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Maxillary Sinus Floor Augmentation Using Autogenous Tooth Bone Graft in Combination with Platelet-Rich Plasma for Dental Implants: Case Series

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Purpose: To determine the benefits of autogenous tooth bone (ATB) graft in combination with platelet-rich plasma (PRP) in the rates of success and survival of dental implants placed simultaneously with maxillary sinus floor augmentation (MSFA).

Materials and Methods: Patients who visited the Department of Oral and Maxillofacial Surgery at Ulsan University Hospital from 2012 to 2014 and underwent simultaneous placement of implants with MSFA using ATB plus PRP were included in the study. Success and survival rates of the implants were evaluated based on the parameters of age and sex of the patient, site, follow-up period, residual bone height before surgery, diameter, and length of implant, sinus mucosa impairment, and postoperative complications.

Result: A total of 23 patients and 67 implants were included in this study. The average age of the patients was 53.78±10.00 years. The average follow-up period after installation of the prosthesis was 53±5 months. The success and survival rates of the implants after placement of prosthesis were 95.52% and 97.01%, respectively.

Conclusion: Combination of ATB and PRP showed high overall success rate, and it can be concluded that this combination is a predictable bone graft procedure for MSFA.

Key Words: Bone substitutes; Dental implantation; Maxillary sinus floor augmentation; Platelet-rich plasma

Introduction

Various bone graft materials and growth factors have been used to augment insufficient alveolar bone for placement of dental implants after extraction of maxillary teeth[1-5]. Frequently used bone graft

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materials include autogenic, allogenic, xenogenic, and alloplastic materials.

Among the various bone graft materials, autogenous bone graft is considered ideal, owing to its osteogenic, osteoinductive, and osteoconductive properties and absence of immune response. However, harvesting of autogenous bone graft is associated with donor site morbidity and low quantity of bone obtained. To overcome these disadvantages, numerous bone graft materials have been introduced. Allogenic bone grafts are not associated with donor-site morbidity and possess osteoinductive and osteoconductive properties. However, use of these grafts may cause immune reaction and infection. Similarly, sufficient bone can be obtained using xenografts without host site complications; however, the material only has osteoconductive ability and can cause immune reaction[3].

To overcome these shortcomings, autogenous tooth bone (ATB) graft was introduced and has been used in guided bone regeneration, ridge preservation, sinus bone graft, and other procedures[6-10]. ATB grafts do not cause immune reaction, as the source is from the patient's own tooth. Moreover, ATB grafts have high potency for bone regeneration and do not cause infection, which can occur with the use of allografts and xenografts[11].

Growth factors included in tooth are expected to be lost during the manufacturing process[12]. Supplementation of growth factors can facilitate bone regeneration. Among the source of growth factors used in implant dentistry, platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) are versatile, considering the ease of extraction from peripheral blood, simple process of manufacturing, and cost-effectiveness[13].

The purpose of the present study was to evaluate the rates of success and survival and complications of implants in patients who simultaneously underwent maxillary sinus floor augmentation (MSFA) with ATB and PRP.

Materials and Methods

The present study included patients who visited the Department of Oral and Maxillofacial Surgery at Ulsan University Hospital from January 2012 to December 2014 and underwent simultaneous placement of dental implants with MSFA using ATB graft.

Inclusion criteria were: 1) absence of systemic disease that could affect bone formation, 2) no immediate implantation after extraction, 3) absence of inflammation or infection in the region of the maxillary sinus, and 4) follow-up period of at least 48 months after implant loading. Age and sex of the patient, site, follow-up period after implant loading, preoperative residual bone height, diameter and length of the implant, sinus membrane perforation, complications, and success and survival rates of the implants were evaluated.

During surgery, ATB (demineralized dentin, AutoBT®; Korea Tooth Bank, Seoul, Korea) was used in powder form combined with 1 ml PRP, which was obtained from peripheral blood of the patients. Lateral approach technique was used, and an absorbable membrane (Ossguide®; Osstem Co., Seoul, Korea) was used in every case. Albrektsson's criteria[14] were used to determine success rate of implants.

