [5–8]. In addition implants can also be placed in a tilted position so that a more distal emergence of the implant neck can reduce the length of the prosthetic cantilevers [9]. The length of the prosthetic cantilever may be a problem because of the consequences it might create. The presence of an extended cantilever generates increased stress and excessive force relief on the implants involved. A retrospective study conducted by Tirone et al., classified fractures according to fracture location in cases of full-arch rehabilitation [10]. This study showed that there was a statistically significant relationship between cantilever extension and two types of fractures considered, fractures that occurred between but not involving the two most posterior screw-access openings (that are more prevalent) and fractures of the distal cantilever. A comparative study by Ozan et al., evaluates the relationship between cantilever length and

implant inclination, concluding that a reduction in force relief on the involved structures and stress on the peri-implant bone can be obtained by reducing cantilever length by tilting the posterior implant [11].

The more implants inserted, the higher the costs for the patient. In addition, a greater number of implants also means more precision in the fabrication of the prosthetic structure that will be passively fitted to finalize the work. Bhering et al. conducted a comparative study between all-on-four and all-on-six treatment concepts [12]. After a distribution of the sample by the material used and the treatment performed, they concluded that all-on-six approach, when it is possible to execute, and stiffer framework materials had the most favorable biomechanical behavior.

In addition, implants can be loaded immediately after their placement without significantly increasing the risk for failures [13], especially in fully edentulous mandibles [14–16], but also in fully edentulous maxillae [17,18].

Edentulous patients would like to have a functional fixed prosthesis without delay, after a minimal surgical intervention and at a reduced biological and financial cost, providing that failure risks are not excessively increased [19]. Therefore, it would be interesting to know whether it could be possible to rehabilitate fully edentulous patients with fixed cross-arch prostheses supported by four-to-five immediately loaded implants. A previous publication of the same patient material presented the 1-year data [18].

The aim of the present retrospective single cohort study was to evaluate the clinical outcomes of immediately loaded maxillary and/or mandibular cross-arch metal-resin screw-retained fixed prostheses on four-to-five immediately placed dental implants without bone augmentation in totally edentulous maxillary and/or mandibular jaws with a 7-year follow-up.

2. Materials and Methods

This study was conducted as a retrospective single-cohort study, in compliance with the ethical standards of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Federico II University of Naples (5 March 2018; No 347/18).

2.1. Study Design

Data from consecutively edentulous subjects, compliant with eligibility criteria reported in Table 1, and rehabilitated with immediately loaded mandibular, or maxillary, or both cross-arch implant-supported prostheses, were retrospectively collected.

Table 1. Inclusion and exclusion criteria.

Inclusion Criteria
<ul style="list-style-type: none"> • Bone volumes allowing the placement of four-to-five implants at least 11 mm in length and with a diameter of at least 4.5 mm; • Subjects treated with immediate post-extractive implants
Exclusion Criteria
<ul style="list-style-type: none"> • General contraindications to implant surgery at the discretion of the surgeon; • Cardio-vascular diseases over the previous 6 months; • Immunodeficient or immunosuppressed patients; • Glucose level above 150 mg/dL; • Pregnancy or lactation; • Irradiation in the head and/or neck in the previous 6 months; • Previous or current treatment with amino-bisphosphonates; • Poor oral hygiene and motivation; • An active infection or severe inflammation in the area intended for implant placement; • Lack of opposing occluding dentition/prosthesis/dentures.

The present article is reported according to the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines (www.strobe-statement.org, accessed on 1 May 2022) and presents the 7-year after-loading data.

2.2. Study Sample

Subjects included in the study were treated between January 2014 and December 2015 in a private dental practice in Sala Consilina, Salerno, Italy.

Subjects were categorized according to what they declared about smoking habits: non-smokers, moderate smokers (up to 10 cigarettes per day), heavy smokers (more than 10 cigarettes per day), and were also classified according to the type of dentition in the opposite jaw (natural/fixed or full dentures).

2.3. Surgical Protocol

All treatments were performed by the same expert operator. Dental and medical history was obtained and clinical examinations and panoramic radiographs were performed on all patients.

Depending on the anatomical conditions, preliminary screening was performed on panoramic radiographs, with patients wearing thermoplastic radiographic guides with small gutta-percha balls as landmarks. When needed, for three-dimensional evaluation of bone volumes, cone beam computed tomography (CBCT) scans were taken still using the thermoplastic radiographic guide [20,21]. Such guides were also used during surgery to facilitate the ideal implant positioning.

Healthy periodontal conditions' stability and periodontal risk factors' control were achieved in all partially edentulous subjects. All patients received professional oral hygiene prior to the implant surgery and prophylactic antibiotic therapy with 2 g of amoxicillin plus clavulanic acid orally one hour prior to the intervention [22]. Patients allergic to penicillin were given 500 mg of clarithromycin 1 h prior to the surgery. Patients rinsed with a chlorhexidine mouthwash 0.2% for 1 min just prior to the intervention [23]. Local anesthesia was administered using mepivacaine with adrenaline 1:100,000 or 1:50,000.

Crestal incisions were made and, in the presence of large bone volumes at implant sites, minimal flaps were elevated up to the coronal portion of the alveolar process. In the presence of reduced bone volumes, larger flaps were elevated, exposing the mental foramina in mandibles or the prominence of the maxillary sinuses.

