A Retrospective Study on Immediate Placement of Neoss Implants with Early Loading of Full-Arch Bridges

Peter Andersson, DDS;*† Werner Degasperi, MD, DDS;* Damiano Verrocchi, DDS;†
Lars Sennerby, DDS, PhD*‡

ABSTRACT

Background: Full-arch clearances of compromised teeth and placement of implant-supported prostheses is one solution for the prosthetic rehabilitation of partially dentate patients.

Purpose: To retrospectively evaluate treatment outcomes after full clearance, immediate placement, and early loading of full-arch fixed bridges.

Materials and Methods: Fifty-five patients subjected to full clearance and placement of 284 Neoss implants (Bimodal™ and Proactive™, Neoss Ltd, Harrogate, UK) in 29 edentulous maxillae and 26 mandibles for early loading (1 to 3 days) of a provisional full-arch bridge were retrospectively evaluated after 1 to 6 years of loading. Osstell™ measurements (Osstell AB, Göteborg, Sweden) were taken at placement and after 3 to 9 months when the provisional bridge was replaced with a permanent one. Marginal bone levels were measured in intraoral radiographs.

Results: All patients (100%) wore a fixed bridge at the time of finalizing the study. A total of 18 failures (6.3%) were encountered during the follow-up, giving an overall cumulative survival rate of 93.7%. All failures occurred in the maxilla (10.6%), and no implants were lost in the mandible. More Bimodal™ (9.0%) than Proactive™ (4.1%) implants failed. Failing implants showed a significantly lower mean primary stability than successful ones ($p = .015$). Failed cases showed a significantly lower average ISQ for all implants ($p = .015$) and a marked decrease to the second registration, while successful cases showed and maintained high ISQs. The average bone loss after 1 year was 0.8 ± 0.5 mm.

Conclusions: Full-arch clearance of severely diseased teeth followed by immediate placement of Neoss implants, early loading with provisional full-arch bridges, and subsequent permanent bridges is a possible treatment modality for partially dentate patients. Caution with this approach is recommended for the maxilla, as opposed to the mandible.

KEY WORDS: dental implants, early loading, edentulous jaws, tooth extraction

INTRODUCTION

Extraction of remaining teeth and subsequent implant therapy to prosthetically restore function and aesthetics may be the most rational solution for many patients with a severely diseased partial dentition. In such cases, implant placement in conjunction with tooth extractions for immediate/early loading of a provisional full-arch bridge is one option.[1–4] The benefits are evident, as the patient will receive a fixed bridge through one surgical procedure without the need for removable dentures and healing periods. It can be concluded from systematic reviews that immediate/early loading is a straightforward approach in the mandible,[5] while the same treatment in the maxilla is less well documented,[6–8] particularly when implants are placed in extraction sockets.[8] Nevertheless, several studies have demonstrated successful results when placing implants in immediate extraction sockets and healed sites for immediate loading of maxillary full-arch constructions, with survival rates from 98% to 99%.[2,3,9,10] However, other studies on the same treatment modality have shown less

*Private practice, Feltre, Italy; †private practice, Fiera Di Primiero, Italy; ‡professor, Department of Oral and Maxillofacial Surgery, Sahlgrenska Academy, University of Gothenburg, Göteborg, Sweden

Reprint requests: Prof. Lars Sennerby, Department of Oral and Maxillofacial Surgery, Sahlgrenska Academy, University of Gothenburg, PO Box, SE 405 30, Göteborg, Sweden; e-mail: lars.sennerby@gu.se

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good outcomes,[1,11,12] with increased failure rates in the maxilla[1,12] and for implants in extraction sockets.[11] These findings indicate that primary stability may be an important factor, due to differences in bone density/volume between the maxilla and mandible,[7] and that the presence of extraction sockets may further impair primary stability. Certain levels of insertion torque and resonance frequency analysis (RFA) measurements have been used as inclusion criteria in order to ensure firm stability prior to loading in immediate loading studies.[13–16] Although good clinical outcomes were reported in these studies, a recent review concluded that primary stability as measured with RFA has a low predictive value for identifying implants at risk for failure.[17] In a study on immediate loading, Glauser and colleagues[18] demonstrated that failing implants showed a continuous drop in RFA measurements until failure. They also showed that implants with a low RFA measurement after 1 and 2 months of loading, but not at implant placement, indicated an increased risk for future failure. This suggests that the influence of loading on the early integration of the implant is critical for the clinical outcome irrespective of primary stability. However, the influence of early loading on implant stability in immediate/early-loaded full-arch restorations after extraction of remaining teeth is not known.

