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Analysis of the cumulative survival rates and risk factors of short implant (≤7 mm) in posterior region : 5-year retrospective study

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Purpose: The objective of this study is to investigate the cumulative survival rates of short implants placed in the posterior region among patients treated at Ewha Woman's University Hospital from 2019 to 2024. And this research aims to compare these survival rates with those of standard and long implants (>7 mm). Additionally, this study analyzed the risk factors that affect the cumulative survival of short implants.

Materials & Methods: A retrospective study using Electronic Medical Record(EMR) and radiographs was conducted on patients who visited the Department of Oral and Maxillofacial Surgery at Ewha Woman's University Seoul Hospital from 2019 to 2024 and had short implants (≤7 mm) placed. A total of 134 patients were included, and 205 implants were placed. The cumulative survival rate over 5 years (60 months) for all short implants was tracked using Life Table analysis. Potential risk factors that could influence implant survival were categorized into host-related factors and implant-related factors. The statistical correlation for each group was analyzed using the log-rank test. Additionally, to assess the impact of these risk factors in combination on implant survival, a statistical analysis was performed using Cox's proportional hazards model to evaluate the relative risk.

Results: The study observed a cumulative survival rate of 94.22% over five years for short implants (≤7 mm) placed in the posterior region. Shorter implants (≤6 mm) had a lower survival rate (86%), while 7 mm implants showed a higher rate (97.3%). Implant diameter did not significantly affect survival, but wider implants exhibited slightly better outcomes. Other host-related factors, such as gender, age, hypertension, diabetes, smoking habit did not show a statistically significant impact on implant survival.

Conclusions: The most critical factor affecting the survival of short implants in this study was the implant length, with ultra-short implants (≤6mm) showing a significantly lower survival rate compared to those that were 7 mm. Short implants are regarded as a safe and predictable treatment option over the long term. Once osseointegration is successfully achieved, the long-term stability of the implants is secured, making them a viable alternative to standard-length implants. **(THE JOURNAL OF KOREAN ACADEMY OF OSSEOINTEGRATION 2024;16(1):1-7)**

Key words: Short implant, Cumulative survival rate, Kaplan-Meier analysis, Cox proportional hazards modeling

INTRODUCTION

Implants are broadly used for oral rehabilitation in patients who are partially or completely edentulous[1]. There are factors such as presence or absence of sufficient bone volume, keratinized mucosa, smoking habits, periodontal disease, and systemic conditions such as diabetes that can contribute to the long-term success and survival of dental implants.

Presence of adequate bone quality and quantity needs to be evaluated prior to surgical interventions for placing implants. However, after tooth extraction, three-dimensional resorption of the alveolar bone occurs[2,3], and reduced alveolar bone height due to post-extraction atrophy and maxillary sinus pneumatization[4], or presence of inferior alveolar nerve becomes a major challenge, especially in posterior regions.

An implant is classified as short if its length is 7 mm or less. In the past, these shorter lengths were deemed inadequate, particularly in the maxilla, due to the bone's qualitative characteristics in this region, which required a minimum of 13 mm from the alveolar ridge to the anatomical structures marking the apical limit of the maxilla, and 10 mm in the case of the mandible. However, advancements in surface treatments and implant designs seem to have overcome these limitations. Recent systematic reviews suggest that short dental implants (6~8 mm in length) can be equally

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Table 1. Characteristics of the short implants included in the study (mm)

Diameter \ Length	5.0	6.0	7.0
4.0			8
4.5			54
5.0	4	45	83
5.5		1	3
6.0		1	5
7.0			1
Total N (%)	4 (2.0%)	47 (22.9%)	154 (75.1%)

Table 2. 5-year cumulative survival rates of short(≤ 7mm) implants installed in posterior region.

Time period	Number of Implants	Number of Failed implants	Cumulative survival rate (%)
0~1 year (0~12 months)	205	9	95.61
1~2 years (13~24 months)	178	2	94.68
2~3 years (25~36 months)	116	0	94.68
3~4 years (37~48 months)	61	1	94.22
4~5years (49~60 months)	29	0	94.22

successful as those 10 mm or greater in length[5-8].

