ORIGINAL ARTICLE

J Korean Dent Sci. 2019;12(1):29-37
https://doi.org/10.5856/JKDS.2019.12.1.29
ISSN 2005-4742

Long-term Retrospective Clinical Study Comparing Submerged Type with External Hex Connection and Non-submerged Type with Internal Morse Taper Connection Implants

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Purpose: This study was aimed to compare the survival and success rates, and long-term crestal bone loss according to the use of 2 connection types of dental implants (submerged-USII and non-submerged-SSII; Osstem Implant®) by analyzing the change in alveolar bone height after 1 year under load and during final follow-up period.

Materials and Methods: Between December 2004 and August 2008, patients with two types of Osstem implants (USII and SSII) were retrieved retrospectively. A total of 92 patients with 284 implants (USII=60, SSII=224) was finally selected. Their mean follow-up period was 7.5 years. The mesial and distal alveolar crestal bone changes were measured using radiographic images and the average was calculated at 1 year after loading and during final follow-up period.

Result: Among the 284 implants, 4 USII and 7 SSII implants were removed, indicating 93.3% and 96.9% survival rates. Of the survived implants, mean crestal bone loss 1 year after loading was 0.39 mm for USII and 0.19 mm for SSII (P=0.018). During the final follow-up, mean crestal bone loss was 0.63 mm and 0.35 mm for USII and SSII, respectively, without statistical significance (P=0.092). According to the criteria for the success and failure of the implant by Albreksson and colleagues, final success rate was estimated as 86.7% for USII and 91.5% for SSII, respectively.

Conclusion At 1 year after loading, the average crestal bone loss was significantly different between USII and SSII; however, both types met the criteria for implant success. During the final follow-up, both groups showed insignificant bone resorption patterns and did not show any pathological clinical symptoms. Therefore, both implants exhibited high long-term stability.

Key Words: Alveolar bone loss; Dental implant-abutment design

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Received for publication February 18, 2019; Returned after revision June 16, 2019; Accepted for publication June 18, 2019

Introduction

Dental implants have shown high success and survival rates, and implant surgery has been a promising treatment modality for the restoration of edentulous alveolar ridge. In the Albrektsson and Donos' study[1], the 5-year and 10-year implant survival rates were reported as 95.7% and 92.8%, respectively. Lindhe and Meyle[2] stated that the biocompatibility of the implants, their surface, health of the implantation sites including the bone, surgical technique, healing period, and design of the prosthesis influenced the success of dental implants. There have been numerous attempts to modify the micromechanical properties, chemical properties and the design of the implant surface to improve the success rate, because improving the patients' conditions has limitations[3,4].

Early implants introduced by Brånemark were submerged types that indicate secondary operation after the healing period of at least 3 months in mandible and 6 months in maxilla. The initial stability can be secured by maximizing new bone formation and bone remodeling process around the implant to achieve high success rate[5]. In contrast, various studies have shown satisfactory osseointegration even with non-submerged implantation, which raised increased interest in single step implant placement[6]. They had several advantages such as reduced patient discomfort due to the absence of additional surgery, better healing of soft and hard tissues, and easier and more convenient prosthetic restoration[7].

Various designs of implants have been introduced to increase the survival rate and success rate and based on their macroscopic design various connection between implant-abutments have been devised. Typically, it can be categorized into external hex connection and internal Morse taper connection. Depending on the connection method, external forces are differently distributed in the abutments[8]. In addition, the interface between the implant and abutment is determined by the connection type, which is important because microgap formation, bacterial leakage, micromovement patterns of abutments, biologic width formation are influenced by the type of the interface[9].

Although there have been numerous studies about implant abutment connection type or implant placement method, according to the database we used between 2004 and 2008, evaluation of the long-term prognosis of the implant would provide an important basis for the development of implant dentistry. The implant systems compared in this study were Osstem Implant® (Osstem Implant Co., Busan, Korea) USII and SSII, that were subject to the identical surface treatment with different connection type. The USII is a submerged type with external hex connection structure, while SSII is a non-submerged type with internal octa connection structure. The purpose of this study was to evaluate the postoperative complications, survival rate, success rate, and marginal alveolar bone loss according to the connection structure and implant types.