When present, residual teeth/roots were carefully extracted to minimize damage to the buccal plate, and sites were thoroughly cleaned from all granulation tissue. SPI-Contact (Thommen Medical; Grenchen, Switzerland) conical-cylindrical implants with a smooth 1.5 mm long collar, 11 mm in length, and 4.5 mm in diameter were inserted. Implants were placed following the protocol suggested by the manufacturer, except for the use of a 4.0 mm profile drill in order to underprepare the sites thus achieving a higher insertion torque. However, in a small number of patients (10%) Anyone (MegaGen Implant, Gyeongbuk, South Korea) implant 4 × 11.5 mm were placed. In case of anatomic limitation, distal implants were distally tilted in the premolar areas (Figure 1) [24].

Implants were placed with the 1.5 mm polished neck in a supracrestal position, also in the case of post-extractive implants. They were inserted with a torque of 70 Newton/cm and, once the motor stopped, implant stability was confirmed manually using the SPI-MONO torque ratchet (Thommen, Grenchen, Switzerland). If one of the four implants could not be placed with a minimum torque of 35 Ncm, a fifth implant was added near to the implant which did not achieve the required torque [25]. If two or more implants could not achieve a torque above 35 Ncm, implants were submerged and loaded conventionally after 3 months [26].

To decrease possible interference with the peri-implant bone, a manual bone profiler was used and healing abutments were placed. To maximize the primary wound closure, a platelet rich fibrine membrane (PRF) was placed to cover the site. PRF has also been shown to be successful in promoting hard and soft tissue healing even in oro-maxillofacial

surgery [27]. Subsequently, healing abutments were positioned and single resorbable sutures (Vicryl 4-0 SH1 plus 22 mm 1/2c; Ethicon, New Brunswick, NJ, USA) were placed.

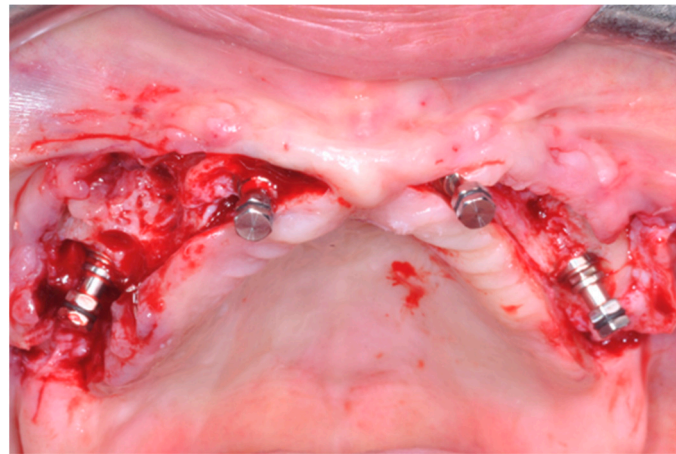


Figure 1. Four implants were placed, the distal ones being distally tilted.

After surgery, analgesics (ibuprofen 600 mg) were suggested to be taken twice a day during meals on patient demand. A soft diet was recommended for 45 days. Oral hygiene procedures were professionally implemented during the days following surgery. Patients were instructed to avoid brushing at the surgical site and rinsing until suture removal, about 10 days after surgery. They were trained to clean the prostheses with a gauze moistened with 0.2% chlorhexidine, then to use a soft and then medium toothbrush and finally the waterjet.

2.4. Prosthetic Protocol

Prosthetic procedures were initiated immediately after implant placement. Patients were trained to clean the prostheses with a gauze moistened with 0.2% chlorhexidine, then to use a soft and then medium toothbrush and finally the waterjet.

Individual trays were used to take impressions and were perforated to allow their seating over the transfers. Impregum F (Espe Dental AG, Seefeld, Germany) was used as the impression material. Definitive screw-retained prostheses were made by placing titanium abutments (VARIOTemp for fixed prostheses, Thommen) on the model, which were connected using titanium rods 2 mm in diameter soldered with an argon syncrystallization device (WELDER INTRAORAL MIDI, Implamed, Cremona, Italy), an intraoral welder, to create a rigid framework. It was not necessary to use angulated abutments for tilted implants since the abutments tolerated substantial disparallelism between implants. The framework was covered with wax and 12 preformed resin teeth were added. The second day, the framework was tried in patient's mouth to check aesthetic, function, and phonetic. It was then finalized with a lining in acrylic resin. Cantilevers including maximum one premolar and one molar in extension per side were allowed. Cantilever length did not exceed 1.5 cm. On the third day after surgery, prostheses were screwed onto the implants using a standard torque of 25 Ncm and the screw households were sealed with gutta-percha. A panoramic radiograph was taken to check proper abutment seating on the implants. Prostheses were designed to have a group function occlusal scheme and were adjusted to have homogeneous occlusal contacts also on cantilevers, when present. Sutures were removed after approximately 10 days by cutting the knot and leaving the remaining portion of the absorbable suture inside the soft tissues to be spontaneously resorbed. Oral hygiene instructions were delivered.

2.5. Follow-Up

Patients were seen again after 1 and 3 months. Primary implant stability was measured at the time of implant placement by insertion torque. At the 3-month follow-up, the

prostheses were rebased and implant stability was simultaneously checked, swinging the implant with the handles of two instruments.

Six months after the surgery, patients were recalled for maintenance therapy and occlusion was checked when screw-retained prostheses were removed to be cleaned (Figure 2). Subsequent maintenance follow-ups depended on the patient's degree of hygiene, verified in the sixth month.



Figure 2. Patient smile at 1 year after loading.

In case of framework fracture, or to prevent them, the original metal-resin prostheses were gradually replaced by newly made screw-retained monobloc white resin (top.lign professional, Bredent, Senden, Germany) prostheses using a reinforced titanium framework, characterized externally by layers of enamel resin of various shades of pink and white colors (monolithic resin metal reinforced prostheses; Figure 3).

