Retrospective Analysis of 56 Edentulous Dental Arches Restored with 344 Single-Stage Implants Using an Immediate Loading Fixed Provisional Protocol: Statistical Predictors of Implant Failure

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Purpose: *The purpose of this retrospective study was to evaluate the effects of implant dimensions, surface treatment, location in the dental arch, numbers of supporting implant abutments, surgical technique, and generally recognized risk factors on the survival of a series of single-stage Straumann dental implants placed into edentulous arches using an immediate loading protocol.* ***Materials and Methods:*** *Each patient received between 4 and 18 implants in one or both dental arches. Periapical radiographs were obtained over a 2- to 10-year follow-up period to evaluate crestal bone loss following insertion of the definitive metal-ceramic fixed prostheses. Univariate tests for failure rates as a function of age (≤ 59 years versus ≥ 60 years), gender, smoking, bone grafting, dental arch, surface type, anterior versus posterior, number of implants per arch, and surgical technique were made using Fisher exact tests. The Cochran-Armitage test for trend was used to evaluate the presence of a linear trend in failure rates regarding implant length and implant diameter. Logistic regression modeling was used to determine which, if any, of the aforementioned factors would predict patient and implant failure. A significance criterion of* P *= .05 was utilized.* ***Results:*** *Data were collected for 344 single-stage implants placed into 56 edentulous arches (39 maxillae and 17 mandibles) of 43 patients and immediately loaded with a 1-piece provisional fixed prosthesis. A total of 16 implants failed to successfully integrate, for a survival rate of 95.3%. Increased rates of failure were associated with reduced implant length, placement in the posterior region of the jaw, increased implant diameter, and surface treatment. Implant length emerged as the sole significant predictor of implant failure.* ***Conclusion:*** *In this retrospective analysis of 56 consecutively treated edentulous arches with multiple single-stage dental implants loaded immediately, reduced implant length was the sole significant predictor of failure.* (Case Series) Int J Oral Maxillofac Implants 2007;22:823–830

Key words: *dental implants, edentulism, failure risk factors, flapless implant placement, immediately loaded implants, implant-supported dental prostheses, implant surfaces*

The introduction of endosseous dental implants has profoundly affected the treatment alternatives available for the fully edentulous patient. The traditional protocol recommends placement of the implants without occlusal load during osseointegration. Currently, there is considerable interest in "same day" restoration of the fully edentulous patient. However, immediate loading of implants with a full-arch provisional fixed prosthesis remains controversial. The question "Does this revised protocol adversely affect successful long-term osseointegration?" must be addressed.

Several clinicians have reported on the survival of multiple dental implants placed into the edentulous arch and immediately loaded with a full-arch, provisional fixed prosthesis.[1–8] These studies have shown survival rates similar to those achieved with the unloaded protocol provided that the implants had no mobility after placement. Immediate loading of dental implants has the advantages of increased masticatory function, excellent stability of the interim prosthesis, minimization of uncontrolled transmu-

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cosal loading caused by a transitional full denture through cross-arch stabilization, and improvement of psychological well-being. In select cases, there is also the opportunity to enhance gingival contours that closely simulate natural dentition.[5,9] Immediate loading has also been found to preserve more pre-existing bone and stimulate bone remodeling.[10]

The purpose of this retrospective study was to analyze the factors that are most likely to predict a negative outcome for the use of the immediately loaded, provisional full-arch fixed prosthesis supported by multiple single-stage implants. Predictors of implant failure may assist the clinician in deciding the appropriateness of this treatment modality for the edentulous patient who desires an implant-supported, metal-ceramic fixed prosthesis.

MATERIALS AND METHODS

Since 1996, the author (RPK) has followed the protocol of same-day restoration of edentulous jaws with cross-arch stabilized, acrylic resin fixed provisional prostheses supported by multiple single-stage implants. Over an 8-year period (1996–2004), 56 consecutive full edentulous arches were restored with metal-ceramic fixed prostheses and monitored for a period of 2 to 10 years after implant placement. The potential risk factors evaluated were smoking, grafted bone, anterior versus posterior implant location, number of implants supporting the fixed interim prosthesis, length and diameter of the implant, age, gender, implant surface treatment, and the use of full-thickness flap reflection versus a modified tissue-punch technique to expose the osteotomy sites. Statistical significance was analyzed using both univariant and multivariant tests.

