ORIGINAL ARTICLE

SURVIVAL AND SUCCESS OF SINGLE-TOOTH DENTAL IMPLANT: A RETROSPECTIVE EVALUATION

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ABSTRACT

The objective of this retrospective study was to assess the long-term success of dental implants that replaced single missing teeth. The success criteria were: absence of, persistent subjective complaints such as pain, foreign body sensation and/or dysesthesia, recurrent peri-implant infection with suppuration, mobility, and continuous radiolucency around the dental implant. Patients were recruited from implant clinic at the College of Dentistry; King Saud University; with at least one year of implant functional loading. In addition, information regarding dental implant satisfaction was collected through a self-administered questionnaire during the recall appointment. Eighty five patients received a total of 141 dental implants. Data showed that the success rate of the single-tooth implant was 94.3%. Screw loosening was the most common complication reported (12.1%). Eleven (7.8%) implants had an exposed metal collar, which was related with minimal (<2 mm) or absence of attached keratinized tissue around the implant. There was no difference between screw-retained and cemented-retained restorations. This study demonstrated high predictability of dental implants used to support single-tooth restorations on long-term evaluation.

Keywords: *Single-tooth implant, implant success, implant survival*

INTRODUCTION

Dental implants have become the standard of care for replacement of the missing teeth. Evidence-based studies confirmed that dental implants have an excellent long-term favorable prognosis when compared to conventional fixed partial dentures.[1–4] Biologic consequences of prostheses failure that sometimes follows may be a cause for concern. Decay, the most frequently reported cause of prosthesis breakdown, results in structural compromise and loss of abutment teeth.[5] Goodacre and Spolnik[6] reported that between 3% and 23% of abutment teeth need endodontics after prosthesis placement. Tooth fracture and post dislodgment compound endodontic failures. Compromise of abutment teeth presents an additional complication upon restoration because teeth that have been further weakened must often support larger prostheses.[7,8]

A meta-analysis on implants in partial edentulism and single-tooth replacement indicated survival rates of 93.6% and 97.5%, respectively.[9] These results are encouraging when compared with a meta-analysis of traditional fixed partial dentures conducted by Scurria *et al*.[10] that demonstrated prosthesis survival of 69% at 15 years. In another meta-analysis of conventional fixed partial dentures, Creugers *et al*[11] reported a survival rate of 74% after 15 years. Lindquist and Karlsson[12] indicated a survival rate of traditional fixed partial dentures that dropped significantly after approximately 10 years. At 8 years, they reported a mean success rate of 97%. In the same patient population, after 14 years, the success diminished to 83%; after 20 years, it fell to 65%. Single-tooth implants should demonstrate improved longevity when compared with traditional fixed partial dentures if long-term studies on implants that replace single teeth continue to reflect the high predictability already established for edentulous and partially edentulous patients. Resin-bonded prostheses were originally intended as reversible alternatives for tooth replacement for single teeth and small edentulous spans. However, adequate retention currently depends on precise preparations that more closely resemble conventional partial coverage restorations. Resin-bonded fixed partial dentures have shown varied success rates, from only 53% over 11 months to 90% over 11 years.[5,13-16]

Implants offer considerable promise for reducing the disadvantages associated with traditional prosthodontic techniques.[17] The advantages of implants over conventionally fixed prostheses include preservation of the adjacent natural teeth from preparation, caries resistance and possible root canal complications with the abutment teeth. Therefore, the replacement of single missing teeth with single implants should be the

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first choice in the treatment plan for replacing single missing teeth. Implant option would enable patients to enjoy the benefits of comfortable function, esthetics, an absence of marginal caries, and better access to oral hygiene.[18-20] The objective of this retrospective study was to evaluate the success of root form dental implants for the replacement of single missing teeth.

MATERIALS AND METHODS

One hundred fifty of completed implant treatment records were reviewed and contacted. The patients have been treated in the implant clinic at the College of Dentistry King Saud University between 1996 and 2016. All patients received one single-tooth implant or more and the implant was loaded for at least one year using Straumann implant system (Straumann; Basel, Switzerland). During the recall appointment, the patients were asked to sign a consent form in order to participate in this study. In addition, the patients were asked to fill a self-administered questionnaire to evaluate their satisfaction with the implants and treatment outcomes. The following exclusion criteria were taken into consideration during the clinical examination: uncontrolled diabetes, severe clenching or bruxism, single-tooth implant less than one-year duration of loading and refusal to sign in the consent form.

Satisfaction Assessment

Twelve items with three grades scale ranging from 1 to 3 were used to assess esthetics, phonetics, mastication, cleanability and cost to benefit ratio:

(1) representing extreme satisfaction, (2) somewhat satisfied and (3) representing extreme dissatisfaction.

