THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL RESEARCH

Risk factors associated with early implant failure: A 5-year retrospective clinical study

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ABSTRACT

Statement of problem. The replacement of lost teeth with dental implants is a widespread treatment whose associated problems are also frequently encountered. Nevertheless, the factors associated with early implant failure have not been well documented. Further analyses of the factors influencing osseointegration establishment are required to maximize the predictability of the procedure and minimize implant failures.

Purpose. The purpose of this retrospective clinical study was to explore the association between possible risk factors and early implant failure.

Material and methods. This retrospective clinical study evaluated 142 participants who received 276 external connection BTI implants between 2007 and 2011. Participant variables (age, sex, systemic disease, tobacco use, alcohol consumption, bruxism, and degree of periodontal disease), implant variables (type of edentulism, localization, area, diameter, length, and bone quality), intervention variables (expansion mechanisms, sinus augmentation techniques, bone regeneration, and implant insertion), and postoperative variables (presence of pain/inflammation at 1 week postsurgery) were studied. A multilevel logistic regression model (mixed effects-type model) was used to determine the influence of variables on early implant failure.

Results. Early implant failure was significantly associated with the male sex (P=.001), severe periodontal disease (P=.005), short implants (P=.001), expansion technique (P=.002), and postoperative pain/inflammation at 1 week postsurgery (P<.001).

Conclusions. Early dental implant failure is more frequent in men and in individuals with severe periodontal disease, short implants, pain/inflammation at 1 week postsurgery, or bone expansion treatment. (J Prosthet Dent 2016;115:150-155)

Osseointegration was originally defined as the direct, structural, and functional connection between the vital bone and the implant surface under a functional load.[1] Albrektsson et al[2] then published a new concept based on the direct anchorage of the implant, defining osseointegration as bone tissue formation with no fibrotic tissue growth at the bone-implant interface as primarily a biomechanical union. Osseointegration is currently considered to be a firm, stable, and long-lasting connection between the implant and periimplant bone tissue[3] and is essential for implant survival. If osseointegration does not take place, the result is biological failure and consequent implant loss.

Rehabilitation with implants has proven predictable and reliable in numerous studies,[4-7] but a small percentage of failed implants remains. Their study requires differentiating between early failures before prosthetic loading (failure to develop osseointegration) and late failures after prosthetic loading (failure in osseointegration maintenance). Early failures are frequently associated with a disruption during the initial phase that leaves fibrous scar tissue between the implant surface and the surrounding bone,[8] while late failures are influenced by multiple factors, including the microbial environment and the prosthetic rehabilitation.[9]

Despite the higher incidence of early failure, most studies have addressed the success of implantation after

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Clinical Implications

Clinicians should be aware of increased risks when placing dental implants in men and those with severe periodontal disease or when using short implants and bone expansion treatment.

prosthetic loading, limiting knowledge of the causes and mechanisms of preloading failures.[10] To date, researchers have associated early implant failure with age,[11] sex, tobacco use,[12,13] type of edentulism, bone quality and volume,[11] implant localization, diameter, and length,[14,15] immune factors, and systemic diseases,[16] among other variables.[10,17-25]

The objective of this study was to explore the association between early implant failure and possible risk factors, including those related to the participant, implant, surgery, and postoperative symptoms, supporting action to improve the likelihood of implant success.

MATERIAL AND METHODS

This retrospective study included 142 consecutive participants receiving external connection self-tapping BTI implants with a bioactive surface (Biotechnology Institute) between 2008 and 2011 in a private dental office in Granada, Spain—276 implants in all. Approval for the study was obtained from the ethical committee of the University of Granada (ref. 635). All participants had signed their informed consent to the implant treatment. General exclusion criteria were implantation at a site of previous implant failure; immediate prosthetic loading of the implant; treatment of the patient with bisphosphonates, chronic antibiotic or corticosteroid therapy, radiotherapy, and/or chemotherapy; and the presence of leukocyte dysfunction or deficiency.

