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Comparison of different sinus augmentation techniques for implant placements: An original research

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***Abstract*---**Aim: The purpose of the present research was to evaluate various sinus augmentation techniques for implant placements. Methodology: Four techniques were evaluated: 1-stage bone-added osteotome sinus floor elevation procedure (BAOSFE) with simultaneous implant placement; 2-stage BAOSFE with delayed implant placement; 1-stage lateral window sinus floor elevation with simultaneous implant placement; and 2-stage lateral window sinus floor elevation with delayed implant placement. Patients were followed

for 18 to 72 months (mean: 52.5 months) after prosthesis placement. Data were analyzed with cone-beam computed tomography. Results: A total of 96 implants from 71 patients were analyzed; pre-treatment, there were no significant differences between patients. Total implant survival was 98.9%. The mean residual bone height was significantly higher in the 1-stage BAOSFE group than the other groups (P <.01); 1 implant in this group failed at 3 months. There was no significant difference in total bone height gain between groups. However, the bone height gain of 1st sinus lifting with 2-stage BAOSFE was significantly lower than the 2-stage lateral window procedure (P<.01). There was no prosthesis failure. Conclusion: The favorable implant outcomes suggest these 1-stage and 2-stage MSFA procedures should be considered as alternative treatment options for patients with extremely atrophic posterior maxilla.

Keywords---atrophic maxilla, dental implants, lateral window sinus augmentation, transalveolar sinus augmentation.

Introduction

Dental implants are now regarded as predictable alternatives for replacing missing natural tooth/ teeth compared to the conventional fixed prosthesis. However, there is a constant challenge faced by a clinician in restoring the posterior maxillary area because of the presence of maxillary sinus. This could be related to the unfavourable pneumatization of the maxillary sinus, post-extraction resorptive patterns, and the often-poor residual alveolar bone quality. These factors decrease the availability of bone for the placement of an implant in the prosthetically driven position. This can be achieved by augmenting the residual ridge either by horizontal/vertical augmentation or in combination. Various techniques and methods have been tried and advocated to manipulate the sinus membrane for successful dental implants placement. All these techniques can be grouped broadly under two categories - direct and indirect. To date, the direct method is referred to as a gold standard in terms of gaining bone width.[1] As with other methods, direct techniques have a considerably higher amount of complications.[2] Sinus elevation is indicated in atrophic maxilla cases or cases where a deficiency of ridge height to place conventional implants. Many prospective studies have proven the high success rate of regular implants with a height of 10-12mm. This makes the sinus augmentation a need in the posterior atrophic maxilla. To be a candidate for the dental implant procedure, a patient must have sufficient bone in the maxillary and mandibular ridge to support these implants. Anatomic limitations often associated with the posterior maxilla are fl at palatal vault, deficient alveolar height, inadequate posterior alveolus, increased pneumatization of the maxillary sinus, and close approximation of the sinus to crestal bone. Maxillary bone, primarily medullary and trabecular, has less quantity and bone density than the premaxilla or mandible. Adjacent cortices of compact bone are generally very thin, providing minimal strength.[3] To increase the amount of bone in the posterior maxilla, the sinus lift procedure, or subantral augmentation, has been developed in the mid-1970s.[4] It is well-accepted techniques to treat the loss of vertical bone height (VBH) in the posterior maxilla

performed in two ways: A lateral window technique and an osteotome sinus floor elevation technique and placing bone-graft material in the maxillary sinus to increase the height and width of the available bone. Experience in the rehabilitation of severely resorbed maxilla is growing.[5] Autogenic bone graft are used most often. The bone seems to be harvested from the iliac crest most often,[6] although several anatomic areas have been used.[7-9] Various bone-grafting materials have been studied for use in maxillary sinus graft s to accelerate the bone healing process and prevent re-pneumonization of the maxillary sinus aft er grafting,[10,11] autogenousbone from the iliac crest or maxillary tuberosity, frozen bone, freeze-dried bone, xenogeneic bone, demineralized freeze-dried bone, and hydroxyapatite. Although these techniques are used to regenerate lost bone, the factors that contribute to the survival rate of sinus augmentation and dental implant placement are still the subject of discussion. The recent literature concerning sinus graft s has shown differing long-term results depending on which type of bone-graft material was used.[12-14] An ideal maxillary sinus bone-grafting material should provide biologic stability, ensure volume maintenance, and allow the occurrence of new bone infiltration and bone remodelling. Over time, bone-grafting materials and implants should achieve osseo-integration. After the restoration of the upper part of the implant has been completed, there should be no bone loss and the materials should be stable; there should be a predictable success rate.[15]

Aim of the Present Study

The purpose of the present research was to evaluate various sinus augmentation techniques for implant placements.