The aim of this retrospective study was to evaluate implant survival in 55 patients treated with clearance of remaining teeth, immediate implant placement, and early loading of full-arch provisional bridges and subsequent permanent bridges.

MATERIALS AND METHODS

Patients

The clinical outcomes of 55 patients (27 male, 28 female) treated in two clinics were retrospectively evaluated. The group represented consecutive patients where, based on clinical and radiographic examinations, the proposed treatment plan included extraction of remaining teeth (mean 4.8 ± 3.3, range 0 to 11) and immediate placement of 4 to 7 implants (mean 5.2) for early loading of a provisional bridge within 3 days. No specific inclusion criteria based on primary stability measurements were used.

The patients had been informed about clinical procedures, anticipated risks, complications, and expected outcome. All patients had given their written consent to the therapy plan and follow-up procedures prior to treatment. All treatment steps were part of the routine procedures at the clinic, and no extra measures were taken for the cause of the study. The study followed the World Medical Association Declaration of Helsinki and the directives given by the local ethical committee at the Feltre Hospital, Feltre, Italy, which does not require ethical approval for retrospective clinical studies.

Implants

A total of 284 implants (Neoss Ltd, Harrogate, UK) of different length, diameter and surface had been placed (Table 1). A total of 170 implants had been used in 29 maxillae, and 114 in 26 mandibles (Table 2). Sixty-two implants (21.8%) were placed in extraction sockets. Although the same principal design of implants had been employed, two different surfaces had been used, specifically the Bimodal™ surface ($n = 116$) from 2005 to 2009 and the Proactive™ surface ($n = 168$) from 2009 to 2011 (both from Neoss). The Bimodal surface is produced by double-blasting and the Proactive implant surface by blasting with titanium particles followed by acid etching. The surface is then chemically modified to reduce surface tensions and to exhibit electrowetting in contact with fluids. According to the manufacturer, the surface roughness (S_a value) on the implant body is

TABLE 1 Type of Implants Used in the Study

	Diameter (mm)			
Length (mm)	3.5	4.0	4.5	Total
Bimodal				
9		5 (1)	1	6 (1)
11	1 (1)	2		3 (1)
13	5 (1)	25 (5)	3	33 (6)
15	4 (1)	68 (3)	1	73 (4)
17		1		1
Total	10 (3)	101 (9)	5	116 (12)
Proactive				
9				
11		18 (2)		18 (2)
13		53 (1)	1	54 (1)
15		95 (3)	1	96 (3)
17				
Total		166 (6)	2	168 (6)

Numbers in parentheses indicate number of failures.

TABLE 2 Location, Type, and Number of Implants Placed per Patient

Location and Type	Number of Cases				Number of Implants
	Total	5 Implants	6 Implants	7 Implants	
Maxilla					
Bimodal	10 (4)	1	9 (4)		59 (12)
Proactive	19 (5)	4 (2)	14 (3)	1	111 (6)
Total	29 (9)	5 (2)	28 (7)	1	170 (18)
Mandible					
Bimodal	12	6	3	3	57
Proactive	14	13	1		57
Total	26	18	4	3	114

Numbers in parentheses indicate number of failures.

about 0.6 µm for Bimodal and 1.0 µm for Proactive. Implant surfaces were never mixed in the same patient.

Clinical Procedures

Surgery. Patients were given 2 g amoxicillin (Augmentin™, GlaxoSmithKline, Verona, Italy) prior to extractions and implant surgery. If required, the patients were also given diazepam (0.15 mg/kg body weight). Surgery was performed under sterile conditions in local anesthesia with articain (4%) with epinephrine (1/100,000) (Septanest™, Septodont, Saint-Maur-des-Fossés, France). The bone was exposed via a midcrest incision and mucoperiosteal flaps. Remaining teeth were carefully luxated with periotomes and luxators and divided if needed in order to preserve bone tissue. Sockets were cleaned from granulation tissue and rinsed with saline. Implant sites were prepared using a 2.2-mm spiral drill for the possibility of making screw-retained crowns and bridges. A 3.0-mm drill was used, which was the final diameter for 3.5 mm–wide implants. When using 4 mm–wide implants, a 3.4-mm drill was used, and a 4.1-mm drill was used for 4.5 mm–wide implants. In case of soft bone, the final drill diameter was reduced one step to improve primary stability. A countersink drill was occasionally used and the implants placed flush with or 1 mm above the bone crest in healed sites. In extraction sites, the implants were submerged 2–3 mm below the margins of the socket. The implants were inserted with a preset insertion torque of 40 Ncm. The final insertion was made using a manual wrench. Implant stability quotient (ISQ) was measured with RFA (Osstell Mentor™, Osstell AB, Göteborg, Sweden). Sterile impression copings were attached to the implants. The flaps were closed and sutured with 4-0 sutures.

