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Analysis of 472 Brånemark System TiUnite Implants: A Retrospective Study

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ABSTRACT

Purpose: The purpose of this retrospective study was to determine the success of Brånemark System TiUnite® implants (Nobel Biocare/Sweden) placed in partially or completely edentulous jaws restored with fixed or removable prostheses.
Patients and Methods: A total of 131 jaws from 110 patients (64 maxillae and 67 mandibles) received 472 implants from July 2003 until March 2008. The patients included 57 men and 53 women, with a median age of 49.6 years and an age range of 16 to 90 years at the time of implant surgery. Twelve maxillae and 10 mandibles were completely edentulous, and 52 maxillae and 57 mandibles were partially edentulous. A single implant was placed in 21 jaws (10 maxillae and 11 mandibles), while multiple implants were placed in the other patients. Among the 131 jaws, removable prostheses were mounted in 10 maxillae and 8 mandibles, and the other jaws were restored with fixed prostheses.
Results: Among the 472 implants, 6 maxillary implants and 5 mandibular implants were unsuccessful. The success rate for the implants was 96.56% (96.07% in the maxillae and 97.18% in the mandibles).

INTRODUCTION

The use of osseointegrated implants to support prosthetic reconstruction has become a common treatment modality for patients with partially or completely edentulous jaws. The early studies of Brånemark *et al.* [10, 11] and Schroeder *et al.* [27, 28] demonstrated a direct bone-to-titanium contact referred to as osseointegration. These studies reported encouraging long-term results associated with titanium implants in fully edentulous patients [1,2].

The surface properties of implants play a key role in the success of osseointegration [4]. The surface of the TiUnite® implant (Nobel Biocare/Sweden) is a highly crystalline, phosphate-enriched titanium oxide characterized by open pores in the low micrometer range [18]. In comparison to machined implant surfaces, this surface has repeatedly proven to elicit a more enhanced bone response [7, 26]. Furthermore, the TiUnite® surface maintains primary stability better than the machined surfaces and shortens the healing time needed to accomplish secondary stability. TiUnite® implants have been commercially available in

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Japan since December 2000, and we began to utilize this product in July 2003 at Kobe University Hospital. The goal of this study was to retrospectively evaluate the outcome of TiUnite® implants in our hospital.

PATIENTS AND METHODS

We identified a total of 110 patients who received the TiUnite® implants between July 2003 and March 2008 in the department of Oral and Maxillofacial Surgery of Kobe University Hospital. All the patients visited our hospital for the replacement of single or multiple teeth by osseointegrated implants. Of the 110 patients, 57 were men and 53 were women. The median age was 49.6 years, with a range of 16 to 90 years, at the time of implant surgery (**Figure 1**). The implantation was performed as a two-stage surgical procedure. There were 22 cases of completely edentulous jaws (12 maxillae and 10 mandibles), and 109 partially edentulous jaws (52 maxillae and 57 mandibles). Alveolar availability at the edentulous sites was evaluated by panoramic radiograph and CT-scan. This imaging provided the most anatomically accurate depiction of the patient's arches in terms of not only vertical height but also bucco-lingual width and alveolar shape. A single implant was placed in only 10 maxillae and 11 mandibles, while the other cases received multiple implants. Removable prostheses were mounted on 10 maxillae and 8 mandibles, and the other cases were treated with fixed prostheses. After implant surgery, all the patients were followed until April 2009.

