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Original Research

A long-term clinical statistical analysis of machined-surface Brånemark implants used in patients undergoing oral and maxillofacial surgery☆

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ABSTRACT

Objective: Dental implants are powerful tools for functional recovery after oral and maxillofacial surgery. Although a variety of different types of implant body have been developed, statistical studies have covered the comparatively short period. Dental implants are now being used for longer periods than ever.

Patients and methods: Herein, we report our more than 27 years of clinical experience with the objective of re-evaluating the performance of machined-surface Brånemark implants.

Results: A total of 454 machined-surface implants, of which 38 were lost, were investigated. The cumulative overall survival rate was thus 87.2%. A comparison between the upper and lower jaws showed that the survival rate was 89.0% in the mandible and 85.1% in the maxilla, with a significant difference. However, there was no significant difference in the sort of bone in which they were embedded, with 90.0% embedded in existing bone and 82.6% in grafted bone. A four-field-table analysis showed that, in Year 27, the rate of "success" was 26%, with 1% "survival", 65% "unaccounted for", and 8% "failure".

Conclusion: Extending the follow-up period means that more patients are lost to follow-up, and a range of different methods must therefore be used for an overall assessment to enable the accurate evaluation of therapeutic outcomes.

1. Introduction

Dental implants are now a recognized prosthetic therapy for occlusal reconstruction. Maxillofacial implant treatment is also useful for functional recovery after oral and maxillofacial surgery. However, this therapy has a short history, and few publications have addressed its long-term outcomes [1]. Clinical investigations of the long-term course of implants would provide vital information for the future development of implant therapy. Although a variety of different types of implant body have been developed and used, statistical studies have only covered the comparatively short period of 5–10 years [2–4]. Recently, however, dental implants are widely used to treat not only older patients, but those in a wide range of age groups, extending their anticipated duration of use. Almost no long-term comparisons taking into account implant shape or surface texture have been performed [5,6]. The osseointegration of titanium dental implants is known to be related to their composition and surface roughness, and since some time ago, various surface types have been developed with the aim of improving osseointegration [7]. Most implants now have rough surfaces, but should bacterial infection of the implant body surface occur, then it is not easily eradicated and may result in implant loss [8].

Early root-form implants were generally machined-surface implants with a smooth surface. The clinical outcomes of machined-surface Brånemark implants used in our department over a 27-year period were investigated. Since an increasing number of patients with long-term implants were lost to follow-up over time, making accurate assessment difficult, two different methods of evaluation were used: the Kaplan-Meier method, with implants classified simply as either lost or not lost; and the four-field-table method, including those patients who were lost to follow-up.

2. Materials & methods

2.1. Patients

The subjects were 63 men and 36 women who had undergone

☆ AsianAOMS: Asian Association of Oral and Maxillofacial Surgeons; ASOMP: Asian Society of Oral and Maxillofacial Pathology; JSOP: Japanese Society of Oral Pathology; JSOMS: Japanese Society of Oral and Maxillofacial Surgeons; JSOM: Japanese Society of Oral Medicine; JAMI: Japanese Academy of Maxillofacial Implants.

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machined-surface Brånemark implant placement in the Department of Oral and Maxillofacial Surgery of Saga University Hospital between January 1989 and November 2004 and who were followed up until December 2015. Zygoma implants were excluded from this study.

2.2. Study parameters

Age at implant placement, underlying disease, number of implants placed, placement site, duration of follow-up, number of implant bodies lost, site of implant body loss, and use of radiotherapy were investigated. The cumulative survival rate of implants was investigated using the Kaplan-Meier method. In this study, the survival rate, not the success rate, of implants was investigated. JMP® Pro 12 (SAS Institute Japan, Tokyo) was used for statistical analysis.

In the four-field-table analysis [9,10], the response evaluation criteria were divided into four categories: “success,” “survival,” “unaccounted for,” and “failure.” More specifically, implants with a surviving superstructure that were functional in the mouth were defined as “success,” those awaiting further surgery were defined as “survival,” those that could no longer be observed because the patient was no longer attending appointments, whether because of death or for other reasons, were classed as “unaccounted for,” and those that dropped out because integration with the surrounding bone was not achieved after placement were classed as “failure.” For the definition of “success” in particular, the criteria suggested by Buser et al. were followed [11].

