의학박사 학위 논문

측방 접근법으로 상악동 골이식을 시행한 임플란트의 임상 예후와 위험인자에 대한 연구

Study of clinical outcome and risk factor of implants placed in grafted maxillary sinus via lateral approach

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이 논문을 의학박사 학위 논문으로 제출함

2022년 02월

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Abstract

Purpose: The aim of this study was to investigate the outcome of dental implants placed in a grafted maxillary sinus and identify possible risk factors for implant failure, and whether there are specific surgical or clinical conditions in which autogenous bone (AB) grafts are more favorable than bone substitutes (BSs) grafts for maxillary sinus floor augmentation (MSFA).

Materials and Methods: The author retrospectively analyzed 386 implants after MSFA in 178 patients. The outcome variables were 1) 2-, 5-, and 10-year cumulative survival rate of the implant, 2) risk factors for implant failure, and 3) correlation between preoperative residual bone height (RBH) and graft materials in terms of implant survival. Graft materials used were divided into five different groups: autogenic, allogenic, xenogenic, combination of allogenic and xenogenic, or combination of autogenic and xenogenic graft. To investigate risk factors for implant failure in MSFA, implant survival according to graft materials, patients' sex and age, surgical site, RBH, healing period prior to prosthetic loading, staged- or simultaneous implantation with MSFA, the crown-to-implant ratio, prosthetic type, implant diameter, and opposite dentition were evaluated.

Results: The cumulative 2-, 5-, and 10-year survival rates of implants placed in the grafted sinus (independent of the graft material used) were 98.4%, 97.1%, and 96.04%, respectively. In regions with a residual bone height of 5.0mm or less, greater RBH was preferable for long-term implant survival (odds ratio=3.475; p=0.035). Implant survival was not significantly different between graft materials, even when RBH was unfavorable.

Conclusions: The placement of dental implants with MSFA is a reliable procedure. Further, RBH is an important predictor of long-term implant survival. There was no specific surgical conditions in which AB was superior to BSs in terms of implant survival after MSFA.

Keywords: Dental implants, Risk factors, Survival rate, Sinus floor augmentation

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Introduction

Placing dental implants in the pneumatized posterior edentulous maxilla can be challenging for practitioners due to its reduced bone height and density. The maxillary sinus bone graft technique was introduced by Tatum[1] and Boyne,[2] and it has proven to be very effective in increasing the bone volume and the implant survival rate in edentulous posterior maxilla with few complications[3-5]. With the increased implementation of dental implants for replacement of missing teeth in the posterior maxillary region, this technique is now routinely employed in patients with poor bone support in the posterior maxilla.[6,7]

Till date, survival rates of dental implants (ranging from 61.7% to 100%) placed in grafted maxillary sinus via lateral window technique have been reported by collecting short- and long-term data.[5] Over the decades, the success of implants in sinus graft surgery is increasing due to the improvement of graft materials used in, micro- and macro-implant design, use of surgical tools such as piezo instruments, and use of less invasive surgical procedures. As the technique gained popularity, many researchers began investigating predictors for implant loss in the grafted maxillary sinus to assess long-term implant stability. Some previous studies have reported clinical outcomes and risk factors for implant failure after MSFA.[5,6] However, additional quantitative studies are still needed to define the rate of long-term implant survival and describe possible predictors for implant failure.

Previous studies have indicated that sinus grafting materials promote bone formation in the space created under the elevated sinus membrane, by facilitating three-dimensional stability of the clot against intra-sinus pressure. To guarantee bone quality and quantity that can ensure the initial and long-term implant stability, researchers have long sought the ideal space-filling graft materials. Despite some limitations, such as possible postoperative patient morbidity, limited quantities, prolonged surgical time, and unpredictable resorption, autogenous bone (AB) has been considered the gold standard for bone grafts to date.[8] Some authors advocate the use of AB because it may have better bone formation capability than bone substitutes (BSs).[9,10] However, there are still no clear indications or guidelines for the use of AB or BSs in dental implants requiring maxillary sinus bone grafts. Therefore, to date, the clinical decision between using AB or BSs has mainly been based on: tissue vitality, defect size, graft size, shape and volume, biomechanical characteristics, graft handling, cost, ethical issues, biological characteristics, and associated complications as well as the surgeon's surgical skill and experience.

