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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

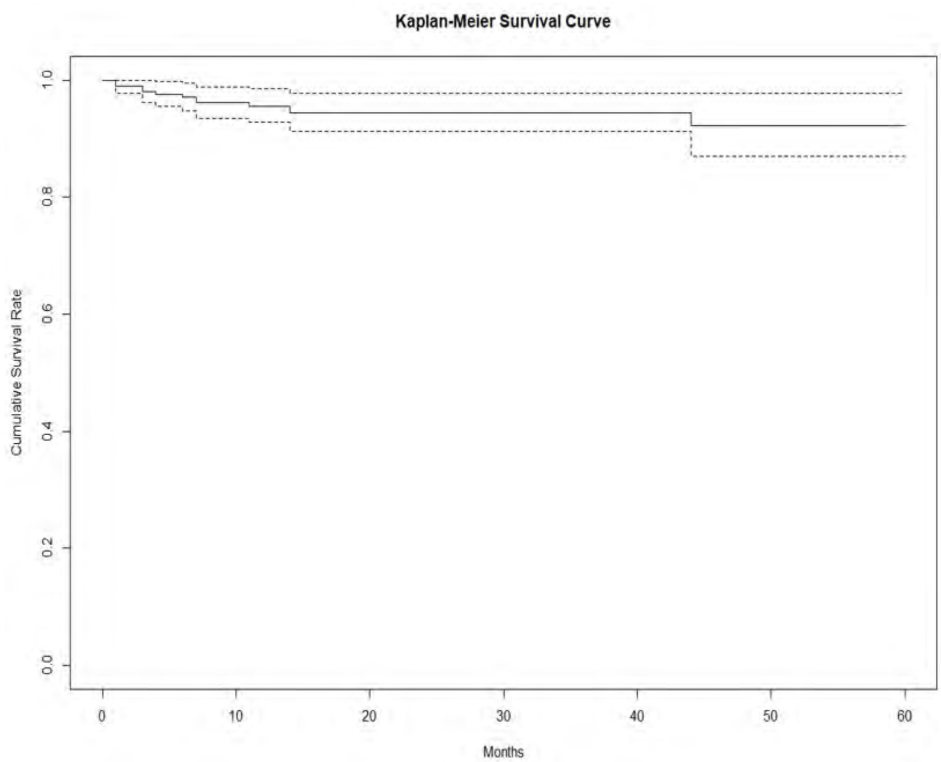

Figure 1. Kaplan–Meier curve of overall short implants.

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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Biomechanical comparison of 3D Finite Elements between umbrella type dental implants and conventional type dental implants, and their stability difference in animal experiment

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Problems during tooth implantation include failure of initial fixation, loss of alveolar bone, and peri-implantitis. Various methods have been proposed to solve these problems, including changing the structure of the implant neck of dental implants ($\phi = 3.3$ mm, L = 10 mm, Neobiotech co. Seoul Korea). We formed an umbrella type structure in the implant neck with the dimension of 0.1 mm, 0.3 mm, 0.5 mm, 0.7 mm, 1.0 mm, investigated its biomechanical significance, and also examined if it would be practically helpful in osteogenesis *in vivo*. For the experiments, we made a finite element model with reference to CT images of patients, in order to compare forces applied to the actual alveolar bone. We produced a model tilted by 10°, similar to actual implants in the mouth, to which we applied 300 Ncm vertical forces in the mouth, and this force divided into vertical force, lateral force, and oblique force. For each of these, we measured principal stress, equivalent stress, lateral displacement, and vertical displacement. For the animal experiment, an implant (Neo-biotech, Korea) with dimensions of 3.3 mm in diameter and 10 mm in length was used in rabbit tibia, and for the experimental group, implants from the same manufacturer were modified with umbrella shapes at the top. The top parts of the modified implants were placed 3 mm above from the superior aspect of the alveolar bone in implantation. Samples were collected after 8 weeks to measure bone growth and removal torque. For the umbrella type implant, there was a decrease in stress transfer of vertical force, lateral force, and oblique force to peri-implant bone as umbrella width increased, while lateral displacement caused by lateral forces and settlement caused by vertical forces also decreased. In the animal experiment, the umbrella type implant resulted in the formation of more alveolar bone, and had a higher removal torque. In conclusion, the umbrella type implant was found to have superior biomechanical properties and osteogenesis. However, further studies are required to investigate whether it is more effective compared to existing implants when it is used clinically. **(THE JOURNAL OF KOREAN ACADEMY OF OSSEOINTEGRATION 2024;16(1):8-20)**

Key words: Umbrella type implant, Biomechanically stable, Safe

INTRODUCTION

Implants have been used for a long time to restore lost teeth, and in arriving at their present state, they have undergone a vast number of advances. However, when bone quality is poor, initial fixation of implants may be unstable, leading to various problems such as absence of osseointegration, or resorption of peri-implant bone. In addition, unexpected problems are often experienced, such as an implant penetrating the maxillary sinus during surgery.

Moreover, complex occlusal forces are generated in the mouth during maintenance of a dental prosthesis mounted on an implant, which causes various problems including failure of the prosthesis, implant fracture, and loss of peri-implant bone.

The differences between implants and natural teeth can clearly be seen in the structure of periodontal tissues, which causes changes in blood flow to peri-implant tissues, and in the difference in susceptibility to inflammation due to discrepancies in the direction of gingival collagen fiber.

In addition, it has also been claimed that since implants are unable to absorb occlusal forces, due to the absence of the periodontal ligament that natural teeth have, excessive occlusal forces are directly transmitted to peri-implant bone, resulting in resorption of the alveolar bone. Hence, there have been a number of efforts to solve these problems. Jeong et al., reported that stability of implants was differently affected by morphological changes to the implants, surface finishing types, and forces occurring in the mouth, such as mastication[1].

Meanwhile, Park et al., performed experiments on resistance to vertical displacement imposed on implants by forming a um-

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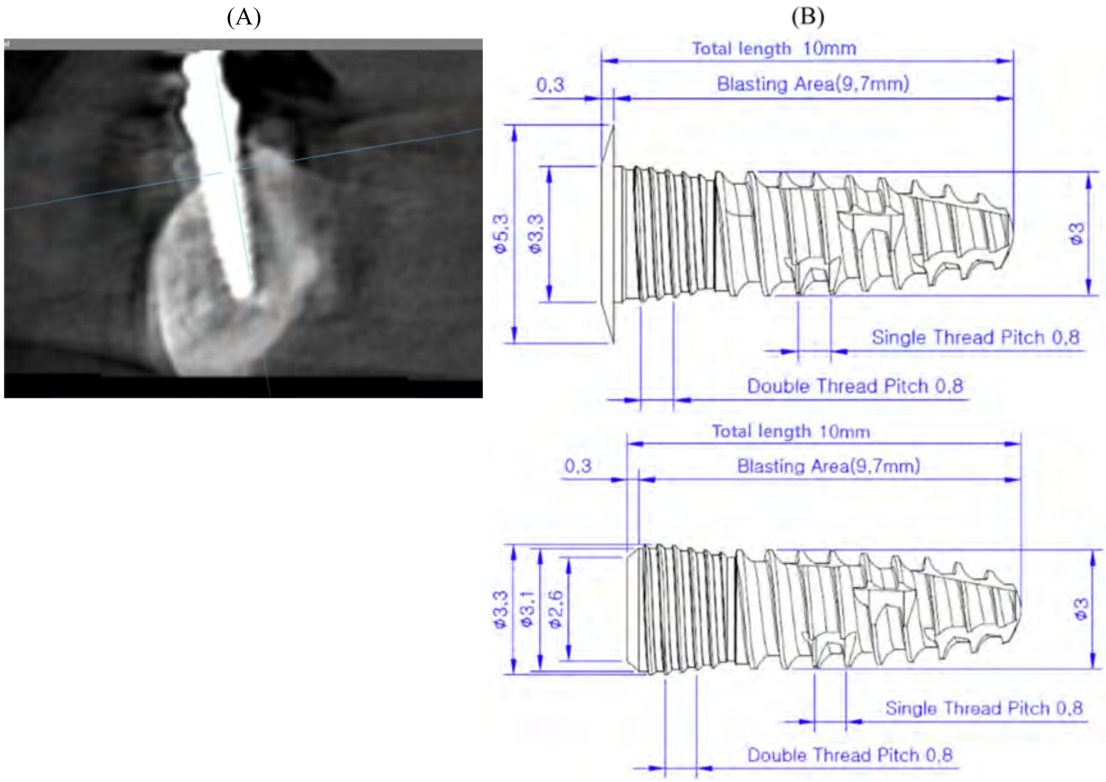


Figure 1. (A) CT Image of Implant by Left Direction (B) The Design of the new implant shape for decreasing deform; Umbrella Type (left), Conventional Type (right).

brella type structure on the top of implant. Although it was just a basic experiment without observation of the various forces, they reported that the structure had a positive effect on dispersal of forces to the implant. However, there have been no additional results.

The present authors modified the top part of the implant to an umbrella type, making a form of implant that would minimize forces transmitted to peri-implant alveolar bone and reduce displacement of the alveolar bone by forces transmitted via the implant. The resulting implants were subjected to analysis using 3D finite element analysis (FEA), in which the peri-implant alveolar bone was divided into cortical bone and cancellous bone.

On the other hand, in order to find out the response of the newly designed implant *in vivo*, the implant was implanted into the tibia of rabbits, and then fundamental experiments were conducted to find out if it was practically helpful for osteogenesis and also on improvement of osseointegration.

MATERIALS AND METHODS

1. Structure of the alveolar bone

Analysis of CT images show the implant as a structure (embedded bar, implant) inserted into the alveolar bone (cortical bone and cancellous bone). A characteristic of this structure is that once force is loaded on the implant in the mouth, the stress is transmitted to peri-implant alveolar bone. At this time, forces inducing settlement into the alveolar bone are generated, along with resistance to implant tilt, and stress is transmitted to peri-implant bone due to the forces of resistance against these forces.

In Figure 1, lateral images of the mandible were obtained through CT cross sectional images taken from an actual patient, a 3D image was constructed based on the images, and then an analysis was attempted. At this time, considering that it is rare for an implant to actually be inserted vertically in the mouth, implant was made in a tilted by 10° in the direction that occlusal force is applied to the alveolar bone. In order to maintain a consistent length, the model was constructed with a 10 mm-long implant.

In Figure 1A, by observing cross-sections taken using a cone

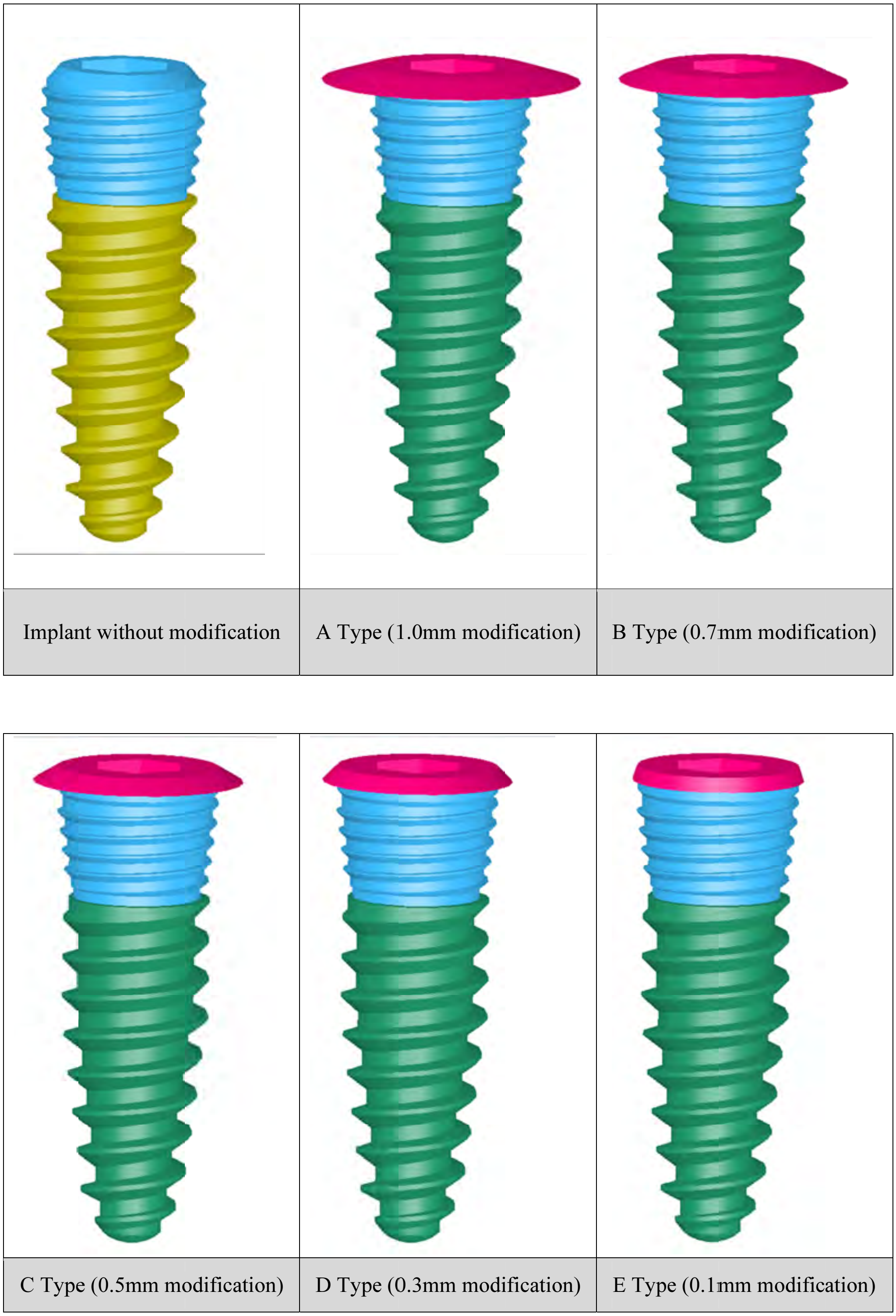


Figure 2. 3D Models of implants with 5 different modifications.

beam-CT, which is often used in dentistry, we made an FEA model from the images.