This study was approved by the Ethics Committee of the Faculty of Medicine, Saga University (2015-05-15).

3. Results

The age at implant placement of the 99 patients treated with machined-surface implants ranged from 17 to 83 years (mean 54.2 years). The underlying condition was severe alveolar ridge resorption and teeth loss in 37 cases, malignant tumor in 27, benign tumor in 14, trauma in 14, cyst in 3, and cleft lip/palate and inflammation in 2 each. In terms of the age distribution, most patients were in their 50 s, and among those older than the 50 s, the most common cause was malignant tumor. The rate of trauma was highest in those in their teens and 20 s (Fig. 1).

A total of 454 implants were placed. Of these, 299 were placed in existing bone, 100 in the upper jaw and 199 in the lower jaw. The other 155 were placed in grafted bone, 65 in the upper jaw and 90 in the lower jaw. All bone grafts were autologous, with both blocks of bone and particulate cancellous bone used. Implant length varied between 7 mm and 20 mm, but most of those used were comparatively long, at 13–18 mm, accounting for 70% of the total, and around 15% had a length of 20 mm (Fig. 2). The implant diameter varied between 3.3 mm and 5 mm, but it was most often 3.75 mm (Fig. 2). The maximum duration of follow-up was 9832 days (approximately 27 years).

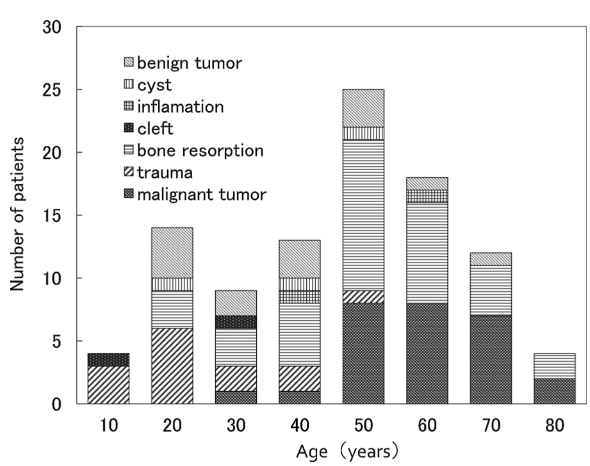

Fig. 1. Age and underlying disease.

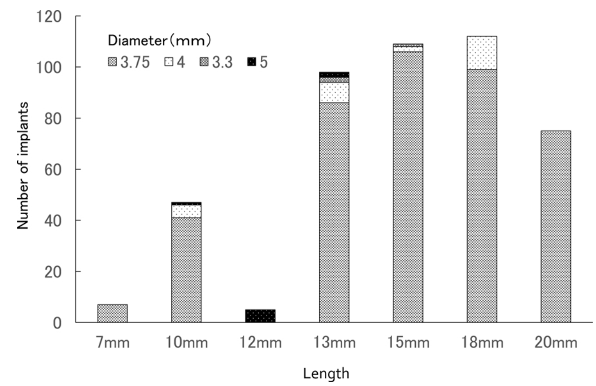

Fig. 2. Implant sizes.

There were 38 lost implants, 21 in the maxilla and 17 in the mandible. Of those lost implants, 21 had been placed in existing bone and 17 in grafted bone. In terms of length, the most common length of implant lost was 13 mm in 12 cases, followed by 15 mm in 8 and 12 mm in 7 (Table 1). Most lost implants fell out within 2 years of placement.

Cumulative implant survival rate for all implants by the Kaplan-Meier method was 87.2% (Fig. 3). The rates were 85.1% for those placed in the maxilla and 89.0% in the mandible. A log-rank test showed that this difference was significant (Fig. 4). The cumulative survival rate for implants placed in existing bone was 90.0%, compared with 82.6% for placement in grafted bone, but this difference was not significant (Fig. 5). A more detailed investigation of existing and grafted bones found that, for implants placed in existing bone, the cumulative survival rates were 81.7% in the maxilla and 94.0% in the mandible, with a significant difference (Fig. 6), whereas for those placed in grafted bone, the rates were 89.7% in the maxilla and 80.5% in the mandible, with a difference that was not significant (Fig. 7).