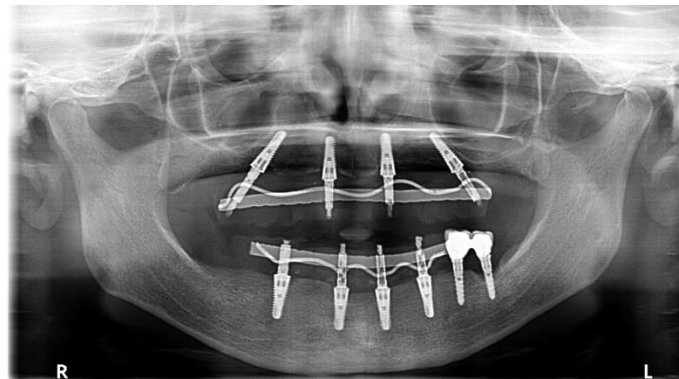


Figure 3. Panoramic view at 7-year after loading. Both prostheses were replaced by monolithic ones in the prosthesis recall program.

2.6. Clinical and/or Radiographic Outcome Measures

The following outcome measures, assessed by the same single expert operator, were retrospectively evaluated:

- Prosthesis failure: a fixed prosthesis lost due to implant failure(s), or requiring to be replaced for any reason [28];
- Implant failure;
- Any prosthetic modification after delivery (soft tissue decubitus, occlusion adjustment, early phonetic problems, prosthetic relining, prosthetic screw replacement, vestibular-lingual prosthetic flange reduction) [29];

- Any other prosthetic complications, also comprising fracture of the abutment screw, framework, detachment of resin teeth, etc.;
- Peri-implant mucositis;
- Peri-implantitis [30];
- Any other biological, also including peri-implant mucosa hemorrhage, soft tissue hypertrophy/hyperplasia, recession, and dehiscence, fistulas, and numbness of the lower lip and chin etc., [29,30].

Periodontal indexes were not collected due to the potential inaccuracy in periodontal probing around dental implants without full-arch prostheses removal [31].

2.7. Statistical Analysis

Frequencies and percentages for categorical data were computed. A chi-square test was used to assess the association between smoke and implant failure. An independent samples *t*-test was used to compare the mean ages of the subjects with failure versus success. A standard statistical software package (SPSS, version 28.0; SPSS IBM, Armonk, NY, USA) was used. The level of significance was set at $p < 0.05$.

3. Results

One-hundred-and-four patients were recruited and treated from January 2014 to December 2015. One-hundred-twenty-seven metal-resin screw-retained fixed prostheses (59 mandibular and 68 maxillary) were delivered on 549 implants (195 were post-extractive implants). The follow-up focused on the time between implant placement and 7 years after implant loading. The main baseline patient, site, and treatment characteristics are presented in Table 2.

Table 2. Patients and interventions characteristics (104 patients).

Patients and Interventions Characteristics	Numbers
Females	61 (58.7%)
Mean age at implant insertion (range)	61.2 years
Non-smokers	60 (57.7%)
Smoking up to 10 cigarettes/day	20 (19.2%)
Smoking more than 10 cigarettes/day	24 (23.1%)
Patients with a positive general anamnesis	32 (30.8%)
Patients wearing dentures in the opposite jaw at implant loading	26 (26%)
Total number of inserted implants	549
Implants inserted in mandibles (59 jaws)	199 (36.3%)
Implants inserted in maxillae (68 jaws)	350 (63.7%)
Implants inserted in fresh extraction sockets (65 patients)	186 (33.9%)
Implants placed with a torque inferior or equal to 35 Ncm (23 patients)	31 (5.7%)
Implants that caused fenestration/dehiscence of buccal bone (17 patients)	29 (5.3%)
Implant sites augmented with inorganic bovine bone only	1 (0.2%)
Implant sites augmented with autogenous bone + inorganic bovine bone + membrane	28 (5.1%)
Number of distally tilted implants (112 prostheses)	224 (40.8%)
Total number of delivered prostheses	127
Total number of maxillary prostheses	68 (53.5%)
Total number of mandibular prostheses	59 (46.5%)

At the time of placement, 30 implants in 22 patients did not achieve the minimal insertion torque required (above 35 Ncm). Twelve maxillary prostheses were conventionally loaded, because at least two implants could not be placed with a torque superior to 35 Ncm.

Twenty-one implants failed in 14 patients (Table 3). Two patients experienced early failures about one month after implant placement, most likely due to infection as they experienced severe pain. One patient lost three mandibular implants in position 3.5, 4.2, 4.5 (implant position replacing the missing tooth in its natural location, indicated according to

the numbering of the dental formula) and another two maxillary implants in position 1.6 and 1.2. The latter also lost, 2 months later, the implant in position 2.3. The remaining six patients lost one implant each (5 maxillary and one mandibular implants) and these failures were discovered 3 months after loading during relining of the prostheses. After the first year, seven patients lost eight implants, two due to fracture and six due to peri-implantitis. Eight of the early failed implants in five patients were post-extractive. One of the patients presenting with implant failure was bruxist and celiac. Patients with celiac disease have increased enamel wear due to these parafunctional activities; these could also increase the masticatory load, which causes prosthetic fractures as well [32].

Table 3. Description of the implant failures that occurred up to 7-year post-loading.