Materials and Methods

This retrospective study recruited patients who had implant surgery using Osstem Implant USII and Osstem Implant SSII, between December 2004 and August 2008, at Seoul National University Bundang Hospital (Seongnam, Korea). The study was conducted under the approval of the Bioethics Review Committee of Seoul National University Bundang Hospital (No. B-1811/505-105). The medical records and radiographs were evaluated and the personal information or facial features of patients involved were strictly kept from being exposed.

The study included 92 patients (44 men and 48 women) with ages between 20 to 90 years (average ages 55.67 years). All patients with without serious systemic diseases were included in the study. Of the 92 patients, 13 had USII implants, 68 had SSII im-

plants, and 11 underwent surgery for both implants. Of the 284 implants placed, 60 were USII and 224 were SSII.

In the USII implants group, 14 implants (23.3%) were placed for the maxillary anterior teeth, 21 implants (35.0%) for maxillary posterior teeth, 6 implants (10.0%) for mandibular anterior teeth, and 19 implants (31.7%) for mandibular posterior teeth. In the SSII implants group, 7 implants (3.1%) were placed for the maxillary anterior teeth, 37 implants (16.5%) for maxillary posterior teeth, 38 implants (17.0%) for mandibular anterior teeth, and 142 implants (63.4%) for mandibular posterior teeth (Table 1). Bone grafting was performed in 51 USII implants (85.0%) and 113 SSII implants (50.4%), including guided bone regeneration, ridge augmentation, extraction socket graft, sinus bone graft, and ridge splitting (Table 2).

Regarding the graft materials, autogenous bone grafts were the most commonly used bone material, followed by deproteinized bovine bone mineral (Bio-Oss [Geistlich Pharma AG, Wolhausen, Switzerland] and Biocera [Oscotec, Cheonan, Korea]), and demineralized freeze-dried bone allograft (Orthoblast II [IsoTis, Irvine, CA, USA], Regenaform [Exactech, Gainesville, FL, USA], and Oragraft [Lifenet Health, Virginia Beach, VA, USA]) (Table 3).

Membranes from three different companies were also used but all were resorbable collagen membrane (Ossix, [Dentsply Sirona, York, PA, USA], Biogide [Geistlich Pharma AG], and Bioarm ACE [Surgical Supply Inc., Woburn, MA, USA]) (Table 4).

We divided postoperative complications into early or delayed, depending on the onset time. Early complications were defined as those occurred immediately after surgery and before prosthetic loading. Delayed complications were defined as those occurred during functioning after prosthetic loading. Complications were detected and diagnosed based on the medical records and radiographic findings[10].

The survival rate was defined as the percentage of implants that remained functional in the oral cavity during final observation. Criteria for implant success were based on those mentioned by Albrektsson et al.[11] including 1) no mobility, 2) radiographic marginal bone resorption less than 1.0 mm during the first year of function and less than 0.2 mm per year thereafter, 3) no pain or abnormality, and 4) osseo-

Table 1. Location of implant placement

Location	USII	SSII
Maxillary anterior	14 (23.3)	7 (3.1)
Maxillary posterior	21 (35.0)	37 (16.5)
Mandibular anterior	6 (10.0)	38 (17.0)
Mandibular posterior	19 (31.7)	142 (63.4)
Total	60 (100.0)	224 (100.0)

Values are presented as number only or number (%).
USII and SSII: Osstem Implant Co.