The 27-year four-field-table analysis showed that 26% (117 implants) were “success”, 1% (4 implants) were “survival”, 65% (295 implants) were “unaccounted for”, and 8% (38 implants) were “failure” (Fig. 8). In terms of changes over time in the four-field-table analysis, the number of implants “unaccounted for” tended to increase as the follow-up period became longer.

4. Discussion

The shape and material quality of the dental implants have both changed over time. Before the current titanium implants, materials such as sapphire and ceramics were used, and prior to the present root form, their shape also varied, with the various types including blades and subperiosteal implants. Similarly, different surface textures have also been developed physically or chemically with the aim of improving osseointegration.

It has thus been scientifically demonstrated that a rough surface is

Table 1
Details of the failed implants length Maxilla Mandible.

	Maxilla		Mandible	
	existing	grafted	existing	grafted
7 mm	2			
10 mm	4	1		
12 mm	1		2	4
13 mm	3	3	4	2
15 mm	1	2		5
18 mm	4			

There was no significant association between implant loss and implant length.

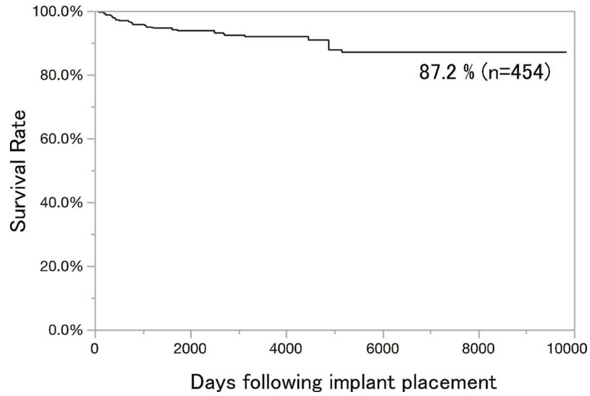

Fig. 3. Kaplan-Meier curves for implant survival through 27 years.

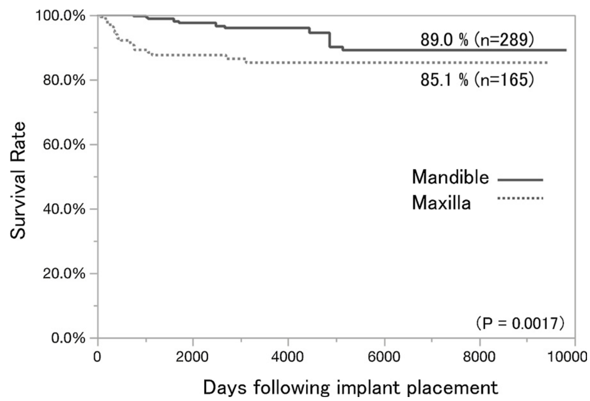

Fig. 4. Kaplan-Meier curves for implant survival, by type of implant placement site.

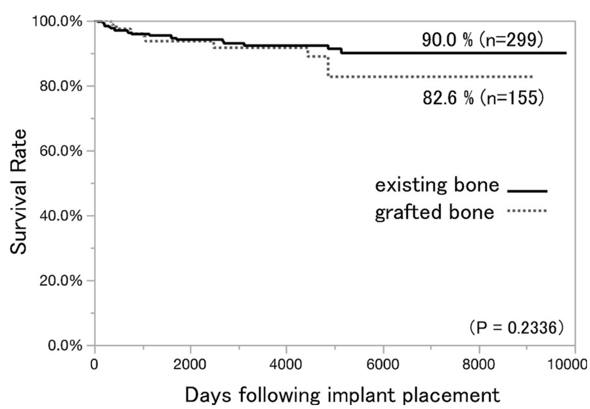

Fig. 5. Kaplan-Meier curves for implant survival, by type of implant inserted bone.

