RISK FACTORS ASSOCIATED WITH EARLY DENTAL IMPLANT FAILURES IN PRINCE RASHID BIN AL-HASSAN MILITARY HOSPITAL

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ABSTRACT

Background: Dental implant failure can be defined as the lack of ability of tissue to establish or maintain bone integration. Previous studies have highlighted various risk factors associated with the occurrence of early implant failure. The aim of this study is to evaluate the association between multiple risk factors with early dental implant failure in the dental implant clinic in the Prince Rashid Bin Al-Hassan Military Hospital in northern Jordan.

Materials and Methods: This retrospective study targeted patients seeking prosthetic replacement of missing teeth by means of dental implants between 2018-2022. A total of 623 dental implants were inserted and the overall failure rate was calculated. Demographic information such as age and gender, and surgical information such as implant site, diameter and complexity of surgical procedure were examined and evaluated for the association between these independent variables and the early failure rate of dental implants.

Results: The overall failure rate of dental implants was 4%. Logistic regression modelling showed that failure was significantly lower in females than males (OR=0.20, p=0.002). The failure rate was lower when regular implants were used compared to narrow implants (OR=0.31, p=0.011). The upper posterior and lower anterior sites showed higher failure rate than the upper anterior site (OR=4.83, p=0.019; OR=5.04, p=0.046, respectively) but there was no significant difference between lower posterior sites and the upper anterior (OR=0.97, p=0.975) or between wide implants and narrow implants (OR=0.80, p=0.79). The failure rate was also higher when advanced surgery accompanied the implant procedure (OR=2.66, p=0.028).

Conclusion: Factors such as gender, implant placement site, implant length and diameter may be considered risk factors for early dental implant failure. Findings could practitioners to evaluate the possible success of their dental implants and to assess the suitability of various implant diameters and the effect of increased complexity of surgical procedures on implant failure.

Keywords: Implants, early failure, risk factors, Jordan

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INTRODUCTION

Dental implantation is a widely used treatment option that has a high level of acceptance by both dentists and patients, with a high success rate (above 97%).[1] The increased needs and demands for dental implants are related to their ability to provide advantages over other types of prosthesis, such as decreasing the need for teeth preparation and the sequelae of exposing dentine, which may lead to caries, pulpal necrosis, endodontic treatment and even loss of teeth. The long-term survival of

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fixed restorations is has been shown to be about 87% at 10 years and 69% at 15 years, compared to implants with about 93-98% at 20 years.[2, 3, 4]

Dental implants can improve masticatory efficiency by decreasing the need for removable prostheses, or improve their performance by gaining better support, stability and retention. Many studies have reported that patients with removable prostheses have reduced masticatory efficiencies.[6, 7, 8, 9,10] Almost 40% of patients no longer use their removable partial denture within five years because of sociodemographic, pain and aesthetic factors.[11] There is a great shift toward improving the performance of prostheses or changing the treatment plan into fixed treatment options.

Although the failure rate of dental implants is very low, there still remains a chance of failure. A dental implant that lasts for at least five years is considered a successful treatment and a 95% survival rate after five years is considered successful therapy.[12, 13] Early failure is defined as occurring before or at the time of abutment connection, or within one year of implant placement. It is usually not the result of acute rejection, but a consequence of bacterial colonization of the implant surface which results in accumulation of fibrous tissue instead of bone.[14] Failure depends on many factors including infection, smoking, patient-related factors and implant-related factors. The increased use of dental implants means that dentists need to be aware of the risk factors that may be associated with increased early failure of implants, such as age, gender, implant diameter, position and complexity of the surgical procedure. This topic has been covered extensively in the literature, with wide variations in the effects of these factors on early failure rate, as shown in **Table 1.**

The present study aims to identify risk factors that could affect implant success and failure according to our experiences at the Prince Rashid Bin Al-Hassan Military Hospital in Jordan.