Table 2. Types of bone grafts

	USII (n=60)	SSII (n=224)
Type of bone graft		
Bone graft	51 (85.0)	113 (50.4)
Without bone graft	9 (15.0)	111 (49.6)
Bone graft method[a]		
Guided bone generation	40 (62.5)	94 (69.6)
Ridge split technique	5 (7.8)	10 (7.4)
Sinus elevation	9 (14.1)	17 (12.6)
Ridge augmentation	6 (9.4)	9 (6.7)
Extraction socket graft	4 (6.3)	5 (3.7)

Values are presented as number (%).
USII and SSII: Osstem Implant Co.
[a]Repetition allowed: If two or more bone grafts were performed, they were respectively classified (USII: n=64, SSII: n=135).

Table 3. Types of bone graft materials

Bone graft material[a]	n (%)
Autogenous bone	114 (44.4)
Bio-Oss	81 (31.5)
Orthoblast II	31 (12.1)
Regenaform	20 (7.8)
Oragraft	5 (1.9)
Biocera	6 (2.3)

[a]Repetition allowed: If two or more bone grafts were performed, they were respectively classified (n=257).

Table 4. Types of barrier membranes (n=97)

Barrier membrane material	n (%)
Biogide	45 (46.4)
Ossix	49 (50.5)
Bioarm	3 (3.1)

integration between implant and surrounding bone without bleeding on probing.

The amount of marginal bone resorption was analyzed based on the apical or panoramic radiographs taken immediately after prosthetic loading. After 1 year of prosthetic loading and during the final follow-up observation, changes in the mesial and distal marginal bone level of the radiographs were measured and mean values were calculated. Independent sample t-tests were performed using the IBM SPSS Statistics program ver. 20 (IBM Corp., Armonk, NY, USA) to statistically analyze the mean difference in long-term bone changes between both groups. The criterion for statistical significance was set at $P<0.05$.

Result

1. Postoperative Complications

Complications were reported in 40 out of 284 implants. USII implants (30.0%, 18/60) and SSII implants (13.8%, 31/224) had postoperative complications. Early complications included osseointegration failure, sensory abnormality, maxillary sinus related problems, and wound dehiscence. Delayed complications included screw loosening associated with prosthetic restoration, peri-implantitis due to persistent inflammation, and peri-implant mucositis (Table 5).

2. Survival Rate

Among the 284 implants, 4 USII implants and 7 SSII implants were removed from oral cavity during follow-up period. 93.3% and 96.9% survival rates, respectively.

Table 5. Types of complications

	USII (n=18)	SSII (n=31)
Early complication		
Osseointegration failure	2 (11.1)	3 (9.7)
Sensory abnormality	2 (11.1)	2 (6.5)
Maxillary sinus related	2 (11.1)	2 (6.5)
Wound dehiscence	5 (27.8)	4 (12.9)
Delayed complication		
Screw loosening	2 (11.1)	2 (6.5)
Peri-implantitis	5 (27.8)	16 (51.6)
Peri-implant mucositis	0 (0)	2 (6.5)

Values are presented as number (%).
USII and SSII: Osstem Implant Co.

Table 6. Reasons of implant failure (n=27)

Reasons of failure	n (%)
Inflammation	15 (55.6)
Poor oral hygiene	4 (14.8)
Occlusal interference	2 (7.4)
Tumor like lesion	1 (3.7)
Unknown	5 (18.5)

3. Marginal Bone Resorption and Success Rate

The duration of follow-up from prosthetic loading until the last visit ranged from 0 months to 13.16 years (mean duration 7.5 years). In the survived implants, average amount of marginal bone resorption 1 year after prosthetic loading was 0.39 mm and 0.19 mm in USII and SSII, respectively, with statistically significant difference (P=0.018). At the final follow-up, mean marginal bone resorption was 0.63 mm and 0.35 mm in USII and SSII, respectively, without statistically significant difference (P=0.092). The success rate was calculated only for cases with more than 1 year of prosthetic loading, and 54 (90.0%) USII cases and 188 (83.9%) in SSII cases fulfilled that condition. According to implant success criteria mentioned by Albrektsson et al.[11], success rates of USII and SSII were 87.03% and 89.89%, respectively.