Patient Number	Implant Position Characteristics and Failure Timing		Symptoms	Patient Characteristics			
				Gender	Age	Smoker	Anamnesis
4	1.6 **	3 *	moderate pain on chewing	F	55	Moderate smoker	Negative
13	1.6 **	1 *	severe spontaneous pain	M	66	Non-smoker	Negative
	1.2 ** post-extractive	1 *	severe spontaneous pain				
	2.3 ** post-extractive	3 *	none				
20	1.6 ** post-extractive	48 *	moderate pain on chewing, peri-implantitis	M	59	Non-smoker	Negative
22	1.3 **	3 *	none	F	65	Heavy smoker	Diabetes treated with OHAs
37	4.2 **	48 *	none, peri-implantitis	M	57	Non-smoker	Diabetes treated with OHAs, previous ischemic attack treated with warfarin
47	2.2 ** post-extractive, torque < 35 Ncm	3 *	moderate pain on chewing	F	66	Moderate smoker	Negative
	2.5 **	36 *	none, peri-implantitis				
	1.5 **	72 *	none, peri-implantitis				
50	1.6 ** fenestrated and augmented with bone + membrane	3 *	none	M	71	Non-smoker	Negative
53	3.5 ** post-extractive	1 *	severe spontaneous pain	F	59	Non-smoker	Negative
	4.2 ** post-extractive	1 *	severe spontaneous pain				
	4.5 ** post-extractive	1 *	severe spontaneous pain				
56	4.3 **	24 *	none, implant fracture	M	69	Heavy smoker	Diabetic and hypertensive
75	1.5 **	48 *	moderate pain on chewing, peri-implantitis	F	66	Non-smoker	Hypercholesterolemia
89	3.1 ** post-extractive	3 *	none	F	65	Non-smoker	Negative
94	3.6 **	12 *	none, implant fracture	M	57	Heavy smoker	Negative
99	2.2 ** post-extractive	3 *	moderate pain on chewing	F	48	Non-smoker	Negative
103	4.5 **	24 *	none, peri-implantitis	M	62	Non-smoker	Negative
	2.5 **	36 *	none, peri-implantitis				

* Months post-loading; ** The position of the implant that replaced the missing tooth in its natural location, indicated according to the numbering of the dental formula.

There was no association between smoke and implant failure ($X^2 = 0.81$; $p = 0.66$) and there were no statistically significant differences in patients' mean age between implant failure (62.2 y) and implant success (61.1 y) ($p = 0.32$).

One-hundred-two prostheses were remade, at least once, in 81 patients.

Two prostheses were remade because of implant failures in two patients. One was actually remade twice, the first time after implant failures and the second time in the frame of the recall program for prosthesis replacement.

Twenty-five original prostheses in 23 patients were not remade and were still in function.

All prostheses were in function at the time of writing this manuscript. Any prosthetic modification after loading is reported in Table 4.

Table 4. Description of normal prosthetic modifications up to seventh year in function.

Patient Number	Type of Modification
2	Soft tissue decubitus; occlusion adjustment
3	Early phonetic problems; occlusion adjustment; prosthetic screw replacement
4	Soft tissue decubitus
6	Occlusion adjustment
7	Soft tissue decubitus; early phonetic problems
9	Prosthetic screw replacement
10	Early phonetic problems
11	Early phonetic problems
13	Occlusion adjustment; early phonetic problems
14	Early phonetic problems
15	Early phonetic problems; occlusion adjustment; prosthesis relining
19	Soft tissue decubitus
21	Early phonetic problems
23	Soft tissue decubitus
26	Early phonetic problems
27	Early phonetic problems
28	Soft tissue decubitus
29	Soft tissue decubitus
32	Early phonetic problems
34	Occlusion adjustment
40	Early phonetic problems
41	Occlusion adjustment; early phonetic problems
42	Soft tissue decubitus
44	Soft tissue decubitus
47	Early phonetic problems
48	Early phonetic problems
52	Early phonetic problems
54	Soft tissue decubitus
56	Early phonetic problems
57	Soft tissue decubitus
60	Prosthetic screw replacement
63	Occlusion adjustment
64	Early phonetic problems
67	Occlusion adjustment
68	Prosthesis relining
69	Vestibular-lingual prosthetic flange reduction
72	Soft tissue decubitus; early phonetic problems; prosthetic screw replacement
74	Early phonetic problems
80	Soft tissue decubitus
81	Prosthesis relining
82	Early phonetic problems
86	Prosthetic screw replacement
87	Early phonetic problems
92	Early phonetic problems
94	Prosthetic screw replacement
98	Occlusion adjustment
99	Prosthetic screw replacement
100	Prosthesis relining; prosthetic screw replacement
101	Early phonetic problems
102	Occlusion adjustment
Total	61 modifications in 57 patients

Peri-implant mucositis due to plaque accumulation occurred in 35 patients (Table 5). They were solved with professional cleaning and chlorhexidine.

Table 5. Description of peri-implant mucositis episodes.

Patient Number	Type of Event
5	Peri-implant mucositis
6	Peri-implant mucositis
7	peri-implant mucositis
15	Peri-implant mucositis
18	Peri-implant mucositis
19	Peri-implant mucositis
21	Peri-implant mucositis
24	Peri-implant mucositis
25	Peri-implant mucositis
27	Peri-implant mucositis
35	Peri-implant mucositis at 4.6
36	peri-implant mucositis
38	Peri-implant mucositis
42	Peri-implant mucositis
46	Peri-implant mucositis
49	Peri-implant mucositis
50	Peri-implant mucositis at 1.3
58	Peri-implant mucositis
60	Peri-implant mucositis (2 episodes)
65	Peri-implant mucositis at 1.5 e 2.5
67	Peri-implant mucositis
68	Peri-implant mucositis at 1.6
69	Peri-implant mucositis
74	Peri-implant mucositis (2 episodes)
79	Peri-implant mucositis
81	Peri-implant mucositis
82	Peri-implant mucositis
86	Peri-implant mucositis (2 episodes)
89	Peri-implant mucositis (2 episodes)
92	Peri-implant mucositis
95	Peri-implant mucositis (2 episodes)
96	Peri-implant mucositis
97	Peri-implant mucositis (2 episodes)
100	Peri-implant mucositis
104	Peri-implant mucositis
Total	42 episodes in 35 patients

Thirty-three prostheses in 30 patients were remade because of prosthesis fractures (details on the number of fractures are described in Table 6). One prosthesis was remade twice. In particular, 25 original metal-resin prostheses had to be remade versus only eight monolithic prostheses. Seventy-six prostheses were remade in the recall program for prosthesis replacement. Of these remade prostheses, 17 were remade a second time, 7 because of fractures beyond repair and 10 for various reasons.