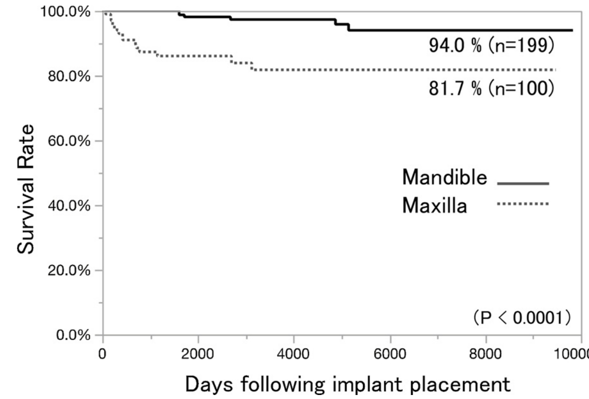

Fig. 6. Survival rate for the placement sites (in existing bone).

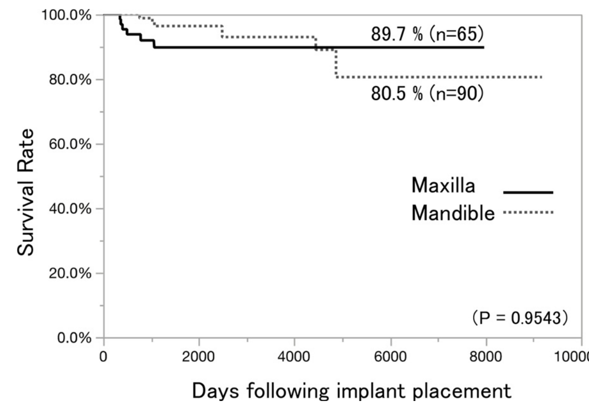

Fig. 7. Survival rate for the placement sites (in grafted bone).

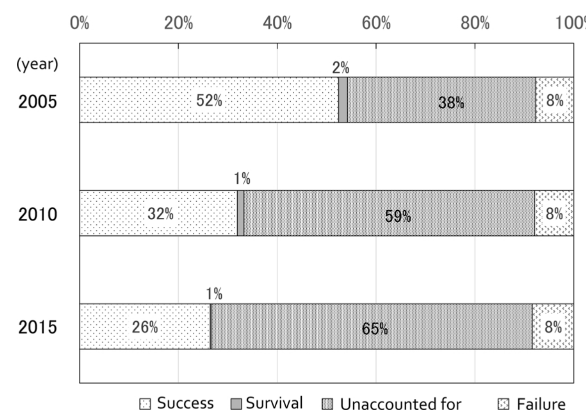

Fig. 8. Four-field-table analysis was affected by the duration of follow-up.

better than a smooth surface from the viewpoints of both osseointegration and biomechanical stability. The implants in clinical use today have undergone surface treatments such as TiUnite, SLA, and OSSEOTITE.

Implant bodies that have undergone this sort of surface processing possess good bone conductivity, which enables early osseointegration to be achieved [7]. However, studies have found that long-term occlusal stress may cause the coating to peel or crack internally. Another problem is that, if this rough surface becomes infected by bacteria, this may cause bone resorption around the implant. It is known that peri-implantitis may develop around the implant body as a result of excessive lateral load or bacterial infection [8]. Peri-implantitis and excessive load are known to be risk factors for delayed implant loss [12]. Since peri-implantitis is a factor that directly affects the outcome of implant treatment, its prevention and management are clinically important. Once a rough or coated surface becomes infected by bacteria, this infection is difficult to eradicate. While the implant body is exposed in the mouth, a surface texture that is hygienic and enables easy plaque control is therefore preferable. The surfaces of the first root-form implants developed by Brånemark were processed by machining, meaning that although they still carried cutting marks, they were smooth, with an outermost surface covered by a thin titanium oxide passive coating. This texture made bacterial infections easy to deal with. Although it has now been established that a rough surface is better for achieving early osseointegration, further studies comparing the long-term survival rate and the incidence of peri-implantitis are still required.