Today, the possibility of using short implants to achieve success rates comparable to those of longer implants is a significant advantage. This approach avoids the need for more invasive surgical techniques that would otherwise be required to prepare the implant site.

The aim of this retrospective study was to determine the success of short dental implants 7 mm or less placed in the partially or completely edentulous posterior region of the jaw.

MATERIALS AND METHODS

1. Subjects

A retrospective study using Electronic Medical Record (EMR) and radiographs was conducted on patients who visited the Department of Oral and Maxillofacial Surgery at Ewha Woman's University Seoul Hospital from 2019 to 2024 and had short implants (≤7 mm) placed. A total of 134 patients were included, and 205 implants were placed (Table 1).

2. Materials

A total of 134 patients were included, and 205 implants were placed (Table 1). All implants were grouped based on age, gender, jaw, and medical history (including hypertension, diabetes, and smoking habit). The cumulative survival rates were then calculated and compared for each group. The majority of implants (154 of 205) were 7 mm long. There were 47 and 4 implants that were 6 mm and 5 mm long, respectively.

3. Methods

The survival time of the implants was defined as the time from the date of placement until the implant was removed after the clinician confirmed failure. To calculate the cumulative survival rate, each implant was examined clinically and radiologically according to the criteria proposed by Cochran et al[9].

1. A functioning implant with successful osseointegration and final prosthesis fitting, with no evidence of mobilization
2. No radiolucent lesion around the implant on radiographs.
3. Implants without symptoms of persistent, irreversible pain, infection, bleeding, or paresthesia

All statistical analyses were performed using R (4.2.2.) software. The cumulative survival rate over 5 years (60 months) for all short implants was tracked using Life Table analysis. Potential risk factors that could influence implant survival were categorized into host-related factors and implant-related factors. The statistical correlation for each group was tested using the log-rank test. Additionally, to assess the impact of these risk factors in combination on implant survival, a statistical analysis was performed using Cox's proportional hazards model to evaluate the relative risk.

RESULT

Over a five-year period from 2019 to 2024, 205 short implants were placed in a total of 134 patients. The average observation period was 2.41 (±1.36) years, with 12 implants failing in 11 patients, and a final cumulative survival rate of 94.22% after 5 years. The life-table and kaplan-meier survival curve for the above analysis are attached below (Table 2, Figure 1).

1. Analysis of host-related factors

Each host-related factor was divided into two groups, and each group was tested for statistical significance of the difference in cumulative survival using the Log-rank test (Table 3).

1) Gender

Of the 205 implants, 126 implants were placed in female during the study, and seven of them were removed. The cumulative