Table 6. Description of biological complications occurred up to seventh year in function.

Patient Number	Type of Complication
2	Peri-implantitis at 3.2
4	Moderate pain on chewing for failure of implant 1.6
7	Intense pain for implant failure (infection) of implants 1.6 and 1.2
13	Spontaneous intense pain for early failure of implants 1.2 and 1.6
16	Moderate pain on chewing for failure of implant 1.5
20	Peri-implantitis (failure) at 1.6
28	Peri-implantitis at 4.6
36	peri-implantitis at 1.5, 1.4, 1.2, 2.2
37	Peri-implantitis (failure) at 4.2

Table 6. *Cont.*

Patient Number	Type of Complication
38	peri-implantitis at 2.4
41	Peri-implantitis at 1.3 and 2.2
47	Moderate pain on chewing for failure of implant 2.2, peri-implantitis (failures) at 2.5 and 1.5
52	Peri-implantitis at 3.6 and 4.6
53	Intense pain for early implant failure (infection) of implants 3.5, 4.2 and 4.5
56	Fracture of implant 4.3 (failure)
57	Peri-implantitis at 3.6
63	Peri-implantitis at 4.2
72	Peri-implantitis at 2.2
75	Peri-implantitis at 1.5 (failed) and 2.5
94	Fracture (failure) of implant 4.3
99	Moderate pain on chewing for failure of implant 2.2; peri-implantitis at 2.3
103	Peri-implantitis (failures) at 2.5 and 4.5
Total	36 Complications in 22 patients

Complications (Tables 6 and 7): 36 biological complications occurred in 22 patients (Table 6), pain in relation to implant failures (7 patients). The failed implants were removed and replaced with other implants. Peri-implantitis affected 15 patients and were treated either with surgical or non-surgical debridement or implant removal.

Table 7. Description of prosthetic complications occurred up to seventh year in function.

Patient Number	Type of Complication
3	Maxillary prosthesis fractured twice; mandibular prosthesis fractured once
7	Maxillary prosthesis fractured twice; monolithic maxillary prosthesis fractured twice
9	Mandibular prostheses fractured 5 times
13	Maxillary prosthesis fractured 5 times; prosthesis chipping
14	Maxillary prosthesis fractured thrice; prosthesis chipping
15	Maxillary prosthesis fractured twice
16	Maxillary prosthesis fractured twice
18	Prosthesis chipping
19	Monolithic mandibular prosthesis fractured once
22	Prosthesis chipping
23	Maxillary prosthesis fractured twice
25	Maxillary prosthesis fractured once
28	Prosthesis chipping
31	Prosthesis chipping; monolithic mandibular prosthesis fractured once
34	Mandibular prosthesis fractured twice
35	Mandibular prosthesis fractured once
38	Maxillary prosthesis fractured once
40	Maxillary prosthesis fracture once; prosthesis chipping
43	Maxillary prosthesis fractured twice; mandibular prosthesis fractured once
44	Monolithic maxillary prosthesis fractured once
45	Maxillary prostheses fracture thrice
48	Maxillary prosthesis fractured twice
54	Maxillary prosthesis fractured 5 times
55	Monolithic mandibular prosthesis fractured once; monolithic maxillary prosthesis fractured once
56	Prosthesis chipping
60	Mandibular prosthesis fractured twice
63	Maxillary prosthesis fractured thrice
64	Maxillary prosthesis fractured once
68	Maxillary prosthesis fractured twice; 1 maxillary prosthesis chipping; 1 mandibular prosthesis chipping

Table 7. Cont.

Patient Number	Type of Complication
69	Maxillary prosthesis fractured once; mandibular prosthesis fractured once; prosthesis chipping
70	Prosthesis chipping
71	Prosthesis chipping
81	Mandibular prosthesis fractured twice
86	Prosthesis chipping
93	Prosthesis chipping
94	Monolithic mandibular prosthesis fractured twice
96	Prosthesis chipping
98	Prosthesis chipping
99	Prosthesis chipping
100	Prosthesis chipping
101	Monolithic maxillary prosthesis fractured once
103	Maxillary prosthesis fractured once; mandibular prosthesis fractured once
Total	86 complications in 42 patients

The following 86 prosthetic complications occurred in 42 patients (Table 7): sixty-seven fractures of the prostheses occurred in 30 patients. Prostheses were either repaired in the lab or replaced by a new more robust monolithic prosthesis. Prosthesis lining chipping affected 19 patients. They were easily repaired in the lab.

No statistical significant difference was found in the association between smoking and mucositis ($p = 0.672$) or peri-implantitis ($p = 0.108$) (Chi-square test). In addition, no statistical significant difference was found comparing the age averages with mucositis or peri-implantitis (t -test).