The purpose of the present study were to investigate the outcome of dental implants placed in a grafted maxillary sinus and identify possible risk factors for implant failure, and whether there are specific surgical or clinical conditions in which AB grafts are more favorable than BSs grafts for maxillary sinus floor augmentation (MSFA). The author hypothesized that there are risk factors for

implant failure in MSFA, and that AB grafts would be more favorable than BSs for implant survival. To investigate this hypothesis, the author evaluated a number of variables to define risk factors: implant survival according to graft materials used (autogenic, allogenic, xenogenic, or combination of two grafts), patients' demography, surgical site, residual bone height (RBH), healing period prior to prosthetic loading, staged- or simultaneous implantation with MSFA, crown-to-implant ratio, implant diameter, prosthetic type, and opposite dentition. The author also assessed the correlation between RBH and graft materials in terms of implant survival rate to determine whether a specific graft material may be more favorable in cases with reduced RBH.

Materials and Methods

Study design and sample

To address the research objectives, the study was designed and implemented as a retrospective cohort study. The study population included all patients who had undergone implantation with an MSFA procedure from January 2008 to December 2015 at Ulsan University Hospital. To be included in the study sample, the patients had to meet the following inclusion criteria: 1) clinical and surgical records available, 2) preoperative panoramic and computed tomography (CT) or cone-beam computed tomography (CBCT) images available, 3) immediate postoperative panoramic or CBCT images available, 4) radiographic images taken immediately before or after prosthetic loading, 5) radiographic images taken during follow-ups, and 6) adherence to periodic maintenance check-ups. Patients who had medical conditions compromising bone healing, were heavy smokers, had preoperative maxillary sinusitis on the CT or CBCT images, or had untreated periodontitis were excluded. The implants were divided into five groups according to the graft materials used: AB only, allografts only, xenografts only, a combination of allografts and xenografts, and a combination of AB and xenografts.

Study variables

The three outcome variables were: (1) 2-, 5-, and 10-year cumulative survival rate of dental implants placed in the grafted maxillary sinus, (2) risk factors for implant failure in MSFA, and (3) association of implant survival with preoperative RBH and graft material type. To investigate risk factors for implant failure in MSFA, implant survival according to graft materials, patients' sex and age, surgical site (premolar or molar), RBH, healing period prior to prosthetic loading, staged- or simultaneous implantation with MSFA, the crown-to-implant ratio, prosthetic type (single or splinted), implant diameter, and opposite dentition were evaluated. Information about patients' demography, implant length and diameter, surgical site, graft material, prosthetic type, opposite dentition, and length of healing period prior to loading were obtained from clinical and surgical records. The crown-to-implant ratios were measured on the first follow-up panoramic image taken after loading, which is usually re-evaluated by 3 months after loading. To assess preoperative RBH, the point corresponding to the center of each implant placement was measured on the preoperative panoramic image. To investigate the correlation between preoperative RBH and graft materials in terms of implant failure, the RBH was categorized into three different ranges: RBH < 3mm, $3 \leq$ RBH ≤ 5mm, and RBH > 5mm.

Procedures

After being provided extensive information about the advantages and

disadvantages of the different graft materials, each patient chose to receive either AB or bone substitutes (BSs) (allogenic, xenogenic, or combinations) for sinus floor augmentation. All MSFA procedures were performed via the lateral window technique, under local or general anesthesia. The grafts were harvested from either an intraoral (i.e., chin or mandibular ramus) or extraoral (i.e., iliac crest) donor site, and were sectioned with a bone mill in the AB-only and AB-xenograft groups. In the xenograft group, deproteinized bovine bone with spongiosa granules of 0.25mm~1.0mm (Bio-Oss®, Geistlich Pharma AG, Wolhusen, Switzerland) was used. In the allograft group, freeze-dried cancellous bone with a particle size of 0.4mm~1.6mm (Allo-Bone plus®, CGBio, Seongnam, Korea) was used. A 1:1 mixture of deproteinized bovine bone and freeze-dried cancellous bone, deproteinized bovine bone and demineralized bone matrix (Orthoblast II®, Isotis Orthobiologics, Irvine, CA, USA), or AB and deproteinized bovine bone, were used for the combinations of BSs or AB and xenogenic grafts, respectively. All the external windows were covered with a collagen membrane (Ossguide®, Osstem, Seoul, Korea). Whenever possible, implantation was performed simultaneously to reduce patient discomfort and psychological burden. The type of implant (Osstem®, Seoul, Korea, or BioHorizons®, Birmingham, AL, USA) used in the MSFA procedure was based on patient preference. The implants were installed as per the manufacturer's instructions. Implants were uncovered and prosthetic rehabilitation was commenced after checking osseointegration.