Prosthetics. Impressions were made at fixture level using Impregum (ESPE, Seefeld, Germany) and a laboratory-made individual open tray. Healing abutments were connected to the implants, and a bite registration was taken using an individual tray. The tray fitted to both the lower and upper jaw and indicated the appropriate intermaxillary relation as determined in presurgical casts mounted in an articulator. The tray had a space in the implant area, which was filled with light body material (Impregum). Additional stitches were added if needed.

After 1 to 3 days, a screw-retained acrylic provisional bridge made on temporary titanium abutments (Neoss) and a metal framework with no or minimal cantilever teeth was connected to the implants (Figure 1). The occlusion was adjusted to achieve group function, and no contacts were allowed at distal cantilevers. Screwholes were closed with Teflon tape and temporary filling material.

Check-ups were made after 1 and 4 weeks. Three to nine months after surgery, a second RFA measurement was made on all implants, and the provisional bridge was replaced by a permanent one if the implants showed good stability. This procedure included new impression, try-ins, and delivery of a final bridge. The type of bridge and material of frameworks varied in this retrospective study. Frameworks were made from milled titanium or cobalt/chrome. Both acrylic and porcelain teeth were used. The bridges were made on Neolink™ abutments (Neoss) for screw-retention. The access holes were

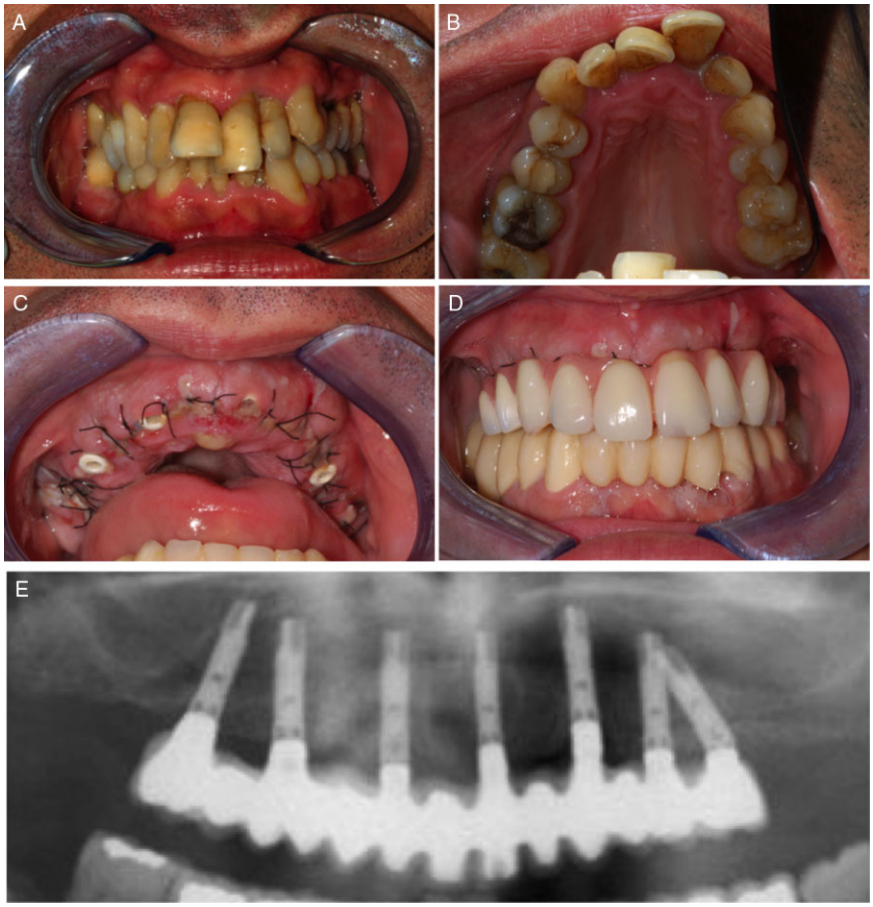

Figure 1 *A*, Preoperative photograph of a patient with severe periodontitis and occlusal problems. *B*, Occlusal view. *C*, Three days after total extraction and placement of seven Proactive implants. *D*, Provisional fixed bridge. *E*, Orthopantomogram showing implants and final bridge after one year of loading.

covered with Teflon tape and composite fillings. Function and occlusion were further checked 2 to 4 weeks after delivery of the prosthetic appliance (Figure 1).