All participants had undergone a preliminary evaluation that included clinical and radiographic examinations, a review of their medical and dental histories, and an assessment of their oral hygiene and commitment to oral hygiene practices and long-term follow-up. A diagnostic evaluation was performed, using cone beam computed tomography, diagnostic casts, and photographs to evaluate the volume and location of available bone in relation to the participant's prosthodontic needs. Based on these data, diagnostic casts were fabricated and mounted on semiadjustable articulators with a facebow transfer, and vertical dimensions were recorded to determine the jaw relationships, available interocclusal rest distance, proposed implant positions, crown-implant ratio, and potential complications. Treatment plans had been developed to meet the functional and esthetic needs of participants. The diagnostic casts were used to create wax patterns and surgical templates to guide implant placement in relation to the planned prosthesis. Treatment plans and alternative options had been discussed with the participants.

Participants had been instructed to rinse with chlorhexidine digluconate for 2 minutes before the surgery and daily for 15 postoperative days. The administration of amoxicillin and clavulanic acid (Augmentin; GSK) as antimicrobial prophylaxis began at 2 hours before surgery and continued for 7 days. All participants had received periodontal treatment before the implantation. Participants had been anesthetized by local infiltration in the maxilla or inferior alveolar block in the mandible. Surgical incisions and flap elevations were performed conservatively to preserve the periosteal vascular supply. Osteotomies were prepared with the aid of a surgical template and using a series of internally irrigated surgical drills with graduated diameters. When required, bone was regenerated by using autogenous bone harvested from the implant drilling mixed with a xenograft (Bio-Oss; Geistlich AG), which was covered with a resorbable barrier membrane (Bio-Gide; Geistlich AG). All implants were placed by a single dental surgeon (M.V.O.G.) in accordance with the manufacturer's instructions.

Study variables were classified as predictor variables and outcome variables.[17] Predictor variables were divided among those related to the participant, the implant, the surgery, and postoperative symptoms. Participant-related variables were age, sex, the presence of systemic disease (yes/no, recording the disease), tobacco use (nonsmoker/smoker), alcohol consumption (yes=daily/no=sporadically or never), bruxism (absent, mild [slight wear of anterior teeth], moderate [major wear of anterior teeth], or severe [anterior guide disappears and there is posterior wear]),[18] and degree of periodontal disease, defined by the percentage of sites with attachment loss greater than 3 mm and categorized as absent (0%), medium (0-32%), moderate (33%-66%), or severe (67%-100%).[19]

Implant-related variables were type of edentulism (complete, presence of teeth in antagonist arch, presence of teeth in same arch not adjacent to the implant, and presence of teeth adjacent to the implant),[20,21] implant site (maxillary/mandibular), area (anterosuperior, posterosuperior, anteroinferior, or posteroinferior), implant diameter (narrow [2.5 mm, 3 mm, or 3.3 mm], standard [3.75 mm or 4 mm], or wide [4.5 mm or 5 mm]), length (short [7 mm, 7.5 mm, 8.5 mm], standard [10 mm or 11.5 mm], or long [13 mm or 15 mm]), and bone quality type I, II, III, or IV according to anatomic criteria and resistance to drilling during implant bed preparation, as proposed by Lekholm and Zarb.[22]

Surgical variables were the use of expansion techniques (no, yes), sinus augmentation (no, atraumatic,

Table 1. Description of participants (n=142) with implants (n=276)