Immediate Loading Protocol

All patients were examined with panoramic radiography or computerized tomography as requested by the surgeon. A surgical guide was fabricated for proper implant placement. A single-stage, solid threaded implant (Straumann, Basel, Switzerland) was used throughout the study. Both titanium plasma-sprayed (TPS) and sandblasted, large-grit, acid-etched (SLA) surfaces were employed.

Prior to April 2000, the surgical protocol included the reflection of a full-thickness flap to expose the osteotomy sites. All of the TPS implants (n = 131) and 17 of the SLA implants (n = 213) were placed in this manner. Subsequent to this date, a modified tissue-punch technique was used to remove only the crestal gingiva coronal to the implant sites.[11] The rationale for this protocol was that it would reduce disruption of the blood supply and surgical trauma, reduce crestal alveolar bone loss, and preserve or enhance the soft tissue contours.[11–14] All of the implants that were immediately placed into function achieved primary stability, as defined by an insertion torque of at least 20 Ncm and the absence of clinically observable mobility. Solid abutments were used in all cases. The provisional fixed prosthesis was relined with an autopolymerizing acrylic resin and luted to the solid abutments with zinc phosphate cement. Regardless of the positions of the most distal abutments, none of the provisional prostheses had cantilever extensions to minimize nonaxial forces. The occlusal design employed was group function in lateral excursions and anterior disclusion in a protrusive mandibular movement. Steep cuspal inclines were avoided in favor of broad occlusal contacts to distribute forces over increased surface areas. The occlusion was evaluated after 24 hours and every 2 to 3 days until a stable maxillomandibular relationship was confirmed.

After a minimum of 3 months for the TPS surface or 6 weeks for the SLA surface, the provisional prosthesis was removed, and the solid abutments were tightened to the recommended torque of 35 Ncm. If this was not achieved, the implant was recorded as a failure and removed. Either another implant recipient site was chosen or, after 4 months of healing, a new implant was placed in the same location. None of the replacement implants was lost. Conventional techniques for the metal framework try-in and, if required, intraoral indexing with verification of the soldered framework accuracy were completed. All 56 dental arches were definitively restored with metal-ceramic fixed prostheses and cemented with a glass ionomer luting agent (GC Fuji Plus; GC Corporation, Tokyo, Japan) onto the solid abutments. Subsequent post-placement periapical radiographs over a 2- to 10-year follow-up revealed no atypical bone loss generally associated with a failing or ailing dental implant.

Research Data

From 1996 to 2004, 43 patients with 56 edentulous jaws were treated in a private practice by the same restorative dentist (RPK) and implant surgeon using 344 single-stage, solid-threaded TPS (n = 131) or SLA (n = 213) Straumann titanium implants (Table 1). There were 12 male patients (27.9%) and 31 female patients (72.1%), with a median and average age of 58 years (range, 35 to 80). Twelve patients were smokers (27.9%) who consumed a minimum of 20 cigarettes each day. Thirteen patients presented with combined maxillary and mandibular edentulism, and 30 patients had single edentulous arches opposing full or partial natural dentition that were restored with either implant-supported restorations or conventional removable partial dentures.