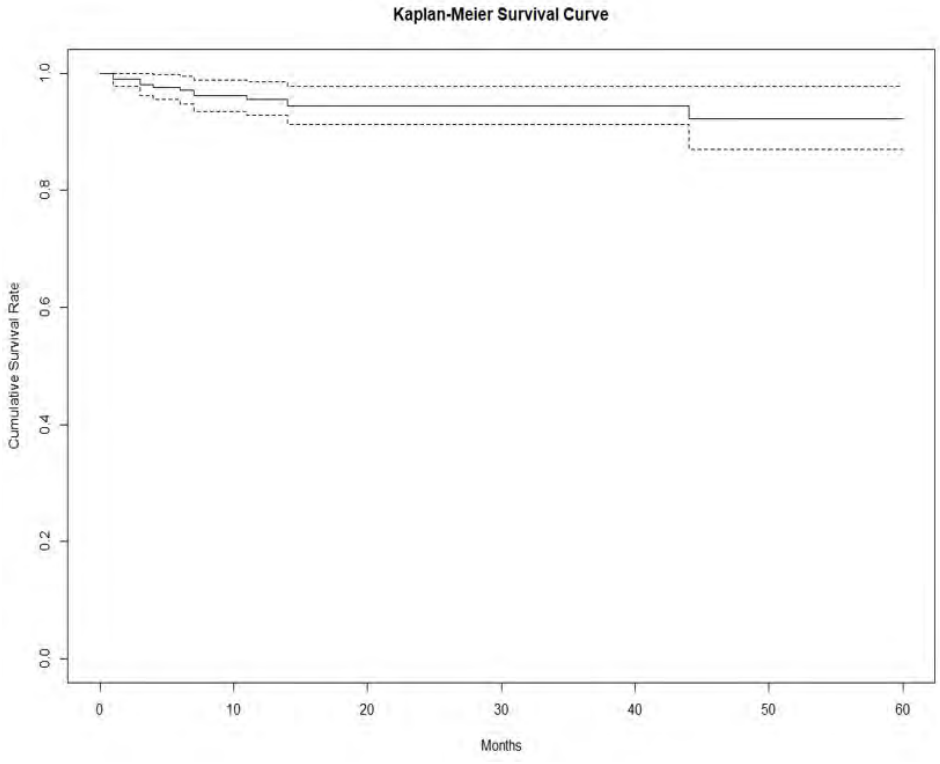

Figure 1. Kaplan–Meier curve of overall short implants.

Table 3. Cumulative survival rate and log–rank test according to the host–related factors

Factors	Categories	No. of implants	Observation period	Cumulative survival rate through 3 years (%)	*P*–value
Gender	Male	79	2.5 [2.3~2.7]	95.0	0.77
	Female	126	2.3 [2~2.5]	94.6	
Age	≤65	75	2.6 [2.3~2.9]	94.2	0.751
	>65	130	2.3 [2.1~2.5]	94.6	
Jaw	Maxilla	38	2.4 [2.1~2.7]	97.1	0.372
	Mandible	167	2.4 [2.2~2.6]	93.8	
Hypertension		81	2.2 [1.9~2.4]	93.9	0.828
Non–hypertension		124	2.6 [2.4~2.8]	94.8	
Diabetes		57	2.4 [2.1~2.7]	96.5	0.391
Non–diabetes		148	2.4 [2.2~2.6]	93.7	
Smoking		20	2.9 [2.5~3.4]	100	0.222
Non–smoking		185	2.4 [2.2~2.5]	93.8	

three-year survival rate was 94.6%. In male, 79 implants were placed, of which five failed. The cumulative 3-year survival rate was 95.0%. Log-rank test showed no significant difference between the two genders (*P*=0.77).

2) Age at the time of implant placement

At the time of implant installation, the patients' ages ranged from 28 to 89 years, with an average of 65.7±10.6 years. Age was analyzed based on the elderly age criterion in South Korea, which is set at 65 years. A total of 75 patients were 65 years or older, and 130 patients were younger than 65 years. The cumulative survival rates of short implants for the two groups were compared using Kaplan-Meier analysis and the log-rank test. The cumulative survival rate was 94.2% for patients aged 65 years or older and 94.6% for patients younger than 65 years, with no statistically significant difference between the groups (*P*=0.751).

3) Jaw

Out of a total of 205 implants, the majority (167 implants, 81.5%) were placed in the mandible, while only 38 were placed in the maxilla. The cumulative survival rate was 93.8% in the mandible and 97.1% in the maxilla, with no statistically significant difference between the two groups (*P*=0.372).

4) Hypertension

A total of 82 short implants were placed patients with hypertension and 123 short implants were placed in patients without hypertension. The cumulative survival rates were 93.9% and 94.8%, respectively, with no statistically significant difference (P=0.828).

5) Diabetes Mellitus

A total of 57 short implants were placed patients with diabetes and 148 short implants were placed in patients without diabetes. The cumulative survival rates were 96.5% and 93.7%, respectively, with no statistically significant difference (*P*=0.391).

6) Smoking habit

Rather, 20 implants placed in smokers were not removed during follow-up, resulting in a cumulative survival rate of 100%, while the cumulative survival rate of 185 implants placed in nonsmokers was estimated to be 93.8%. The cumulative survival of implants in nonsmokers was slightly lower, but this was due to the very low number of implants placed in smokers (N=20) and no statistical significance was observed (*P*=0.222).