Panoramic radiographs were taken annually beginning from implant loading to final follow-up. Marginal bone loss was measured on the mesial and distal aspects of the implants, and the area showing more severe loss was considered. All data was evaluated by descriptive analysis.

Result

A total 67 implants were analyzed in 23 patients. The study population included 14 male and 9 female. Mean age of the male patients was 53.36±10.85 (mean±standard deviation) years and that of female patients was 54.44±9.10 years, and that of the total patient group was 53.78±10.00 years. Mean follow-

Table 1. Summary of perioperative data

No.	Sex/age (yr)	Site	Residual bone height (mm)	Fixture diameter (mm)	Fixture length (mm)	Sinus mucosa impairment	Postoperative complications	Total follow-up (mo)
1	M/49	#17	6.33	4	12	No		57
		#16	5.16	5	12	No		
		#15	4.77	4	12	No		
		#14	7.31	4	12	No		
		#24	3.54	4	12	No		
		#25	2.61	4	12	No		
		#26	3.4	5	12	No		
		#27	4.4	4	12	No		
2	F/52	#16	3.18	5	12	Yes	Failed to osseointegrate	57
		#17	2.77	5	12	Yes	Failed to osseointegrate	
3	F/61	#26	5.49	5	12	No		63
4	M/60	#26	6.07	4	15	No		63
		#27	7.3	5	15	No		
5	M/53	#14	4.92	4	12	No		57
		#15	8.45	5	12	No		
		#16	5.53	5	12	No		
		#17	5.46	5	12	No		
6	F/36	#27	4.32	4.5	12	No		60
7	M/62	#26	6.69	4	12	No		58
8	F/47	#26	2.31	5	10.5	Yes		57
		#16	6.7	5	12	No		
9	M/50	#15	3.29	4.5	12	No		55
		#16	4.7	4.5	12	No		
		#17	3.84	4	12	No		
		#25	2.14	4.5	12	No		
		#26	2.38	4.5	12	No		
		#27	3.61	4.5	12	No		
10	F/62	#16	5.85	4.5	11.5	No		49
		#15	4.46	4.5	11.5	No		
		#14	4.14	4	13	No		
		#24	5.14	4	13	No		
		#25	7.65	4.5	11.5	No		
		#26	5.13	4.5	11.5	No		
11	M/57	#27	4.53	5	12	No		47
12	M/21	#14	8.69	4	12	No		48
		#15	6.16	4	15	No		
		#24	4.31	4	12	Yes		
		#25	2.92	4	12	Yes		

Table 1. Continued

No.	Sex/age (yr)	Site	Residual bone height (mm)	Fixture diameter (mm)	Fixture length (mm)	Sinus mucosa impairment	Postoperative complications	Total follow-up (mo)
13	M/55	#14	3.92	4.5	11.5	No	Infection	48
		#16	2.62	5	11.5	No		
		#24	3.39	4	13	No		
		#26	3	4.5	11.5	No		
14	M/58	#16	6.46	4	12	No		50
		#17	3.38	5	12	No		
15	M/63	#16	3.18	5	11.5	No		48
		#25	2.43	4	11.5	No		
		#26	4.78	4	11.5	No		
16	M/52	#15	5.77	4.5	13	No		48
		#16	6.07	4.5	13	No		
		#17	3.79	4.5	13	No		
17	F/64	#16	2.15	4	12	No		48
		#17	2	5	12	No		
		#26	3.16	4	12	No		
		#27	2.19	4	12	No		
18	M/66	#27	4.05	5	11.5	No		48
19	M/54	#26	2.54	4	12	No		48
20	M/47	#16	3.15	5	11.5	No		48
		#26	2.15	5	11.5	No		
		#27	2.16	5	11.5	No		
21	F/55	#14	8.69	4	12	No		79
		#15	5.92	5	10.5	No		
		#16	6.69	5	10.5	No		
22	F/62	#26	2.77	4	13	No		51
23	F/51	#14	4.81	4	12	No		48
		#25	5.01	5	12	No		
		#26	3.39	4	12	No		
		#27	3.16	5	12	No		

M: male, F: female.

up period was 53±5 months. Mean preoperative residual bone height was 4.45±1.11 mm. Postoperative complications included removal of two implants due to failure of osseointegration and infection in one case. Rate of complications was 4.48% (Table 1).