Follow-Up. The patients had been followed up for at least 1 year and up to 6 years (mean 2.9 ± 1.5 years) at the time of completion of the study. As part of the general routines, the patients had been contacted annually for clinical and radiographic examinations. Patients were enrolled in an individually designed maintenance care program for professional cleaning and examinations if needed.

An implant was considered a survival if clinically stable, complying with the function of supporting the prosthesis, and causing no discomfort to the patient.

Failure was defined as removal of an implant because of any reason.

Intraoral or panoramic radiographs were taken at impression and after 1, 3, and 5 years or on any suspicion of pathology. Due to the varying follow-up and availability of radiographs, only 1-year data are presented in the present study.

Marginal bone levels were measured in available intraoral radiographs taken at baseline (within 5 days from surgery) and after at least 1 year of loading. The upper corner of the coronal shoulder of the implant was used as reference point, and measurements from the reference point to the first bone contact at the mesial and distal aspects of the implant were performed using a PC and specially designed software (ImageJ, National Institutes of Health, Bethesda, MD, USA) (Figure 2). A mean bone level value was calculated for each implant and time point.

Statistics. The chi-square test for comparison of two proportions was used to analyze implant survival. The Wilcoxon signed-rank test and the Mann-Whitney *U*-test were used to find possible differences when analysing the RFA data (MedCalc Software bvba,

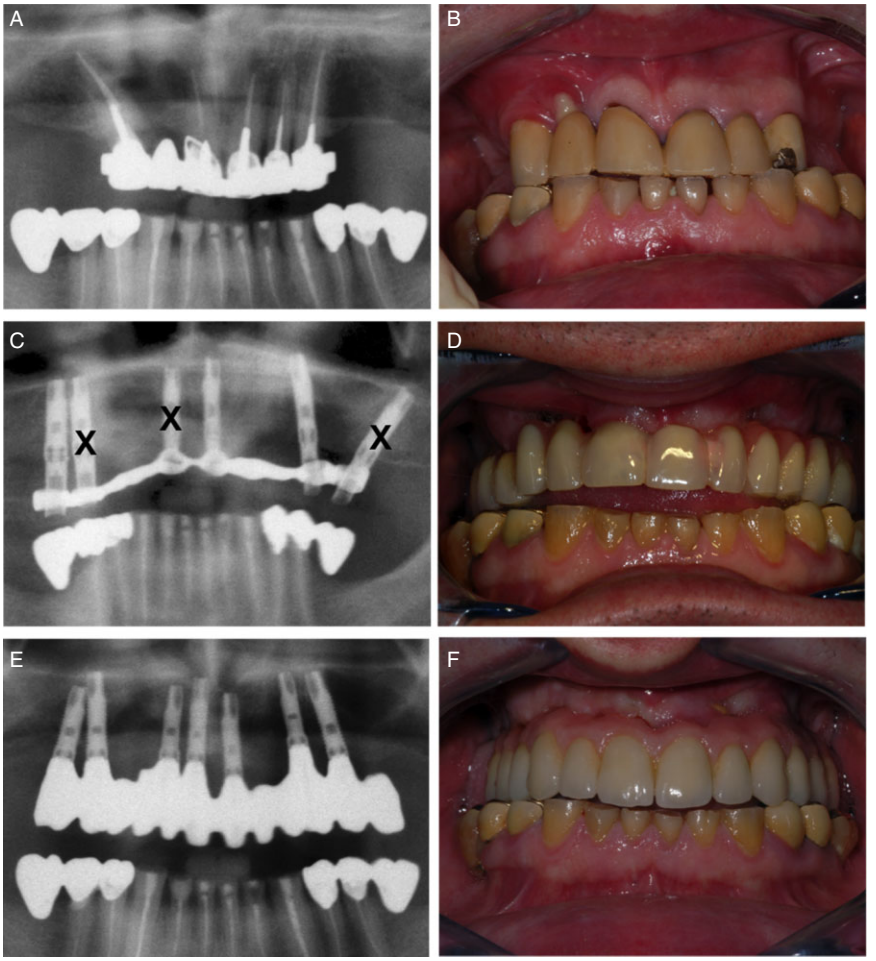

Figure 2 *A*, Preoperative orthopantomogram of a maxillary case. *B*, Clinical appearance. Note attrition of lower teeth. *C*, Postoperative orthopantomogram after total extraction and placement of six Bimodal implants and a provisional bridge. Three of the implants were lost (X) after 3 months of loading. *D*, Clinical appearance. Note poor occlusion with lower jaw. *E*, Orthopantomogram taken 3 years after placement of additional 4 implants and manufacturing of a permanent bridge. *F*, Clinical view of final bridge.

Ostend, Belgium). A difference was considered significant if $p \leq .05$.