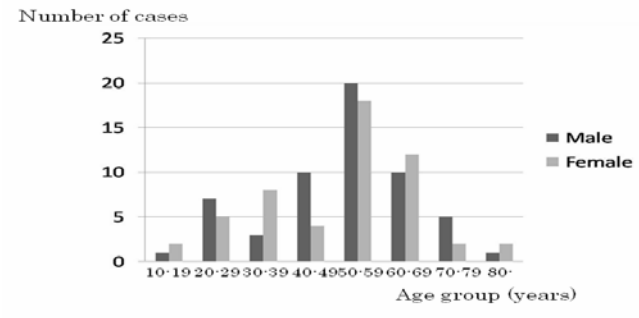

Fig.1. Distribution of age and sex

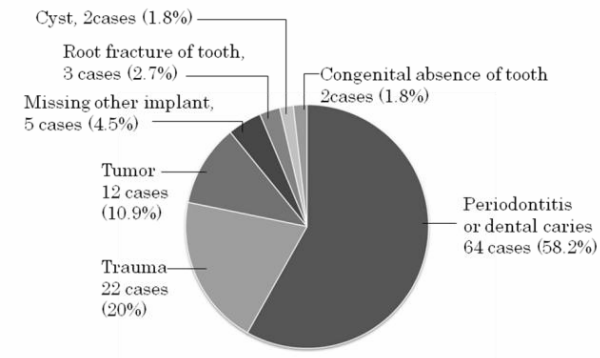

Fig.2. The cause of missing dental articulation

RESULTS

A total of 131 jaws from 110 patients (64 maxillae and 67 mandibles) had 472 implants placed from July 2003 through March 2008 in our hospital. Among the study subjects, 51 patients (46.4%) directly visited our hospital, 32 patients (29.1%) were referred from private dental offices, 16 (14.5%) were from other hospital dentistry, and 11 (10.0%) were from medical clinics. The reasons for the missing teeth included periodontitis or dental caries (64 cases/58.2%), trauma (22 cases/20%), tumor (12 cases/10.9%), loss of previous implants (5 cases/4.5%), tooth root fracture (3 cases/2.7%), cyst (2cases/1.8%), and congenital absence of teeth (2cases/1.8%) (**Figure 2**).

Distributions of the implant sites are shown in **Figure 3**. The majority of the fixtures were placed in the first premolar region of the maxilla and in the first molar region of the

mandibles. For dental implant preparation, various methods of alveolar bone augmentation were performed in 41 maxillae and 10 mandibles (**Table I**). Among the maxillae, 28 cases

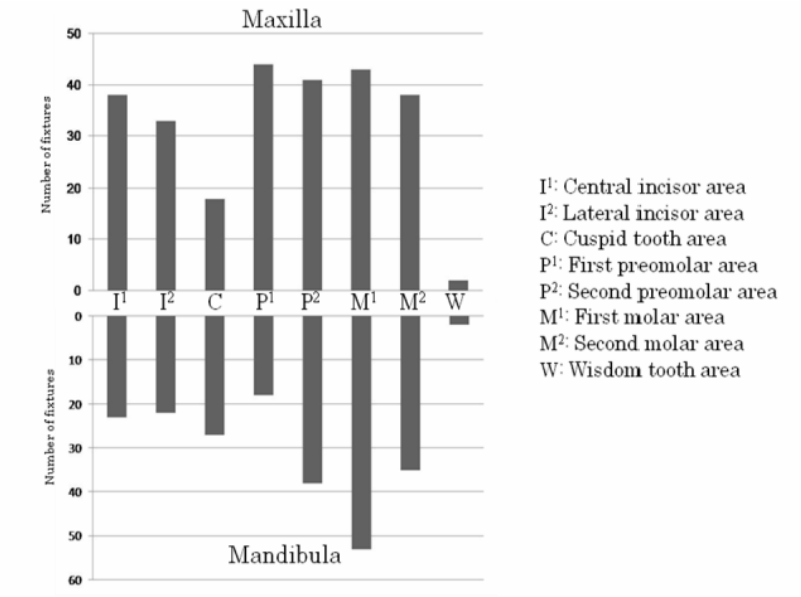

Fig.3. Distribution of the fixture implanted

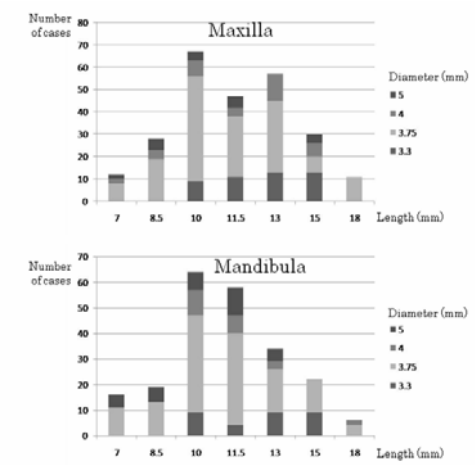

Fig.4. Distribution of the fixture size

(37 sides) underwent maxillary sinus lifting, 11 cases received bone grafts, 2 cases had osteotome sinus floor elevation, and one case underwent guided bone regeneration. In the mandibles, vertical distraction osteogenesis was performed in 6 cases, bone grafting was performed in 5 cases, and guided bone regeneration was used in a case. The fixtures sizes are demonstrated in **Figure 4**. The fixture with a 3.75 mm diameter and 10 mm length was most frequently employed in both the maxilla (18.7%) and the mandibles (17.4%). The other frequently used sizes were 3.75 mm in diameter/13 mm in length on the maxilla and 3.75

mm in diameter/11.5 mm in length on the mandibles. The risk factors associated with implant therapy are shown in **Table II**. There were 42 smokers (220 implants), 3 patients receiving steroidal treatment (7 implants), 3 patients with diabetes (10 implants), 2 patients undergoing radiation therapy (12 implants), 2 patients with a metal allergy (3 implants), and a patient with osteoporosis (5 implants).