Statistical analysis

Treatment data were evaluated using descriptive analysis (mean ± standard deviation, frequency, and range), and analysis of variance (ANOVA), followed by Scheffe post-hoc analysis. were used to compare data between groups. Kaplan-Meier analysis was performed to identify differences in implant failure according to graft materials used and correlation between preoperative RBH and graft materials in terms of implant failure. A uni- and multivariate logistic regression model were used to evaluate the risk factors for implant failure, and a stepwise approach was used to identify possible risk factors. All statistical analyses were performed using Statistical Product and Service Solution software (version 24, SPSS Inc., Chicago, IL, USA) and R package (version 3.5.3, R Foundation for Statistical Computing, Vienna, Austria). The significance level was set at 0.05.

Results

In total, 482 patients received implantation with MSFA during the study period. Of those, 178 (93 men, 85 women) patients with an average age of 58.54 ± 8.78 years met the inclusion criteria; in these patients, 386 implants were analyzed. The mean follow-up duration after prosthetic loading was 72.81 ± 29.40 months. Parameters such as patients' demographic information (sex and age), surgical site, and duration of prosthetic loading are summarized according to the graft materials used (Table 1a). Thirteen (3.37%) of 386 implants were lost. Five of those were lost early, prior to prosthetic loading, due to failed osseointegration, while eight were lost late, after prosthetic loading (44.5 ± 24.33 months). Therefore, the cumulative 2- and 5-year survival rates of implants placed in the grafted sinus (independent of the graft material used) were 98.4% and 97.1%, respectively.

Table 1a. Patients' demographic and clinical data: full data

	Sex (M/F)	Age (year)	Surgical site (P1/P2/M1/M2)	Preoperative RBH (mm)	Period of prosthetic loading (months)
Autograft	16/8	54.79 ± 9.45	4/14/24/19	4.02 ± 1.31	56.38 ± 25.41
Xenograft	9/11	57.10 ± 7.77	2/5/13/11	4.51 ± 1.82	63.58 ± 25.25
Allograft	16/13	61.48 ± 7.97	4/13/29/23	4.60 ± 1.38	94.35 ± 32.23
Combination of BSs	38/38	58.44 ± 9.29	3/25/74/55	4.33 ± 1.67	72.02 ± 28.07
Combination of Auto + xenograft	14/15	52.48 ± 9.14	3/10/30/23	4.24 ± 1.25	71.73 ± 21.00

BSs: bone substitutes P1: first premolar, P2: second premolar, M1: first molar, M2: second molar.

Of those 178, 98(48 men, 50 women, and 202 implants) patients with an average age of 58.74 ± 8.64 years met the inclusion criteria for 10-year implant survival rate. The mean follow-up periods after implantation and prosthetic loading were 119.41 ± 18.35 months (Table 1b). Other parameters such as preoperative RBH, implant diameter, healing period prior to loading, crown-to-implant ratios, methods of implant placement (simultaneous/staged), prosthetic type (single/splinted), and state of the opposite dentition are summarized in Table 2. The mean preoperative RBH was 4.50 ± 1.67mm, ranging from 0.99 to 7.80mm. Eight (3.96%) of 202 implants were failed. Two of those were lost early (prior to prosthetic loading) due to failure of osseointegration, while 6 were lost late (31.33 ± 30.07 months after

prosthetic loading). Therefore, the cumulative 10-year survival rates of implants placed in the grafted sinus (independent of the graft material used) were 96.04%, as seen during the follow-up period (Table 2 and Figure 1).

Table 1b. Patients' demographic and clinical data: 10-year survival

	Sex (M/F)	Age (year)	Surgical site (P1/P2/M1/M2)	Preoperative RBH (mm)	Period of prosthetic loading (months)
Autograft	9/2	59.43 ± 6.24	2/7/13/8	4.66 ± 1.82	112.40 ± 9.72
Xenograft	4/6	59.87 ± 5.09	1/1/8/6	4.53 ± 2.01	113.81 ± 3.58
Allograft	10/12	61.89 ± 7.64	1/7/18/17	4.80 ± 1.50	105.06 ± 32.90
Combination of BSs	16/17	60.61 ± 9.02	0/11/34/22	4.50 ± 1.68	112.59 ± 15.79
Combination of Auto + xenograft	9/13	52.26 ± 8.24	1/7/22/16	4.10 ± 1.56	111.86 ± 11.16

BSs: bone substitutes, P1: first premolar, P2: second premolar, M1: first molar, M2: second molar.