RESULTS

Implant and Bridge Survival

A total of 18 failures (6.3%) in 9 patients (16.4%) were encountered during the 1 to 6 years of follow-up, giving an overall cumulative survival rate of 93.7% (Table 3 and Figure 2). All failures occurred in the maxilla (10.6%), and no implants were lost in the mandible (Table 4). The difference between jaws was statistically significant at implant level ($p = .0008$), but not at patient level. Sixteen early failures occurred during the first 3 to 7 months after placement, and two implants failed after 18 and 23 months in function.

The overall failure rate was 10.3% for Bimodal implants and 3.6% for Proactive implants (Table 4). The difference was statistically significant at implant level ($p = .043$), but not at patient level. One patient lost four Bimodal implants, two patients lost three Bimodal implants each, one patient lost two Bimodal implants, one patient lost two Proactive implants, and four patients lost one Proactive implant each (Table 5).

TABLE 3 Life Table

Follow-Up (Years after Placement)	Implants	Failures	Not Yet Due	Cumulative Survival Rate (%)
1	284	16		94.4
2	239	1	29	94.0
3	131	1	107	93.7
4	102		28	93.7
5	56		46	93.7
6	11			93.7

TABLE 4 Analysis of Failure Rates at Implant and Patient Levels

	Number of Implants or Patients (Failures)	Failure Rate (%)	*p* Value
Implant level			
Mandible	114 (0)	0	
Maxilla	170 (18)	10.6	.0008
Bimodal implants	116 (12)	10.3	
Proactive implants	168 (6)	3.6	.042
Ø 3.5 and/or 9–11 mm	36 (6)	16.7	
Ø 4.0/4.5 and/or 13–17 mm	248 (12)	4.8	.018
Distal implants	110 (100	9.1	
Mesial implants	174 (8)	4.6	NS
Healed sites	222 (13)	5.9	
Extraction sockets	62 (5)	8.1	NS
Patient level			
Mandible	26 (0)	0	
Maxilla	29 (9)	31.0	NS
Bimodal implants	22 (4)	18.2	
Proactive implants	33 (5)	15.2	NS

NS = not significant.

Although few narrow (3.5 mm) and/or short implants (9–11 mm) were used ($n = 36$), most with Bimodal surface, a high proportion of these failed (16.7%). The corresponding failure for wider (4.0 and 4.5 mm) and/or longer (13–17 mm) ($n = 248$) was 4.8% (Table 4). The difference between jaws was statistically significant at implant level ($p = .018$) but not at patient level.

TABLE 5 Characteristics of Failed Implants

No.	Gender/Age	Jaw	Bone	Position	Implant	ISQ 1	ISQ 2	Early or Late
4	F/73	Maxilla	B3	13	B/4/13	75	—	Early
			C3	15	B/4/9	67	—	Late
5	M/58	Maxilla	B2	11	B/4/13	66	—	Early
			B2	13	B/4/13	75	—	Early
			B2	27	B/4/15	77	—	Early
6	F/39	Maxilla	B3	14	B/4/15	66	63	Late
			B2	21	B/4/13	73	—	Early
			B2	23	B/4/15	73	—	Early
			B3	24	B/4/15	72	—	Early
7	F/59	Maxilla	B3	15	B/3.5/15	75	—	Early
			B3	23	B/3.5/11	71	—	Early
			B3	25	B/3.5/13	69	—	Early
23	F/77	Maxilla	B3	24	P/4/15	75	55	Early
25	M/59	Maxilla	B3	13	P/4/13	64	25	Early
39	F/58	Maxilla	C2	25	P/4/11	75	—	Early
42	F/52	Maxilla	C2	14	P/4/11	63	—	Early
52	M/51	Maxilla	B3	15	P/4/15	67	20	Early
			B3	25	P/4/15	70	10	Early

ISQ = implant stability quotient; B = Bimodal; P = Proactive.

TABLE 6 Analysis of Osstell Measurements

	ISQ at Placement	*p* Value	Mean ISQ at Follow-Up	*p* Value
Mandible	78.5 ± 3.2		78.0 ± 3.1	
Maxilla	73.2 ± 4.9	.0001	71.4 ± 9.7	.0001
Bimodal implants	75.3 ± 5.7		75.4 ± 5.3	
Proactive implants	75.2 ± 4.5	NS	72.9 ± 10.3	NS
Failed implants	70.7 ± 4.3		39.7 ± 23.9	
All successful implants	75.6 ± 4.9	.015	75.0 ± 4.9	.0001
Successful maxillary implants	73.5 ± 4.9	.015*	73.0 ± 4.8	.0001*
Successful maxillary cases**	74.1 ± 2.1		73.9 ± 2.4	
Failed maxillary cases**	71.2 ± 3.0	.015	65.4 ± 4.3	.015

ISQ data are given as mean ± SD. Mean is mean number of implants unless otherwise indicated.
*Compared with failed implants.
**Mean number of patients.
ISQ = implant stability quotient; NS = not significant.