The risk factors associated with patients were analyzed using a Cox proportional hazards model, as shown in Table 4. Multivariate analysis showed that none of the patient-related factors had a statistically significant impact on implant survival.

2. Analysis of implant-related factors

Two types of implants were used, SA (Sand Blasted with Alumina and Acid etching) and CA (Calcium Sand Blasted with Alumina and Acid etching) implants (Osstem Ltd, South Korea), with short implant lengths of 5 mm, 6 mm, and 7 mm. The diameters ranged from 4 mm to 7 mm (Table 1).

1) Diameter

The majority of implant diameters was 4.5 mm and 5.0 mm with the smallest diameter was 4.0 mm and the largest was 7.0 mm. The short implants were divided into 3 groups (D1, D2, D3) according to their diameter range (Table 5).

- D1 included diameters of 4.0 mm and 4.5 mm, and the number of implants included was 62.
- D2 included 5.0 mm and 5.5 mm diameters, and the number of implants included was 136.
- D3 included 6.0 mm and 7.0 mm diameters and the number of implants included was 7.

When comparing 3-year cumulative survival rates, the widest implant group (D3) had the highest survival rate of 100%, followed by the D2 (94.6%) and D1 (93.5%) groups. This may sug-

Table 4. Results acquired using Cox's proportional hazards model

Covariate	Categories	β	Standard Error	*P*-value	Hazard ratio
Gender	Male/Female	−0.583	0.591	0.324	0.558
Age	>65/≤65	−0.0708	0.628	0.910	0.932
Jaw	Mx./Mn.	0.0122	0.311	0.412	0.719
Hypertension	No/Yes	0.0346	0.601	0.954	1.04
Diabetes	No/Yes	−0.724	0.785	0.356	0.485
Smoking Habit	No/Yes	−18.6	7502.0	0.998	0.000

Table 5. Cumulative survival rate and log-rank test according to the implant-related factors

Factors	Categories	No. of implants	Observation period	Cumulative survival rate through 3 years (%)	*P*-value
Diameter (Ø)	D1 (<5 mm)	62	2.4 [2.2~2.6]	93.5	0.79
	D2 (5 mm≤ <6 mm)	136	2.5 [2.2~2.7]	94.6	
	D3 (6mm≤)	7	2.4 [2.1~2.7]	100	
Length	L1 (≤6 mm)	51	2.6 [2.3~2.9]	86.0	0.0011*
	L2 (6 mm<)	154	2.4 [2.2~2.6]	97.3	

gest that the wider the diameter of the implant, the higher the cumulative survival rate, but the number of cases was very small (N of D3=7) and not statistically significant.

2) Length

Three implant lengths were used: 5 mm, 6 mm, and 7 mm. The 5 mm and 6mm were categorized as L1 and the 7 mm as L2, and the cumulative survival rates were compared (Table 5).

- L1 included lengths of 5.0 mm and 6.0mm, and the number of implants included was 51.

- L2 included length of 7 mm, and the number of implants included was 154.

The 3-year cumulative survival rate was 86.0% for L1 (shorter) and 97.3% for L2 (longer), a statistically significant difference (P=0.0011).

This suggests that shorter implants of 7 mm or less, especially those of 6mm or less, have slightly inferior survival rates compared to conventional implants.

3. Analysis of Failed implants

The 12 removed short implants observed in this study are summarized in Table 6. Implant failure was determined by clinical and radiologic evaluation, and a total of 12 implants were removed during the observation period (60 months).

The study found that short implants were most often removed early period (within 1 year) during the 5-year follow-up period, mainly due to failure of osseointegration, resulting in mobility and pain.

There were only three cases of late period removal (>1 year), all with fixed prostheses, and all due to peri-implantitis.

DISCUSSION

The cumulative survival rates for short implants were found to be 94.7% over three years and 94.2% over five years. These results align with other studies that suggest the success of short implants can be comparable to standard or long implants.