Table 2. Clinical data according to graft materials: 10-year survival

		Autograft	Xenograft	Allograft	Combination of BSs	Combination of Auto and Xenograft	p-value
Survival period (month)‡		121.23±9.84	122.13±2.55	114.84±31.38	120.54±15.90	119.91±11.21	0.466
Preoperative RBH (mm)‡		4.66±1.83	4.53±2.01	4.80±1.49	4.51±1.69	4.10±1.56	0.371
Healing period (month)‡		8.83±2.12	8.31±1.74	9.26±2.40	7.97±1.28	8.04±1.40	0.002
Implant diameter (mm)‡		4.45±0.52	4.31±0.48	4.16±0.46	4.26±0.54	4.43±0.54	0.059
Cr/implant ratio‡		0.90±0.17	1.03±0.21	0.89±0.24	0.89±0.20	0.87±0.21	0.115
Prosthetic type†	Single	1 (3.3%)	3 (18.8%)	5 (11.6%)	12 (17.9%)	7 (15.2%)	0.370
	Splint	29 (96.7%)	13 (81.3%)	38 (88.4%)	55 (82.1%)	39 (84.8%)	
Opposite dentition†	Implant	17 (56.7%)	5 (31.3%)	12 (27.9%)	37 (55.2%)	13 (28.3%)	0.001
	Natural dentition	13 (43.3%)	9 (56.3%)	31 (72.1%)	26 (38.8%)	33 (71.7%)	
	RPD	0 (0.0%)	2 (12.5%)	0 (0.0%)	4 (6.0%)	0 (0.0%)	
Implant survial†	Survival	29 (96.7%)	16 (100.0%)	39 (90.7%)	65 (97.0%)	45 (97.8%)	0.497
	Fail	1 (3.3%)	0 (0.0%)	4 (9.3%)	2 (3.0%)	1 (2.2%)	

† Fisher's exact test, ‡ One-way ANOVA

One (3.33%) implant in the AB group (RBH > 5mm) was lost after 69 months of loading. In the allogenic bone group, four (9.3%) implants (one early loss, RBH < 3mm; three late loss, one in RBH < 3mm and two in RBH > 5mm) were lost, where one late loss occurred at 1 month, another at 4 months, and the other at 48 months after prosthetic loading. Two (2.98%) implants in the combination of BSs group (one early loss, 3mm RBH 5mm; and one late loss, RBH < 3mm) were failed, where one late loss occurred at 63 months after prosthetic loading. In the combination of AB and xenogenic bone group, one (2.17%) implant was failed, which was a late loss occurring at 39 months after loading, with RBH < 3mm (Figure 1).

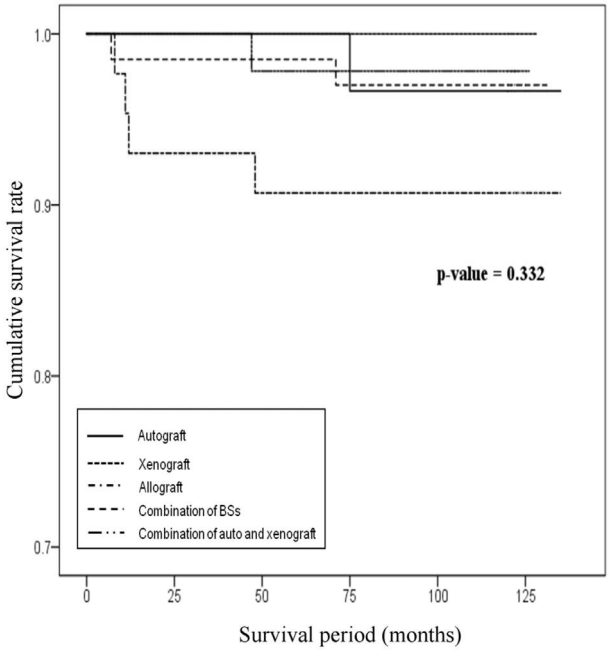

Figure 1. Kaplan-Meier cumulative survival rate according to graft materials used

There was no specific risk factor for implant failure among the given variables except RBH and implant diameter. In regions with a residual bone height of 5mm and less, RBH was affected positively, in that a greater RBH was preferable for long-term implant survival (odds ratio=3.475; p=0.035). When RBH was more than 5mm, there was no statistical correlation between RBH and long-term implant survival. Implant diameter, in contrast to RBH, negatively affected long-term implant survival when RBH was 5mm or less (odds ratio=0.033; p=0.006) (Tables 3-6). On the other hand, there was no graft material that specifically favored long-term implant survival and the author could not identify any correlation between graft materials and RBH in terms of implant survival (Figure 2 A and B).