Ten of the failed implants had served as the most distal abutment, giving a failure rate of 9.1% for these and 4.6% for mesial implants (Table 4) (p = NS).

Five implants placed in extraction sockets (8.1%) and 13 in healed sites (5.9%) failed (Table 4) (p = NS).

All patients wore a fixed provisional ($n = 5$) or permanent ($n = 50$) bridge at the time of study completion.

The nine patients with implant failures had additional surgery and new implants placed. Six of these patients got a permanent bridge after another 3 to 4 months of healing. Three patients who experienced four or three implant failures had a new provisional bridge made. Two of these patients had to be reoperated twice, in order to have a sufficient number of integrated implants for a permanent bridge. Their final bridges were connected 12 and 23 months after the initial surgery. One patient who had an early failure had a new permanent bridge remade due to late loss of a second implant after 23 months, which was replaced with two new ones. A total of 22 additional implants were placed in the nine patients with failures, of which one failed (not included in the analysis).

Implant Stability Measurements

The mean ISQ for all implants was 75.3 ± 5.0 at placement and 74.0 ± 8.4 after 3 to 9 months ($p \leq .05$). The stability was higher in the mandible at both time points (78.5 ± 3.2 and 78.0 ± 3.1 ISQ) than in the maxilla (73.2 ± 4.9 and 71.4 ± 9.7 ISQ) ($p \leq .05$). The Proactive and Bimodal implants showed similar stability at placement (75.2 ± 4.5 vs. 75.3 ± 5.7 ISQ) (p = NS), and Proactive implants showed a lower stability at follow-up (72.9 ± 10.3 vs. 75.4 ± 5.3 ISQ) ($p \leq .05$) (Table 6).

The failed implants showed a lower primary stability (70.7 ± 4.3 ISQ) than all successful (75.6 ± 4.9 ISQ) ($p \leq .05$) and successful maxillary ones (73.5 ± 4.9 ISQ) ($p \leq .05$). Moreover, the failed implants showed a more significant drop until follow-up (39.7 ± 23.9) than all successful (75.0 ± 4.9 ISQ) ($p \leq .05$) and successful maxillary ones (73.0 ± 4.8 ISQ) ($p \leq .05$) (Table 6).

Analysis of average patient ISQ values in the maxillary cases revealed a lower primary stability for failure cases (71.2 ± 3.0 ISQ) than for successful cases (74.1 ± 2.1 ISQ) ($p \leq .05$). Moreover, failure cases showed a marked decrease to the second measurement (65.4 ± 4.3), while the successful cases showed the same degree of stability (73.9 ± 2.4 ISQ) ($p \leq .05$) (Table 6 and Figure 3).

Analysis of implant failure rates above primary ISQs from 60 to 75 revealed increased failure rate with decreased ISQ. For instance, implants above 75 ISQ had a failure rate of 0.7%, while the failure rate was 6.5% when implants with an ISQ of 60 were included (Table 7).

Marginal Bone Levels

The marginal bone level was situated on average 0.6 ± 0.6 mm (range 0 to 2.1 mm) below the reference point at baseline and 1.4 ± 0.5 mm (range 0.2 to 3.6 mm) after at least 1 year in function. The average marginal bone resorption was calculated at 0.8 ± 0.5 mm (range 0 to 3.2 mm) after at least 1 year in function.