Table 1 Results of Implant Placement Using the Immediate Loading Protocol

Patient	Location (tooth no.)	Length and diameter*	Date loaded	Failures (site)
1	5,6,8,9,11,12	*10,14,12,12,14,12*	10/18/04	0
1	20,22,27,29	*12,14,14,10*	10/18/04	0
2	4,6,8,9,11,13	**8,10,10,10,8,8**	10/28/99	1 (4)
3	4,6,8,9,11,13	**6**,12+,12,12+,12+,**6**	7/23/98	0
3	20,21,23,27,28,29	8,10,12,12,10,12	8/6/98	0
4	4,6,8,9,11,13	**12,12**,12,12,**10,12**	10/9/03	0
5	3,6,8,9,11,14	*8*,14,10,10,12,*8*	4/23/04	2 (3,14)
6	4,6,8,9,11,13	**8**,10+,12,12,10+,**8**	11/16/97	0
7	4,6,9,11,13	*12*,**16**,14,**16**,*12*	9/4/03	0
8	20,21,23,27,28,29	**10**,12,12+,12+,12,**10**	3/17/98	0
9	5,6,8,11,12	*10*,14,10,**8**,*10*	4/12/01	2 (11,12)
10	4,5,6,11,12,13	**8,16**,14,14,**16,8**	8/4/03	0
11	4,5,6,7,9,10,12,13	**6**,12,12,10,12,12,10,**6**	2/10/97	0
11	20,21,22,27,28,29	10,10,14,14,10,10	2/10/97	0
12	4,5,6,7,10,11,12,13	**6**,8,12+,10,12,12+,**8,6**	1/2/98	1 (5)
12	19,20,21,23,28	10,12,14,16,16	7/17/96	1 (20)
13	20,22,24,27,29	*10*,**12,12,14**,*10*	6/7/01	0
14	5,6,8,9,11,12	**8,14**,14,14,**14,6+**	6/10/02	2 (5,12)
15	4,6,8,9,11,13	**12,14,12,12,14,12**	9/23/04	0
15	20,22,27,29	**12,12,10,10**	9/23/04	0
16	5,6,8,9,11,12	*8*,**16,12,12,10**,*8*	4/13/00	0
17	5,6,7,10,11,12	**8,14,12**,12,**12,6+**	2/23/04	0
17	20,22,27,29	*10*,**12,12**,*8*	2/23/04	0
18	4,5,6,7,10,11,12,13	**8,8,12**,12,**10,10,8,8**	7/30/98	0
19	5,6,8,9,11,12	**10**,*12*,**8**,*10*,*12*,**10**	12/28/00	0
20	4,6,8,9,11,13	*12*,16,14,14,14,*12*	4/23/04	0
21	3,4,5,6,8,9,11,12,13,14	**10**,10,12,14,**12,12**,14,14,12,**10**	5/6/99	0
21	20,22,27,29	*12*,**12,12**,*12*	5/6/99	0
22	4,6,8,9,11,13	**10,12,12,12,12,10**	10/27/04	0
22	19,20,22,27,29,30	*12*,**14,12,14,12**,*12*	10/27/04	0
23	21,24,26,28	**12**,12,14,12	8/9/99	0
24	20,21,22,27,28,29	**12,14,12,8,14,12**	5/30/02	0
25	4,6,8,9,11,13	**12,12,12,12,14,10**	8/16/01	0
26	4,5,6,7,8,9,10,11,12,13	**8,8**,12,10,10,10,10,12,8,**8**	1/3/96	0
26	21,22,24,26,27,28	**10,12**,12,10,**12,10**	1/3/96	0
27	3,4,5,6,11,12,13,14	*12*,**12,14,16,14,16,16**,*12*	7/28/03	2 (3,14)
28	3,5,6,8,9,11,12,14	*12,10*,14,14,14,14,*12,10*	3/31/04	0
29	5,6,7,10,11,12	12,14,14,14,14,14	7/3/96	0
30	5,6,8,9,11,12	**12,14**,12,12,**12,10**	8/23/03	2 (9,12)
31	5,6,8,9,11,12	*8,12*,12,12,*14,14*	5/21/01	1 (5)
31	20,21,22,27,28,29	*10*,**12,14,14,12**,*10*	5/21/01	0
32	4,6,8,11,13	*10*,**14,14**,14,*10*	2/20/03	0
33	4,5,9,11,13,14	*10*,**12**,10,**10**,*8,8*	6/1/00	0
34	4,6,8,9,11,13	*8*,**12,12,12,10**,*6+*	4/12/01	1 (13)
35	4,6,8,9,11,13	*12*,**16,14,14,16**,*10*	3/13/03	0
36	5,6,8,9,11,12	**8,16**,14,**14,16,6+**	10/27/03	1 (12)
36	20,22,27,29	*10*,**14,12**,*10*	10/27/03	0
37	4,6,8,9,11,13	*10*,14,14,14,14,*10*	5/17/01	0
38	3,4,5,6,8,9,11,12,13,14	**6,10,12**,14,**14,14**,14,**12,8,8**	4/23/98	0
38	19,20,21,24,26,28,29,30	**12,14,14**,14,14,14,**14,12**	4/23/98	0
39	4,5,6,8,9,11,12,13	**12**,16,16,12,10,14,14,8	3/10/99	0
39	20,22,24,27,29	12,14,12,12,**10**	3/17/99	0
40	4,6,8,9,11,13	*12*,**14,10,12**,12,*12*	8/26/04	0
41	3,4,5,8,9,13,14	**12,12,10,12,12,10,10**	1/31/00	0
42	4,6,8,9,11,13	**14**,16,16,16,16,**8**	6/29/00	0
43	5,6,9,11,12	12,**14,12,14,12**	6/7/99	0