2. Implant types

The implants used in the experiments were conventional implants from Neo-biotech and umbrella type implants, in which the neck part of the conventional implants was modified. Values used for FEA were selected with reference to the implant manufacturer's design plans, and the surface of each implant used in the animal experiment was treated with RBM.

Figure 1B shows the diagrams of the conventional type and the umbrella type implant, in which the structure of the upper part was modified to have little effect on the alveolar bone and to reduce deformation (settlement and tilt) by forces.

The widths of umbrella protrusion for the umbrella type were set at 1.0 mm, 0.7 mm, 0.5 mm, 0.3 mm, and 0.1 mm, and then the ability to disperse forces resist displacement were observed for each subtype.

In Figure 2, FEA using a 3D model was performed for the conventional type and the umbrella types with varying umbrella width. Helix pitch from the middle part to the bottom part of each implant was 0.8 mm, whereas that of the upper part was 0.4 mm. In addition, protrusions were made on the top part of the umbrella type implants, which functioned to cover the alveolar bone positioned near the upper part of the implants, dispersing transmitted force, preventing infection from outside, blocking downward movement of soft tissues, and decreasing deformation of implants caused by masticatory force (Figure 2).

3. Finite Element Model

A finite element model was constructed based on CT images taken from an actual patient, in which cortical bone and cancellous bone were added, and an implant shape was inserted. The shape of the alveolar bone was made by using coordinates obtained from cone beam CT images, and extended models up to 10 mm in the z axis were made for convenience. The alveolar bone surrounding the implants was constructed as a dense mesh to increase the accuracy of analysis (Figure 3, 4).

Figure 3 shows the finite element models.

4. Comparison of material properties

Properties of materials to be applied for finite element analysis were compared with reference to the literature, and these have been summarized in Table 1.

5. Structure formation and load setting in the finite element model

Lin et al., reported that the range of occlusal force in natural teeth was 297N–669N, and the range of occlusal force after restoration by implant was 42N–412N (Lin et al., 2010), based on which the present study set 300N as the standard load. Also 300N of load was applied in the L2 direction which was defined as the oblique load. This takes into account the fact that the implants in the CT images taken to make the finite element model were tilted by 10°, and that it is generally difficult to perform perfectly vertical implantation in implant surgery (Figure 5).

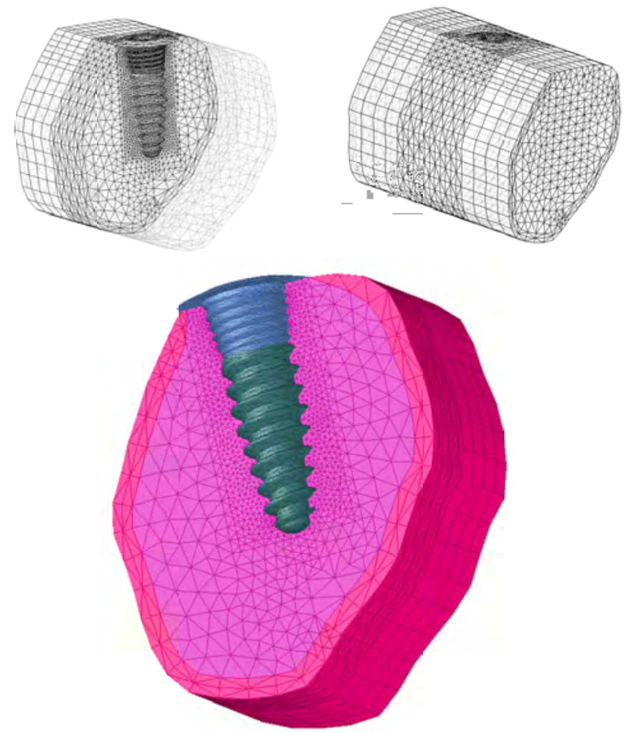


Figure 3. 3D Finite Element Model using the Visual FEA.

The loads to be applied in each direction were calculated as below, in which the direction of the implant itself was set as the vertical direction for force transfer and L2, corresponding to the direction of occlusion, was used for the oblique load in the mouth.

L2 : Oblique Load : 300 N

L1 : Vertical Load : 300 * cos(10°) = 295.4 N

L3 : Horizontal Load : 300 * sin(10°) = 52.1 N

6. Interpretation

The model was made using tetra and prism elements, the number of nodes was 13236, and the number of elements was 62902. 3D solid structure and linear static analyses were used.

7. Animal study

An animal experiment was performed to investigate the *in*

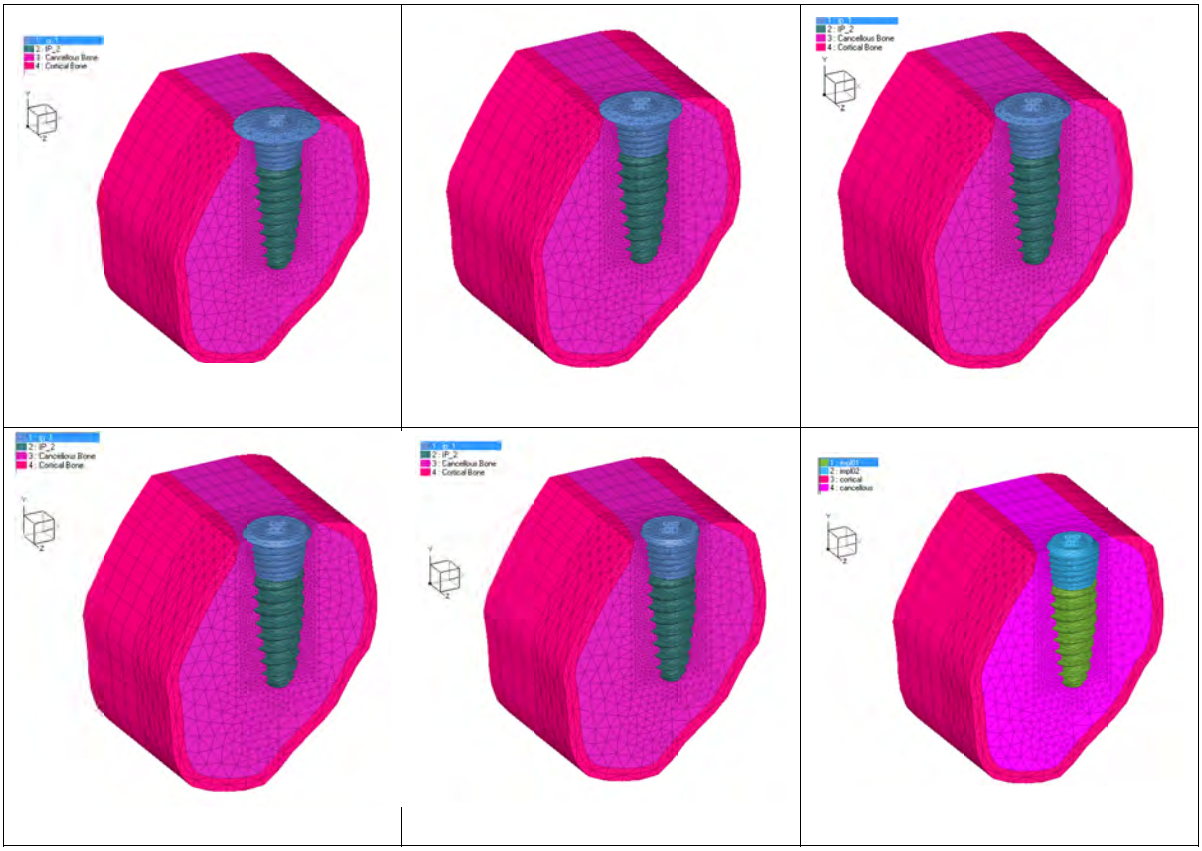


Figure 4. 3D Model demonstrating the new umbrella type implants and implant without change.

Table 1. Comparing mechanical properties of material

Material	Young's modulus	Poisson ratio
Cortical bone	14.8	0.30
Cancellus bone	1.85	0.30
Titanium	110	0.32
Cobalt-chromium alloy	220	0.30

vivo response in terms of the effect of the umbrella part of the implant on osteogenesis. 8 New Zealand white rabbits (2.5 kg) were used in the experiment. Regions to be implanted on both tibias of each rabbit were marked, followed by implantation. At this time, the widths of the region for implantation were increased by 1 mm up to 4 mm in depth from the upper part of implants on both sides, in order to measure osteogenesis (Figure 6).

Anesthesia was conducted by mixing Rompun and Zoletil in a ratio of 1:1 (0.5 cc each), and administering by intravenous injection. The implant with a 1 mm long umbrella (experimental group) and the implant without modification (control group) were inserted into the tibias of each rabbit.

Implants (Neo-biotech, Korea) with dimensions of 3.5 mm in diameter and 8 mm in length were used as fixtures in the experiment, and implants for the experimental group were made by the same manufacturer with modifications. The rabbits were sacrificed after 1 month, followed by biopsy to measure removal torque and the degree of osteogenesis. Rabbits were sacrificed by the method of mixing Rompun and Zolatil in the same ratio (0.5 cc each), followed by intravenous injection, and then air was injected into the heart (Figure 7).

Removal torque was measured by using a torque tester from Ostem, and during the biopsy, ground polished bone specimens were made together with the implants together for biopsy, followed by Villanueva stain and observation for the extent of osseointegration (Figure 8).

CONCLUSIONS

1. Umbrella type implant has better biomechanical characters by force distribution
2. Animal study shows the umbrella type implant activate more bone formation

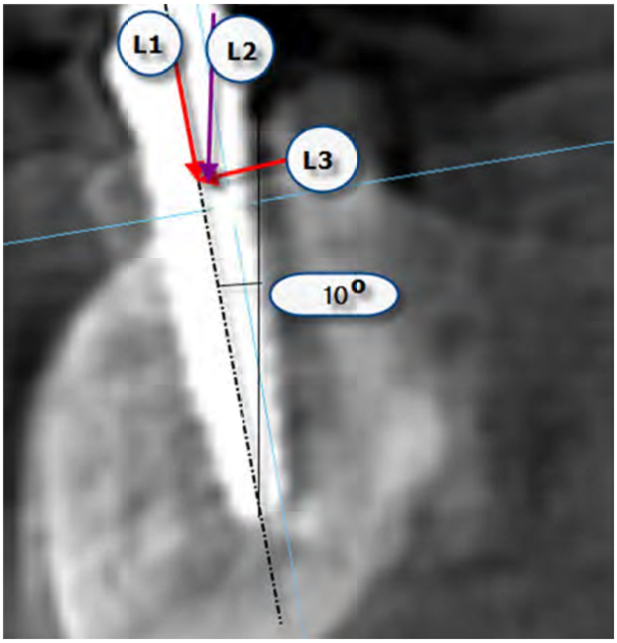


Figure 5. Applied Load and Direction.

3. Umbrella type implant can be used clinically

ANALYSIS

1. Summary

Analysis was performed on 6 implant types, including the umbrella types (Umbrella Type 1 – Umbrella Type 5) and the conventional type, for the 3 kinds of loads on implants: vertical load, horizontal load, and oblique load. In order to investigate deformation characteristics caused by occlusal forces, analysis was performed on the vertical settlement pattern of implants (settlement, Y displacement) and horizontal displacement, in terms of implant tilt (Tilt, horizontal displacement/implant length).

2. Analysis of implant deformation

Analysis was performed on tilt of implants relative to the horizontal force (Figure 9A, 9B, Table 2) and the extent of settlement degree relative to the vertical load (Figure 10A, 10B).

Figure 9A shows the implant tilt due to horizontal forces, in which the degree of tilt caused by the force on the implant was calculated by the following equation.

$\delta = [[u_{t} - u_{b}]]/[[H_{ip}]]$

δ : tilt of implant

u_{t} : horizontal displacement of upper part of implant

u_{b} : horizontal displacement of bottom part of implant

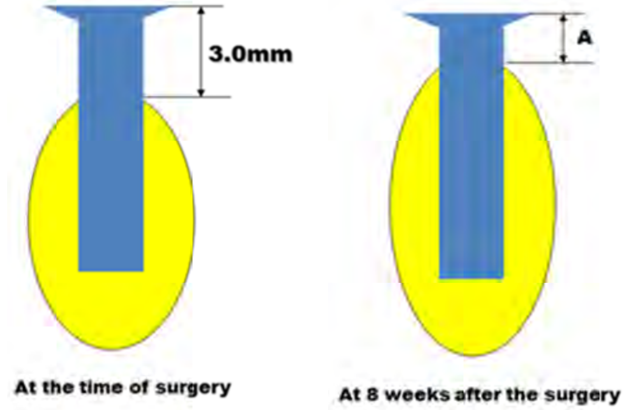


Figure 6. Both side of distance between top of implant and the alveolar crest (A) was measured. Bone gain ratio was calculated as (1−(A/3.0))×100.