Of the 472 implants, only 6 maxillary implants and 6 mandibular implants were unsuccessful (success rates: 96.07% and 97.18%, respectively). Twelve implants were completely lost, and the overall success rate was 96.56% in this study (**Figure 5**). Details of failure cases are presented in **Table III**. There were 6 smokers, 2 patients undergoing radiation therapy, and 1 patients receiving steroidal treatment; however, there were no unsuccessful implants in patients affected by diabetes, metal allergy or osteoporosis. Among the 12 failed implants, 5 implants failed prior to loading, and 7 implants failed after loading. As to the implants that failed before loading, case number 6 was a smoker whose fixture was placed on the bone augmented region with beta-tricalcium phosphate as a bone substitute. This patient's implant was removed 16 months after placement. Case number 10 was a smoker undergoing radiation therapy whose implant failed 16 months after the stage I surgery. The other 3 cases (case numbers 7, 9, and 11) were affected by heat-induced bone tissue injury (HBTI). These cases involved mandibular implants, and they failed within 10 months after fixture placement. On the contrary, in the cases that failed after loading, only 1 implant (case number 2) was removed surgically because oral cancer recurred near the fixture. The other 6 implants had been overloaded by occlusal pressure in combination with various other negative factors. Case number 1 was a smoker who received a long-span fixed bridge (not the cantilever type) in which the rearmost fixture failed 56 months after the stage I surgery. Case number 3 had a large maxillofacial prosthesis after total maxillectomy without other risk factors and lost 2 implants at the 4th month after the stage I surgery. Case number 5 also had a large maxillofacial prosthesis after total maxillectomy. This patient was a smoker whose implant was placed in the maxillary sinus lifting region within the radiation field. The implant failed 9 months after the stage I surgery. Case number 4 was a smoker undergoing steroidal treatment whose implant dropped out because the beta-tricalcium phosphate around the fixture was absorbed. Case number 8 had no risk factors, and an implant placed obliquely against the occlusal plane was lost 22 months after the placement.

There were only 2 cases receiving radiation therapy in this study, and both cases lost an implant. Case number 5 failed after loading, while case number 10 was lost before loading. Case number 5 had maxillary cancer complicated with non-Hodgkin lymphoma in the bilateral orbital region. The patient was irradiated with a total dose of 80 Gy. Case number 10 had tongue cancer and was irradiated at a total dose of 40 Gy.

The median implant survival duration in the failure cases was 14.3 months with a range of 1 to 56 months, and the diameter and length of the failure fixtures varied.

Table I. The kinds of alveolar bone augmentation

Mandibula/10 cases		Maxilla/41 cases	
Vertical distraction osteogenesis	6 cases	Maxillary sinus lifting	28 cases /37 sides
Veneer bone grafting	5 cases	Veneer bone grafting	11 cases
Guided bone regeneration	1 case	Osteotome sinus floor elevation	2 cases
		Guided bone regeneration	1 case
Others	14 cases	Others	5 cases

Some methods overlap in the same case.

Table II. Risk factors of implant therapy

Risk factor	No. of cases /no. of implants
Smoking	42 cases/220 implants
Steroid	3 cases/7 implants
Diabetes	3 cases/10 implants
Radiation therapy	2 cases/12 implants
Metal allergy	2 cases/3 implants
Osteoporosis	1 case/5 implants