Overall survival rate of the implants was 97.01% and success rate was 95.52%. Male patients showed success rate of 97.67% and survival rate of 100%, wherein one out of 43 implants did not meet the success criteria. Female patients demonstrated 91.67% success and survival rates, wherein failure was observed in two out of 24 implants. Site of implant placement was divided into premolar and molar areas. Premolar area showed success rate of 95.83%, wherein one implant did not meet the success criteria, and survival rate of 100%. In the molar area, 95.35% success and survival rates were observed, wherein two out of 43 implants were removed due to failure of osseointegration. Twenty-eight implants with a diameter of 4 mm were placed that showed

Table 2. Summary of outcomes

Variable	No. of implants	Implant success rate (%)	Implant survival rate (%)
Sex			
Male	43	97.67	100.00
Female	24	91.67	91.67
Site			
Premolar	24	95.83	100.00
Molar	43	95.35	95.35
Diameter of implant			
4 mm	28	100.00	100.00
4.5 mm	15	93.33	100.00
5 mm	24	91.67	91.67
Length of implant			
<10 mm	0	n.a.	n.a.
10~12 mm	58	94.83	96.55
>12 mm	9	100.00	100.00
Sinus mucosa impairment			
Yes	5	60.00	60.00
No	62	98.39	100.00
Postoperative complications			
Yes	3	0	33.33
No	64	100.00	100.00
Total	67	95.52	97.01

n.a.: not applicable.

100% success and survival rates. Fifteen implants were placed with a diameter of 4.5 mm that showed 93.33% success rate and 100% survival rate, wherein failure was observed in one implant. With regard to the 24 implants with a diameter of 5 mm, the success and survival rates were 91.67%, wherein failure was observed in two implants. Length of the majority of the implants placed were between 10 to 12 mm (58 implants), no implant being less than 10 mm. In the 10 to 12 mm implants group, one implant did not meet the success criteria and failure was observed in two implants. The success rate of implants in this group was 94.83% and survival rate was 96.55%. There were nine implants with length over 12 mm, which showed 100% rates of success and survival. Concerning sinus membrane perforation, failure was observed in two out of five implants in the perforation group and with 60% rates of success and survival. Among the implants in the group without sinus perforation, one out of 62 implants failed to meet the success criteria and showed 98.39% success rate and 100% survival rate. With regard to postoperative complications, out of three, two implants failed and one implant did not meet the success criteria; therefore, showed 0% success rate and 33.33% survival rate. Sixty-four cases without complications showed 100% success and survival rate (Table 2).

Discussion

After the loss of maxillary molars, alveolar bone resorption occurs along with the pneumatization of the maxillary sinus, which may require grafting in order to gain sufficient dimensions of bone for implant placement[15]. Generally, autograft is considered the ideal bone graft material. However, due to availability of insufficient amount of graft and rapid resorption, allografts, xenografts, and alloplastic grafts were introduced[1-3].

Recently, ATB graft was developed and several studies have reported the benefits of the material. Kim et al.[16] reported the contents and regenerative potential of ATB graft through histological and electromagnetic analysis. Moreover, another study by the same group insisted that density, roughness, and uniformity of ATB graft were similar to cortical bone and physicochemical properties were similar to those of autografts[17].

Several studies on the clinical application of ATB graft have reported favorable outcomes. Lee et al.[18] performed vertical and horizontal ridge augmentation on nine patients, of mean age 49.88±12.98 years, with a postoperative follow-up period of 35±5.31 months, using ATB in the form of powder or block. Postoperative complications observed were wound dehiscence and hematoma; however, no complications occurred in relation to the graft material. The reported implant survival rate was 96%. Mean mar-

ginal bone loss at one year after loading was 0.12±0.19 mm.

In long-term follow-up study of 5 years, Kim et al.[19] reported changes in the alveolar bone in five cases. Changes in buccal height ranged from –0.4 to –3.3 mm and that of alveolar ridge width ranged from –0.4 to –4.2 mm. Changes in bone area ranged from –8.1% to –36.2%. Formation and maintenance of corticocancellous bone was successful except for one case, which showed buccal marginal bone resorption of 1 mm during 79 months of follow-up.