(A)

(B)

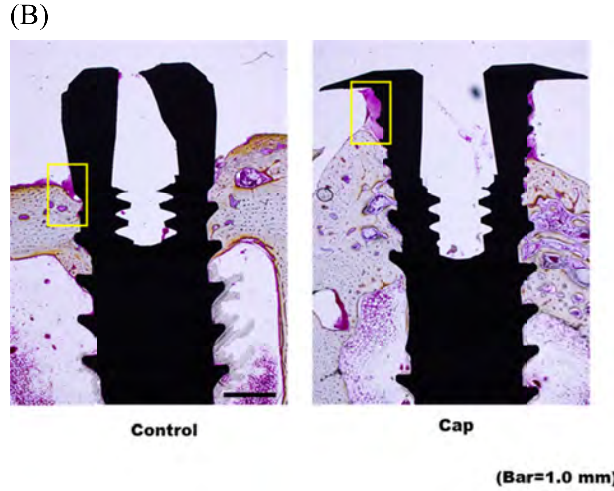
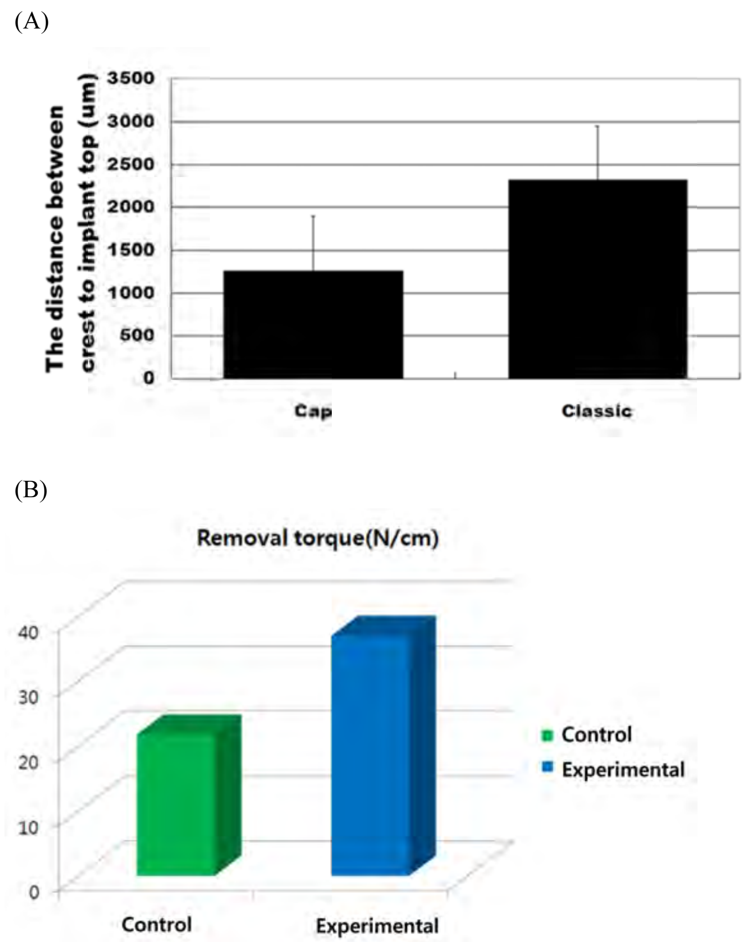


Figure 7. (A) An implant implanted in tibia of rabbit. (B) Difference of bone gaining pattern between control and experimental group.



21.75 ± 6.84 N/cm 37 ± 3.12 N/cm
Mann-whitney test (p=0.029)

Figure 8. (A) The distance between the alveolar crest to the implant top was 1264.2±633.0 μm in the umbrella type implant. It was 2319.8±635.8 μm in control (p=0.002). (B) Removal torque.

H_{ip} : implant height

Figure 9B is a graph showing horizontal displacement when a horizontal force is applied to the implant, where the degree and direction of displacement are displayed according to the position from the top to the bottom of the implant. As umbrella length increased, horizontal displacement by the same load decreased and tilt became smaller, as shown in the figure.

The position for the axis of rotation in the conventional type was higher, with more severe horizontal displacement, which may cause more stress to be transmitted overall, not only to the alveolar crest, but also to peri-implant bone tissue.

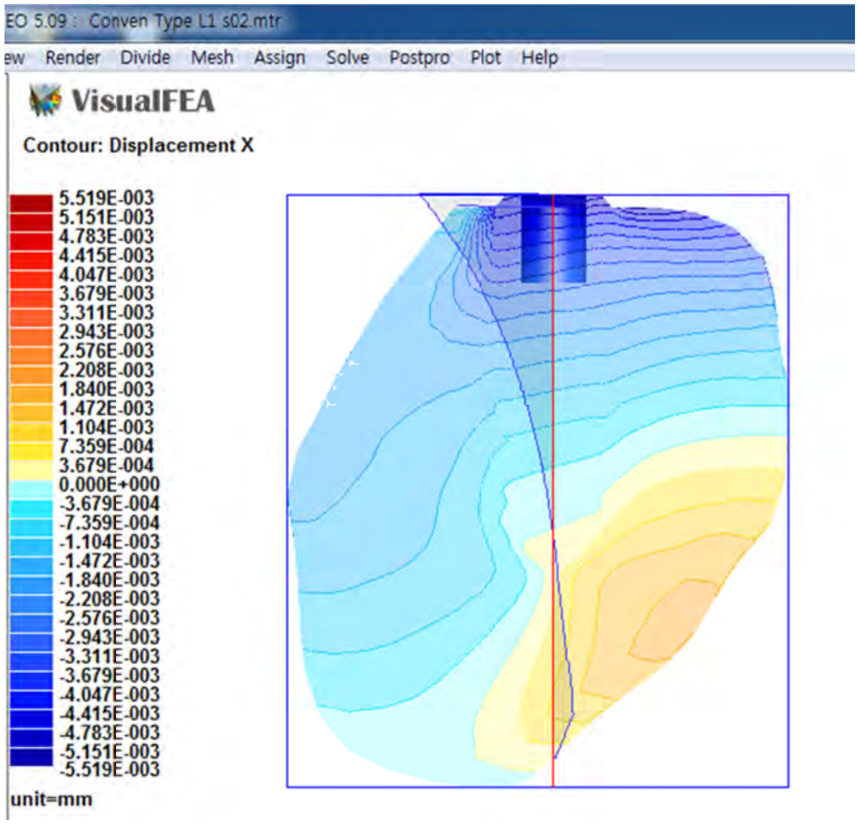
Table 2 shows tilt and displacement values of the bottom part and the top part depending on implant type. The maximum displacement and the maximum tilt were found in the conventional type. In contrast, the minimum value was found in the 1.0 mm-long umbrella.

Figure 10A shows settlements by vertical load (settlement, Y displacement). Loads applied to the implant increase stress on cortical and cancellous bone, causing settlement. In the interpretation of 3D FEA, analysis of settlement makes it possibly to investigate how well an implant type adapt to human the alveolar bone.

Figure 10B shows settlement depending on position of the alveolar bone for Umbrella Type 1 – Umbrella Type 5 and the conventional type. As the implant approaches the conventional type, the extent of settlement increases, demonstrating a large inhibitory effect of the umbrella on settlement.

Table 3 shows the extent of settlement due to vertical load, in which the conventional type resulted in the highest settlement, and as umbrella length increased, settlement decreased.

(A)



(B)

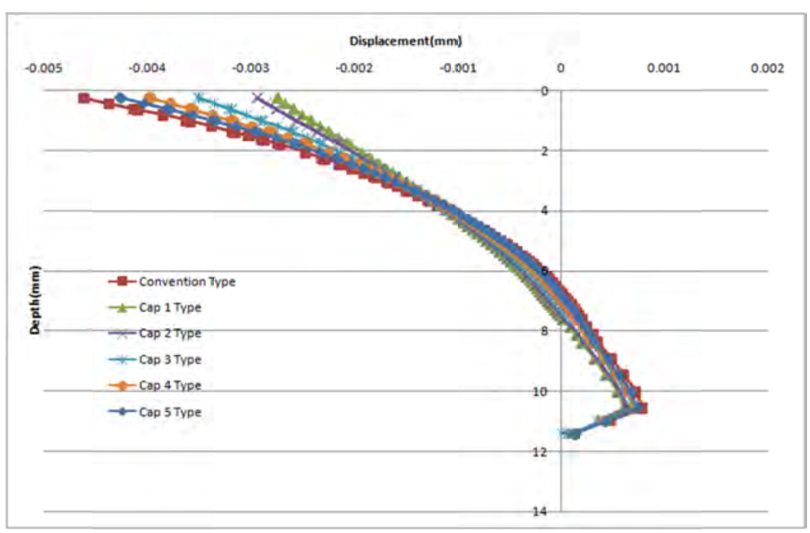


Figure 9. (A) X displacement Contour Example. (B) Comparison of Horizontal (X) displacement versus Depth.

3. Stress on the alveolar bone

Figure 11A shows von Mises stress on the alveolar bone. The bone will broken at the point where stress intensity is equal to this stress.

$$\sigma_{eq} = \sigma_{Von\ mises} = \sqrt{\frac{1}{2}\left[(\sigma_1 - \sigma_3) + (\sigma_1 - \sigma_3) + (\sigma_1 - \sigma_3)\right]}$$

$\sigma_{eq} < \sigma_a$: Safe

$\sigma_{eq} \geq \sigma_a$: Fracture or Failure

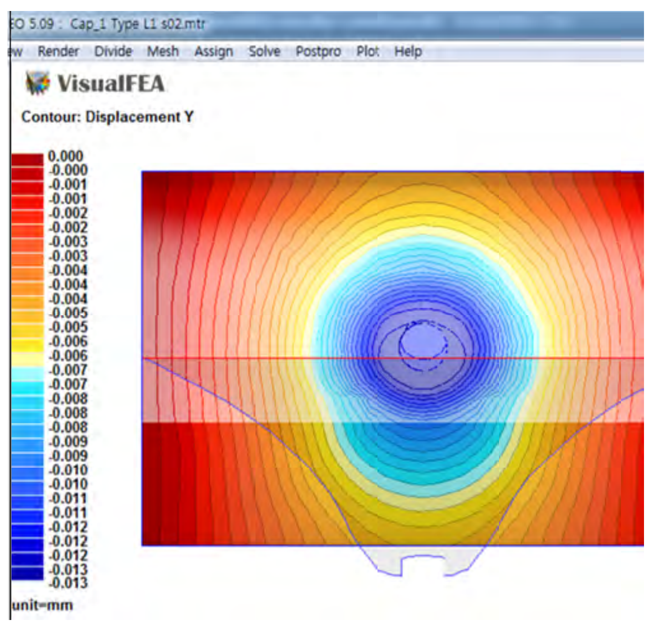
Here, σ_a : Allowable strength of applied subject

Figure 11B shows von Mises stresses calculated for cancellous

Table 2. Tilts and Displacements of the new designed implants

Items		Type of the new Shape of implants					Conventional Type
		Umbrella 1	Umbrella 2	Umbrella 3	Umbrella 4	Umbrella 5	
Tilt		3.390E-04	3.709E-04	4.407E-04	4.957E-04	5.289E-04	5.776E-04
Displacement	Bottom	5.453E-04	6.378E-04	6.971E-04	7.157E-04	7.377E-04	7.842E-04
	Top	−2.845E-03	−3.071E-03	−3.710E-03	−4.241E-03	−4.551E-03	−4.992E-03

(A)



(B)

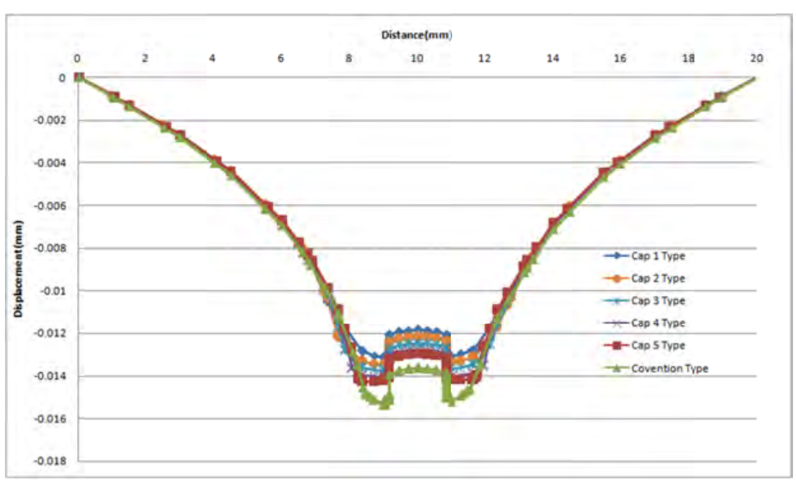


Figure 10. (A) Settlement (Y displacement) by Vertical Load. (B) Comparison of Settlements (Y displacement) versus Distance.

bone and cortical bone, where stress on cortical bone was found to be higher for Umbrella Types 1 and 2. In contrast, there was no outstanding difference in the stress on cortical bone calculated for Umbrella Type 3 – Umbrella Type 5, and the conventional type.

In addition, stress on cancellous bone was smaller for Umbrella Type 1 – Umbrella Type 3, whereas stress was found to be higher for Umbrella Types 4 and 5 and the conventional type. The umbrella size was bigger in the umbrella type implants in

Table 3. Settlements of the new designed implants and Conventional Type

Items	Type of the new designed implants					Conventional Type
	Umbrella 1	Umbrella 2	Umbrella 3	Umbrella 4	Umbrella 5	
Settlement (mm)	1.314E-02	1.348E-02	1.376E-02	1.406E-02	1.427E-02	1.534E-02

(A)

(B)

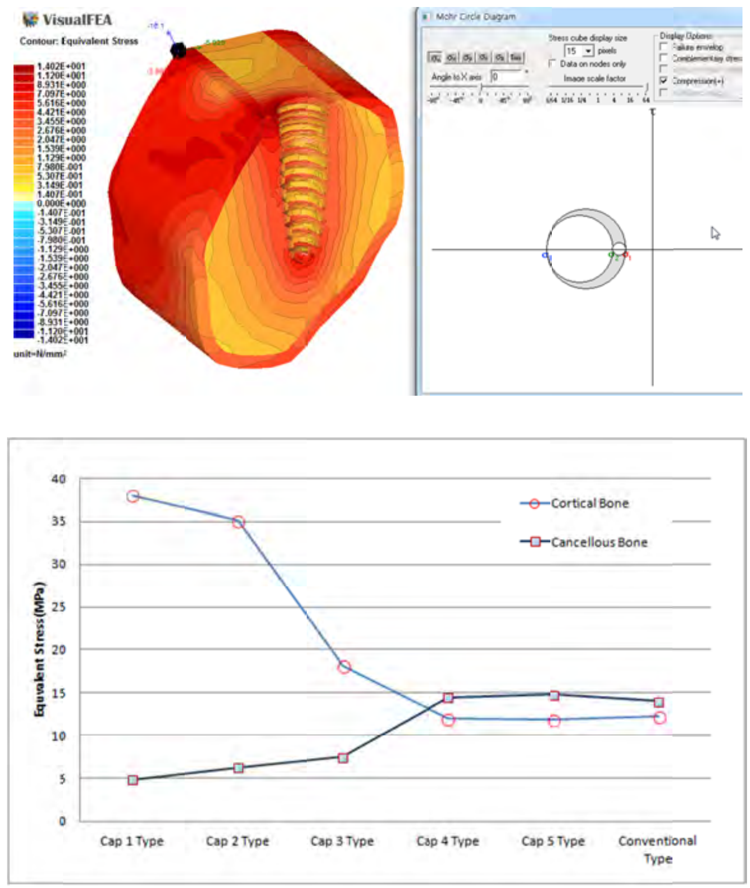


Figure 11. (A) Concept of von Mises stress. (B) von Mises Stress (conventional type implants versus the new designed implants).

which the umbrellas directly contacted the cortical bone, which tended to reduced stress on cancellous bone, while increasing stress on cortical bone.