The failure rates of the USII and SSII were 12.96% and 10.10%, respectively, when the implants were loaded for 1 year after prosthetic restoration. Rea-

sons of failure could be classified into 5 major categories: inflammation, poor oral hygiene, occlusal interference, tumors, and unknown causes (Table 6). Of those, inflammation was most common, which was directly related to the complications caused by implant surgery.

Discussion

This study presents long-term survival and success rates, and crestal bone loss of submerged type with external hex connection and non-submerged type with internal Morse taper connection implants. Within the limited information available and due to the nature of retrospective study design, it was not possible to synchronize all the clinical and radiographic information. Of the 284 implants, which were placed between December 2004 and August 2008, cumulative survival rate of USII and SSII were 93.3% and 96.9%, respectively. Of the surviving implants, mean crestal bone loss 1 year after loading was 0.39 mm for USII and 0.19 mm for SSII which was statistically significant (P=0.018). During the final follow-up, mean crestal bone loss was 0.63 mm and 0.35 mm for USII and SSII, respectively, but was not statistically significant (P=0.092). According to the success and failure criteria of the implant by Albrektsson et al.[11], final success rate was 86.7% and 91.5% for USII and SSII, respectively.

The implants used in this study were treated with resorbable blast material (RBM) on the titanium surface and they had different external hex and internal octa connection types. RBM has the advantage of increasing the surface area by forming irregularities on the implant surface by spraying the particles, demonstrating excellent biocompatibility and activation of cell reaction through the rough surface[12]. According to Novaes et al.[13], RBM-treated implants have higher bone-implant contact than untreated machined surfaces. Piattelli et al.[14] reported that almost complete direct osseous tissue formation was observed on the implant surface treated with RBM. In a study by Coelho et al.[15], it was reported that removed RBM-treated implants showed relatively good osseointegration based on the requirement of higher torque when removing as compared to products that had undergone other surface treatment processes.

Implant connection type can be classified into external connection type and internal connection type, depending on the fixture-abutment connection method. Osstem USII is the same external hex connection type used in early Branemark implant systems and is connected to each other by the combination of external hexagonal structures and internal hexagonal parts[16]. USII is mostly submerged type but can be placed as a non-submerged type if the bone condition is good. This type of design has the advantage of low possibility of failure of the fixture when lateral pressure is applied. However, the disadvantages include frequent loosening and possibility of fracture of hexagonal structure when the height is low[17].

Osstem Implant SSII is an internal connection type that is used in Straumann ITI implant to improve stability in overcoming the clinical complications of external connection type[18]. If the abutment and the fixture are internally joined, a mechanical connection is established in the morphology of its hexagonal structure and the friction force between screw-fixture. As non-submerged type implants, SSII allows the connection to be located above the alveolar bone, so that the depth of the joint can be deepened by increasing the length of the screw. However, in the case of multiple restorations, it is difficult to fit the insertion path and hence difficult to fit the prosthesis and the possibility of tearing of the outer wall increases[19].

The USII implants used in this study was the external hex connection type and SSII was the internal Morse tapered connection type. One year after the prosthetic loading, USII and SSII showed 0.39 mm and 0.19 mm of radiographic marginal bone resorp-

tion, respectively, with a statistically significant difference. However, both products showed low bone resorption. When the final bone change was analyzed for average 7.5 years, the bone resorption was 0.63 mm in USII and 0.35 mm in SSII. This revealed lesser bone resorption in SSII, but the value was not a statistically significant difference.

According to a systemic review by Palacios-Garzón et al.[20], there was no significant difference between the articles that showed less marginal bone resorption pattern in the internal connection type and those that did not find statistically significant difference between two connection types. Furthermore, most studies have shown a high survival rate, indicating that it is difficult to clearly assess between external and internal connection types. This is consistent with our findings that SSII of the internal connection type showed less bone resorption pattern but did not significantly differ from the external connection type.

There are several other research results that concurs with our paper. Menini et al.[21] dealt with within-person randomized split-mouth controlled trial to evaluate the internal and external connections. They reported that after 12 months in function, both implants provided good clinical outcomes without statistically significant difference.