METHODS

Sample

Retrospective study data were collected from dental implant clinic documents for patients who underwent prosthetic replacement of missing teeth for the period from January 2018 to January 2022. Patients who were medically fit and received dental implants were included. Patient's records including age, gender, identification number, medical history, implant date, implant diameter, implant site and type of surgical procedure were reported in an Excel spreadsheet. The total number of implants was 636, 13 implants for patients who had systemic conditions such as uncontrolled diabetes and immune deficiency that might increase the risk of early implant failure were excluded. In total, 623 dental implants met our inclusion criteria.

Study Variables

Independent variables were demographic variables of age and gender (male or female) and surgery-related variables of implant diameter, implant site and type of surgical procedure.

Implants were divided into three main groups according to diameter: narrow (<3.75 mm), regular (3.75-4.3 mm) and wide (>4.3 mm). Based on implant location, recorded implants were classified into anterior maxilla, posterior maxilla, anterior mandible and posterior mandible.

Regarding the complexity of surgical procedure, implants were classified into simple procedures and procedures with advanced surgery which included immediate implants, the need for bone grafting, sinus lifting and ridge expansion or splitting.[26]

Statistical Analysis

Logistic regression was used to evaluate the effect of the independent variables (demographics, implant and surgical variables) on implant outcomes. The logistic regression models were used at the implant level, wherein the implant outcomes (dependent variable) considered the statistical unit with patients presenting or not presenting implant failures (failure/no-failure).

Logistic regression evaluated whether gender (male/female), implant location (upper anterior, upper posterior, lower anterior or lower posterior), implant size (narrow, regular or wide) and if advanced surgery was performed (yes/no) were associated with implant failure (outcome). The developed model was used to calculate the probability that can determine implant outcomes of each observation (failure/no-failure) given the input predictors, using the following equation:

$$P(y) = 1/\left(1+\exp^{-(\beta 0+ \beta 1*x1 + \ldots + \beta k*xk)}\right)$$

Where P(y) is the calculated probability; B denotes the model's parameters (coefficients) and X refers to input parameters (demographics, implant and surgical variables).

A multivariate logistic regression effect of patient and implant variables on implant failure was evaluated. Odds ratios (OR) and their 95% confidence intervals (CI) were computed. Model evaluation and variable selection was performed based on statistical significance (p-value < 0.05). The results of the final model were presented as an estimated OR of each significant patient and/or implant variable. Logistic regression was performed using R (version 3.6.3, R Foundation for Statistical Computing) and RStudio (2021.09.1+372 'Ghost Orchid' Release, RStudio, PBC).

Ethical Considerations

This study has been approved by the ethical committee of the Royal Jordanian Medical Services.

RESULTS

Participant characteristics are shown in **Table 2**.

The data contained 623 implant outcome (dependent variable) observations, in which 598 observations (96%) were no-failure (failure = 0) and 25 observations (4%) were failures (failure = 1). The data also contained multiple patients and implant variables (independent variables; predictors) including age, gender, implant location, implant size and if advanced surgery was performed.

The overall age range of the patients was 19-94 years with the median age of about 52 years, which was almost the same as that for failed implants at 20-88 years and 52 years, respectively. The gender distribution was almost equal between the implants, at 313 (50.2%) female and 310 (49.8%) male, with an early failure rate of about 1.6% for female patients and 6.5% for males. According to implant diameter, the implants were distributed in three main groups: narrow, with 230 implants (36.9), regular, with 368 (59%) and wide, with 25 (4%), with failure rates of 6.1%, 2.4% and 8%, respectively. Most of the implants (73%) were placed in the posterior area, with almost no difference between the maxilla and mandible; the lowest percentage (6.9%) were in the anterior mandible, which showed the highest failure rate (6.9%). The lowest failure was seen in the anterior maxilla. Just over one-fifth of implants (133; 21.3%) were inserted with advanced surgical procedures, including sinus lifting, ridge splitting, bone grafting and immediate implant placement. All of these procedures were associated with an increased failure rate of 7.5%.