In previous studies, there has been extensive research on the various factors that influence the survival of dental implants[10-13]. In this study, factors such as gender, age at the time of implantation, jaw location (maxilla or mandible), hypertension, diabetes, smoking habits, implant diameter, and implant length were examined to determine their influence on implant survival.

Recent advancements in implant surface treatment technologies have been rapid. Notably, techniques such as acid etching and sandblasting have been reported to significantly enhance osseointegration capabilities[14]. More recently, trends in implant surface treatment involving nanoparticles and nanostructures have also been introduced[15].

As various surface treatment technologies have developed, the definition of short implants has evolved over time. For instance, Goodacre et al. (2003)[16] considered implants less than 10 mm to be short implants, reporting a failure rate of 10%, which was significantly higher compared to implants longer than 10 mm, which had a failure rate of 3%. Esposito et al. (2011)[17] later defined short implants as those measuring less than 8 mm. In 2020, Andrea Torres-Alemany et al.[8] defined implants shorter than 6mm as short implants.

The study found that the length of the implant had a statistically significant impact on survival. Specifically, shorter implants (≤6 mm) had a lower cumulative survival rate of 86%, while im-

Table 6. Characteristics of removed short implants

Case	Age	Gender	Jaw	Diameter	Length	Survival Period (year)	Prosthetics	Reason of removal
Implant 1	71	M	Mn.	4.0	7.0	0.1	N/Y	Osseo-integration failure
Implant 2	74	F	Mn.	4.5	7.0	0.3	N/Y	Osseo-integration failure
Implant 3	63	M	Mn.	5.0	6.0	0.6	N/Y	Osseo-integration failure
Implant 4	66	F	Mn.	5.0	6.0	0.6	N/Y	Osseo-integration failure
Implant 5	68	M	Mn.	5.0	6.0	0.5	N/Y	Osseo-integration failure
Implant 6	62	F	Mn.	5.0	5.0	0.3	N/Y	Osseo-integration failure
Implant 7	81	M	Mx.	4.5	7.0	0.9	Bridge	Pain/Fistula
Implant 8	73	M	Mn.	4.0	7.0	0.1	N/Y	Osseo-integration failure
Implant 9	60	F	Mn.	5.0	6.0	1.2	Bridge	Peri-implantitis
Implant 10	60	F	Mn.	5.0	6.0	1.2	Bridge	Peri-implantitis
Implant 11	71	F	Mn.	5.0	6.0	3.7	Single crown	Peri-implantitis
Implant 12	88	F	Mn.	5.0	6.0	0.3	N/Y	Osseo-integration failure

N/Y, Not yet.

plants of 7 mm had a survival rate of 97.3%. This is similar to the findings of the study by Rameh et al.[10] and Weng D et al.[18].

Although factors such as gender, age, jaw location, and medical conditions like diabetes and hypertension were analyzed, none showed a statistically significant effect on survival. Smoking also did not show a significant difference in this study. However, this contrasts with the findings of Mustapha, A.D. et al. (2020)[19], who reported that smokers have approximately a 140.2% higher risk of implant failure. The discrepancy in our study's results may be due to the small sample size of smokers included.

Most of the implant failures (9 out of 12) occurred within the first year, indicating that the success of osseointegration plays a critical role in the prognosis of short implants. Conversely, if osseointegration is successful, short implants can perform just as well as standard-length implants. This emphasizes the importance of initial implant stability and integration in determining long-term success, suggesting that short implants are a viable option if proper osseointegration is achieved.

This is consistent with the findings of Albrektsson et al. (1986)[20] where the study demonstrated that once osseointegration is confirmed, dental implants exhibit a very low failure rate, with survival rates exceeding 90% over a 10-year period.

CONCLUSION

1. The most critical factor affecting the survival of short implants in this study was the implant length, with ultra-short implants (≤6 mm) showing a significantly lower survival rate compared to those that were 7 mm.

2. Other host-related factors, such as gender, age, and health conditions, did not show a statistically significant impact on implant survival.

3. According to the study, short implants are considered a safe and predictable treatment option in the long term. Once osseointegration is successfully achieved, the long-term stability of the implants is secured, making them a viable alternative to standard-length implants.

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