Table 3. Univariate logistic regression for implant loss: full data

		B	S.E	O.R	95% C.I	p-value
Sex	Male	Reference				
	Female	-0.124	0.722	0.883	0.215 - 3.634	0.864
Age		0.017	0.041	1.017	0.938 - 1.103	0.678
Preoperative RBH		0.219	0.223	1.245	0.804 - 1.929	0.326
Healing period		0.013	0.201	1.013	0.684 - 1.501	0.948
Graft material	Autograft	Reference				
	Xenograft	17.836	10048.242	55706029.06	0.000 -	0.999
	Allograft	-1.090	1.145	0.336	0.036 - 3.169	0.341
	Combination of BSs	0.114	1.245	1.121	0.098 - 12.858	0.927
	Combination of Auto and Xenograft	0.439	1.434	1.552	0.093 - 25.795	0.759
Implant diameter		-2.227	0.696	0.108	0.028 - 0.422	0.001
Cr/implant ratio		0.433	1.760	1.542	0.049 - 48.560	0.806
Opposite dentition	Implant	Reference				
	Natural dentition	-0.232	0.745	0.793	0.184 - 3.413	0.755
	RPD	17.907	16408.711	59832401.59	0.000 -	0.999
Prosthetic type	Single	Reference				
	Splint	0.767	0.843	2.154	0.413 - 11.246	0.363
Surgical site	1st premolar	Reference				
	2nd premolar	0.000	19288.578	1.000	0.000 -	1.000
	1st molar	-18.313	17974.857	0.000	0.000 -	0.999
	2nd molar	-18.112	17974.857	0.000	0.000 -	0.999
Methods of implant placement	Simultaneous	Reference				
	Staged	0.286	1.087	1.331	0.158 - 11.205	0.732

Table 4. Clinical data with residual bone height of 5mm or less: 10-year survival

		Autograft	Xenograft	Allograft	Combination of BSs	Combination of Auto and Xenograft	p-value
Survival period (month)‡		122.73±4.06	121.40±1.43	116.38±27.33	118.80±20.20	119.39±13.11	0.859
Preoperative RBH (mm)‡		3.14±1.09	3.25±1.22	3.71±0.92	3.40±1.09	3.31±0.97	0.487
Healing period (month)‡		9.27±2.19	9.00±1.56	9.96±2.56	8.00±1.24	8.06±1.32	0.000
Implant diameter (mm)‡		4.29±0.51	4.20±0.42	4.18±0.44	4.30±0.52	4.45±0.56	0.308
Cr/implant ratio‡		0.86±0.13	1.07±0.24	0.91±0.27	0.90±0.17	0.84±0.20	0.045
Prosthetic type†	Single	0 (0.0%)	3 (30.0%)	2 (8.3%)	3 (7.5%)	6 (18.2%)	0.112
	Splint	15 (100.0%)	7 (70.0%)	22 (91.7%)	37 (92.5%)	27 (81.8%)	
Opposite dentition†	Implant	10 (66.7%)	3 (30.0%)	12 (50.0%)	22 (55.0%)	7 (21.2%)	0.001
	Natural dentition	5 (33.3%)	6 (60.0%)	12 (50.0%)	14 (35.0%)	26 (78.8%)	
	RPD	0 (0.0%)	1 (10.0%)	0 (0.0%)	4 (10.0%)	0 (0.0%)	
Implant survival†	Survival	15 (100.0%)	10 (100.0%)	22 (91.7%)	38 (95.0%)	32 (97.0%)	0.833
	Fail	0 (0.0%)	0 (0.0%)	2 (8.3%)	2 (5.0%)	1 (3.0%)	

† Fisher's exact test, ‡ One-way ANOVA

Table 5. Univariate logistic regression for implant loss with residual bone height of 5mm or less: 10-year survival

		B	S.E	O.R	95% C.I	p-value
Sex	Male	Reference				
	Female	0.286	0.931	1.331	0.214 - 8.259	0.759
Age		0.056	0.046	1.058	0.967 - 1.157	0.218
Preoperative RBH		1.032	0.497	2.805	1.060 - 7.428	0.038
Healing period		-0.192	0.211	0.826	0.546 - 1.249	0.364
Graft material	Autograft	Reference				
	Xenograft	0	16408.714	1.000	0.000 -	1.000
	Allograft	-18.805	10377.785	0.000	0.000 -	0.999
	Combination of BSs	-18.258	10377.785	0.000	0.000 -	0.999
	Combination of Auto and Xenograft	-17.737	10377.785	0.000	0.000-	0.999
Implant diameter		-3.147	1.119	0.043	0.005 - 0.385	0.005
Cr/implant ratio		-1.759	1.979	0.172	0.004 - 8.336	0.374
Opposite dentition	Implant	Reference				
	Natural dentition	0.585	0.932	1.794	0.289 - 11.156	0.531
	Denture	18.37	17974.842	95027931.93	0.000 -	0.999
Prosthetic type	Single	Reference				
	Splint	-18.178	10742.024	0.000	0.000 -	0.999
Surgical site	1st premolar	Reference				
	2nd premolar	0.000	29958.017	1.000	0.000 -	1.000
	1st molar	-18.313	28420.665	0.000	0.000 -	0.999
	2nd molar	-18.135	28420.665	0.000	0.000 -	0.999
Methods of implant placement	Simultaneous	Reference				
	Staged	0.032	1.141	1.032	0.110 - 9.665	0.978