One of the distinctive characteristics of this study was the length of the implant bodies used. In the early days of dental implants, they were generally placed by drilling through both layers of cortical bone.

Relatively long implant bodies measuring 15–20 mm in length were therefore often used.

It was found that implant bodies placed in existing bone in the upper jaw were more frequently lost than those placed in the lower jaw, a similar result to those of other studies [12,13]. However, most of these lost implants were comparatively long, with a length of 13 mm or 15 mm. Generally speaking, the survival rate improves proportionally to the length of the implant body. Although the type of implant body used was different, Nevins et al. [14] found that implants less than 10 mm long had poorer treatment outcomes compared with those longer than 10 mm. Hasegawa et al. [15] also carried out a multivariate analysis that found that implant length under 8.5 mm was a risk factor for implant loss. Although the length of the implant body is undoubtedly a risk factor that affects implant loss, the present results suggest that it may not be the only such factor. In terms of timing, most implant bodies were lost within 2 years of placement, and early loss tended to be more common in the upper jaw. It has also been shown that loss is less likely to happen once osseointegration has been achieved [12,13]. The suggestion has been made that factors such as the state of occlusion and habits may also encourage loss. In this study, prosthetic aspects such as the shape of the superstructure used on the implant body or the condition of the opposing tooth were not investigated, and future studies of factors contributing to implant loss are required.

Formerly, most patients undergoing implant treatment were older people, but today it has become an accepted prosthetic therapy for a wide range of age groups. Implants are thus now expected to endure for much longer, and long-term clinical evaluation is necessary. Their clinical efficacy after 5 years is generally regarded to exceed 95%, but in this study, the cumulative survival rate for all implants was 87.2%. This was somewhat below the results reported by Lekholm et al. [16] from a 10-year study of same implant bodies. One reason for the low cumulative survival rate in the present study was the longer follow-up period. Another reason was that most of the patients in the present study had undergone oral and maxillofacial surgery and may, therefore, have included more patients with poor conditions.

A significant difference in cumulative survival rates between the maxilla and the mandible has also been reported in other studies, but the fact that there was no significant difference in the cumulative survival rate between grafted and existing bones differed from some other published results [17]. One reason may have been that the bone grafts used in our department were mostly large bone pieces used for jaw reconstruction [18,19].

Many studies of the outcomes of implant treatment have used methods that only evaluate failure. Albrektsson and Zarb regarded the removal of an implant for any reason as failure [9], but the loss of implants during jaw resection caused by recurrence of a malignant tumor or post-radiotherapy osteomyelitis, for example, should be characterized as “unaccounted for” rather than as “failure”. The longer the follow-up period, the greater the number of patients who will be lost to follow-up, and it is therefore difficult to make an accurate assessment on the basis of cumulative survival rate alone. Therefore, a four-field-table analysis was also used in the present study as a second method of evaluation. In Year 27, 27% were either “success” or “survival.” Although a proportion of patients will inevitably be lost to follow-up, this can be compensated for, to some extent, by the efforts of medical professionals. It is important to talk to patients in such a way that they remain motivated during follow-up appointments.

In the follow-up of implant treatment, using an appropriate evaluation method is important for providing feedback on clinical experience. In particular, when assessing treatment outcomes after a long follow-up period, carrying out a four-field-table analysis in addition to using Kaplan-Meier curves to evaluate cumulative survival rates may enable the evaluation of the true survival rates and trends in all patients in the institution concerned. New techniques for evaluating patients with long-term implants must also be explored.

5. Conclusion

A clinical statistical analysis of the long-term course of machined-surface Brånemark implants was performed. Although this type of implant body has now almost fallen into disuse, its outcomes were comparatively good, and if initial fixation can be achieved, then it is also resistant to infection, making this surface texture very suitable for long-term use. Future studies to compare it with other surface textures in long-term use will be needed, and the development of surface textures with standard geometries and biochemical properties will also be required in the future.

Conflict of interest

The authors declare that they have no competing interest.

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