All patients (n = 43) had Straumann single-stage, solid-screw implants (n = 344). The implants were placed in 56 fully edentulous jaws and loaded at the same appointment. Both TPS (n = 131) and SLA (n = 213) surfaces were used. Diameters of 3.3 mm (n = 120), 4.1 (n = 166), or 4.8 mm (n = 58) were used.***Bold** font denotes a diameter of 4.1 mm, *italic* font denotes a diameter or 4.8 mm, and normal font denotes a diameter of 3.3 mm. The universal tooth numbering system was used. The symbol "+" represents Esthetic Plus implants, which have a roughened surface length of an additional 1 mm coronal to the rough-smooth interface. This has the effect of an additional 1 mm placed into bone.

Table 2 Characteristics and Statistical Relevance of Failed Implants—Implant Specific

		Failures		
	Implants (n)	n	%	*P*
Surface				
TPS	131	2	1.5	.03
SLA	213	14	6.6	
Location				
Anterior	182	4	2.2	.001
Posterior	162	12	7.4	
Diameter (mm)				
3.3	120	3	2.5	.02
4.1	166	5	3.0	
4.8	58	7	12.1	
Length (mm)				
6/6+	11	4	36.4	< .001
8	37	7	18.9	
10	72	2	2.8	
12	126	3	2.4	
14	77	0	0	
16	21	0	0	
Jaw				
Maxilla	261	15	5.7	.13
Mandible	83	1	1.2	
Implants per arch				
4	24 (0/6)	0	0	.61
5	35 (4/3)	2	6.9	
6	192 (25/7)	11	5.7	
7	7 (1/0)	0	0	
8	56 (6/1)	3	5.4	
10	30 (3/0)	0	0	
Surgical technique				
Full flap	148	3	2.0	.07
Tissue punch	196	13	6.6	

The implants ranged in length from 6 to 16 mm, with diameters of 3.3 mm (n = 120), 4.1 mm (n = 160), or 4.8 mm (n = 58). Thirteen implants were EstheticPlus (Straumann). These implants were identical to the standard-design Straumann implant except for an additional 1 mm of roughened surface coronal to the rough-smooth interface. Therefore, the effective length of the implant surface in bone was increased by 1 mm.

The definitive metal-ceramic fixed prostheses consisted of 10 to 12 dental units and were supported by 4 to 10 implants (mandibular arch only), with 6 implants being the most frequent (60.7%). Thirteen prostheses had single molar pontic distal extensions of approximately 11 mm, which represents the average mesial-distal dimension of a first molar.

A number of variables that may have an influence on the survival or failure of immediately loaded, full-arch prostheses were recorded. These included smoking, the presence of grafted bone, placement in the maxilla versus the mandible, the use of a TPS surface versus an SLA surface, anterior versus posterior implant location, surgical technique (full flap/tissue punch), diameter and length of implant, age, gender, and the number of implants supporting the fixed prosthesis (Tables 2 and 3). All bone grafting procedures were limited to autogenous cranial bone, with implants placed approximately 5 to 6 months later. An additional 4 weeks were added to the manufacturer's recommendation for osseointegration prior to definitive fabrication of the metal-ceramic prosthesis. In no case were simultaneous augmentation combined with placement of immediately loaded implants.

Statistical Methods

An analysis was undertaken to characterize both patient-specific and implant-specific failure and to determine the variables that might significantly predict failure. The purpose in dividing the statistical analysis into 2 parts was to separate these factors in order to reliably interpret the possible predictors of failure in each population. Without any patient-specific factors present in the implant-specific analysis, the implant was used as the unit of analysis under the assumption of statistical independence among implants. However, this assumption cannot be tested, and the results must be interpreted with caution.

The following characteristics were considered possible predictors of patient-specific failure: gender, age (≤ 59 years versus > 60 years), smoking status, the presence of grafted bone, and posterior location of implants. Implant location was classified as maxilla only, mandible only, or both dental arches in a single patient. Implant-specific characteristics that were analyzed included surface treatment, anterior or posterior location in the dental arch, diameter, length, jaw (maxilla or mandible), and surgical technique (eg, full-flap reflection or flapless tissue punch).