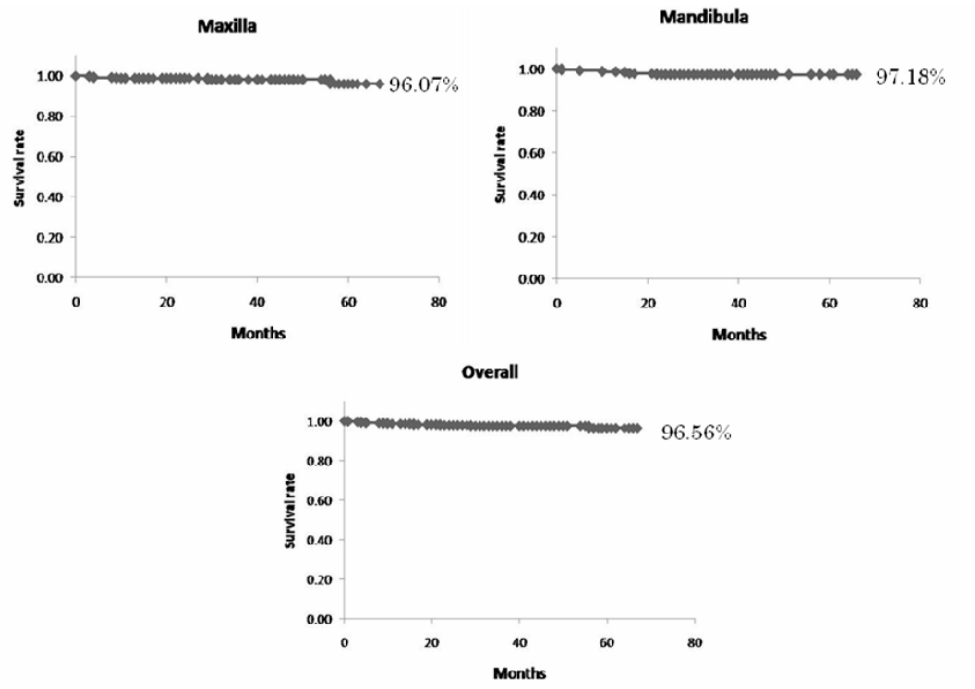

Fig.5. Success rate

Table III. Details of failure cases

Case No.	Sex /age	Jaw	Risk factors	Local incidents	Type of prosthesis	Failure implants	
						No. (survival months)	Diameter (mm) /length (mm)
1	F /59	U	Smoking	Overload MSL with autogenous bone	Fixed prosthesis	1 (56)	5/8.5
2	F /83	U	None	Recurrence of oral cancer	Removable MP	1 (3)	3.75/8.5
3	M/79	U	None	Overload	Removable MP	2 (4)	3.75/13, 3.75/7
4	F /34	U	Steroid Smoking	Implantation with beta-TCP Overload	Fixed prosthesis	1 (29)	3.3/13
5	M/59	U	Radiation Smoking	Overload MSL with autogenous bone	Removable MP	1 (9)	3.75/10
6	M/43	L	Smoking	Implantation with beta-TCP	Before loading	1 (16)	4/11.5
7	M/56	L	Smoking	HBTI of drilling	Before loading	1 (2)	3.75/10
8	F /56	L	None	Overload	Fixed prosthesis	1 (22)	3.75/8.5
9	M/71	L	None	HBTI of drilling	Before loading	1 (1)	5/10
10	M/51	L	Radiation Smoking	None	Before loading	1 (16)	3.75/7
11	F /36	L	None	HBTI of drilling	Before loading	1 (10)	4/18

U; Maxilla
L; Mandibula

MSL; Maxillary sinus lifting
HBTI; Heat-induced bone tissue injury
TCP; Tricalcium phosphate

MP; maxillofacial prosthesis

The first clinical studies reporting the success of osseointegrated implants were retrospective studies of completely edentulous arches treated with Brånemark implants (Nobel Biocare/Sweden) [1, 2]. In these studies, the success rates for implants were 86% in the mandible and 78% in the maxilla after 15 years of function. The success rates of this implant system have increased in recent years, and Astrand *et al.* observed a 99.2% survival rate in edentulous arches 20 years after implantation [6]. Currently, the ITI implant system (Straumann/Switzerland) is as common as the Brånemark implant system. Ferrigno *et al.* evaluated the long-term outcomes of 1286 ITI implants in fully edentulous arches and reported a cumulative success rate of 95.9% after ten years [16]. Astrand *et al.* demonstrated that there were no statistically significant differences between the outcomes of the ITI and Brånemark implant system [5].

The surface properties of implants are key factors for successful osseointegration [4]. Recently, the surface of the Brånemark implant system was changed from a machined-surface to the TiUnite® surface. This surface is characterized by many open pores in the low micrometer range [18], which are thought to improve the bone-to-titanium surface contact. The success rate for the TiUnite® surface implants was higher (98.6%) than that for the Brånemark implants with machined-surfaces (92.1%) [7]. The TiUnite® implant employed in this study had an overall success rate of 96.56%. Clinical studies have indicated that peri-implant bone loss, a major cause of implant failure, is associated with overload [19, 25]. In particular, excessive occlusal load in a lateral direction is considered to be a common reason for implant failure [19, 20]. Among the failure cases in this study, 2 patients (3 implants) were edentulous with an extensive maxillary defect after the total maxillectomy and a heavy maxillofacial prosthesis resulted in excessive lateral pressure in the implants. Among the other cases with occlusal overload, 1 implant had been placed obliquely from the occlusal plane and intense lateral pressure was placed on the fixture. On the other hand, many studies have shown that a shorter implant length is associated with implant failure [17]. Misch *et al.* observed a low success rate (85.3%) for implants less than 10 mm in length [24]. In this study, the median length of failure implants in cases of overloading loading was 9.4 mm.