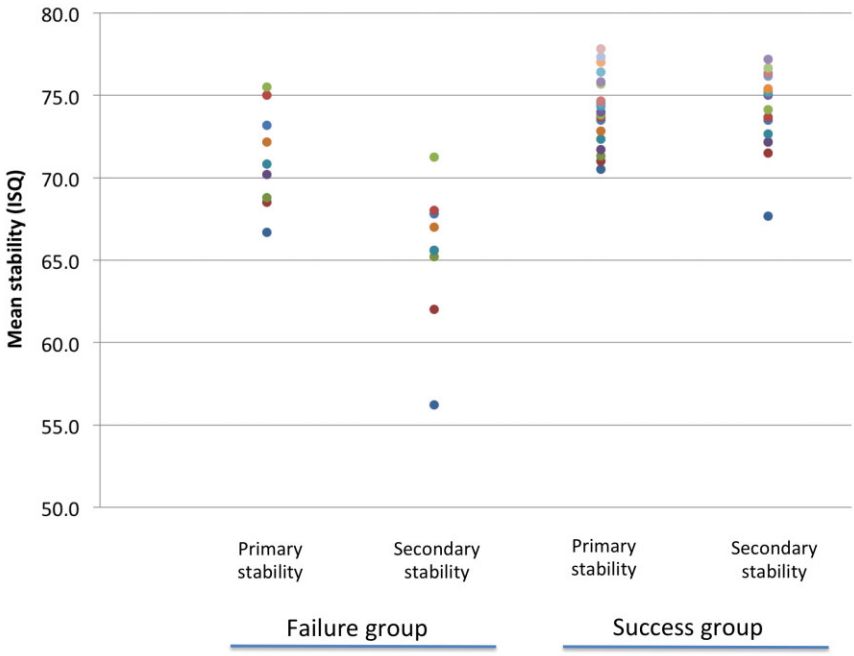

Figure 3 Graph showing patient means of implant stability quotient (ISQ) measurements of stable implants in successful and in failure cases at surgery and after follow-up.

DISCUSSION

The present study showed that extraction of remaining teeth and simultaneous implant placement for early loading of a provisional full-arch bridge is a possible treatment modality in patients with a severely diseased partial dentition. The results indicate that this is a straightforward procedure in the mandible and also when using only four implants, as no implants and prostheses were lost during the retrospective follow-up. This is in line with other studies on immediate/early loading in the mandible using various implant designs placed in healed and extraction sites.[1,4,19,20] The present investigation also showed that the therapy constitutes a challenge when prescribed for the maxilla. More than 10% of the implants placed in the maxilla were lost, which is more than initially expected by the present authors based on previous papers published at the time when the first patients in the study were treated.[2,3,13,21] Compared with the mandible, the difference was statistically significant at implant but not at patient level, which reflects the relatively low number of patients in the study. The results are also different from those of recent publications on the same treatment modality, which have shown higher survival rates,[3,9,10] although some authors have reported lower survival rates, and especially in the maxilla.[1,11,12] The reason may be related to patient selection, inclusion criteria based on primary stability, and the type/number of implants that were used. For instance, Balshi and colleagues[3] placed a mean of 10 implants per patient and reported a survival rate of 99%, while in the present study a mean of 5.9 implants were placed in the maxilla. Furthermore, the above-mentioned studies used moderately rough implant surfaces, while most of the failures in the present study were experienced with the minimally rough Bimodal surface. The failure rate of the moderately rough Proactive implants used in our study was 3.6% for all and 5.3% for maxillary implants, which is in line with the results of Covani and colleagues.[12] In spite of the failures, all patients received and maintained a fixed bridge throughout the present study, although additional

TABLE 7 Survival Rates for Implants above Different Primary ISQs

ISQ	Survival Rate (%)
>75	0.7
>70	4.2
>65	5.9
>60	6.5

ISQ = implant stability quotient.

implants had to be placed, and three new provisional bridges and one new permanent bridge had to be made. The present authors consider that the benefits of the evaluated protocol still outweigh the drawbacks of a conventional two-stage protocol when taking the number of surgical interventions and time into account. However, it must be stressed that the patient should be thoroughly informed about the possibility of implant failure and that additional treatments may be needed.

Analysis of the failures revealed that surface factors such as diameter/length had an impact on the outcome, at least when tested at implant level. Also, implants placed in a distal position showed a numerically higher failure rate than implants in mesial positions, although not statistically significantly different. Thus, short/narrow implants with a Bimodal surface placed as the most distal abutments were prone to failure, which is in line with previous studies of the same implants[22–26] and with experiences with minimally rough machined implants.[27]

Differences in implant stability in extraction sockets can depend on the surgical technique. For instance, in a maxillary extraction socket, the implant can often be placed in the palatal aspect, leaving only a few marginal threads not engaged with bone. In the newly extracted and totally edentulous jaw, implants can be placed in both extracted and healed sites to secure stability and a good distribution of implants. In the present study, 21.8% of implants were placed directly into extraction sockets, and implant failure was slightly higher in extraction sockets than in healed sites. Ji and colleagues reported a failure rate of 22.5% for immediate implants, compared with 7.8% for implants in healed sites, when evaluating 297 implants supporting 50 immediately loaded full-arch bridges after a mean follow-up of 42.1 months.[11] Other studies on the same treatment modality have shown no or small differences between extracted and healed sites.[9,10,28] In a systematic literature review of randomized clinical trials, Esposito and colleagues concluded that there was insufficient comparative data but suggested that immediate implants were less successful than implants placed in healed sites.[29] In another review, Atieh and colleagues concluded that application of immediate load to single tooth implants in extraction sockets may increase the risk for failure.[30]