4. Discussion

The aim of the present retrospective single cohort study was to assess the clinical outcomes of immediately loaded maxillary and/or mandibular cross-arch metal-resin screw-retained fixed prostheses on four-to-five immediately placed dental implants without bone augmentation in totally edentulous maxillary and/or mandibular jaws with a 7-year follow-up, in order to evaluate whether four-to-five immediately loaded implants supporting fixed cross-arch prostheses could be a reliable treatment option to rehabilitate edentulous patients

The choice to evaluate all clinical outcomes is aimed to analyze the average performance of this type of rehabilitation in a medium-to-long-term follow-up.

The findings of the present study are encouraging since only 14 patients lost in total 21 implants up to 7 years after loading and all patients have their implant-supported fixed prostheses in function. Of the 549 implants inserted, 21 failed and 18 dropped out, showing an implant survival rate at seven years of 96%. More specifically, 3 patients out of 14 lost three implants each, while 1 patient lost 2 implants, and the remaining 10 patients lost 1 implant each.

One-hundred-and-two prostheses were remade, which is a high number. However only 2 prostheses were remade because of implant failures, the other 33 prostheses had to be remade because of mechanical failures of the prostheses themselves. In particular, 25 of the original metal-resin prostheses constructed adding commercially available denture teeth had to be remade versus only 8 of the replacement monolithic metal-resin prostheses. This clearly indicates an insufficient robustness of the original delivered metal-resin prostheses. This type of prosthetic design should be considered as a provisional and not as a definitive prosthesis. Therefore, it was decided to start a free-of-charge recall program to replace the original metal-resin prostheses with a new and more robust design. A similar problem was described in a 5-year post-loading prospective study including 80 patients rehabilitated with immediately loaded screw-retained prostheses supported by only two mandibular implants [33]. Two different types of frameworks were used: titanium laser-welded rods

and cast silver-palladium alloy frameworks. Significantly, more mechanical complications occurred at laser-welded prostheses (19 patients out of 46 versus 6 patients out of 34; $p = 0.032$). In particular, nine laser-welded prostheses versus only one cast prostheses had to be remade.

Only those implants that achieved an insertion torque superior to 35 Ncm were immediately loaded. This appears to be a clinically sound decision. In fact, a randomized controlled split-mouth trial, evaluating the clinical outcome of immediately loaded implants placed with an insertion torque between 25 and 35 Ncm versus implants placed with a torque superior to 80 Ncm, showed statistically scarcer failure using insertion torque above 80 Ncm [34]. In addition, no implant inserted with a torque above 30 Ncm failed either. An insertion torque superior to 80 Ncm is a very high torque and it may be that good results could be obtained also with lower torque values, as suggested by the present study or by another trial in which implants inserted with a torque of 32 Ncm were also loaded immediately [35]. Most likely, an insertion torque superior to 35 Ncm for loading four-to-five splinted implants, as in the present study, is adequate to ensure good success rates of immediately loaded implants.

Most of the early implant failures affected immediate post-extractive implants (8 out of 12). This observation is in line with other studies that showed trends for post-extractive implants to fail more often than delayed-placed implants [13,36]. During the follow-up, two implant fractures occurred, which may indicate an excessive loading on the implant in relation to its robustness.

Complications may seem very frequent when compared with other similar studies. A special effort was made to detect and report all events, also those less commonly. In the majority of studies, complications are under-reported, if not reported at all, which can generate a great bias in implantology. Knowledge of complications may help to solve them.

Compared with the 1-year follow-up publication, it was decided to consider soft tissue decubitus, occlusion adjustments, early phonetic problems prosthetic relining, prosthetic screw replacement, and vestibular-lingual prosthetic flange reduction as normal prosthetic modifications instead of real prosthetic complications. The same consideration was made for peri-implant mucositis, which were solved with professional cleaning and chlorhexidine. This decision was made since, once solved, they rarely recurred during the follow-up period. The real complications were divided into biological complications and prosthetic complications (Tables 6 and 7).

The decision of replacing the original metal-resin prostheses with the monoblock white resin ones led to a reduction of fracture percentage from 76% to 12%. The more common complications of monoblock prostheses were prosthetic chippings, which were easily repaired in the lab without the necessity of making a new prosthesis.

The major limitation of the present study is the retrospective design. In addition, treatments were delivered under normal clinical conditions, using broad patient inclusion criteria, therefore the results of this could be extrapolated to wider patient populations with similar characteristics. However, the number of patients treated could be further expanded to have a more representative sample and different types of implants could be used.

5. Conclusions

Immediately loaded cross-arch prostheses supported by four-to-five implants are a viable therapeutic option. Monoblock prostheses presented a lower percentage of fractures than non-mono-block metal resin prostheses, making them a better option.