Table 4 shows equivalent stress, or von Mises stress. The stresses generated on cortical and cancellous bone changed dramatically from umbrella type 4. Based on this table, it is determined that the umbrella type implants effectively decreased stress on the alveolar bone (Table 4).

DISCUSSION

Design of implants is a highly important factor for determining not only the surgical method for implantation, but also the properties of the implant. In particular, successful fixation of the implant in the bone and the maintenance of a stable state are crucial elements in the osseointegration process. In addition, implant design also affects maintenance of the alveolar bone and the occurrence of periodontal disease following long-term use of the implant.

Kim et al., studied initial responses of proximal tissues depending on implant type by inserting 3 trans mucosal type implants into Beagle dogs. They reported that implant type affected the difference in bone resorption and the level of proximal soft tissue formation. In addition, they claimed that more initial con-

Table 4. Equivalent (von Mises) Stress of Cortical Bone and Cancellous Bone (MPa).

Items	New Shape of implants					Conventional Type
	Umbrella Type 1	Umbrella Type 2	Umbrella Type 3	Umbrella Type 4	Umbrella Type 5	
Cortical Bone	38.05	35.2	18.2	12	11.9	12.2
Cancellous Bone	4.841	6.246	7.49	14.5	14.8	14

nective tissue would be more helpful in the long term prognosis of the implant, because the tissue would be maintained even after the implant had fulfilled its function. This is interpreted to be consistent with existing knowledge of the relationship between biologic width and the health of the periodontal tissue[3].

Elias et al. studied the effects of different implant morphologies, surface appearance, surgical methods, and bone quality on initial fixation of implants. According to their study, influencing factors on initial fixation were the condition of the alveolar bone, surgical method, and design of implant[4], and a number of researchers have made efforts to increase initial fixation and success rate of implantation by modifying the design, length, and width of implants[5-7].

On the contrary, Norton reported that secondary implant stability, which is a process caused by remodelling of osseous tissue after implantation of implant in the bone, is more important than simple initial fixation. Hence, Norton even claimed that it would be unnecessary to apply a force of at least 20 Ncm in implantation of a standard sized implant[8]. This claim is based on a study by Barewal et al., in which any implant would lose its stability after 3~4 weeks no matter how firmly the implant was established in the bone. In particular, Barewal et al. reported a difference in the change in initial fixation depending on the presence or absence of cortical bone, whereas it seems that the umbrella design in the present study was helpful in fixation external to the bone tissue, meaning that this design could increase initial fixation ability when cortical bone was weak[9].

Pilliar RM reported that implant design affected remodelling of peri-implant bone. In addition, when bone tissue was absorbed at the upper part of implant, and osseointegration occurred only at the bottom part of implant, it is thought that bending forces could increase the chance of mechanical fatigue fracture by masticatory force. This phenomenon has been also reported to occur in prostheses applied to the hip joint or knee joint, where it was also mentioned that prostheses with a rough surface had a high osseointegration effect[10,11].

Park et al. attempted to increase initial fixation ability during implantation and minimize the stress on the alveolar bone by modifying the neck design of the implant[12]. A umbrella structure was added to the neck of the implant, and then degree of displacement of implant in response to vertical and horizontal forces loaded on implant, as well as the level of stress to peri-implant bone, were observed using a finite element method. In the results of this experiment, the implant with a umbrella structure had a much higher resistance to displacement by vertical and horizontal forces than conventional implants, and stress transmitted to peri-implant bone also remarkably decreased. In addition, stress was mostly transmitted to the surface of cortical bone, meaning that the implant is placed in a highly stable condition within the alveolar bone. Therefore initial fixation ability of the implant should increase, and the ability to tolerate excessive occlusal force should be enhanced.

It is a well known fact that optimal dispersal of occlusal force in the mouth significantly affects the long term prognosis of implants, so there have been attempts for a long time to analyze the force applied to implants by occlusal force, as well as the influence of this force on the surrounding region. Various methods were attempted before the finite element method became universal. In particular, French et al. used a photoelastic model to analyze transmission of stresses to peri-implant region by type, and also performed a comparative analysis of implants designed to properly disperse occlusal force[13-15].

In addition, Torsiglieri et al. performed an experiment in which they made a model of a severely atrophied mandible, conducted implantation with various types of implants, applied a force directly, and measured the ability of the implants to withstand forces in poor bone quality and their ability to tolerate forces in the mouth. They also performed observations in which they standardized the morphology of the mandible, and measured and observed the output after applying forces directly[16].

In the present study, we were able to apply forces with an actual direction and intensity in the mouth by using an FEA that was structurally similar to the actual situation in the mouth. Direction of force and elasto-plastic behavior of the areas affected by it were determined with reference to a study by Lee et al[17].

Simsek et al. applied a vertical force, a force tilted buccolingually by 60°, and a horizontal force, based on vertical implantation into the jaw, and measured the compressive and tensile forces that were transmitted to the jaw using a finite element model. When forces were transmitted to the neck part of the implant, a tensile force was conveyed to the buccal side, and a compressive force was conveyed to the lingual side. As the gap between two implants was wider, tensile force to the buccal side increased, whereas when the gap between two implants was narrower, compressive force to the lingual side increased[18].

Multiple researchers have conducted studies using finite element methods to assess the effects of implant design on peri-implant bone, and effects have been reported according to the cross section of implants, as well as differences in transmission of force depending on the upper structure of implants[19,20]. In particular, Bozkaya et al. analyzed the concentration of forces according to the implant region, by direct applications of various forces using 5 types of commonly used implants available commercially. They found that stresses from conventional occlusal force were concentrated on the upper part where the cortical bone was, regardless of implant type. In general, this phenomenon may be because the force loaded on the implant had effects on physiological phenomena at the border area between the upper part of the alveolar bone and implant, regardless of implant type.

The present study applied 300 Ncm of vertical force, calculated the oblique force and horizontal force loaded on implant with 10° of tilt using a 3-D model, and applied the force working in each direction. Erkman et al. also used 300 Ncm of vertical force and a 3-D FEA model, in which they compared biomechanical responses to forces loaded on two different materials using a 3-D model[21].

When the results of the present study are analyzed, as the force is concentrated on the upper part of the implant where it contacts cortical bone, there was a decrease in stress inside the alveolar bone, where the majority of contact between the implant and bone occurs. Since this implant shape is a highly advantageous structure for stable maintenance within the bone, it is considered greatly helpful in promotion of initial osteogenesis for patients with poor bone quality.

In addition, an increase of resistance in the umbrella area greatly suppresses the extent of downward settlement of the implant due to vertical forces, so that the umbrella type is highly advantageous for preventing the implant from entering the maxillary sinus in cases of maxillary sinus augmentation, where the implant often fails to hold the load due to poor bone quality.

Therefore, it is expected that the required time from implantation to loading of masticatory force would be reduced, and this early restoration of masticatory force would elevate satisfaction of patients. Multiple researchers have been studying ways of reducing the time from implantation to loading, and Szmukler-Moncler et al., proposed more detailed and reasonable standards. In particular, they suggested that, in the early stages, patients should carefully and strictly decide the time a force or load needs to be suddenly applied, and that success rate should be increased through modifications, such as the method of using a splint to connect implants together and minimize micromotion[22].

In addition, since the umbrella type implant promoted osteogenesis at the bottom part in animal experiment, clinical application of the umbrella type implant would be helpful for osteogenesis at the peri-implant region, leading to elevation of torque generated during removal of implant, and promotion of osteogenesis at the peri-implant region. Therefore, this implant design is considered to give additional stability to the implant when implantation is performed on area with severe bone loss or poor bone quality, and it is also expected to have positive outcomes when applied in practice.

CONCLUSION

3D FEA was performed on newly designed umbrella type implants, and the effects of the implant modifications on the alveolar bone (cortical bone and cancellous bone) were as follows:

- As umbrella length increased, settlement and tilt of implant decreased, indicating that the umbrella was highly effective for stable establishment of the implant in the bone.
- Stress on cortical bone was calculated to be higher for wider umbrellas, whereas the 0.3 mm umbrella had a smaller effect on stress reduction. In contrast, stress on cancellous bone increased as the umbrella width decreased, and the 0.3 mm umbrella showed the minimum stress reduction.
- As the umbrella width increased, the implants showed an improvement in stable establishment, and stress on cortical bone increased, while stress on cancellous bone decreased.

Therefore, the umbrellas 0.3 mm~0.5 mm in length are considered optimal, based on their stabilizing effect for establishment, and relatively small impact on osseous tissue. In addition, it is also necessary to consider methods to prevent concentration of stress at the site where the umbrella directly contacts to the osseous tissue by making the margin of the umbrella into a round shape.

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Effect of wing structure on immediate placement ; a case report

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Immediate implant placement was mentioned by Lazzra and after then many controversies had evoked and developed until now. For doing immediate placement, one of most important matter is to manage the remnant space of extracted socket correctly. It is recommended to do bone graft if the gap between the implant and alveolar bone is wider then 2 mm. it is mostly successful but sometimes we confront very difficult situations such as too big defects and/or the defects involves neighbor tooth or implant. It may be very difficult to recover and grafted area may go to fail. If the grafted material may be positioned stably, immediate placement on large defect will be more successfully. A patient visit my clinic with severe pain on lower anterior bridged teeth. Abutment teeth are involved with bone defect by severe peri-implantitis. Bridge is removed with all the anterior teeth extraction and implant was inserted immediately. We used wing structured implant on the top of implant body. The wing structure protects grafted materials form soft tissue invasion and protect underlying grafted bone. Final prosthodontics are finished after 3 months. The patient was followed until 2019.03.13. Peri-implant soft tissue looks very health without bleeding and peri-implant bone loss. Furthermore defected neighboring bone was grown up and recover to normal bone level. Wing structure may protect the grafted bone from dissiperation and also inhibit soft tissue grown down in to grafted site. **(THE JOURNAL OF KOREAN ACADEMY OF OSSEOINTEGRATION 2024;16(1):21-24)**

Key words: Wing structure, Immediate implant placement, Bone regeneration

CLINICAL CASE

71 years old male patient visited dental clinic with severe pain on lower anterior bridge from #33 to #43. Abutment teeth was extracted. Irregularly formed bone was trimmed with chisel and round bur (Figure 1, 2).

Three implant was inserted with autogenous bone graft on defected site (#33, #43).

Temporary bridge is fabricated for aesthetic recovery (Figure 3, 4).

After 2 monthes, we checked the implant. No inflamation around implant without mobility. Final bridge was seated 3 monthes after operation (Figure 5, 6).

After 7 years, defected bone around implant was filled with new bone and soft tissue level also grow upward to normal level (Figure 7, 8).

Figure 1. 71 years old patient visited with severe pain on lower anterior teeth.

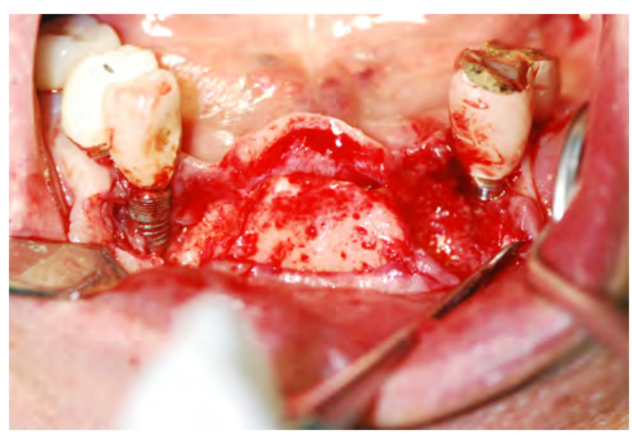

Figure 2. Mobile teeth was extracted and sever bone loss around implant can be seen.

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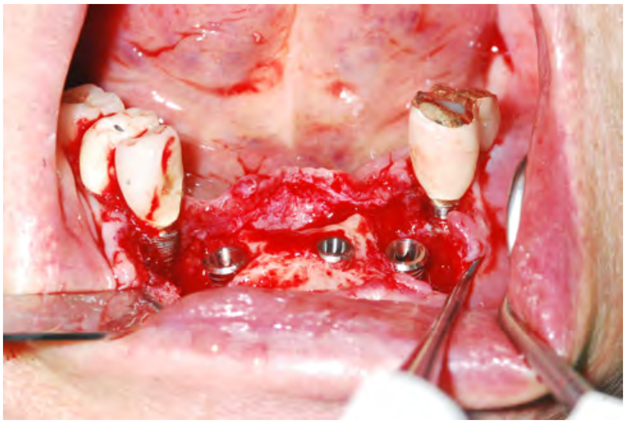

Figure 3. Implant was placed after flattening th alveolar bone. Distal portion of implant on #33, #43 can not be supported by healthy bone.