For the purpose of this analysis, patients were deemed failures if they had at least 1 implant failure. The dataset contains characteristics that were measured once for each implant (Table 2) and once for each patient (Table 3). The implant-specific and patient-specific variables could not be combined in the same analysis, since the unit of measurement of each was different. SAS version 8.0 (SAS Institute, Cary, NC) was used for the statistical evaluations. A significance criterion of $P = .05$ was utilized. Failure rates were tabulated as counts and percentages. Univariate tests for failure rates as a function of age, gender, smoking, bone grafting, dental arch, surface type, anterior versus posterior placement, number of implants per arch, and surgical technique were made using Fisher exact tests. The Cochran-Armitage test for trend was used to evaluate the presence of a linear trend in failure rates regarding implant length and implant diameter. Logistic regression modeling was used to determine which, if any, of the aforementioned factors would predict patient or implant failure.

Table 3 Characteristics and Statistical Relevance of Failed Implants—Patient-Specific and Implant-Specific

		Failures*				Failures*	
	Patients (n)	n	%	*P*	Implants (n)	n	%
Smoking status							
Smokers†	12	5	41.7	0.111	95	7	7.4
Nonsmokers	31	5	16.1		249	9	3.6
Presence of grafted bone							
Yes	2	1	50.0	0.415	14	2	14.3
No	41	9	22.0		330	14	4.2
Jaw							
Maxilla only	26	7	26.9	0.735	158	12	7.6
Mandible only	4	0	0		21	0	0
Both	13	3	23.1		165	4	2.4
Age							
≤ 59 years old	12	6	7.3	0.721	164	8	4.9
> 60 years old	31	4	19.1		180	8	4.4
Gender							
Male	12	5	41.7	0.111	110	8	7.3
Female	31	5	16.1		234	8	3.4

*All failures occurred prior to fabrication of the definitive fixed prosthesis. For the purposes of this study, a patient failure was considered the failure of at least 1 implant.
†All smokers smoked at least 20 cigarettes per day.

RESULTS

In all cases, the loading period followed the protocol recommended by the manufacturer, that is, 3 months for the TPS surface and 6 weeks for the SLA surface. Thirty-nine maxillary jaws received 261 implants, of which 246 (94.3%) survived, and 17 mandibular jaws received 83 implants, with 82 (98.8%) surviving (Table 2). In total, there were 10 patient failures out of 43 patients in this study and 16 implant failures out of a total of 344 implants. Although the 10 patient failures constituted a small dataset, the analyses were intended to be exploratory and offer insight into factors that might determine failure on the patient level. The absence of statistical significance for any of these factors should not interpreted as a lack of association; it only reflects the available data.

There were no statistically significant differences in failure rates between male and female patients ($P = .111$), between patients less than or equal to 59 years old and those at least 60 years of age ($P = .721$), among smokers compared to nonsmokers ($P = .111$), or in grafted bone compared with native bone ($P = .415$). There were no statistically significant differences in failure rates among patients with implants placed in the maxilla only, those with implants placed in the mandible only, and those with implants in both jaws ($P = .735$). Additionally, logistic regression modeling was used to determine which, if any, patient-specific parameters would predict failure. None of these variables was found to be a statistically significant predictor of patient failure.

Among the implant-specific variables analyzed, jaw (maxilla versus mandible), number of implants supporting the fixed prosthesis, and surgical technique did not show statistically significant differences in failure rates. However, there were significantly higher rates of failure for implants placed in the posterior quadrant of the jaw ($P = .001$), decreased implant length ($P < .001$), increased diameter ($P = .02$), and the SLA surface ($P = .03$).

The following implant-specific variables were entered into a separate logistic regression model to predict implant failure under the assumption that implants were statistically independent from 1 another: implant length, diameter, number of implants per arch, surface type, location of the implant (maxilla versus mandible), and implant location (posterior versus anterior). Type of surgical technique (full flap versus tissue punch) was also entered into this model to examine any possible effect on implant failure. In a backward logistic regression model, all variables were eliminated with the exception of implant length and surface type.

The transition from the TPS to the SLA surface occurred shortly after the introduction of the SLA surface by the manufacturer in early 2000. It was known a priori that type of surface used and surgical technique were confounded; the TPS implants were all placed with full-flap reflection, whereas only 17 SLA surface implants were placed using this surgical technique.