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References

1. Brånemark, P.I.; Hansson, B.O.; Adell, R.; Breine, U.; Lindström, J.; Hallén, O.; Ohman, A. Osseointegrated Implants in the Treatment of the Edentulous Jaw. Experience from a 10-Year Period. *Scand. J. Plast. Reconstr. Surg. Suppl.* **1977**, *16*, 1–132. [[PubMed](#)]
2. Chan, M.H.; Nudell, Y.A. All-on-4 Concept Update. *Dent. Clin. N. Am.* **2021**, *65*, 211–227. [[CrossRef](#)] [[PubMed](#)]
3. Tavelli, L.; Borgonovo, A.E.; Re, D.; Maiorana, C. Sinus Presurgical Evaluation: A Literature Review and a New Classification Proposal. *Minerva Stomatol.* **2017**, *66*, 115–131. [[CrossRef](#)] [[PubMed](#)]
4. Lim, H.C.; Kim, S.; Kim, D.H.; Herr, Y.; Chung, J.H.; Shin, S.I. Factors Affecting Maxillary Sinus Pneumatization Following Posterior Maxillary Tooth Extraction. *J. Periodontal Implant Sci.* **2021**, *51*, 285–295. [[CrossRef](#)]
5. Urban, I.A.; Monje, A. Guided Bone Regeneration in Alveolar Bone Reconstruction. *Oral Maxillofac Surg. Clin. N. Am.* **2019**, *31*, 331–338. [[CrossRef](#)]
6. Lang, N.P.; Hämmerle, C.H.; Brägger, U.; Lehmann, B.; Nyman, S.R. Guided Tissue Regeneration in Jawbone Defects Prior to Implant Placement. *Clin Oral Implant. Res.* **1994**, *5*, 92–97. [[CrossRef](#)]
7. Gallucci, G.O.; Benic, G.I.; Eckert, S.E.; Papaspyridakos, P.; Schimmel, M.; Schrott, A.; Weber, H.-P. Consensus Statements and Clinical Recommendations for Implant Loading Protocols. *Int. J. Oral Maxillofac. Implant.* **2014**, *29*, 287–290. [[CrossRef](#)]
8. Caggiano, M.; D’Ambrosio, F.; Giordano, F.; Acerra, A.; Sammartino, P.; Iandolo, A. The “Sling” Technique for Horizontal Guided Bone Regeneration: A Retrospective Case Series. *Appl. Sci.* **2022**, *12*, 5889. [[CrossRef](#)]
9. Zampelis, A.; Rangert, B.; Heijl, L. Tilting of Splinted Implants for Improved Prosthodontic Support: A Two-Dimensional Finite Element Analysis. *J. Prosthet. Dent.* **2007**, *97*, S35–S43. [[CrossRef](#)]
10. Tirone, F.; Salzano, S.; Rolando, E.; Pozzatti, L.; Rodi, D. Framework Fracture of Zirconia Supported Full Arch Implant Rehabilitation: A Retrospective Evaluation of Cantilever Length and Distal Cross-Sectional Connection Area in 140 Patients Over an Up-To-7 Year Follow-Up Period. *J. Prosthodont.* **2022**, *31*, 121–129. [[CrossRef](#)]
11. Ozan, O.; Kurtulmus-Yilmaz, S. Biomechanical Comparison of Different Implant Inclinations and Cantilever Lengths in All-on-4 Treatment Concept by Three-Dimensional Finite Element Analysis. *Int. J. Oral Maxillofac. Implant.* **2018**, *33*, 64–71. [[CrossRef](#)] [[PubMed](#)]
12. Bhering, C.L.B.; Mesquita, M.F.; Kemmoku, D.T.; Noritomi, P.Y.; Consani, R.L.X.; Barão, V.A.R. Comparison between All-on-Four and All-on-Six Treatment Concepts and Framework Material on Stress Distribution in Atrophic Maxilla: A Prototyping Guided 3D-FEA Study. *Mater. Sci. Eng. C Mater. Biol. Appl.* **2016**, *69*, 715–725. [[CrossRef](#)] [[PubMed](#)]
13. Esposito, M.; Grusovin, M.G.; Maghaireh, H.; Worthington, H.V. Interventions for Replacing Missing Teeth: Different Times for Loading Dental Implants. *Cochrane Database Syst. Rev.* **2013**, *2013*, CD003878. [[CrossRef](#)] [[PubMed](#)]
14. Chiapasco, M.; Abati, S.; Romeo, E.; Vogel, G. Implant-Retained Mandibular Overdentures with Brånemark System MKII Implants: A Prospective Comparative Study between Delayed and Immediate Loading. *Int. J. Oral Maxillofac. Implant.* **2001**, *16*, 537–546.
15. Romeo, E.; Chiapasco, M.; Lazza, A.; Casentini, P.; Ghisolfi, M.; Iorio, M.; Vogel, G. Implant-Retained Mandibular Overdentures with ITI Implants. *Clin. Oral Implant. Res.* **2002**, *13*, 495–501. [[CrossRef](#)]
16. Cannizzaro, G.; Leone, M.; Esposito, M. Immediate versus Early Loading of Two Implants Placed with a Flapless Technique Supporting Mandibular Bar-Retained Overdentures: A Single-Blinded, Randomised Controlled Clinical Trial. *Eur. J. Oral Implant.* **2008**, *1*, 33–43.
17. Giordano, F.; Esposito, M. Immediate Loading of Fixed Protheses in Fully Edentulous Jaws—1-Year Follow-up from a Single-Cohort Retrospective Study. *Eur. J. Oral Implant.* **2017**, *10*, 339–348.
18. Cannizzaro, G.; Leone, M.; Esposito, M. Immediate Functional Loading of Implants Placed with Flapless Surgery in the Edentulous Maxilla: 1-Year Follow-up of a Single Cohort Study. *Int. J. Oral Maxillofac. Implant.* **2007**, *22*, 87–95.
19. Lee, D.J.; Saponaro, P.C. Management of Edentulous Patients. *Dent. Clin. N. Am.* **2019**, *63*, 249–261. [[CrossRef](#)]
20. Sbordone, C.; Toti, P.; Brevi, B.; Martuscelli, R.; Sbordone, L.; Di Spirito, F. Computed Tomography-Aided Descriptive Analysis of Maxillary and Mandibular Atrophies. *J. Stomatol. Oral Maxillofac. Surg.* **2019**, *120*, 99–105. [[CrossRef](#)]