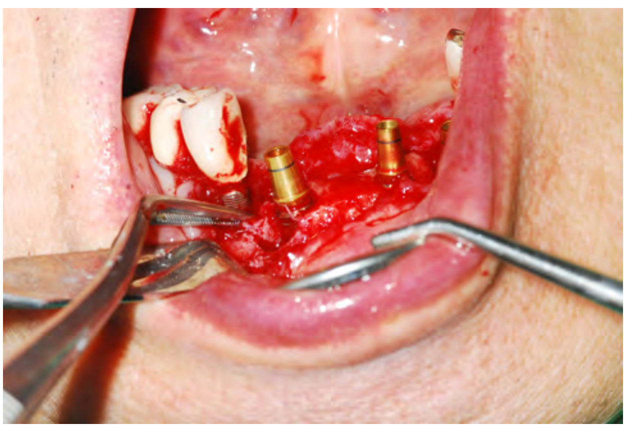

Figure 4. Autogenous bone graft was done to fill up the defected site and to cover the exposed implant surface. Abutment for immediate temporalization was engaged.

Figure 5. Two weeks after surgery. Healed well without inflammation, but defected ridge is remained between implant and tooth. Several portion of implant thread exposed.

Figure 6. Panoramic view after implantation. Radioluscent shadow can be seen around implant.

Figure 7. After two years, Peri-implant soft tissue looks very healthy and proving depth around implant is decreased markedly.

DISCUSSION

In spite of many arguments and problems related immediate implant placement the technique and concepts are developed. And as a results it becomes one of a safe and convenient treatment options.

In 1992 Werbitt et al[2]. yielded an article. In this report, intact extraction socket is not necessary to do extra surgery but to overcome compromised situation, bone graft and/or guided tissue regeneration is done simultaneously. They insisted that the advantages of immediate implant placement are 1) treatment time is significantly reduced, 2) ridge contour can be preserved, 3) better aesthetics and biomechanics due to more ideal axial position

In addition of these advantages of immediate implant placement, the patient is supported psychologically. In spite of these advantages, several disadvantages are there also: it has high risk for implant failure, unpredictable future hard and soft tissue level, difficulty to achieve initial stability[3].

We do immediate implant placement in lower anterior area and this zone is very sensitive for aesthetic matters. To get the aesthetic result in anterior region (upper and lower) following matters must be checked before treatment; scallop of the periodontium, level of crest and interproximal bone, smile line, morphology of the gingival tissue[4].

In our case, both site of distal alveolar bone of #33 and #43 had been resorbed severely due to peri-implantitis of neighboring implants. So first few months after surgery, gingiva around the implanted site shows deep defect and part of neighbored implant thread was exposed.

Usually to recover the defect, subepithelial connective tissue graft may be helpful for further augment tissue height and thickness. It also affect to gaining bone level[5]. But in our case, the soft tissue and hard tissue is recovered to relatively normal level without any other extra surgery. and as a result, the implanted area is very good esthetically and the implants are maintains healthy. This phenomenon is very unique so mostly not occurred as usual.

Figure 8. After 7 years, Alveolar bone around implant is recovered well.

About this kind of healing pattern, of course it must be studied further, we only guessing that the grafted bone under wing structure were protected stably and as a result the sound new bone is made.

Although immediate implant placement has such many advantages, one of main problem in aesthetic area, such as maxillary anterior teeth, is alveolar bone resorption after tooth extraction. Hyunh-Ba et al. studied about the thickness of alveolar bone around the tooth. And find every alveolar bone is resorbed after extraction of tooth so if one want to do immediate implant placement, it is better to do bone graft or guided bone regeneration for compensating bone resorption[6].

Juodzbalys studied with Wang about soft and hard tissue assessment. They fine the importance of bone volume and stable and healthy peri-implant soft tissue. So the authours concluded if extraction socket is compromised, bone graft and soft connective tissue graft will be helpful.

Implant position is one of the important matter for successful implant treatment. From Botticelli's study, the gap between buccal alveolar bone and implant body will filled with new bone and if the gap is within 2 mm, newly formed bone will filled completely but outer buccal bone is resorbed about 56%.

But this situation is already healed site and bone loss was occurred due to peri-implantitis and periodontitis, further bone loss around implant is less predicted. Only remaining matter is well manage the defected site so the infected condition do not affect the implant.

We do bone graft on the defected site without extra membrane, cancellous bone was filled firstly and cortical bone was covered onto it for separate the grafted particle bone from soft tissue grow in.

As a result grafted bone did not spread out to surrounding tissues. This is possible due to the wing structure on the top of implant. May it hold the underlying grafted bone and also it inhibits soft tissue grow down to the grafted site.

CONCLUSIONS

Immediate implant placement is requisite option for rehabilitate aesthetic zone. To overcome some disadvantage of immediate implant placement, case selection must be done carefully. Guided bone regeneration procedure with hard tissue and soft tissue must be considered. In this troubled case, wing structured implant is so helpful for more easy and reliable bone graft. It also seems to help to keep soft tissue healthy.

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Interdisciplinary approach for implant site development: orthodontic molar uprighting with long-term follow-up

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The prolonged absence of teeth often results in mesial tilting of adjacent molars and bone resorption, creating challenges for implant placement. This case highlights a multidisciplinary approach combining orthodontic molar uprighting with mini-implant anchorage and ridge augmentation for implant site development in a patient with severe mesial tilting of the mandibular second molar. Orthodontic treatment created sufficient mesiodistal space (6.25 mm occlusally and 0.7 mm cervically) over 8 months, while ridge augmentation using Bio-Gide and Bio-Oss enhanced buccal bone volume for implant stability. A stable implant (Osstem TS III SA) and prosthesis were maintained for 12 years without complications, demonstrating the success of this combined approach. This case underscores the importance of addressing tooth angulation and bone deficiencies for functional and esthetic long-term outcomes. **(THE JOURNAL OF KOREAN ACADEMY OF OSSEOINTEGRATION 2024;16(1):25-30)**

Key words: Tooth uprighting, Orthodontic tooth movement, Implant site development

INTRODUCTION

Clinicians frequently face challenges associated with inadequate mesiodistal space when performing dental implant procedures in edentulous regions. These challenges typically occur when tooth loss is left untreated for an extended period, resulting in tilting and mesial drifting of the adjacent teeth and edentulous ridge resorption[1]. Particularly in the posterior region, various problems may occur, such as insufficient space for implant placement, distal drifting of premolars, extrusion of opposing teeth, occlusal interferences during protrusive and lateral movements, and difficulties in prosthesis adaptation[2]. In such cases, clinicians may choose implant therapy while accepting certain restorative limitations or consider modifying the site to accommodate implant placement[3]. However, if adequate space for implant placement can be achieved, implant-supported restorations not only eliminate the need for additional preparation of adjacent teeth but also provide optimal functional and esthetic outcomes[1,4-7].

This case report describes a multidisciplinary approach applied to a 45-year-old male patient with severe mesial tilting of the mandibular second molar due to the long-term absence of the mandibular first molar. The treatment combined orthodontic molar uprighting with mini-implant anchorage and ridge augmentation to restore ideal conditions for implant placement. Notably, the outcomes were monitored over a long-term follow-up period of 12 years, demonstrating stable functional and esthetic results throughout this period.

CASE REPORT

A 45-year-old male patient visited our clinic with a chief complaint of difficulty chewing due to discomfort in both molar regions. His medical history was unremarkable and did not include health issues impacting dental treatment. With the prolonged absence of the mandibular right first molar, mesial tilting of the mandibular right second molar occurred (Figure 1). The plan was to create adequate space in the mandibular right first molar area by uprighting the mandibular right second molar, followed by implant placement. In the initial stages, after extracting the mandibular right third molar, the mini-implant was placed between the roots of the mandibular right first and second premolar for anchorage. To achieve indirect skeletal anchorage, the target tooth was positioned in an ideal position on a setup model, and a nickel–titanium (NiTi) spring was fabricated on the model teeth.

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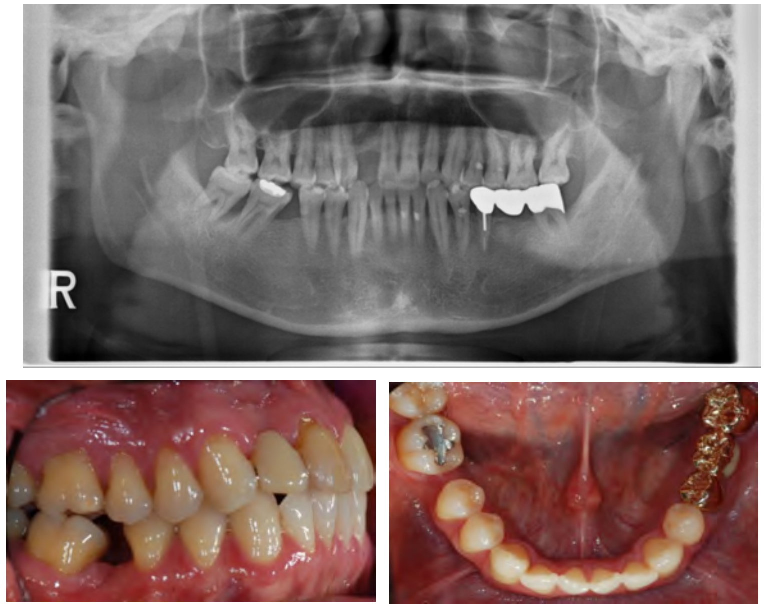

Figure 1. Pretreatment panoramic radiograph and intraoral photograph. Space reduction due to mesial tilting of the molar is observed.

The spring was then transferred to the planned position using light-cured resin. Subsequently, a 0.016×0.016 NiTi straight uprighting wire (Dany Harvest Co., Seoul, Korea) was engaged from the mandibular right second premolar to the mandibular right second molar to initiate molar uprighting[8]. The patient visited the dental clinic monthly for follow-up, including clinical examination and periapical radiography to measure the distance between the mandibular right second premolar and second molar (Figure 2). During visits when activation was no longer effective, the NiTi wire was replaced and reapplied with a new one. At the 8-month follow-up, uprighting and space creation were completed. Subsequently, an Osstem TS III SA implant (Osstem Implant Co., Ltd., Seoul, Korea) of 5.0 mm in diameter and 11.5 mm in length was placed in the area of the mandibular right first molar. The prolonged absence of the tooth resulted in buccal bone resorption (Figure 2), necessitating bone grafting to augment the buccal bone post-implantation. The grafting procedure used Bio-Gide (Geistlich Pharma AG, Wolhusen, Switzerland) of 13×25 mm and Bio-Oss (Geistlich Pharma AG, Wolhusen, Switzerland) 0.25 g grafting materials. The patient underwent a 3-month healing period after the bone graft. During this period, a .019×0.025-inch stainless steel wire (Tri-flex™, RMO®, Denver, CO, USA) was used for space maintenance. After the healing period, OSSTEL® (Osstel W&H, Göteborg, Sweden) was used to assess the implant's stability, which yielded an Implant Stability Quotient of 74/74, indicating good primary stability. Subsequently, a customized abutment and final porcelain-fused-to-Zirconia crown were fabricated and fitted. The crown, with shade A2, was selected to match the natural color of the adjacent teeth, restoring the patient's masticatory function (Figure 3).

After the prosthesis placement, periodic maintenance was performed annually, during which radiographs were taken, and periodontal and prosthetic evaluations were conducted. Additionally, angulation assessments were performed based on the radiographs, comparing the tooth axis of the mandibular second premolar and second molar with the axis of the mandibular first molar implant. The changes in angulation were analyzed by comparing the pre-treatment, post-treatment, and follow-up periods.

RESULTS

Table 1 shows the amount of space gained through orthodontic treatment. On the occlusal side, an increase of approximately 6.85 mm was observed over 8 months, whereas on the cervical side, an increase of about 0.7 mm was noted. During this procedure, no rotation or extrusion of the molar occurred, and the position of the second premolar, which served as the anchor, was maintained. With the successfully developed implant site, the dental implant placement and the bone graft around the implant were completed without any complications.

The final prosthesis has been maintained for 12 years without notable complications or bone loss (Figure 3). Table 2 illustrates

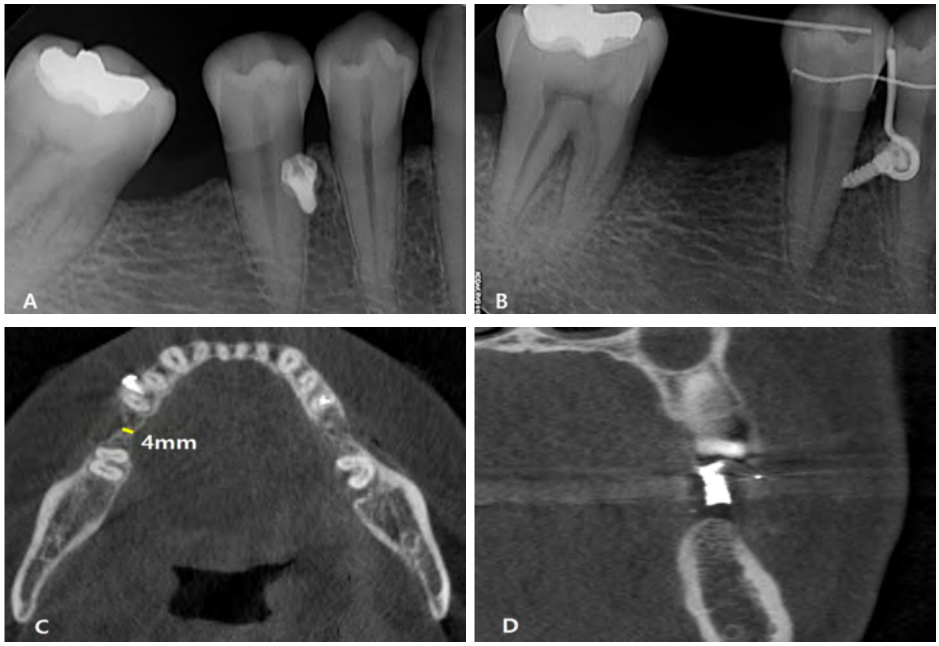

Figure 2. Progress periapical radiographs and preoperative CBCT. (A) Before uprighting. (B) After 8 months of appliance delivery. (C) An axial view of preoperative CBCT revealed an atrophied ridge on the buccal side of the mandibular right first molar region. (D) Coronal view with a surgical stent.