During the clinical examination, the following aspects were covered:

1) Demographic variables (patients' name, age, gender and education level).

2) Medical conditions and smoking status were recorded.

3) Clinical examination (tooth number, cause of extraction, placement date, implant length and diameter, type of stage (I or II), bone graft, membrane, site type (mature, grafted, immediate), crown placement date, crown type (cemented or screw-retained), use of antibiotic, presence of pain, discomfort, pus discharge, amount of keratinized tissue, mobility, avoid eating, porcelain fracture and, screw loosening.

Radiographic Examination

Periapical radiograph was taken during the recall visit. The x-ray was scanned and interpreted utilizing Scion Image for Windows (Scion Corporation, Frederick, MD, USA) to measure the bone loss from mesial and distal aspects of the implants. The implants were examined for successful tissue integration according to success criteria described by Buser *et al.*[3] with each implant being classified as "early failure" because of recurrent peri-implant infection or implant mobility or "successful" based on the criteria which depend upon clinical and periapical radiographic examinations of each site.

Criteria for success from Buser et al.[3] (1997):

1. Absence of persistent subjective complaints such as pain, foreign body sensation, and/or dysesthesia

2. Absence of recurrent peri-implant infection with suppuration

3. Absence of mobility

4. Absence of continuous radiolucency around the implant

The collected data were subjected to statistical analysis. $P < 0.05$ was considered significant. Data were statistically evaluated with IBM SPSS Statistics for Windows, Version 15., IBM Corp., Armonk, NY, USA using *Chi-square* test at significance of 0.05.

RESULTS

Demographic Data

A total of 141 implants were analyzed for the purpose of this study. None of the contacted patients refused to sign the consent form. The study group consisted of 85 patients (57 females, 28 males) with age ranging between 20-73 years. The drop on the number of patients were either due changes in the contact numbers or they moved out of the city or passed away.

Main Reasons for Single-Tooth Loss (Table1)

The main reason of tooth loss for which the implant was inserted was caries and unrestorablility of the involved teeth (70.9%), followed by root canal failure

TABLE 1: REASONS FOR TOOTH REPLACEMENT

Reason for extraction/ absence	Number of teeth (%)
Caries	100 (70.9%)
Root canal failure	12 (8.5%)
Fracture	2 (1.4%)
Trauma	9 (6.4%)
Periodontal disease	7 (5%)
Resorption	0 (0%)
Congenital absence	11 (7.8%)
Unknown	0 (0%)
Total	141

TABLE 2: INTERPROXIMAL BONE LEVEL

Side of bone loss	0.0-1.0mm (%)	1.1-2.0mm (%)	2.1-3.0mm (%)	3.1-4.0 mm (%)	4.1-5mm (%)	> 5 mm (%)	Total
Mesial	129 (91.5)	9 (6.4)	0 (0)	1 (0.7)	1 (0.7)	1 (0.7)	141
Distal	128 (90.8)	9 (6.4)	1 (0.7)	1 (0.7)	2 (1.4)	0 (0)	141

TABLE 3: BIOLOGICAL AND PROSTHETIC COMPLICATIONS

Complications	No. of implants (%)
Persistent parasthesia	1 (0.7%)
Screw loosing (screw retained)	17 (12.1%)
Screw fracture	1 (0.7%)
Broken abutment	1 (0.7%)
Fabrication of new prosthesis	2 (1.4%)
Implant removal & Reimplantation	4 (2.8%)
Metal collar exposure	11 (7.8%)

TABLE 4: DISTRIBUTION OF IMPLANT ACCORDING TO THE JAW AND REGION (ANTERIOR, POSTERIOR)

	Maxilla (%)		Mandible (%)		Total
Success	67 (97.1)		66 (91.7)		133
Failure	2 (2.9)		6 (8.3)		8
	Anterior (%)	Posterior (%)	Anterior (%)	Posterior (%)	
Success	24 (100)	43 (95.6)	3 (75)	63 (92.6)	133
Failure	0 (0)	2 (4.4)	1 (25)	5 (7.4)	8
Total	24 (17)	45 (31.9)	4 (2.8)	68 (48.2)	141

TABLE 5: IMPLANT SUCCESS BY DIAMETER

Implant diameter	4.8 mm (%)	4.1 mm (%)	3.3 mm (%)	Total
Success	31 (96.9)	69 (92)	33 (97.1)	133
Failure	1 (3.1)	6 (8)	1 (2.9)	8
Total # implant	32	75	34	141

(8.5%).

Distribution of the Implants According to Site Classification

Most of the implants were inserted in a mature site (80.1%), while 9.2% of the implants were inserted in a mature site with guided bone regeneration (GBR) procedure. Ten (7.1%) implants were immediately placed in freshly extracted sockets.