According to systemic review by de Medeiros et al.[22], there was generally less marginal bone loss in the internal connection type. However, this seems to be due to the platform switching concept that is mainly adopted by the internal connection type. Systemic review by Caricasulo et al.[23] also reported that the internal connection type showed less bone loss, but this was due to the platform switching concept. They additionally mentioned that this factor appears to have a more significant effect on the bone level than the connection type.

Several systemic reviews[20,22,23] related to the implant-abutment connection type have pointed out that previous reports have only analyzed the connection type by using the same macro-design and the micro-surface treatment method of implant fixture. In this study, we examined implant fixtures that have been subjected to the same surface treatment process as those introduced by the same implant company.

The complications in this study included six major problems such as peri-implantitis, peri-implant mucositis, failure of osseointegration, screw loosening, sensory abnormality, and maxillary sinus problems. Of the total 40 implants, 21 presented peri-implantitis complication with rapid bone loss and gingival recession. Sub-periimplant curettage was performed to remove inflammatory tissue, followed by treatment with chlorhexidine solution, minocycline ointment local injection, laser detoxification, and systemic antibiotic therapy as part of the treatment[24]. Periodic maintenance care was performed when the inflammation stopped after the treatment, and surgical therapy or implant removal was continued when the inflammation was progressive. As a result, the number of implants removed was 4 in USII and 7 in SSII. Main causes for removal were peri-implantitis and osseointegration failure. On the other hand, the cases with peri-implant mucositis showed very good response to the treatment for inflammation. Additionally, in patients diagnosed as screw loosening, the prosthesis was fixed again to solve the problem after confirming the maintenance of bone-to-implant osseointegration[25]. In cases of sensory abnormality, all were placed mandible posterior region. It doesn't seem to have relation with product itself, rather anatomical characteristics of intrabony nerve canals in mandibular region[26]. We prescribed medicine and applied laser therapy, and no patient exhibited persistent abnormal sensation[27].

The USII used in this study is mainly submerged, and the SSII is mainly designed for non-submerged placement. However, we performed the submerged healing or non-submerged healing according to the patient's individual anatomical conditions such as bone quality, bone mass, and angle of implantation, which is why analysis on the surgical method was

not carried out. There have been many studies on the success, survival, and marginal bone resorption of submerged and non-submerged healing methods in placing implants. Siadat et al.[28] reported that in the implants placed in the mandibular posterior region, the two-stage implant placement (0.65±0.71 mm) showed a higher bone resorption than the one-stage implant placement (0.41±0.53 mm; P=0.02), but without significant difference at 6 months and 12 months after prosthetic loading. Cecchinato et al.[29,30] also showed very little bone resorption up to 1 year after loading with one-stage and two-stage methods, but from 2 years after implantation, marginal bone resorption patterns didn't seem to be related to the surgical method.

Regardless of the surgical technique, the vertical distance between the implant shoulder and adjacent crestal bone is an issue. According to a systemic review by Palacios-Garzón et al.[31], it is not possible to conclude that particular vertical distance between the implant and alveolar bone is superior than another. However, with respect to soft tissue, subcrestal placement of implant fixture is preferred in case of thin biotype. Histologic studies by Degidi et al.[32] showed that bone resorption was observed in all implants, but bone was still located above the implant shoulder when placed subcrestally.

This study evaluated the long-term success and survival rates of each implant system based on the degree of marginal bone change around the implants and the contents of medical records. However, due to the limitation of retrospective study, standardized radiographs were not taken at every step of the procedure and couldn't be compared at each postoperative follow up period. A well-planned protocol for the operation, follow-up of implant systems, and prospective consideration of the possible effects of the detailed procedures used in implant placement should follow.

Conclusion

Implants in this research have been followed during mean period of 7.5 years (0 months to 13.16 years), both USII and SSII groups showed very low bone resorption tendency and no pathological clinical symptoms at the final follow-up. Consequently, the long-term survival and success rates were found to be comparable to the other implant systems.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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