Figure 3. Intraoral photographs and a panoramic radiograph showing the results of the treatment. The images show no signs of periodontal pathology and demonstrate stable maintenance of the final prosthesis without significant complications. (A, B) Intraoral photographs taken after the completion of the implant prosthesis. (C) Panoramic radiograph taken 12 years after follow-up.

the angles of the teeth and implant based on the long axes. In the pre-treatment stage, radiographic analysis revealed a tilting of 37.5 degrees, which improved to 8.2 degrees following orthodontic treatment. During the 10-year follow-up period, no significant changes in this angle were observed. Moreover, the angle between the adjacent teeth and the implant remained stable

Table 1. Mesiodistal edentulous space measurements

Period	Occlusal side (mm)		Cervical side (mm)	
	Measured distance	Increase compared to the previous follow-up	Measured distance	Increase compared to the previous follow-up
Pretreatment	2.75	-	9.8	-
2 months	3.65	0.9	10.1	0.3
3 months	4.25	0.6	10.25	0.15
5 months	5.75	1.5	10.35	0.1
6 months	7.25	1.5	10.45	0.1
8 months	9.0	1.75	10.5	0.05

Table 2. Changes in angles based on the long axis of the teeth during orthodontic treatment

Period	Angulation (°)		
	Between RL5 and RL7	Between RL5 and RL6i	Between RL6i and RL7
Pre-treatment	37.5	-	-
After upright completion	8.2	-	-
After implant placement	7.9	3.7	4.2
5-year follow-up	7.9	3.6	4.3
10-year follow-up	7.8	3.5	4.3

RL5: right mandibular second premolar; RL6i: right mandibular first molar implant; RL7: right mandibular second molar

throughout the follow-up period. Although the analysis was based on periapical and panoramic X-rays, rather than three-dimensional CBCT superimposition, the results provide valuable insights into the long-term stability of the treatment.

DISCUSSION

The current case, treated in 2012 and first reported in 2014[8], demonstrates the successful application of a combined orthodontic and surgical approach to correct the tilt of the mandibular second molar and facilitate implant placement in the mandibular first molar region. This approach effectively simplified implant site preparation by correcting tooth angulation and addressing bone deficiencies. Moreover, a multidisciplinary strategy that integrated post-orthodontic implant placement and prosthetic restoration minimized the risk of relapse and ensured stable functional and esthetic outcomes, which were sustained over a 12-year long-term follow-up.

Before the implant placement, the available space is assessed based on the size and shape of the opposing and adjacent teeth, esthetics, occlusion, and the dimensions of the selected implant[9]. Placing an implant in an area with insufficient space can result in supporting bone loss on adjacent root surfaces, papilla blunting, and compromised esthetics[10,11]. Moderate to severe inclination of molars adjacent to edentulous spaces, often caused by the loss of adjacent teeth, negatively affects periodontal health and the prognosis of dental prostheses[12]. This inclination reduces the available space for restoration, making it challenging to create anatomically harmonious restorations, which can lead to irregular interproximal contact areas and excessive embrasure spaces[3]. These conditions may promote food impaction and plaque accumulation, which if inadequately controlled, have been associated with the development of peri-implantitis and peri-implant mucositis[13].

In this regard, the integration of orthodontic molar uprighting with ridge augmentation provides an effective solution for implant site development in patents with mesial tilting and significant bone loss. Correcting this tilt through orthodontic uprighting is crucial for creating adequate mesiodistal space and leveling the occlusal plane, enhancing prosthetic stability and helping prevent complications such as food impaction and caries[14-16].

Various devices have been developed for minor tooth movements[17-21], among which mini-implant anchorage allows for stable, controlled force application, enabling precise molar uprighting without affecting the adjacent teeth. This technique is widely supported in the literature for its effectiveness in achieving predictable molar angulation correction, which is beneficial for implant site preparation[22-24]. Using mini-implant for anchorage allows clinicians to minimize treatment time while enhancing periodontal health and setting a strong foundation for future implants[6,7].

Even with the use of mini-implants, achieving the desired outcomes may take several months[12,22,25,26], and when bone grafting procedures for implant site development are required, they are typically performed after the completion of orthodontic treatment, requiring additional time before implant placement[5]. To address these challenges, the combination of selective osteotomy and ridge augmentation induces regional acceleratory phenomenon, accelerating bone turnover, reducing healing time, and simultaneously reinforcing structural support around the implant[22,23]. Additionally, Wang et al. reported two split-mouth comprehensive cases where ridge augmentation and orthodontic molar uprighting were simultaneously performed for implant site development, achieving surgically accelerated molar uprighting of 1.6 times faster and successfully attaining 2.5~5.0 mm of horizontal bone augmentation[1].

However, selecting the appropriate mechanics for molar uprighting requires careful consideration of various orthodontic and surgical approaches, as well as the anatomical characteristics and the patient's facial pattern[4]. This careful consideration helps prevent common complications, such as concomitant tooth extrusion, unintended movement of adjacent teeth, hyperocclusion or anterior bite opening[27]. During this process, the interdisciplinary approach is expected to minimize the need for additional interventions, shorten the overall treatment duration, and enhance patient satisfaction by providing a comprehensive solution for complex cases where conventional methods may be insufficient.

CONCLUSION

This case report emphasizes the importance of a multidisciplinary approach in optimizing implant site preparation for complex cases. Simultaneously addressing tooth angulation and bone deficiencies improves functional and esthetic outcomes while ensuring long-term implant success.

COMPETING INTERESTS

The authors report no conflicts of interest related to this study.

ETHICAL APPROVAL

Not required.

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Appropriate surgical management of tooth periapical lesions causing maxillary sinusitis to closure of oroantral fistula: a case report

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Purpose: Unlike mandibular teeth, periapical lesions of maxillary teeth, especially in the posterior region, are often located near the maxillary sinus. This proximity increases the likelihood of acute or chronic maxillary sinusitis. Consequently, the extraction of posterior maxillary teeth with periapical lesions associated with sinusitis requires significant caution and expertise. Improper or inexperienced extraction techniques can lead to complications such as oroantral fistula formation or the displacement of teeth into the maxillary sinus. This paper aims to introduce effective methods for the extraction and management of posterior maxillary teeth in cases of maxillary sinusitis caused by periapical lesions.

Materials & Methods: In this case, the patient underwent the extraction of left maxillary teeth #16, #17, and #18, along with the removal of surrounding maxillary sinusitis and periodontitis lesions. The maxillary sinus was treated using an endoscope, followed by nasal gauze packing. A crestal bony defect in the oral cavity was covered with platelet-rich fibrin (PRF), and then a water-soluble titanium mesh (Ti-mesh) was used for fixation with screws. PRF was applied again for additional coverage, and a mucosal releasing incision was made followed by suturing to ensure proper healing and closure.

Results: Five days postoperatively, the sinus packing gauze was removed through the nasal cavity, and the patient reported a reduction in pain. Ten days after surgery, exposure of the titanium mesh (Ti-mesh) was observed intraorally; however, irrigation did not reveal any involvement of the maxillary sinus. At the 1-month and 2-month follow-ups, the patient reported no pain, and no oroantral fistula was observed. Though the Ti-mesh remained exposed intraorally, mucosal epithelialization was noted between the mesh. At the 3-month follow-up, the exposed Ti-mesh was removed. Waters' views taken at the 1-, 2-, and 3-month intervals showed progressive healing and recovery of the maxillary sinus.

Conclusions: In the management of maxillary sinusitis caused by periapical lesions, the extraction of the causative teeth, removal of the associated maxillary sinus inflammation, and the use of platelet-rich fibrin (PRF) and titanium mesh (Ti-mesh) can effectively prevent the formation of an oroantral fistula. Additionally, this approach may reduce the likelihood of medication-related osteonecrosis of the jaw (MRONJ) associated with osteoporosis medications, making it a highly effective treatment strategy. **(THE JOURNAL OF KOREAN ACADEMY OF OSSEOINTEGRATION 2024;16(1):31-36)**

Key words: Platelet rich fibrin, Oroantral fistula, Titanium mesh, Maxillary sinusitis, Tooth periapical lesion

INTRODUCTION

The posterior maxilla is structurally closely related to the maxillary sinus. As the dentition, including deciduous, adolescent, and permanent teeth, develops from infancy through adolescence, the surrounding bone structure undergoes changes, resulting in the pneumatization of the maxillary sinus extending toward the apices of the maxillary teeth. This anatomical proximity explains why periapical lesions of the posterior maxillary teeth can easily involve the maxillary sinus[1].

A pathological connection between the maxillary sinus and the oral cavity is referred to as an oroantral fistula (OAF). This condition may result from insufficient surgical skill or the displacement of a tooth or dental fragment into the maxillary sinus. OAF can lead to maxillary sinus infections via the oral cavity and cause discomfort due to the migration of food particles or liquids from the oral cavity through the maxillary sinus into the nasal cavity. Oroantral fistula (OAF) is sometimes also referred to as oroantral communication (OAC) or oroantral connection. Pathologically, OAF specifically refers to cases where an OAC has un-

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dergone epithelialization, forming a persistent fistulous tract. The formation of OAF can significantly impact a patient's quality of life, leading to chronic discomfort, recurrent sinus infections, and functional disturbances. Consequently, various surgical techniques, including the use of different types of flaps, are employed to close and manage OAF effectively, aiming to restore both function and quality of life[2]. Among the various methods to prevent the formation of an oroantral fistula (OAF), the most ideal approach is to directly seal the defect with mucosal coverage, promoting natural healing. However, if epithelialization occurs as a result of airflow through the oroantral communication (OAC) before the mucosal regeneration is complete, the OAC can develop into a persistent OAF. This highlights the importance of early and effective closure of the communication to prevent epithelialization and subsequent fistula formation[3].

Therefore, promoting mucosal healing before epithelialization occurs is a critical concept in preventing the formation of an oroantral fistula (OAF). To achieve this, various materials have been utilized, including autogenous bone, membranes, and platelet-rich fibrin (PRF). Among these, the use of autogenous bone and PRF has been extensively documented in the literature as effective approaches for sealing oroantral fistulas and facilitating healing[3].

As mentioned in various studies, platelet-rich fibrin (PRF) is obtained by centrifuging blood at a specific time and speed, which results in three distinct fractions: the upper part, which is platelet-poor plasma; the middle part, which consists of a fibrin clot and is the platelet-rich portion; and the lower part, composed of erythrocytes. The platelet-rich fibrin, as it dehydrates, releases growth factors that play a crucial role in mucosal and bone healing. Systematic reviews have demonstrated the effectiveness of PRF in the management of oroantral fistulas, where it has been used to promote healing and prevent complications such as fistula formation[4].

Titanium mesh (Ti-mesh) has already been widely used in various oral and maxillofacial surgical fields. Specifically, it has been employed in combination with various flap techniques to effectively close oroantral fistulas[5,6]. Due to its hydrophilic properties, Ti-mesh has become a valuable material for use in the oral cavity, offering easy handling and minimal technique sensitivity. This ease of use has made it a popular choice in numerous oral surgical procedures, where it can provide stable support and facilitate healing, especially in the context of oroantral fistula repair[7].

In the treatment of maxillary sinusitis, many studies have reported the use of endoscopy to remove the infected maxillary sinus membrane, thereby promoting healing. This technique is commonly employed to facilitate the restoration of the healthy Schneiderian membrane, which is essential for the proper healing of the sinus lining. By using endoscopic techniques, surgeons can effectively clear the infection and provide a controlled environment for the healing of the sinus membrane, improving outcomes and reducing complications[8].

Therefore, this paper aims to present an ideal approach for the treatment of patients with fibrotic lesions at the apices of teeth causing maxillary sinusitis. By proposing appropriate surgical interventions, the goal is to prevent and manage the formation of oroantral fistulas that may arise from extractions, offering an effective method for addressing both the underlying sinusitis and the prevention of fistula formation.

MATERIAL AND METHOD

1. Patient story

The patient is a 71-year-old female who presented to the Department of Oral and Maxillofacial Surgery at Incheon St. Mary's Hospital on July 18, 2024, with primary complaints of right maxillary tooth pain and migraine. Her medical history includes osteoporosis, for which she has been on zolendronate therapy since 2018, and hypertension. Additionally, she suffered a knee fracture due to osteoporosis, with a bone mineral density (BMD) of -2.6, and received zolendronate and Prolia injections over a three-year period.

Clinical examination revealed grade 2 to 3 mobility in teeth #16, #17, and #18 on the right maxilla. A panoramic radiograph showed bone resorption from the apex of tooth #16 to tooth #18, with particularly evident dentin caries extending to the cervical region of tooth #17. Opacification of the right maxillary sinus was observed, and subsequent facial CT imaging revealed lesions at the apices of teeth #16, #17, and #18 associated with maxillary sinusitis extending to the ostiomeatal complex (Figure 1). The patient exhibited all five classic symptoms of chronic maxillary sinusitis: nasal obstruction, headache, periorbital pressure, postnasal drip, and olfactory disturbance.