Distribution of the Implants According to Staging Protocol

Regarding the type of implant staging; 78.7% of the implants were placed according to one -stage surgery; while 21.3% were placed according to two-stage surgery protocol. There were no statistically significant differences according to the staging protocol.

Interproximal Bone Level (Table 2)

The bone level was classified as follows: ≤ 1mm, 1-2 mm, 2.1-3 mm, 3.1-4 mm, 4.1-5 mm, and > 5 mm. Most of the implants (91.5% and 90.8%) lost ≤ 1mm at the mesial and distal aspects, respectively. Only one implant (0.7%) lost > 5 mm of bone at the mesial aspect and two implants (1.4%) lost between 4.1-5 mm of bone at the distal surface.

TABLE 6: FREQUENCIES AND PERCENTAGES OF THE QUESTIONNAIRE VARIABLES.

#	Questions	Highly Satisfied (%)	Somewhat satisfied (%)	Not satisfied (%)
1	Esthetics	82(96.5)	0(0)	3(3.5)
2	Phonetics	82(96.5%)	1(1.2)	2(2.4)
3	Function	77(90.6%)	6(7.1%)	2(2.4%)
4	Cleansibility	81(95.3%)	3(3.5%)	1(1.2%)
5	Implant vs. Extraction	54(63.5%)	8(9.4%)	23(27.1%)
6	Willing to undergo treatment again	82(96.5%)	2(2.4%)	1(1.2%)
7	Advise others for implants	84(98.8%)	1(1.2%)	0(0%)
8	Pre-operative information	71(83.5%)	6(7.1%)	8(9.4%)
9	Comfortable with dentist	78(91.8%)	6(7.1%)	1(1.2%)
10	Implant similar to the natural tooth	75(88.2%)	5(5.9%)	5(5.9%)
11	Time of treatment	62(72.9%)	15(17.6)	8(9.4%)
12	Cost of treatment	73(85.9%)	5(5.9%)	7(8.2%)
	Overall Average	73(88.3%)	5(5.7%)	5.1(6%)

Biological Complications

One patient reported persistent paresthesia that lasted up to the recall appointment (10 years period). Eleven (7.8%) implants exhibited an exposure of the metal collar; none of them were in the esthetic zone. Four (2.8%) implants were removed and replaced immediately with new fixtures.

Prosthetic Complications (Table 3)

The most common prosthetic complication was screw loosening, which was reported in 17 implants (12.1%).

Over All Success and Survival Rates

Only four implants failed and replaced resulting in a survival rate of 97.2%. The cause of failure was overloading in 3 implants and periimplant abscess formation in one implant.

Eight implants were considered failing according to the success criteria resulting in a success rate of 94.3%. All the failing implants in this study had continuous radiolucency around the implant and one of them had persistence paresthesia.

Distribution and success of the Implants According to Jaw Location (Table 4)

Of the total number of implants, 69 (49%) were placed in the maxilla and 72 (51%) in the mandible. The implants in the maxilla had a success rate of 97.1%; while those on the mandible had a success rate of 91.7%. However; this difference was not statistically significant *(P > 0.05)*.

Distribution and Success of the Implants According to Tooth Position

Mandibular first molars (34%) were replaced more frequently than other teeth. In contrast; the lower incisors (2.8%) were the least to be replaced.

The majority of the patients (78.8%) had posterior implant restorations; while 21.2% had anterior restorations. The maxillary anterior teeth had the highest success rate of 100%, followed by the maxillary posterior teeth of 95.6%. In addition; the mandibular posterior teeth had a success rate of 92.6% and the lower anterior teeth had the lowest success rate of 75%.

Distribution and Success of the Implants by Diameter and Length (Table 5)

The small diameter implants had the highest success rate of 97.1%, followed by 96.9% for the wide neck implants, and then the regular neck implants which had the success rate of 92 %.

The long implants had a success rate of 95.5% while the short implants had the success rate of 77.8%.

Implant Success according to screw vs. cemented

The screw-type implants had the highest success rate of 100%, on the other hand, the cemented-type implants had a success rate of 92.7%.

Implant Success according to the amount of keratinized tissue

The implants with 2mm and more of keratinized tissue had a success rate of 97.4%, while the implant

with <2mm of keratinized tissue had a success rate of 80%.