Clinical follow-up studies on the Bimodal surface have in general shown high survival rates and minor crestal bone loss after 1 to 5 years of follow-up.[15,22–26] When analyzing the implant failures in the present study it was obvious that more than twice as many Bimodal than Proactive implants failed, which was a statistically significant difference at implant but not at patient level. This may indicate that the rougher Proactive surface resulted in a stronger bone tissue response than the Bimodal one, as also shown in animal research.[31] A recent clinical study comparing the two types of surfaces showed more favorable results for Proactive implants when placed in augmented sites but not in healed sites.[32] This is in line with previous findings when comparing minimally with moderately rough implants used in challenging situations such as early/immediate loading[7] or in bone augmentation situations.[33,34] The apparently different clinical performance of different surfaces in challenging situations may be explained by how they are integrated in bone. Experimental studies have shown implants with a rough topography to integrate by so called contact osteogenesis, which implies differentiation of mesenchymal cells to osteoblasts and bone formation directly on the implant surface.[35] In contrast, a smooth surface topography seems to induce distance osteogenesis, which means that bone is formed at a distance from the implant and reaches the surface by time. Thus, with time it seems both smooth and rough implant surfaces reach the same degrees of bone-to-implant contact,[36,37] which may explain the lack of clinical differences in two-stage procedures.[38]

As only Bimodal implants were used in the first patients, the learning curve may be another plausible explanation for the better outcome with Proactive implants. For instance, the early experiences from 10 Bimodal failures in three patients made the present authors aware of the importance of fit, proper occlusion, and thoroughly informing the patient on how to use the bridge. For instance, one patient who lost three Bimodal implants had used his maxillary provisional bridge/lower teeth to lift curd during cheese production shortly after surgery. Previous follow-up studies on the Bimodal implant surface have indicated narrow and short implants to be more prone to failure than wider and longer ones.[23,24] In the present study, no narrow and few short implants with Proactive had been used.

The failed implants in the present study showed primary stabilities from 63 to 77 ISQ, which is higher or similar to what has been proposed as an inclusion criterion for immediate loading in previous studies on immediate loading.[13–16] In our study, no implants with

a primary ISQ above 77 failed; thus, ISQ 77 could be proposed as a safe level. Nevertheless, an increased failure rate was seen with decreasing ISQ, and failed implants showed a significantly lower mean stability than successful ones, which is in line with previous findings. However, Glauser and colleagues showed that follow-up measurements after 1 and 2 months of immediate loading better correlated with future failure than the primary stability value.[18] In the present study, measurements were taken at placement and then when switching to a permanent bridge after 3 to 9 months. As most failures occurred during the early healing period with a provisional bridge, most failed implants were mobile at that stage; a second measurement could be taken of only five failing implants. These measurements showed a dramatic loss of stability for failing implants from 70.7 ISQ ($n = 18$) to 39.7 ISQ ($n = 5$). An average ISQ was calculated based on all successful implants (excluding failing implants) in failed and successful maxillary cases. Interestingly, the analysis revealed significantly lower average primary stability for the nine failed cases (74.1 vs. 71.2 ISQ) as well as a marked decrease to the second registration (73.9 vs 65.4 ISQ). The findings indicate that implant failure in the totally edentulous maxilla is not an isolated event influencing only one implant; rather, all implants are negatively affected. This suggests that inclusion criteria for immediate loading based on ISQ measurements should be based on mean patient values rather than single implant values. Moreover, it is possible that follow-up measurements should be made more frequently in order to identify failing implants with falling ISQs, as demonstrated in other studies.[18,22] A recent systematic review supports this view, concluding that RFA measurements of primary stability have a poor predictive and discriminative ability to identify implants at risk for failure.[17]

The radiographic analysis in the present study was restricted to the first year of loading due to the varying follow-up times of the patients. On average, 0.8 mm of bone loss was noted, which is in line with other studies on the same implant system and surfaces.[22–26]

Different definitions of immediate and early loading have been agreed upon at consensus meetings.[39,40] Loading within 24 hours after implant placement was used as the definition of immediate loading by the present authors. Hence, all bridges in the present study were early-loaded.

The present study showed that clearance of remaining teeth and simultaneous implant placement for early loading of a provisional full-arch bridge is a possible treatment modality in patients with a severely diseased partial dentition. Although a straightforward procedure in the mandible, implant failure and need of additional implants is to be expected in the maxilla. Moreover, moderately rough-surfaced implants seem to perform better than minimally rough ones in the maxilla.

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