Table 6. Multivariate logistic regression for given variables with residual bone height of 5mm or less: 10-year survival

	B	S.E	O.R	95% C.I	p-value
RBH	1.246	0.589	3.475	1.095 - 11.030	0.035
Implant diameter	-3.426	1.240	0.033	0.003 - 0.369	0.006

B: β, beta

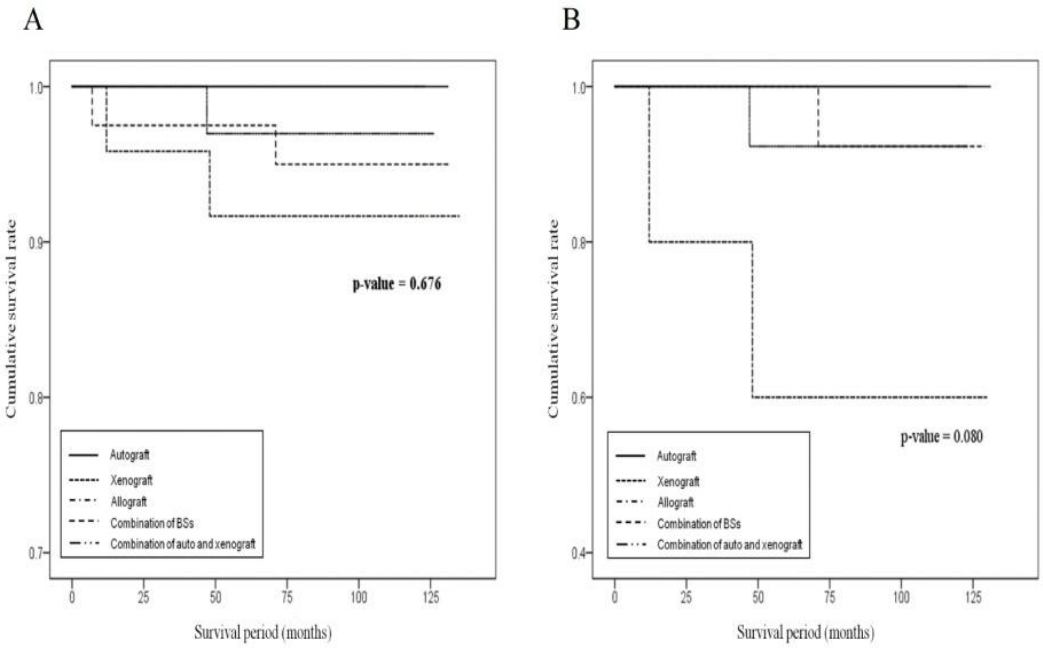

Figure 2. Correlation between preoperative RBH and graft materials in terms of implant failure: Kaplan–Meier cumulative survival rate. A, Residual bone height of 5mm and less. B, Residual bone height of less than 3mm.

Discussion

To maintain space under the elevated maxillary sinus membrane to allow a blood clot to serve as the scaffold on which bone-forming cells, arising from the sinus walls[11] and Schneiderian membrane,[12] can differentiate and form new bone, the use of graft materials in this space is advocated.

In the present study, the author evaluated the outcome of dental implants placed during MSFA, described possible predictors for implant failure, and identified a correlation to determine whether a specific graft material is more favorable for ensuring survival in cases with reduced RBH. The results indicated that implantation during MSFA via lateral approach is a very predictable procedure with a 10-year cumulative survival of 96.04%, and in less than 5mm, RBH is a risk factor for long-term implant survival. Furthermore, it seems that graft material is not a predictor for implant survival with MSFA even when RBH is unfavorable. The results of the present study concur with a previous study where RBH was regarded as an important factor for implant success and survival after bone grafts.[8-11]