Under general anesthesia, teeth #16, #17, and #18 were extracted. Concurrently, fibrous inflammatory tissue surrounding the extraction sites was excised. The lesions related to maxillary

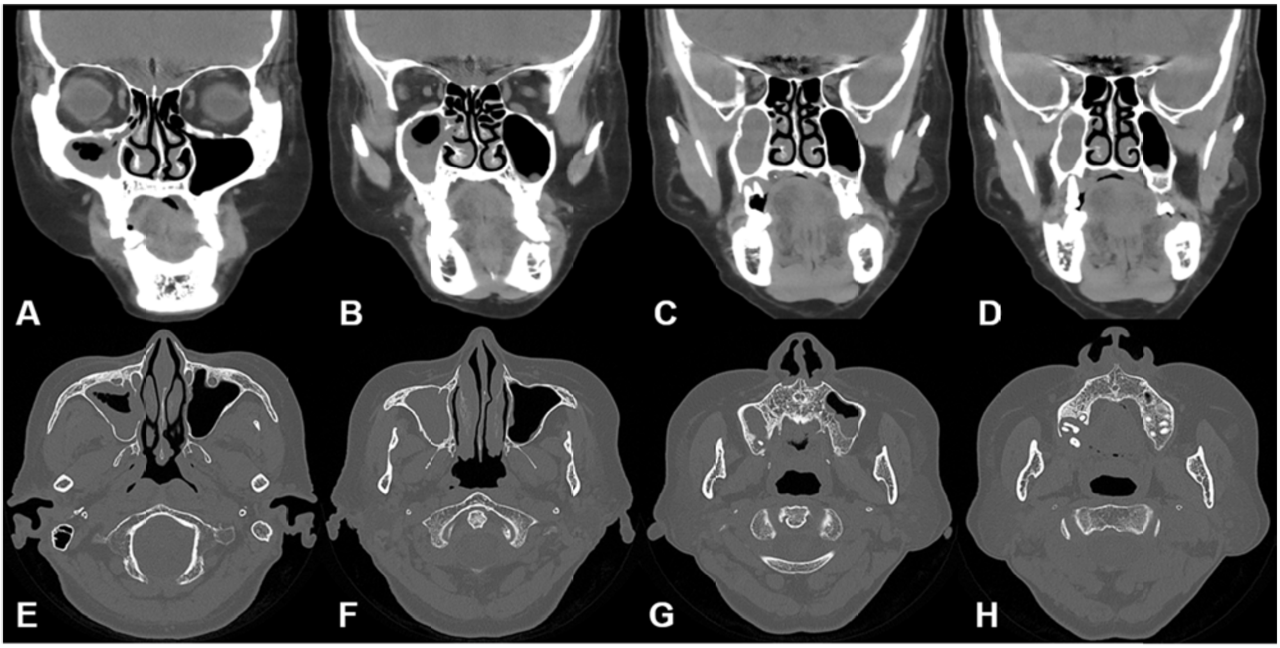

Figure 1. Preoperative facial CT views: Coronal view (A~D), Axial view (E~H).

sinusitis were removed using endoscopic guidance and rhinoforceps, followed by multiple irrigations with normal saline. Sinus packing was performed via the ostium, and the extraction sockets were covered using a three-layer closure technique involving platelet-rich fibrin (PRF), titanium mesh, and releasing mucosal direct closure.

Postoperative assessments included Waters' view radiographs conducted at one-week post-surgery, with panoramic radiographs analyzed at one, two, and three months postoperatively. Clinical photographs and symptom assessments were conducted to evaluate treatment outcomes.

RESULTS

1. Panoramic view

Preoperatively, bone resorption was observed in the maxillary bone around teeth #16, #17, and #18. One week postoperatively, the area was stabilized with titanium mesh (Ti-mesh), but the socket had not yet fully healed, resulting in a lower bone density, which appeared as reduced opacity on the radiograph. However, by the 1-month follow-up, ossification (new bone formation) began around the Ti-mesh, and opacity increased around the mesh, showing a stable healing pattern. Upon comparing the panoramic radiographs taken at 2 months and 3 months post-surgery, there was a noticeable increase in opacity, indicating further healing and bone maturation around the Ti-mesh (Figure 2).

2. Waters' view

The comparison of preoperative, operative day, and postoperative Waters' view radiographs taken at 1 week, 2 months, and 3 months showed the following findings: At 1 week postoperatively, opacity was observed due to the presence of blood clot and hematoma, which is typical after surgery. However, by the 1-month follow-up, the opacity had significantly decreased, indicating the resolution of the initial postoperative changes. At 2 months and 3 months post-surgery, the radiographs showed normal findings, with no further signs of sinus opacification, confirming successful healing of the maxillary sinus and surrounding structures (Figure 3).

3. Clinical Photo Taking

1) On the Day of Surgery

All surgeries were performed under general anesthesia, and postoperatively, clamoxin injection (amoxicillin sodium 500 mg, potassium clavulanate 100 mg) and NSAIDs were administered, followed by close monitoring of the patient's progress. After the extraction of the teeth and removal of maxillary sinusitis and fibrotic lesions at the apices of the teeth using endoscopic techniques, the sinus was packed with gauze, followed by the application of platelet-rich fibrin (PRF), titanium mesh (Ti-mesh), and

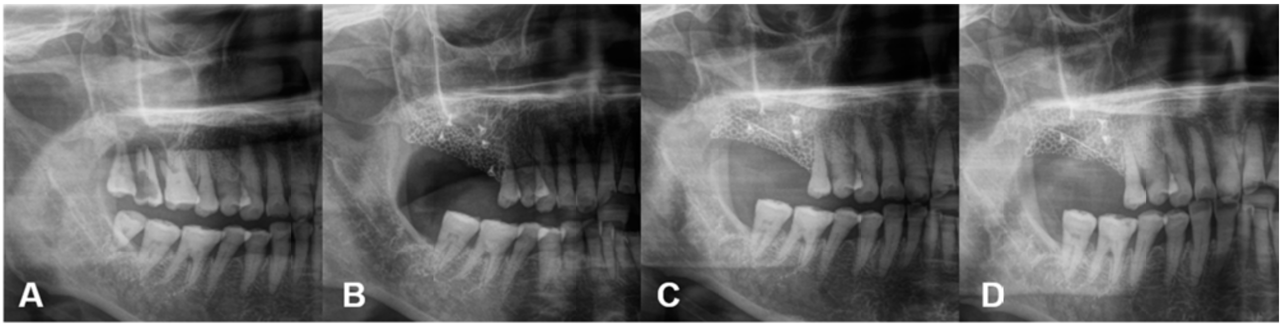

Figure 2. Preoperative panoramic view (A), Panoramic view on the day of surgery (B), One-month postoperative panoramic view (C), Two months postoperative panoramic view (D), Three months postoperative panoramic view (E).

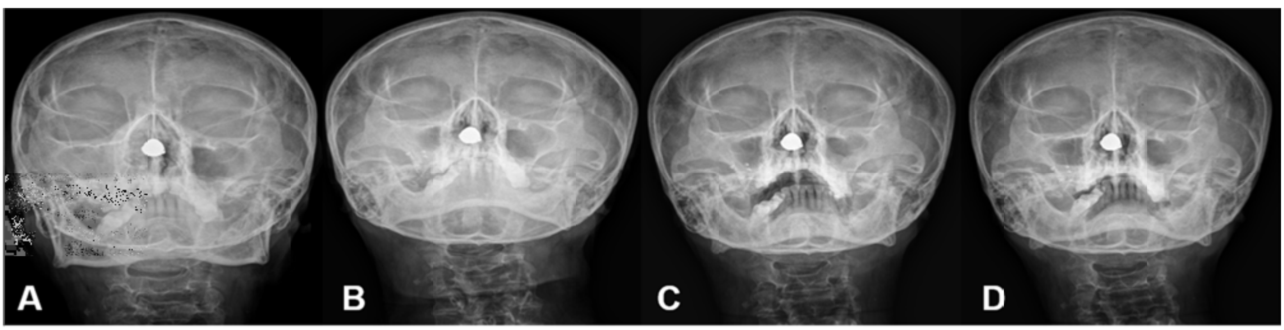

Figure 3. Waters' view on the day of surgery (A), One month postoperative (B), Two months postoperative (C), Three months postoperative (D).

gingival suturing. Upon comparison of the postoperative images, no oroantral fistula was observed at 1 month, and the patient reported no symptoms. However, exposure of the Ti-mesh was noted, and mucosal epithelialization was observed beneath the mesh.

At the 2-month follow-up, Ti-mesh exposure was still present, but the area of exposure had decreased. At this point, the Ti-mesh was adjusted using a high-speed round bur to expose the mucosa underneath, promoting direct healing. At the 6-month follow-up, the Ti-mesh was removed, and bone grafting is planned beneath the mucosa to further support healing and restore the bone structure (Figure 4~6).

2) One Month Post-Surgery

Exposure of the Ti-mesh was observed, but the patient did not report any symptoms of oroantral fistula, nor was there any invasion of oral food into the sinus. Additionally, the patient did not complain of symptoms related to maxillary sinusitis, such as nasal congestion, abnormal odor, postnasal drip, tenderness, or headache (Figure 6).

3) Two Months Post-Surgery

The exposed Ti-mesh was adjusted using a high-speed round bur to reveal the intact mucosa beneath, which helped promote perfect healing. Again, the patient did not report any symptoms of maxillary sinusitis, including nasal congestion, abnormal odor, postnasal drip, tenderness, or headache (Figure 6).

DISCUSSION

In this case, the use of platelet-rich fibrin (PRF) and titanium mesh are highlighted as materials that are not operator-sensitive and are easy to use. They are especially effective for bone augmentation, making them ideal for oral surgery applications[9]. However, the aspect of the procedure that could be considered operator-sensitive is the management of maxillary sinusitis. Although this paper does not focus extensively on this aspect, it is a complex procedure requiring an understanding of the structural position and function of the sinus using an endoscope. This complexity necessitates further study on the role and dynamics of the ostiomeatal complex, a critical structure in sinus drainage connecting the anterior ethmoid cells, maxillary sinuses, and frontal sinuses. Its components include the maxillary sinus opening, uncinate process, ethmoid bulla, ethmoidal infundibulum, and hiatus semilunaris[10]. Ensuring the patency of these structures and the removal of infected sinus membranes are crucial components of successful surgery.

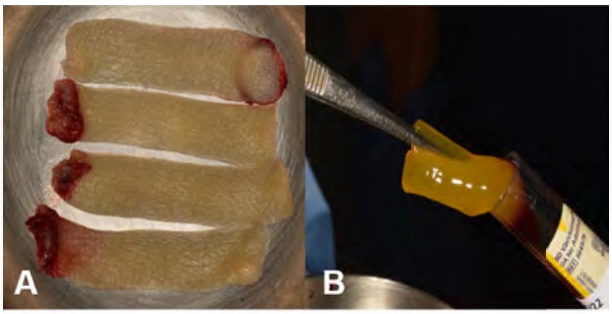

Figure 4. Platelet-rich fibrin after centrifugation used on the day of surgery (A, B).

The key consideration in this case report is that premature tooth extraction and bone grafting may contribute to the development of Medication-Related Osteonecrosis of the Jaw (MRONJ). The patient has been receiving zolendronate and Prolia injections since 2018, with a Bone Mineral Density (BMD) measurement indicating osteoporosis at -2.6. Consequently, efforts were made to minimize invasiveness during extraction and surgical management of the perialveolar soft tissue, aiming to prevent bone bleeding. Moreover, the use of Platelet-Rich Fibrin (PRF) not only enhances bone formation and reduces inflammation but also plays a significant role in preventing medication-induced osteomyelitis[11].

Therefore, in terms of the currently debatable concept of a drug holiday, only zolendronate was held to avoid potential rebound effects, while the Prolia injections were continued without

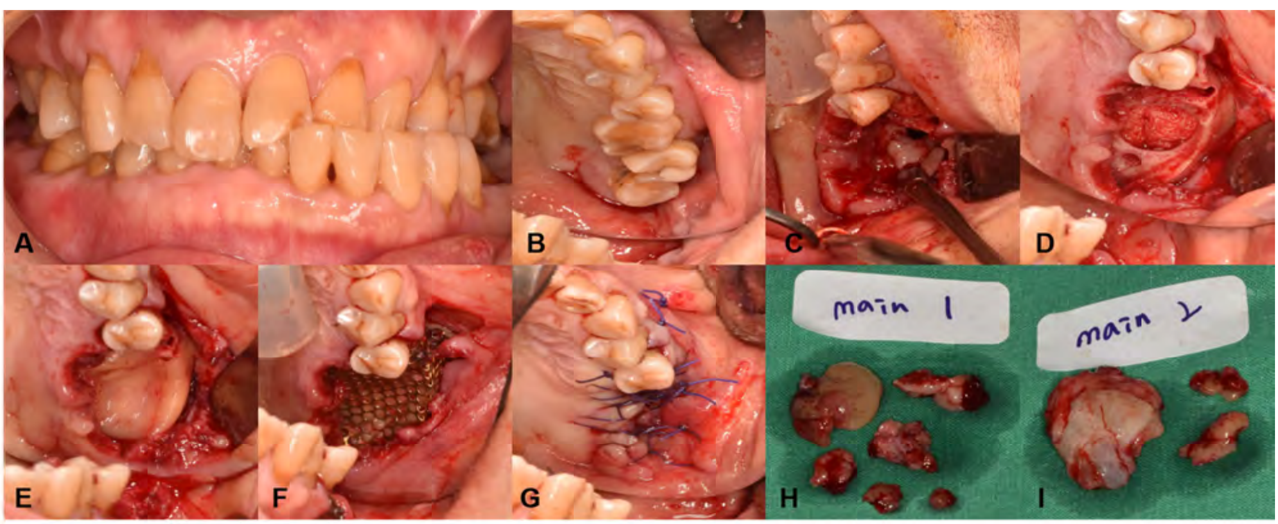

Figure 5. Clinical photographs on the day of surgery: Patient occlusion (A), Clinical image of the surgical site in the right maxilla (B), Removal of infected maxillary sinus tissue post-extraction (C), Clinical photo after gauze packing of the maxillary sinus (D), Clinical image showing platelet-rich fibrin coverage of the surgical site (E), Coverage with titanium mesh (F), Mucosal direct closure (G), Main mass of maxillary sinusitis at the apices of teeth #16, #17, and #18 (H, I).

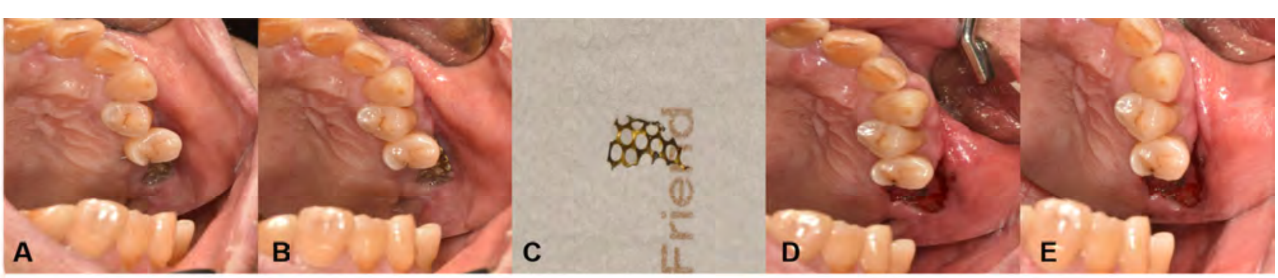

Figure 6. Clinical photographs one month postoperative, showing exposed titanium mesh in the oral cavity (A, B). Removal of the titanium mesh at two months postoperative (C), and removal of the exposed titanium mesh at two months postoperative (D, E).

interruption. Considering the positive outcomes observed with the combined use of PRF and titanium mesh, it is anticipated that future developments in titanium mesh that retain PRF could be effectively applied in various oral and maxillofacial surgical procedures.