21. Di Spirito, F.; Toti, P.; Brevi, B.; Martuscelli, R.; Sbordone, L.; Sbordone, C. Computed Tomography Evaluation of Jaw a Trophies before and after Surgical Bone Augmentation. *Int. J. Clin. Dent.* **2019**, *12*, 259–270.
22. D'Ambrosio, F.; Di Spirito, F.; Amato, A.; Caggiano, M.; Lo Giudice, R.; Martina, S. Attitudes towards Antibiotic Prescription and Antimicrobial Resistance Awareness among Italian Dentists: What Are the Milestones? *Healthcare* **2022**, *10*, 1585. [[CrossRef](#)] [[PubMed](#)]
23. Ramaglia, L.; Di Spirito, F.; Sirignano, M.; La Rocca, M.; Esposito, U.; Sbordone, L. A 5-Year Longitudinal Cohort Study on Crown to Implant Ratio Effect on Marginal Bone Level in Single Implants. *Clin. Implant Dent. Relat. Res.* **2019**, *21*, 916–922. [[CrossRef](#)] [[PubMed](#)]
24. DE Vico, G.; Bonino, M.; Spinelli, D.; Schiavetti, R.; Sannino, G.; Pozzi, A.; Ottria, L. Rationale for Tilted Implants: FEA Considerations and Clinical Reports. *Oral Implant.* **2011**, *4*, 23–33.
25. Greenstein, G.; Cavallaro, J. Implant Insertion Torque: Its Role in Achieving Primary Stability of Restorable Dental Implants. *Compend. Contin. Educ. Dent.* **2017**, *38*, 88–95, quiz 96. [[PubMed](#)]
26. Tettamanti, L.; Andrisani, C.; Bassi, M.A.; Vinci, R.; Silvestre-Rangil, J.; Tagliabue, A. Immediate Loading Implants: Review of the Critical Aspects. *Oral Implant.* **2017**, *10*, 129–139. [[CrossRef](#)]
27. Cortese, A.; Caggiano, M.; Carlino, F.; Pantaleo, G. Zygomatic Fractures: Technical Modifications for Better Aesthetic and Functional Results in Older Patients. *Int. J. Surg.* **2016**, *33* (Suppl. 1), S9–S15. [[CrossRef](#)]
28. Papaspyridakos, P.; Bordin, T.B.; Kim, Y.-J.; El-Rafie, K.; Pagni, S.E.; Natto, Z.S.; Teixeira, E.R.; Chochlidakis, K.; Weber, H.-P. Technical Complications and Prosthesis Survival Rates with Implant-Supported Fixed Complete Dental Prostheses: A Retrospective Study with 1- to 12-Year Follow-Up. *J. Prosthodont.* **2020**, *29*, 3–11. [[CrossRef](#)]
29. La Monaca, G.; Pranno, N.; Annibali, S.; Di Carlo, S.; Pompa, G.; Cristalli, M.P. Immediate Flapless Full-Arch Rehabilitation of Edentulous Jaws on 4 or 6 Implants According to the Prosthetic-Driven Planning and Guided Implant Surgery: A Retrospective Study on Clinical and Radiographic Outcomes up to 10 Years of Follow-Up. *Clin. Implant. Dent. Relat. Res.* **2022**, 1–14. [[CrossRef](#)]
30. D'Ambrosio, F.; Caggiano, M.; Schiavo, L.; Savarese, G.; Carpinelli, L.; Amato, A.; Iandolo, A. Chronic Stress and Depression in Periodontitis and Peri-Implantitis: A Narrative Review on Neurobiological, Neurobehavioral and Immune-Microbiome Interplays and Clinical Management Implications. *Dent. J.* **2022**, *18*, 10–49. [[CrossRef](#)]
31. Papaspyridakos, P.; Barizan Bordin, T.; Kim, Y.-J.; DeFuria, C.; Pagni, S.E.; Chochlidakis, K.; Rolim Teixeira, E.; Weber, H.-P. Implant Survival Rates and Biologic Complications with Implant-Supported Fixed Complete Dental Prostheses: A Retrospective Study with up to 12-Year Follow-Up. *Clin. Oral Implant. Res.* **2018**, *29*, 881–893. [[CrossRef](#)]
32. Amato, M.; Zingone, F.; Caggiano, M.; Iovino, P.; Bucci, C.; Ciacci, C. Tooth Wear Is Frequent in Adult Patients with Celiac Disease. *Nutrients* **2017**, *9*, 1321. [[CrossRef](#)] [[PubMed](#)]
33. Cannizzaro, G.; Felice, P.; Lazzarini, M.; Ferri, V.; Leone, M.; Trullenque-Eriksson, A.; Esposito, M. Immediate Loading of Two Flapless Placed Mandibular Implants Supporting Cross-Arch Fixed Prostheses: A 5-Year Follow-up Prospective Single Cohort Study. *Eur. J. Oral Implant.* **2016**, *9* (Suppl. 1), 165–177.
34. Cannizzaro, G.; Leone, M.; Ferri, V.; Viola, P.; Gelpi, F.; Federico, G.; Esposito, M. Immediate Loading of Single Implants Inserted Flapless with Medium or High Insertion Torque: A 6-Month Follow-up of a Split-Mouth Randomised Controlled Trial. *Eur. J. Oral Implant.* **2012**, *5*, 333–342.
35. Ottoni, J.M.P.; Oliveira, Z.F.L.; Mansini, R.; Cabral, A.M. Correlation between Placement Torque and Survival of Single-Tooth Implants. *Int. J. Oral Maxillofac. Implantol.* **2005**, *20*, 769–776.
36. Esposito, M.; Barausse, C.; Pistilli, R.; Jacotti, M.; Grandi, G.; Tuco, L.; Felice, P. Immediate Loading of Post-Extractive versus Delayed Placed Single Implants in the Anterior Maxilla: Outcome of a Pragmatic Multicenter Randomised Controlled Trial 1-Year after Loading. *Eur. J. Oral Implantol.* **2015**, *8*, 347–358. [[PubMed](#)]