Jeong et al.[9] reported implant survival rate of 96.15% in MSFA with ATB on evaluation of 100 implants in 51 patients. Kim et al.[11] reported mean resorption of 0.76 mm annually in case of MSFA with ATB. Lee et al.[20] conducted a histomorphometric study on various graft materials used in sinus augmentation. Bone graft materials were divided into three groups: ATB in group 1, Orthoblast II® (Integra Co., Irvine, CA, USA)+Biocera® (Osscotec, Cheonan, Korea) in group 2, and DBM® (Synthes, West Chester, PA, USA)+BioOss® (Geistlich Pharm AG, Wolhusen, Switzerland) in group 3. After a healing period of 4 months, new bone formation in group 1 was 52.5%±10.7%, 52.0%±23.4% in group 2, and 51.0%±18.3% in group 3 with no significant difference between the groups. Ratio of new bone to residual bone graft material was 81.3%±10.4% in group 1, 72.5%±28.8% in group 2, and 80.3%±24.0% in group 3.

According to the results of the above-mentioned studies, overall clinical outcomes of ATB were similar or superior to other types of bone grafts. However, the disadvantages of ATB were the requirement of customized preparation for each tooth, prolonged time taken for preparation (several days), and increased cost. Tooth extraction and simultaneous placement of implant cannot be performed due to sequential issues[21]. Additionally, the amount of bone graft obtained is insufficient due to the limited number of teeth extracted[22]. Among the various sources of growth factors used in implant dentistry, many studies have been conducted on PRP since it is easy to obtain from patients' own blood. Fioravanti et al.[13] reported that PRP is a safe and cost-effective procedure in promotion of healing of hard and soft tissues. PRP has been used in combination with different types of bone grafts such as hydroxyapatite, xenografts, and demineralized freeze-dried bone allograft with positive results[23-25].

Kim et al.[26] reported use of demineralized dentin matrix with recombinant human bone morphogenetic proteins-2 in beagle dogs and showed 48% bone formation at 12 weeks, compared to 75% with autogenous graft. Kim et al.[8] reported the use of demineralized tooth block with PRP in sinus augmentation with favorable results. Consistent with the results of the above-mentioned clinical studies, the present study conducted using ATB and PRP demonstrated good clinical results. Success and survival rates of implants after fixation of prosthesis were 95.52% and 97.01%, respectively. Sinus perforation occurred in five cases, out of which failure was observed in two cases with postoperative complications. Sinus perforation and complication rate were application of redundancy, and number of cases was to small that success and survival rate appeared to show low values. Except this case, all other cases showed success rate of 91.67% to 100%, irrelevant of the variables assessed.

In the present study, two implants failed in one patient, placed in the region of #16, #17, due to inability to achieve adequate primary stability and perforation of the sinus membrane during surgery. During second surgery, the implants were removed due to failure of osseointegration and successfully finished after augmentation using autograft. One case, which did not meet the success criteria proposed by Albrektsson et al.[14] showed exudates due to infection after implant placement but survived with periodontal treatment. Etiology of the infection around implants is unclear; however, it was hypothesized to

occur due to loss of periodontal tissues and plaque accumulation in the adjacent tooth. The correlation between infection and the bone graft material was also unclear. The adjacent tooth was subsequently extracted and replaced with an implant. The infected implant was maintained without further problems following periodontal treatment.

The present study has some limitations. The design of the study was retrospective in nature that focused mainly on success and survival rates of implants using only panoramic x-ray. High resolution CT and histological analysis are required for analysis that is more accurate. In addition, the mean follow-up period of this study was 53 months and future studies must include longer duration of follow-up to arrive at a more definite conclusion. However, the observation of the present study was that combination of ATB and PRP can provide favorable results in the rates of success and survival of implants placed following sinus augmentation.

Conclusion

Combination of ATB and PRP in sinus augmentation showed high overall success rate and can be considered a predictable procedure. Further comparative studies with other materials and longer duration of follow-up are required to arrive at a definite conclusion regarding the effectiveness of ATB and PRP.

Conflict of Interest

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

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