Results showed that the odds of implant failure decreased by 80% in female patients compared with male patients. Similarly, the odds of implant failure decrease by 69% and 20% for regular and wide implants compared with narrow implants, respectively. The odds of implant failure saw a 4.8-fold increase (OR =4.83) and five-fold increase (OR = 5.04) for implants located in the upper posterior and lower anterior, respectively, compared with implants located in the upper anterior. Similarly, the odds of implant failure saw a 2.7-fold increase (OR=2.66) when advanced surgery was performed.

The failure rate was significantly higher in males (p=0.002), lower anterior teeth (p=0.046), and upper posterior implants (p= 0.019). The most successful implant diameter was the regular diameter (p= 0.011), with no significant increase in the failure rate of wide implants in relation to narrow implants. Many dental implant sites need to be prepared by performing some advanced surgical procedures such as ridge splitting, bone grafting and sinus lifting. Table 2 shows that these procedures are associated with a significant increase in the early failure rate with a p-value of 0.028.

In summary, logistic regression revealed that gender, implant location, implant size and advanced surgery showed statistically significant ORs. Parameter estimates of the final model and ORs are shown in Table 3 and Table 4, respectively.

Also, the Hosmer-Lemeshow Goodness-of-fit test was conducted in R. The results showed a small Chi-squared value (4.71) with a larger P-value (0.7) which indicates a good logistic regression model fit.

DISCUSSION

Our study showed that the primary reason for early failure of unsuccessful implants was a failure to osteointegrate. In keeping with other studies, we examined risk factors associated with early dental implant failure and discussed the effect of many variables or predictors in the failure rate such as age, gender, implant position, diameter and type of surgical procedure.

The gender variable has a significant correlation with implant failure with increased risk in males in our study. Similarly, Bobra et al.[25] demonstrated male gender is a risk factor for failure, which was explained by Al Hamadani et al.[27]as being due to a better attitude of female patients toward oral health and being quicker to seek dental implants after tooth extraction. However, other research has not shown a gender-based statistical correlation (Oztel et al.[24]; Staedt et al.[28]), so further research into this factor is needed.

For the implant diameter variable, we found that regular implants have the lowest failure rate, and there is no statistically significant difference between wide and narrow implants. This might be related to the fact that wide implants are usually used in posterior areas which are characterized by poor quality of bone with low insertion torque. This usually requires more complex surgical procedures such as maxillary sinus augmentation, guided bone regeneration and split crest technique. Likewise, narrow implants are usually used in areas with decreased bone quantity which may require procedures like split crest, ridge expansion and guided bone regeneration to improve bone quantity.[27] Our findings support those of Shivu et al. [13] and Baqain et al.[29], but other work such as Nguyen et al. [26] and Staedt et al. [28] has not shown any significant differences between different implant diameters.

With regard to implant site, we found that the lower anterior area has the highest failure rate despite being the best area in terms of quality in the mouth, this may be explained by the increased density with less vascularity of bone when compared with other areas.[30] In addition, our study revealed significantly lower failure rate for the upper anterior area compared with the lower anterior and upper posterior, with no difference compared with the lower posterior site. Maxilla has been reported as the site with the higher failure rate in many studies, explained by the poor quality of bone and the increased need for the split crest technique to increase the width of the ridge as a result of decreased quantity of bone.[31] However, there are some variations in the results between the anterior and posterior. For example, Oztel et al.[24] found that the upper anterior area has the highest failure rate, while Nguyen et al.[26] found the highest failure in the upper posterior.

The final variable was the com plexity of the surgical procedure. We found that the more complex the procedure, the higher the failure rate. Although a statistically significant correlation between failure rate and bone augmentation was not shown in some studies, [25, 26] other studies reported a statistical correlation between failure and increased procedural complexity. [15, 21, 24]

One of the major limitations of the current study is the imbalance in the dataset. Data contained only a 4% failure rate which may affect the predictability of the regression model. Model predictably can be improved by adding more data with failure outcomes, which are currently unavailable.