Drilling procedures during dental implant preparation cause mechanical damage to the bone as well as heat-induced bone tissue injury (HBTI) [13]. It was demonstrated that when the test implants were heated to a temperature above 47 degrees C for 1 minute, bone regeneration was significantly impaired [14]. HBTI sometimes occurs during drilling for implant placement, and early bone absorption around the fixtures usually occurs before loading. In this study, the median implant duration in HBTI cases was 4.3 months, while that of the total failure cases was 14.3 months. Appropriate irrigation during drilling restricts the maximum temperature to 33.8 degrees C for 5 seconds [15]. The conventional irrigation method is the external irrigation drilling system employed by the Brånemark system, whereas the internal irrigation system has recently been adopted by other dental implant systems. Although the internal irrigation system is thought to improve the delivery of coolant to the bone-drill interface, Benington *et al.* have demonstrated that there is no significant difference between internal and external irrigation systems in regard to temperature generated via the drilling procedure [9]. However, delivering coolant to the tip of a long length drill is difficult in the external irrigation system. Actually, the median length of implants in HBTI cases was 12.7mm, which was longer than that of the cases that failed after loading. Moreover, all of the HBTI cases occurred in the mandible rather than the maxilla. Clinicians generally believe that the bone quality is different between the maxilla and the mandible. Crrrently, the most popular method of bone quality assessment was developed by

Lekholm and Zarb (L&Z) using a scale of 1-4 [23]. Bone quality of the mandible is generally assessed at a lower point on the scale because of its dense quality, which is advantageous to the mechanical success of implants in osseo-integration. Dental implants in the mandible have been demonstrated to usually have higher success rates than those in the maxilla [29]. However, drilling procedures in the dense quality cause higher frictional heat therefore the majority of HBTI cases occurred in the mandible.

There are many types of alveolar bone augmentation used as a preparation for dental implants. Based on the type of material used, alveolar augmentation is categorized as autogenous bone grafting, bone substitute grafting, alveolar distraction osteogenesis, and guided bone regeneration (GBR). Alveolar bone augmentation is also classified based on particular techniques, which include maxillary sinus lifting, osteotome sinus floor elevation, ridge splitting, socket preservation, and onlay/inlay/veneer grafting. Uckan *et al.* demonstrated that the implant success rate was slightly higher in the autogenous onlay bone grafting cases compared with the alveolar distraction osteogenesis cases [30]. Aghaloo *et al.* also reported that the implant success rate was 95.5% for GBR, 94.7% for distraction osteogenesis, 90.4% for onlay/veneer grafting, and 83.3% for combinations of onlay, veneer, and interpositional inlay grafting [3]. In our 11 failure cases, 4 cases underwent alveolar bone augmentation in which there were no cases with distraction osteogenesis, 2 cases involved maxillary sinus lifting with autogenous bone, and 2 cases underwent bone augmentation with beta-TCP. In general, a complication of maxillary sinus lifting is perforation of the Schneiderian membrane. The implant success rate in maxillary sinus lifting procedures with an intact membrane was higher (98%) than in those with a perforation (88.6%) [31], whereas other reports have shown no statistically significant difference between them [8, 21]. Perforation of the Schneiderian membrane occurs in 10%-35% of procedures [31]. In this study, 9 of 37 (24.3%) maxillary sinuses had a perforation, and the implants in these cases did not fail. It was noteworthy that all of our failed implants with alveolar bone augmentation were observed in smokers. Klokkevold *et al.* demonstrated that there were statistically significant differences in success rates for implants between smokers and nonsmokers [22], and smoking is thought to have an adverse affect on implant success. On the other hand, Klokkevold *et al.* also showed no difference in the implant success rate between patients with and without diabetes [22], and Dao *et al.* suggested that osteoporosis is not a risk factor for dental implants [12]. In our study, there were no failed implants in patients with diabetes or osteoporosis. Consequently, it is considered that the factors involved in implant failure in this study were radiation, overload, bone augmentation, and HBTI, and these factors were exacerbated by smoking.

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