Participants (n=142)		Participants with Implants (n=276)					
		Implants		Surgical		Postoperative	
Variable	**n (%)**	**Variable**	**n (%)**	**Variable**	**n (%)**	**Variable**	**n (%)**
Age (y)[a]		Edentulism type		Expansion techniques[b]		Pain/inflammation at 1 wk postsurgery	
≤ 40	35 (24.65)	Complete	7 (2.54)	No	218 (78.99)	No	256 (92.75)
41-60	80 (56.34)	Presence of teeth in antagonist arch	18 (6.52)	Yes	58 (21.01)	Yes	20 (7.25)
> 60	27 (19.01)	Presence of teeth in the same arch	46 (16.67)	Sinus augmentation			
Sex		Presence of teeth in the same arch adjacent to the implant	205 (74.28)	No	254 (92.03)		
Female	90 (63.38)	Localization		Atraumatic	18 (6.52)		
Male	52 (36.62)	Maxillary	156 (56.52)	Conventional	4 (1.45)		
Systemic disease		Mandibular	120 (43.58)	Regeneration			
No	83 (58.45)	Area		No	249 (90.22)		
Yes	59 (41.55)	Anterosuperior	43 (15.58)	Yes	27 (9.78)		
Periodontal disease		Posterosuperior	112 (40.58)	Implant placement			
No	62 (43.66)	Anteroinferior	16 (5.80)	Motor	159 (57.61)		
Slight	26 (18.31)	Posteroinferior	105 (38.04)	Motor+torque ratchet	117 (42.39)		
Moderate	31 (21.83)	Implant diameter					
Severe	23 (16.20)	Narrow	44 (15.94)				
Tobacco use		Standard	198 (71.74)				
No	105 (73.94)	Wide	34 (12.32)				
Yes	37 (26.06)	Implant length					
Alcohol consumption		Short	16 (5.80)				
No	139 (97.89)	Standard	189 (68.48)				
Yes	3 (2.11)	Long	71 (25.72)				
Bruxism		Bone quality					
No	76 (53.52)	Type I	22 (7.97)				
Slight	38 (26.76)	Type II	91 (32.97)				
Moderate	19 (13.38)	Type III	136 (49.28)				
Severe	9 (6.34)	Type IV	27 (9.78)				

[a]Mean ±standard deviation = 48.49 ±12.1.
[b]Bone-condensing technique.

conventional), bone regeneration (yes/no), and motor alone or motor with torque wrench for the final implant placement. The postoperative variable was the presence of pain/inflammation at 1 week postsurgery (yes/no). The outcome variable was early implant failure (implant loss before prosthetic loading; yes/no). For all categorical variables, the first category was used as the reference category.

The statistical tests used are described in the table footnotes. SPSS v22.0 for Windows (SPSS Inc) was used for the descriptive analysis (percentages, means with standard deviation), and STATA 12.0 (StataCorp LP) was used to account for the clustering (multiple implants, n=276, in participants, n=142). A multilevel logistic regression model (mixed effects-type model) was constructed that included all study variables as potential predictors and the participants as the random effects factor; following a backward stepwise procedure and including variables with a significance below 5%. Interactions between variables that were found to be significant were tested in the regression model, but none showed significance ($P<.10$), which can be attributed to the small number of failures; for this reason, significance values were not included in the model.

RESULTS

The study sample comprised 276 implants placed in 142 participants during a 5-year period; 16 of these failed before prosthetic loading, an early failure rate of 5.79%. The mean age of the participants was 48.49 ±12.14 years (range 20-78 years), 52 (36.62%) were men, and 90 (63.38%) were women; 41.55% had systemic disease, 26.06% were smokers, 2.11% consumed alcohol, 46.48% were bruxers, and 56.34% had periodontal disease. Results for the remaining study variables are included in Table 1.

In the bivariate analyses, a significant association was found between early implant failure and sex (P=.038), periodontal disease (P=.007), implant length ($P<.001$), bone quality (P=.029), expansion technique application (P=.003), and presence of pain/inflammation at 1 week after surgery ($P<.001$). The association with smoking was

Table 2. Bivariate associations between study variables and early implant failure (N=276)