Implant survival after MSFA with various graft materials has been evaluated for different RBHs in several studies. Although AB is considered to have superior bone formation capability over BSs, previous reports have demonstrated that BSs are biocompatible and are not limited in terms of quantity, and have achieved reliable results in MSFA procedures,[13-17] complicating the choice of appropriate graft material for MSFA. Therefore, the advantages or specific clinical and surgical conditions indicating the use of AB in MSFA must be carefully evaluated. Rosen and colleagues have demonstrated that RBH is the most influential factor for implant survival in sinus floor elevation procedures.[18] In their multicenter study, which implemented various graft materials, the implant survival rate was 96% or higher when RBH was > 5mm; however, it decreased markedly, to 85.7%, when the RBH was ≤ 4mm. Similarly, Zinser et al. reported that the RBH is a significant predictor of implant failure in MSFA, where the relative risk of implant failure was increased 3.01 times for RBH < 3mm as compared to RBH >10mm.[17] Moreover, in severe atrophic cases with an RBH of < 4mm, autogenic bone grafts showed a superior effect of implant survival over that of BSs; therefore, AB grafts should be considered in highly atrophic cases. However, in the present study, not even severely reduced RBH was found to be very important for implant survival in MSFA, regardless of the graft materials used. This is in agreement with several previous reports in which implant survival after MSFA with various graft materials and different RBHs was analyzed. Ferreira et al. demonstrated survival rates of implants with rough surfaces of 98.6% after MSFA using 100% anorganic bovine bone, and there was no statistical significant association with RBH.[19] Al-Nawas et al. in their meta-analysis reported that implant survival seems to be independent of the biomaterial used in MSFA.[13] Likewise, when considering only the graft

materials used for MSFA and RBH in terms of implant survival, AB did not seem to have marked advantages over BSs.

In the present study, healing periods prior to prosthetic loading were longer than those in other previous studies (Table 2). Usually, longer healing periods can improve graft maturation and bone quality, which subsequently increases implant survival rates.[20-22] De Vicente and colleagues reported that a healing period of 9 months after maxillary sinus augmentation with DPBB and AB resulted in an implant survival rate of 98.9%.[23] Jensen and colleagues demonstrated that early bone-to-implant contact in MSFA was more advanced with autogenous grafts, and worst with xenografts.[24] However, in contrast with the early phase, there was no statistically significant difference between the grafting materials in the later phase.[3] This agreed with a meta-analysis that compared bone graft materials via histomorphometrical evaluation of human bone biopsies from MSFA, where AB enabled faster initial bone formation, but the final amount of bone formation did not differ from that observed with BSs.[25] The present study implies that, if implants inserted in MSFA are allowed healing periods that are sufficient for graft maturation and bone quality, so as to allow prosthetic loading, the healing period itself would no longer be a risk factor for implant survival.

In respect of the implant placement stage after MSFA, Zinser et al. reported that a two-stage delayed implantation had a 2.56 times lower risk of implant failure than one-stage procedures.[17] However the present study showed no statistically significant difference in implant removal between one- or two-stage implantation procedure, which is in accordance with Felice et al.[26] In their research, implants placed in 1 to 3mm of bone height were evaluated and no statistically significant differences were observed. In the present study, the implant was inserted into the grafted sinus simultaneously, if the primary implant stability could be ensured.

From a biomechanical point of view, the crown-to-implant ratio, prosthetic type (splinted or non-splinted-implant crown), implant diameter, and opposite dentition could be risk factors for implant removal. In terms of stress distribution, a lower crown-to-implant ratio and splinted multiple crowns with a large diameter implant could theoretically be more beneficial. However, wide diameter of implants were found to be another risk factor for implant failure when RBH < 5mm. From a biomechanical point of view, large diameter implants should benefit the patient due to stress distribution, and in general, narrow diameter implants are known to be susceptible to implant failure[7,18] or peri-implant disease. Daniel Rodrigo et al. reported that an implant diameter of < 3.5mm was a high-risk factor peri-implant disease.[27] In contrast, many recent studies have reported that implant diameter does not influence the long-term prognosis of the dental implants.[20-22] De Souza et al. reported that narrow diameter implants placed to support single crowns in the posterior region did not differ from standard diameter implants in terms of marginal bone level, implant survival, and success rates.[28] There was a high

tendency to choose a wide diameter implant in areas where bone quality and RBH was reduced, to compensate for unfavorable conditions in the present study. Buccal cortical thickness has been shown to be an important factor when it comes to preventing bone loss, therefore, the author presume that the reason for wide diameter implant being a predictor is related to the narrowing of the buccal wall after installation of wide diameter implant at unfavorable RBH.