Therefore, the predictors of failure were examined in 2 ways. First, the surface type and the remaining main effects were placed into a backwards logistic regression

Table 4 Failure Comparison of Implant Surface and Surgical Technique

Surgical technique	TPS	SLA	Total
Full flap	131 (2)	17 (1)	148 (3)
Tissue punch	0 (0)	196 (13)	196 (13)
Total	131 (2)	213 (14)	344 (16)

Number of implants is shown, with the number of failures shown in parentheses. Virtually all of the failures occurred in major diagonal cells (ie, in implants that had both of the variables in question or neither of them). Thus, the interaction term could not be estimated.

Table 5 Immediately Loaded Implants by Diameter and Length

Diameter (mm)/ length (mm)	Implants (n)	Failures n	Failures %	*P*
3.3				
6	0	0	0	.08
8	4	1	25.0	
10	23	0	0	
12	44	1	2.3	
14	40	0	0	
16	9	0	0	
4.1				
6	10	2	20.0	< .001
8	24	3	12.5	
10	29	1	3.5	
12	59	0	0	
14	31	0	0	
16	12	0	0	
4.8				
6	1	1	100.0	.01
8	9	3	33.3	
10	20	1	5.0	
12	24	2	8.3	
14	6	0	0	
16	0	0	0	

model. Only length and surface type emerged as statistically significant. The analysis was repeated with surgery technique and the remaining main effects (except for the surface type). Surgical technique and length were found to be significant. This confirmed the assumption that surface type and surgical technique were confounded. The significant effects only (surface type, length, and surgical technique) were included together, with the interaction between surface type and surgical technique into a separate logistic regression model.

Only smaller implant length emerged statistically significant from this latter analysis ($P < .001$); both surface type and surgical technique were insignificant. In addition, the interaction term was not estimable because of the pattern of failures in the groups of implants that had TPS and full flap or neither TPS nor full flap (Table 4).

A Cochran-Armitage trend test was used to determine whether consistent increases in implant diameter and length yielded a corresponding significant change in failure rates. Failure rates were found to significantly increase with increasing implant diameter ($P = .02$), whereas they significantly decreased with increasing length ($P < .001$). However, it should be noted that a preponderance of large-diameter implants was also short, which affirms the influence of implant length upon success. Table 5 shows the differences in failure rates among the implants of specific lengths and diameters.

No patient-specific characteristics were found to predict patient failure. Among the implant-specific variables, there was a significant increase in failure rate with implants placed into the posterior segment of the dental arch, shorter implant lengths, wider implant diameters, and surface treatment. The apparent negative effects of implant diameter were influenced by the decision to use wider implants in areas that could not accommodate longer implants. Of the implants measuring 8 mm in length or less (n = 48), only 4 (8.3%) were 3.3 mm in diameter, in contrast to 34 (70.8%) that were 4.1 mm and 10 (20.9%) that were 4.8 mm in diameter (Table 5). Also, the influence of implant surface was confounded by the timing of the use of flapless tissue-punch surgery. When logistic regression was carried out on the implant variables, only shorter implants emerged as a predictor of failure.

DISCUSSION

In this study, the immediate loading of dental implants was examined in 56 edentulous arches of 43 patients. The maxillary arches received 261 implants, of which 15 failed, for a survival rate of 94.3%. The mandibular arches received 83 implants, with 1 failure, for a survival rate of 98.8%. These survival rates are similar to those reported by Grunder[6] and Degidi et al.[7,8]

A variable that confounded the apparent significance of the surface treatment was the transition from a full-flap reflection of the alveolar bone to a flapless modified tissue-punch surgical technique[11] prior to the implant osteotomy. All TPS (n = 131) and 17 SLA implants were placed using full-flap reflection, while only SLA implants (n = 196) were placed with the flapless technique.

The advantages of the tissue-punch protocol include maintenance or enhancement of the soft tissue contours, reduction of alveolar bone resorption secondary to full-thickness reflection with disruption of blood flow, and reduced surgical trauma and postoperative pain. However, there are increased challenges inherent in the flapless technique caused by impaired visualization of the alveolar ridge. Dehiscence and fenestrations are less apparent due to the "blindness" of the procedure. Preoperative 3-dimensional radiographic and clinical evaluations are important to avoid these complications. Surgical expertise and experience also must be considered carefully when planning such a procedure.