Variable	Implant Success (%)[a]	Early Failure (%)[b]	P
Participants			
Age (y)			.34
≤ 40	52 (98.11)	1 (1.89)	
41-60	144 (92.31)	12 (7.69)	
> 60	64 (95.52)	3 (4.48)	
Sex			.038
Female	165 (95.38)	8 (4.62)	
Male	95 (92.23)	8 (7.77)	
Systemic disease			.63
No	144 (93.51)	10 (6.49)	
Yes	116 (95.08)	6 (4.92)	
Periodontal disease			.007
No	109 (99.09)	1 (0.91)	
Slight	44 (93.62)	3 (6.38)	
Moderate	55 (98.21)	1 (1.79)	
Severe	52 (82.54)	11 (17.46)	
Tobacco use			.06
No	189 (96.43)	7 (3.57)	
Yes	71 (88.75)	9 (11.25)	
Bruxism			.99
No	143 (93.46)	10 (6.54)	
Slight	68 (93.15)	5 (6.85)	
Moderate	34 (100)	0 (0)	
Severe	15 (93.75)	1 (6.25)	
Implant variables			
Edentulism type			.45
Complete	7 (100)	0 (0)	
Presence of teeth in antagonist arch	15 (83.33)	3 (16.67)	
Presence of teeth in same arch	44 (95.65)	2 (4.35)	
Presence of teeth in same arch adjacent to the implant	194 (94.63)	11 (5.37)	
Localization			.23
Maxillary	144 (92.31)	12 (7.69)	
Mandibular	116 (96.67)	4 (3.33)	
Area			.44
Anterosuperior	38 (88.37)	5 (11.63)	
Posterosuperior	105 (93.75)	7 (6.25)	
Anteroinferior	16 (100)	0 (0)	
Posteroinferior	101 (96.19)	4 (3.81)	
Implant diameter			.33
Narrow	40 (90.91)	4 (9.09)	
Standard	189 (95.45)	9 (4.55)	
Wide	31 (91.18)	3 (8.82)	
Implant length			<.001
Short	11 (68.75)	5 (31.25)	
Standard	181 (95.77)	8 (4.23)	
Long	68 (95.77)	3 (4.23)	
Bone quality			.03
Type I	21 (95.45)	1 (4.55)	
Type II	83 (91.21)	8 (8.79)	
Type III	133 (97.79)	3 (2.21)	
Type IV	23 (85.19)	4 (14.81)	
Surgical variables			
Expansion techniques			.004
No	211 (96.79)	7 (3.21)	
Yes	49 (84.48)	9 (15.52)	
Sinus augmentation			.14
No	241 (94.88)	13 (5.12)	
Atraumatic	16 (88.89)	2 (11.11)	
Conventional	3 (75)	1 (25)	
Regeneration			.19
No	236 (94.78)	13 (5.22)	
Yes	24 (88.89)	3 (11.11)	
Implant placement			.69
Motor	149 (93.71)	10 (6.29)	
Motor+torque ratchet	111 (94.87)	6 (5.13)	
Postoperative variable			
Pain/inflammation at 1 wk postsurgery			<.001
No	246 (96.09)	10 (3.91)	
Yes	14 (70)	6 (30)	

(continued on next column)

[a]Number of successful implants (percentage).
[b]Number of early-failed implants (percentage).

close to significant (P=.062). No other study variable was significantly related to implant failure (Table 2).

The significant variables listed above were entered into the multivariate model (Table 3), in which the male sex (P=.001), severe periodontal disease (P=.005), short implants (P=.001), bone expansion (P=.002), and the presence of pain/inflammation at 1 week (P<.001) retained their significant effect, which was no longer observed for bone quality (P=.23). The odds ratios may be overestimated because of the small percentage of failures, although odds ratios strongly indicate the effect of the different factors but not of its size.

DISCUSSION

A significantly higher risk of early implant failure was found in men than in women (P=.001), in line with the findings by Sverzut et al[12] of a 1.255-fold higher risk in men. This may be attributable to the more frequent tobacco consumption among men, although this variable was not deemed significant in the study by Sverzut et al[12] or in the present investigation. In contrast, Manor et al[9] reported a higher risk in young women than in young men, and other studies found no relationship between sex and early implant failure.[13,20,23]

In the present study, the risk of early implant failure was significantly higher (P=.005) in the participants with advanced or severe periodontal disease than in those with no or less severe periodontal disease, in agreement with reports by Safii et al[25] and Koldsland et al.[6] Numerous authors have shown periodontal disease to be a risk factor in implant therapy, but further research is required on its relationship with early implant failure.

Table 3. Multilevel logistic regression model for early implant failure (N= 276)

Variable	Odds Ratio (95% CI)	P
Sex male (female as reference)	24.56 (3.49-173.02)	.001
Periodontal disease (no as reference)		
Slight	39.81 (0.06-24634.63)	.259
Moderate	0.57 (0.002-133.58)	.838
Severe	1442,48 (9.11-228284.8)	.005
Bone quality	0.35 (0.06-1.95)	.23
Expansion yes (no as reference)	63.98 (4.66-877.94)	.002
Short implants (standard as reference)	40.04 (4.49-356.72)	.001
Pain/inflammation at 1 wk postsurgery (no as reference)	336.98 (21.38-5311.95)	<.001

CI, confidence interval. Variables with P values <.05 were included in backward stepwise model (see statistical analysis).