Satisfaction Analysis (Table 6)

The data showed that 88.3% of the subjects answered the overall satisfaction question with the highest response (highly satisfied); while 5.7% were somehow satisfied and 6% were not satisfied. Majority of the patients 96.5% were strongly willing to undergo the same treatment again if necessary and 98.8% would advise others for implant restorations. Regarding the satisfaction with the treating dentist; 91.8% were highly satisfied. Furthermore, 63.5% of the patients stated that implant procedure was somewhat similar to extraction; while 27.1% of them thought that it was more difficult. Less than one-fifth (17.6%) of the patients were somewhat satisfied with the time spent until completion of treatment. On the other hand; 85.9% of the subjects were highly satisfied with the cost of treatment. Regarding, the satisfaction with an esthetics; majority of the patients (96.5%) were highly satisfied and only 3.5% were not satisfied.

DISCUSSION

Implant placement is the preferred treatment modality to replace a missing single-tooth. This treatment option could serve as a valid and predictable treatment modality, with a high survival rate reported in this and other studies. In this report; four single implants failed with a survival rate of 97.2%. The main causes of the failure of the implants were infection and overloading. Review of the literature has shown a similar percentage of survival for single-tooth implant restorations. Walter *et al*[21] reported 236 cases of single tooth replacement in the maxillary anterior area with a 96% survival rate at 5 years. In addition, Dhanrajani and Al-Rafee[22] reported 93.8% survival rate after 5-year period. In the present study, the success rate according to the success criteria was 94.3%.

Bone quality in different anatomic zones can influence implant success. In the present study, it was reported that the maxilla has a higher success rate than the mandible, 97.1%, and 91.7%, respectively. This is in disagreement with the majority of the implant studies.[23-25] However; the difference could be explained; the failed implant was placed in diabetic patients and/or smoker patients with poor bone quality; in addition to the violation of the mandibular canal in one patient. The regular-collar implant had high success rate. The objectives of using wide-bodied implants are to increase bone-to-implant contact, achieve bicortical stability, favorable distribute the occlusal load, and create a more esthetic emergence profile.[26] Recently, it was postulated that increased implant diameter may encroach upon the critical bone volume needed for osseointegration.[27]

Implant length was considered to contribute to implant success.[28] Shorter implants had high failure rates independent of the implant design. In the present study, implant length did not influence the long-term implant success, which is in agreement with others.[29,30] Abutment screw loosening was a common complication encountered during the recall. This is also often mentioned in the literature.[31-33] Cemented-retained prosthesis showed lower success rate than the screw-retained crowns. The difference was attributed to the remaining cement around the crown margins and below the tissue level; which was a contributing factor for bone loss at the crestal level. No demographic variables were related to the overall satisfaction at a statistically significant level. These results are in agreement with those of Levi *et al.*[34], Kiyak *et al.*[35] and Al-Hamdan and Meshrif[36].

The present study has provided basic information about patient satisfaction with dental implants and treatment outcome. The information might bring more attention to the patients' subjective evaluation of the dental treatment generally and implants in specific in addition to the opinions of the clinician. Two female subjects stated that they avoided eating hard food on their implant and only one female reported having discomfort after completion of the treatment. It is worth also to mention that Vermylen *et al.*[37] reported 30% of the subjects were avoiding eating or chewing on the implant.

In this study, 96.5% of the patients were willing to have implant treatment to be performed for them again. This result is in close agreement with De Bruyn *et al.*[38] who reported that 90% of their patients were willing to undergo the same treatment again if necessary. In contrast, Vermylen *et al*.[37] Gibbard and Zarb[33] reported that 50% and 53% of their patients respectively were willing to have implant surgery again. This higher difference could be due by their small sample sizes of 40 and 30, respectively.

In this study, 63.5% of the patients stated that implant procedure was somewhat similar to extraction. This result is in close agreement with Al-Hamdan and Meshrif[36] who reported that 70% of their patients stated that implant procedure was somewhat similar to extraction.

In the present study, the cost of treatment was not a significant factor for patient satisfaction since the patients are paying only the cost of the materials . This result is in agreement with Muller *et al.*[39] However, Leviet *et al.*[35], Akagawa *et al.*[40] and Zimmer *et al.*[41] reported a significant correlation between the cost of the treatment and general patient satisfaction. Furthermore, Tepper *et al*.[42] reported that 79% of the subjects thought that treatment cost was high. In the present data, 96.5% of the patients were satisfied with

the esthetic result of their implants. This is in close agreement with Vermylen *et al.*[37] who reported 68% satisfaction with esthetics. Furthermore, Chang *et al*.[43] reported 84% satisfaction with esthetics. Further studies on different populations with larger sample sizes are necessary to throw more light on current findings.

CONCLUSIONS

Within limitations of this study, the following conclusions can be drawn:

1. The overall success rate of single-tooth implant was 94.3%.
2. The narrow neck, long and screw-type implants had the highest success rate.
3. Majority (88.3%) of the patients were highly satisfied with the overall treatment.
4. Patients' satisfaction with esthetic of the treatment was high.

Conflict of Interest

The author certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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