Additionally, the patient reported difficulty in dietary intake due to the absence of bilateral molars, leading to the need for bone reconstruction and implant placement as subsequent considerations. Consequently, a plan is in place to remove the titanium mesh and perform bone grafting subperiosteally after a minimum of six months. PRF is expected to be utilized during this intervention, as it may effectively address any fistulas that may arise during the procedure.

In this paper, surgical procedures were conducted with a deep understanding of these anatomical structures and the operative processes involved in treating maxillary sinusitis. Postoperative analysis was conducted using Waters' view, panoramic radiographs, and assessment of the patient's specific symptoms. Upon follow-up, the patient showed no remaining symptoms of maxillary sinusitis, such as nasal obstruction, postnasal drip, foul odor, headache, or tenderness, indicating successful healing.

CONCLUSION

The management of dental treatments related to various forms of maxillary sinusitis requires meticulous surgical precision. Even minor inadequacies in technique may result in significant complications for the patient, such as the development of oroantral fistulae and recurrence of maxillary sinusitis. This study advocates for the appropriate surgical management of odontogenic diseases causing maxillary sinusitis using platelet-rich fibrin (PRF) and titanium mesh. By implementing these techniques, we aim to effectively prevent the formation of oroantral fistulae and reduce the likelihood of recurrent maxillary sinusitis, thereby establishing an ideal surgical approach.

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Study on the stability of short implant and roll of wing structure with 4 cases

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When we meet highly vertically resorbed alveolar bone, we have two choices. Usually vertical augmentation is firstly considered and use the short implant for the second option. In this article we want to report using short implant for too much atrophied alveolar bone is very useful and can be done successfully instead of doing GBR for vertical augmentation. From 2020 the author used short implant (6 mm, 7 mm) for atrophied alveolar bone without vertical augmentation. Mora then 50 short implants (mainly 6 mm) were used. It is maintained healthy with satisfied results for both of the patients and clinician. Usually we call short implant it is less than 8 mm length, but in this article the short implant is 6 mm or 7 mm in length. So it increases the crown/implant ratio. Although the concepts of crown/implant ratio is changed and it is mainly ignored, still now many practitioners have negative image for the high crown/implant ratio. This preconceived opinion makes them hesitate using short implant. But by the results of my cases, short implant is one of safe and convenient option for rehabilitate the atrophied jaws. **(THE JOURNAL OF KOREAN ACADEMY OF OSSEOINTEGRATION 2024;16(1):37-41)**

Key words: Short Implant, Wing structure

CLINICAL CASES

1. Case 1.

64 years old female patients extract teeth due to severe periodontitis on left lower molar (#36,37). After extraction, very big defect is left as a result of advanced periodontitis (Figure 1-1). I choose the short implant (6 mm length, 7 mm diameter) to avoid inferior alveolar nerve injury (Figure 1-2). When implant is placed, initial stability is not so good, so we must wait more 4 months and do progressive loading. After 8 months final prosthodontic work is finished. And bone around implant is healing well (Figure 1-3). And after 3 years peri-implant bone is more matured (Figure 1-4). The patient is very much satisfied because of simple treatment procedure and very good result.

2. Case 2

67 years old female patient want to do implant treatment. But the bone on that site is too widely defected. When extract #36, patient suffered due to pain with advanced periodontitis (Figure 2-1). Short implant was placed (6 mm length) with bone graft

Figure 1-1. Severe alveolar bone defect on #36, 37 site. Implant placement : 2021.01.22. with bone graft (Bio-oss).

Figure 1-2. After implant placement. Bone around #36 implant is so scarcely formed.

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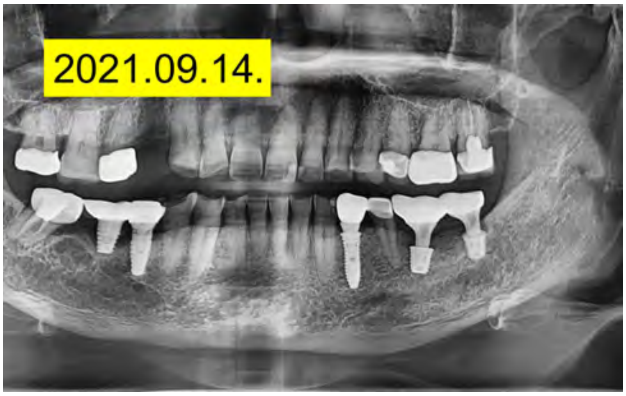

Figure 1-3. After 8 months, bone is well forming.

Figure 1-4. Bone is fully formed after 3 years. Bone around implant is over grew. The patient is very much satisfying with this result.

Figure 2-1. #36 tooth was extracted due to advanced periodontitis.

(Osteon II). Healing abutment was connected. But the bone around implant is relatively week (Figure 2-2). After 7 months bone is well healed so crown is seated (Figure 2-3). Bone around implant is grow over the implant neck level (Figure 2-4).

Figure 2-2. Implant is inserted, Mesial and distal alveolar bone is not strong enough.

Figure 2-3. 7 months after Implant placing. Bone around implant became healthy.

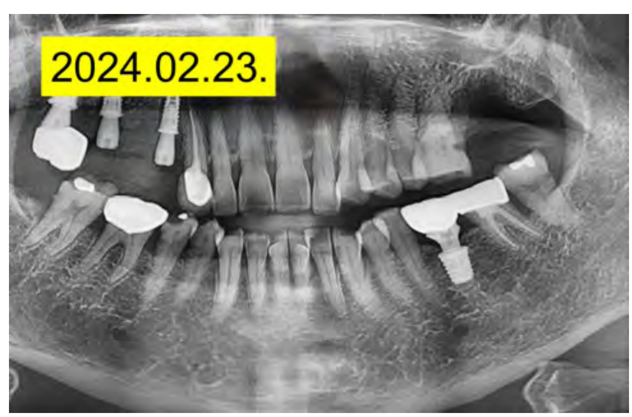

Figure 2-4. 3 years later, Bone is grow over the implant.

3. Case 3

71 year old female patient extracted right 2nd premolar (#15) due to advanced dental caries with periodontitis. After extraction, remaining bone is not enough for regular length implant because

Figure 3-1. Alveolar bone is highly resorbed and maxillary sinus is enlarged. So remaining alveolar bone is not enough to put regular implant (over 8 mm in length).

Figure 3-3. About Two years later the implant is maintaining stable.

Figure 3-2. Short implant is placed instead of doing any other extra surgery.

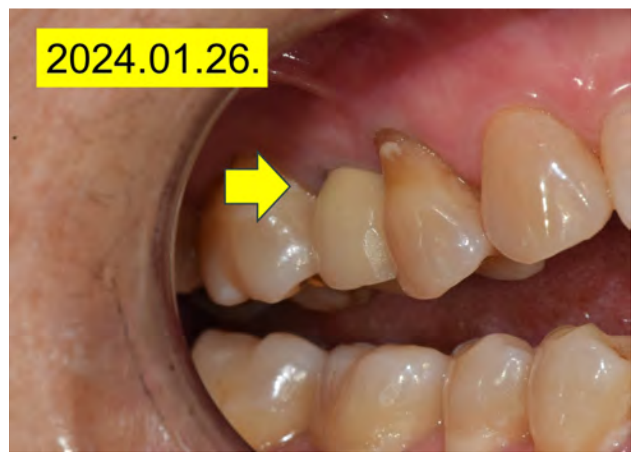

Figure 3-4. In addition to stably maintaining alveolar bone, peri–implant soft tissue is also healthy.

only 7 mm alveolar bone is remained (Figure 3-1). So I decided to put implant with 7 mm length, and implant is installed safely without doing sinus graft or other types of bone graft (Figure 3-2).

The bone around implant is going harden with time goes and when we check the patient after 2 years, bone around implant is fully matured and bone level is maintained well (Figure 3-3). Not only maintaining bone level, peri-implant mucosa also shows very healthy with pinkish color without swelling or bleeding (Figure 3-4).

4. Case 4

61 years old femail patient come to my clinic with missing on right maxillary 2nd molar (#17) with much resorbed alveolar bone. First consideration for treatment is sinus graft. But I choose another option, that is use short implant without sinus graft. The implant is positioned very deeply. So it looks very unstable (Figure 4-1). In spite of my worry, implant is healed well and as a result, strong osseointegration can be obtained. More than one year, the implant maintains healthy without onother problems (Figure 4-2).

DISCUSSION

In case of sever inflamed tooth extraction or extract the implant which is involved advanced peri-implantitis, bone destruction occurs widely. So implantation on this site is very difficult due to lack of vertical height and/or sufficient alveolar bone width.

One of way to overcome this situation, clinicians can choose

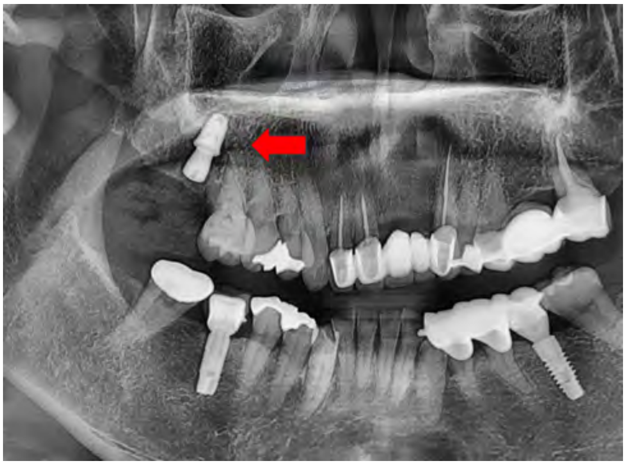

Figure 4-1. We put implant in this extreme situation without sinus graft and/or GBR.

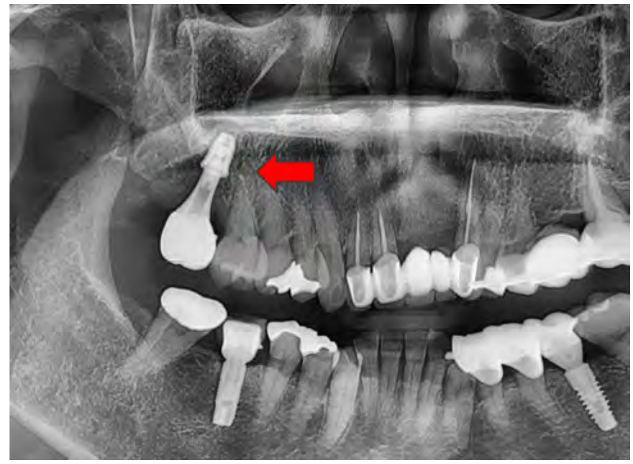

Figure 4-2. Implant and peri implant alveolar bone is maintaining stable with healthy peri-implant soft tissue for more one year and the patient satisfies for the result.

guided bone regeneration (GBR). But vertical bone augmentation technique is so sensitive, the results are mainly depend on the clinician's technique. The process also give difficulties to both patients and clinicians. And the amount of gaining bone is limited, so some times it is not sufficient to do implant as we want to be.

If it is possible to put short implant successfully without GBR or minimal GBR, it would be the best way for the patient and also for the surgeon.

Short Implant has several advantages

1. Simple and quick process
2. Without complex and difficult surgery with minimal complications
3. Patients feel more comfortable and more satisfied

But when using short implant, the clinician must consider about high implant/crown ratio. This unfavorable state in mechanically, careful management is needed.

In 2016 Lemon[1] et al studied about short implant. They compared the success rates of short implant with regular implant. They evaluated survival rate of implant, marginal bone loss, complications, and prosthesis failures. And they concluded that short implants are considered a predictable option to treat the posterior area. But they insisted that less then 8 mm (7 mm or 6 mm) implants are not predictable for success results.

In maxillary area, where only small amount remaining alveolar bone is, two options are there. Firstly considering option is sinus graft and pit implant longer then 10 mm length implant. And another option is using short implant (6 mm). But until now for many clinicians, using short implant is not familiar and do not want to use them.

Yan et al[2] reported that treating with short implant (6 mm) shows better result then using 10mm implant with sinus graft. Using short implant shows less complications less marginal bone loss and same survival rate. And by the authors experience, this concept is acceptable.

Nasand et al[3] also reported that short implant has better result than implant with vertical augmentation because surgical process of vertical augmentation leaves more complications. It is because now a days more clinicians prefer using short implants instead of doing complicated extra surgical procedure.

But due to preconceived opinion[4] of negative image on the short implant, many clinicians hesitate to use short implant until now. They prefer doing sinus graft or vertical augmentation with consuming their energy to do difficult extra surgery.

Although one of recent report 6 mm implant has more failure rate then regular implant (87% compared to 100%), this study was done only limited number of cases. But the authors declare that short implant is one of good options for atrophied jaw[5].

Further extreme reports are issued by Carlo et al[6] they used 4 mm implant on posterior atrophic mandible and concluded that it is seem to be a good clinical option. But for the extra short implant, we must study more for safe management of patients.

CONCLUSIONS

1. Short Implant can be used safely and conventionally on the site of severely resorbed alveolar bone of both mandible and maixllar even though it is at posterior molar area.

2. It can be done without sinus graft and/or GBR, surgical process is simple and as a result it leaves less complications.
3. We used Wing structured implant. It shows more stable due to high initial stability and support bone formation. Because of easy surgical procedure, it has high satisfaction for both the clinicians and the patients.

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