Campelo and Camara[14] reported that fenestrations occurred with 2.73% of their sample and dehiscence with 2% using the flapless surgical procedure. During the 10-year study period, there was an initial high failure rate that declined significantly as experience increased; this change was attributed to a learning curve and patient selection. The authors concluded that the technique required surgical care and stressed the importance of drill angulation to avoid perforation of the cortical plates.

A similar correlation with potential complications inherent in the flapless technique was also observed in this study. Table 6 shows a general increase in success as the surgeon gained experience. The failure rate was 8.4% for the first 95 implants placed in this manner versus a 4.9% failure rate over the following 101 implants. Furthermore, in the last year of the study, the percentage of failures was reduced to 2.9% of the 68 implants placed. No similar pattern was found using full-thickness tissue reflection.

Unfortunately, the timing of the surgical protocol change corresponds to the introduction of the SLA surface. This serves to confound the statistical relevance of both the change in implant surface and the change in surgical technique. As there are no reports in the literature to indicate that the SLA surface has been less successful than the original TPS surface, it seems more likely that the tissue-punch surgical protocol influenced the failure rate. Data from additional patients treated in the same manner may shed light on this issue; data collection is continuing.

The dilemma for the surgeon is whether to sacrifice crestal bone, disrupt the normal blood flow, and risk loss of optimal soft tissue contours inherent in the full-thickness flap reflection or accept the risk of dehiscence and fenestration during flapless implant placement. It appears possible to decrease the risk of potential complications of flapless implant placement with experience.

However, it may be possible to decrease the incidence of complications with experience. The prudent clinician should consider the advantages of the modified punch technique in the fully edentulous arch with optimal soft tissue contour. These include increasing the facial attached gingiva, maintenance of the proximal papilla and alveolar crestal cortical bone, minimization of surgical trauma and postoperative discomfort, and favorable patient acceptance. Advances in digital radiographic imaging and computer-aided reformatting allows "virtual" placement of implants prior to treatment. This information can guide the clinician during the flapless surgery and minimize the inherent complications of this technique.

Table 6 Distribution of Implant Failure Using the Flapless Tissue-Punch Technique by Year

	2000–2003	2003–2004	2004
Implants (n)	95	101	68
Failures* (n)	8 (8.4)	5 (5.0)	2 (2.9)
Patients (n)	4	6	7

*Percentage shown in parentheses.

Previous researchers have reported prognostic risk factors, including placement in maxillary bone, tobacco use, implant length, implant location (eg, posterior), previous history of endodontic treatment in the recipient site, treatment protocol, and immediate placement of the implant.[15–24] In a statistical evaluation of 487 Brånemark implants, Herrmann et al[23] recently reviewed a compilation of 4 multicenter studies using 1 specific implant in single-tooth restoration, partial edentulism, full edentulism restored with overdentures, and full edentulism restored with fixed prostheses. The authors determined that the major predictors of implant failure in these applications were jawbone quality and shape in addition to short implant lengths.

Clinicians are equivocal regarding the minimum number of implants required to support a fixed prosthesis. In this report, a range of 4 to 10 implants was used, with a decrease in numbers occurring over time. There were no significant differences in failure rate related to the number of supporting implants. The most frequent arrangement was 6 implants in the maxilla and 4 implants in the mandible supporting a 10-unit fixed prosthesis. This configuration is a more cost-effective treatment approach for edentulous patients who desire fixed restorations.

This study is limited solely to immediate loading of multiple implants of 1 design from a single manufacturer placed into fully edentulous arches using cross-arch stabilized provisional fixed prostheses. It initially appeared that smoking, grafted bone recipient sites, and maxillary bone are predictors of higher failure rates. Logistic regression analysis revealed that these factors were not significant, which conflicts with other reports.[15–21] However, shorter implants were found to be associated with increased failure rate, a finding confirmed by many other clinicians.[16,19–24]

CONCLUSION

Statistical analysis using Fisher exact tests and logistic regression in this retrospective study of 56 edentulous arches restored with 344 immediately loaded Straumann single-stage implants indicated that decreased implant length is a significant predictor of failure. Although the SLA surface initially was shown to be a significant predictor of failure, the tissue-punch surgery was a confounding factor. A subsequent logistic-regression model resulted in absence of statistical significance for both surface type and surgical technique. As this study confirmed that implant length continues to be a factor in the successful integration of dental implants, it would be appropriate to inform patients who are contemplating full-arch, immediately loaded fixed implant restorations that short implant lengths are associated with increased failure.

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