Table 1: Results of previous studies

Study	Year	Implants	Risk factors				
			Age	Gender	Implant diameter	Implant site	Complexity of surgical procedure
Yang et al.[4]	2021	2053	-	+	-	+	**
Shivu et al.[13]	2021	252	**	+	+	**	**
Vehemente et al.[15]	2002	677	-	**	**	-	+
Moy et al.[16]	2005	4680	+	**	**	-	**
Alsaadi et al.[17]	2007	6946	-	**	+	+	**
Bornstein et al.[18]	2008	1817	-	**	**	-	**
Esposito et al.[19]	2009	761	**	**	**	**	-
Busenlechner et al.[20]	2014	13147	-	**	-	-	**
Daubert et al.[21]	2015	225	**	**	+	**	+
Hasegawa et al.[22]	2016	907	+	**	-	**	**
Grisar et al.[23]	2017	1139	**	**	+	**	**
Oztel et al.[24]	2017	302	-	-	-	+	+
Bobra et al.[25]	2017	774	-	-	-	+	-
Nguyen et al.[26]	2021	1931	**	+	-	+	-

+ statistically significant association; - not significant; ** not evaluate

Table 2: Sample Characteristics

Characteristics	Number of Implants		Number of Implants with Failure
Age (years), median, (range)	52 (19-94)		51 (20-88)
Gender, n%	Female	313 (50.2)	5 (1.6)
	Male	310 (49.8)	20 (6.5)
Implant Size, n%	Narrow	230 (36.9)	14 (6.1)
	Regular	368 (59.1)	9 (2.4)
	Wide	25 (4.0)	2 (8.0)
Implant location, n%	Upper anterior	126 (20.2)	3 (2.4)
	Upper posterior	234 (37.6)	15 (6.4)
	Lower anterior	43 (6.9)	4 (9.3)
	Lower posterior	220 (35.3)	3 (1.4)

Table 3: Parameter Estimates for the Final Logistic Model

Parameter	Estimate (SE)	z value	p value	2.5% CI	97.5% CI
Intercept	-3.311 (0.64)	-5.177	2.25E-07	-4.565	-2.058
Female compared to male	-1.591 (0.522)	-3.047	0.002	-2.615	-0.568
UP compared to UA	1.575 (0.673)	2.341	0.019	0.256	2.893
LA compared to UA	1.617 (0.811)	1.994	0.046	0.027	3.206
LP compared to UA	-0.026 (0.849)	-0.031	0.975	-1.690	1.637
Regular compared to narrow	-1.164 (0.462)	-2.516	0.011	-2.070	-0.257
Wide compared to narrow	-0.223 (0.839)	-0.266	0.79	-1.867	1.421
AS versus without AS	0.978 (0.447)	2.191	0.028	0.103	1.854

* AS: advanced surgery; CI: confidence intervals; LA: lower anterior; LP: lower posterior; SE: standard error; UA: upper anterior; UP: upper posterior

Table 4: Odds Ratios for the Final Logistic Model

Parameter	OR (95% CI)
Intercept	0.04 (0.01 – 0.13)
Females compared to male	0.20 (0.07 – 0.57)
UP compared to UA	4.83 (1.29 – 18.04)
LA compared to UA	5.04 (1.03 – 24.68)
LP compared to UA	0.97 (0.18 – 5.14)
Regular compared to narrow	0.31 (0.13 – 0.77)
Wide compared to narrow	0.80 (0.15 – 4.14)
AS versus without AS	2.66 (1.11 – 6.38)

AS: advanced surgery; CI: confidence intervals; LA: lower anterior; LP: lower posterior; SE: standard error; UA: upper anterior; UP: upper posterior

DISCUSSION

Within the limitations of this study, the selected variables have been shown to have a considerable association with an increased risk of early failure of dental implants. We found that the male gender, lower anterior site, increased complexity of the surgery increased the failure rate, on the other hand, the use of regular implant diameter was accompanied with the best success. These factors should be considered in dental implant planning. Better awareness of patients toward dental implants is needed to choose the best time to seek treatment and reduce the complexity of the procedure. Some treatment modifications may increase the success rate, such as changing the length or diameter of the implant. A better assessment of patient- and implant-related factors may reduce failure rate. Future research with a larger sample size exploring other risk factors for implant failure might improve our understanding of the causes of early dental implant failures.

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