In the present study, the risk of early implant failure was higher in participants treated with short implants (P=.001) than in those receiving standard or long implants. No association was observed between implant diameter and early failure. In this sense, Alsaadi et al[20] associated both shorter length (<10 mm) and larger diameter (5 mm) with higher failure risk, and Noguerol et al[11] reported a higher frequency of early failure in implants shorter than 15 mm and with a diameter larger than 4 mm. More recently, early loss has been associated with short implants by Olate et al[14] and with narrow implants by Baqain et al.[15]

Although implants in type IV bone were associated with early implant failure in the bivariate analysis, the significance of the bone quality variable was lost in the multivariate analysis. Various studies have considered poor bone quality to be a predisposing factor for early implant failure,[11,20,23] although Alsaadi et al[21] also found that poor quality bone had no effect on the early implant failure rate.

Multivariate analysis showed that the risk of early failure was significantly higher in participants who received expansion treatment than in those who did not (P=.002). Huynh-Ba et al[24] reported that the risk of early implant failure is not modified by sinus augmentation but is increased with complications during surgery. In a retrospective cohort study of 5787 BTI dental implants, the same type as used in our study, Anitua et al[5] described a 2.5-fold higher implant failure risk with the use of techniques such as sinus augmentation, bone expansion, and bone graft treatment.

We could find no published data on the relationship between implant loss and pain/inflammation at 1 week after surgery, which was 1 of the variables most strongly associated with implant failure in the present investigation (P<.001). Therefore, further evaluation of this association is warranted.

In this study of early implant failure, no association was found with the age of the participants, as reported by most studies,[18,20,23] although Noguerol et al[11] reported a higher failure rate in patients aged between 41 and 60 years than in those older than 60 years, concluding that advanced age is not a disadvantage in implant treatment.

Tobacco use was more frequent in men, and the presence of the sex variable in our multivariate analysis would account for the loss of significance for this variable, which showed a borderline significant relationship with early implant failure in the bivariate analysis (P=.62). Although Sverzut et al[12] claimed that tobacco use per se could not be considered a risk factor, numerous studies have related smoking to early implant failure.[5-7,11,20,23,24] A higher tendency was found toward early implant failure in smokers than in nonsmokers, as also concluded by Bornstein et al[13] and Alsaadi et al.[21]

No association was found between early implant failure and the presence of systematic disease in our participants. A retrospective study by Alsaadi et al[20] reported a tendency toward early implant failure in patients with Crohn's disease and osteoporosis and also, in a later study,[21] with type 1 diabetes, radical hysterectomy, and gastric disorders. However, Bornstein et al[13] found that evidence supporting the relative or absolute contraindication of implantation in patients with systemic disease was weak.

In addition, no association was found between type of edentulism and early implant failure, whereas Alsaadi et al[20,21] observed a significant failure increase in implants with the presence versus absence of adjacent teeth. The mandibular or maxillary localization was not related to early implant failure in our participants, in contrast to some previous findings of a 3-fold higher failure rate in maxillary sites[4] and, within the maxilla, of a higher tendency for failure in the posterior area.[23] Alsaadi et al[20] initially reported that failure was more frequent in the posterior mandible and maxilla than in the anterior mandible, but they found no association between implant localization and early implant failure in a subsequent study,[21] in agreement with the present findings.

The low percentage of implant failures in this series (5.79%) means that some of the elevated odds ratios calculated are overestimated and cannot be considered as nonbiased estimations but rather as indications of a significant and undeniable effect.

CONCLUSION

Within the limits of a retrospective study of implants of a specific type applied by a single surgeon, this report shows that the risk of early implant failure is higher in men, participants with severe periodontal disease or short implants, participants treated with bone expansion techniques, and those with pain/inflammation at 1 week after surgery. More studies are required to establish whether these results can be generalized for other implant systems and to explore the role of other patient-related variables. Further research is warranted to analyze the factors that influence osseointegration establishment to maximize the predictability of the procedure and minimize implant failures.

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