Blanes et al. stated in their systematic review that the crown-to-implant ratio implant-supported prosthesis does not influence the peri-implant crestal bone loss.[29] On the other hand, Villarinho and colleagues reported that the clinical crown-to-implant ratio is a predictor of bone loss. In the present study, the crown-to-implant ratio was 0.96 ± 0.24mm (range from 0.5 to 1.78mm).[30] The result means within the data assessed, the crown-to-implant ratio itself is not risk factor of implant failure. Likewise, there were no statistically significant differences in terms of implant survival in single- or splinted-crown restoration, implant diameter, and opposite dentition, which is in accordance with the findings of previous studies.[24,31]

The present study had some limitations, as other retrospective studies. Additionally, the author could not ascertain whether maxillary sinus membrane perforation occurred during the procedure, based on the medical records and radiographic images of the study samples. Although maxillary sinus membrane perforation during a sinus lifting procedure is usually known not to affect implant survival rates,[32,33] possible graft contamination and consequent failure in osseointegration could not be excluded. Another limitation was the configuration of the maxillary sinus. Maxillary sinus width, i.e., the distance between the lateral and medial wall, is an important consideration for sinus bone augmentation. The MSFA procedure basically resembles that of a guided bone regeneration procedure, where intact bony wall is considered as the critical factor. A narrower sinus width is more favorable than a wider configuration in terms of faster vascular supply from the wall into the graft material.[11] Moreover, due to the limitations of retrospective study, the author could not make clear the occurrence of postoperative complications, such as postoperative maxillary sinusitis or infection, according to bone graft materials.

Although the paper has some limitations, the findings offer reasonable scientific evidence for clinicians and patients to choose a less invasive graft material for MSFA in specific surgical conditions, by avoiding harvesting intra/extra AB, by defining implant risk factors in MSFA, as well as determining the correlation between RBH and graft materials in implant survival.

Conclusion

The current study shows that placing dental implants with MSFA is a reliable procedure with 2-, 5-, and 10-year cumulative survival rates of 98.4%, 97.1%, and 96.04%, respectively. RBH is an important predictor for long-term implant survival, because in regions with bone height of 5mm or less, RBH was affected positively, and higher RBH is preferable for long-term implant survival. The graft material is not an important factor for long-term implant survival as long as sufficient healing periods are allowed for bone consolidation. However, the risk factors for implant failure in MSFA may be multi-factorial and future studies with more variables are should be designed to determine the risk factors for long-term implant survival in MSFA.

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국문 요약

연구목적

측방 접근법으로 상악동 골이식 후 식립한 임플란트의 장기 생존율을 조사하고 임플란트 장기 생존에 영향을 주는 위험인자를 알아보았다. 또한 임플란트의 장기 생존율 측면에서 자가골이 골대체재에 비해 유리한지를 조사하였다.

연구방법

측방 접근법으로 상악동 골이식술을 받은 178명의 환자에서 386개의 임플란트를 후향적으로 분석하여 임플란트의 2, 5, 10년 생존율을 조사하였다. 환자의 나이와 성별, 식립 부위, 잔존치조골 높이, 골이식재 종류, 임플란트가 골유착 되기까지의 치유 기간, 식립 방법, 치관-임플란트 비율, 임플란트 보철물의 연결 여부, 임플란트 직경 및 대합치의 상태 등에 따라 386개 임플란트를 구분하여 이들 변수가 임플란트 생존율에 위험인자가 될 수 있는지 조사하였다. 이를 위해 골 이식재는 자가골군, 동종골군, 이종골군, 자가골과 이종골의 혼합군 및 동종골과 이종골의 혼합군으로 분류하였으며 잔존치조골 높이는 3mm 이내, 3mm 이상 5mm 이하, 5mm 초과로 구분하였다.

결과

측방 접근법으로 상악동 골이식술을 시행한 임플란트의 2년, 5년, 10년 생존율은 각각 98.4%, 97.1%와 96.04%였다. 잔존골 높이가 5mm 이하일 때는 임플란트의 생존율이 잔존골 높이에 영향을 받았으며(odds ratio=3.475; p=0.035), 5mm를 초과하면 잔존골 높이에 영향을 받지 않았다. 대신 골이식재의 종류는 임플란트의 장기 생존에 영향을 주지 않았다.

결론

상악동 골이식술은 임플란트의 장기 생존 측면에서 유용한 술식으로 밝혀졌다. 잔존치조골 높이가 높은 것이 상악동 골이식술을 동반한 임플란트의 생존에 더 유리했지만 골이식재 종류는 영향을 주지 않는 것으로 보아 상악동 골이식술에서 자가골이 골대체재에 비해 유리하다고 할 수는 없어 보인다.