Methodology

Patients were selected by convenience sampling and were candidates for this retrospective study from March 2020 to March 2021. They were assessed preoperatively for ridge topography and treatment planning of sinus augmentation and implant placement using cone-beam computed tomography (CBCT). A total of 71 patients met the inclusion criteria and were placed into groups based on the sinus lifting technique used for implant placement: 1-stage BAOSFE, simultaneous implant placement (B1); 2-stage BAOSFE, delayed implant placement (B-2); 1-stage lateral window sinus lift, simultaneous implant placement (L-1); and 2-stage lateral window sinus lift, delayed implant placement (L-2). The 1-stage and 2-stage BAOSFE (B-1 and B-2, respectively) was performed with xenograft to elevate the sinus membrane to at least 10mm. Simultaneous implant placement and suturing for primary closure was performed in the B-1 procedure. A period of at least 6 months was allowed for graft healing, at which time implant osseointegration was assessed; implant uncovering and prosthesis fabrication were performed sequentially. For the B-2 procedure, implants were placed 6 months or more after sinus augmentation. If the ridge height was determined to be insufficient at this time, BAOSFE was performed again before implant placement. The 1- and 2-stage lateral window sinus lifting (L-1 and L-2, respectively) was performed by preparing a lateral bony window with round-headed diamond burs; the sinus membrane was elevated by excavators. For the L-1 procedure, the inner part of the sinus cavity was grafted with xenograft, followed by simultaneous implant placement. The graft was then packed around

and over the implants. Measurements were determined by clinical examination and CBCT radiographs. Data were collected for each group regarding implants per patient, position of implant, and implant length and width. CBCT images were used for measures of RBH before surgery and total bone height gain after all treatments were complete for 4 groups. Graft healing time and the bone height gain of 1st sinus lifting prior to implant placement was determined for both 2-stage surgery groups (B-2 and L-2). Descriptive statistics of implant characteristics for the 4 treatment groups were calculated as means and standard deviations (SD). The distribution of the implant length and width for each group was analyzed by Chi Square test. The Mann–Whitney U test was used to compare differences in graft healing time and the bone height gain of 1st sinus lifting between B-2 and L-2 groups after the first stage of surgery. The significance level for all statistical tests was set at $P<.05$.

Results

A total 96 implants were placed in 71 patients. The mean age of the patients did not differ significantly between groups. Number of implants between groups differed significantly ($P<.01$). In groups B-1, B-2, and L-2, most patients had one implant placement: 84.2% in B-1, 73.9% in B-2, and 64.7% in L-1. (Table 1) However, 66.7% of patients (n=8) in group L-2 received 2 implants, and this was the only group in which 1 patient received 4 implants. The mean number of days of surgical treatment (from first surgery to completion of the last surgery) differed between groups ($P<.01$); for the B-1 and L-1 groups the mean was 270.27 days (standard deviation, SD=114.99) and 263.00 days (SD= 63.02), respectively; compared with 401.43 days (SD=117.32) and 458.87 days (SD=139.98) for B-2 and L-2 groups, respectively. Pre- and post-treatment measures of implant sites were determined from CBCT images. All implants had an initial RBH <3mm. The mean RBH was 2.78mm (SD=0.45) for the B-1 group, significantly higher than the other groups ($P<.01$). However, mean bone height gain of 1st sinus lifting at time of implant for the L-2 group (8.44mm, SD=2.72) was significantly greater than the B-2 group (5.43mm, SD=2.21). (Table 2) Outcome measures 18 to 72 months (mean: 52.5 months) following prosthesis placement did not differ significantly between groups; there was no prothesis failure. After a 3-month healing period, a new implant was placed and the prosthesis was delivered after 10 months; the implant survived more than 4 years.

Discussion

The dental implant has a role in the replacement of lost tooth, especially when it is desirable to avoid preparing adjacent teeth that have no caries, restorations. The direct and indirect sinus lift procedure could be used to augment the sinus floor thereby augmenting the alveolar ridge to place implant of sufficient length. Previous studies have suggested sinus augmentation with BAOSFE should be limited to patients with an RBH of ≥5mm; lateral window sinus lift should be performed when the RBH is <4 mm.[16] Rosen et al found success of implant placement using BAOSFE was better when the RBH was ≥ 5mm, regardless of whether a 1-stage or 2-stage procedure was used.[17] A meta-regression analysis of the association between RBH and success of implants following lateral window or osteotome sinus elevation techniques by Chao et al found implant survival rates

with a lateral window sinus lift were positively associated when the RBH was ≥5mm.[18] However, no relationship could be determined for transalveolar sinus lift techniques because the included studies lacked sufficient data for an initial RBH of <4mm. A more recent meta-analysis by Calin et al showed an initial RBH of >4mm did not impact implant success or failure; however, an initial RBH of < 4mm was positivity associated with implants inserted in combination with transalveolar sinus elevation techniques.[19] A lateral window sinus lift technique has been shown to produce a greater bone height gain without the limitation of the size of the pre-operative RBH.[20] Our success with implant placement in the L-1 and L-2 group is further evidence that RBH is not a limitation for lateral window sinus lift; total bone height gain was similar for both groups. Both transalveolar sinus lift procedures also resulted in long-term survival of implants. The mean total bone height gain of 8.31mm for the B-1 group is similar to a study by Winter et al.[21] In the present study, the implants were all >8mm in length, ranging from 8.5 to 13mm, and all but one was successful. These findings are in contrast to those reporting an association of shorter implants with lower success rates. In earlier studies, short implants were defined as an infrabony length of less than 8 mm.[22] Whereas the predictability of standard implants ≥10 mm is high because a longer length provides better distribution of functional forces throughout the implants.[23,24] More recent studies have reported comparable survival rates for short and standard-length implants. For instance, a systemic review of 17 studies using short implants (8mm) placed after or simultaneously with the transalveolar or lateral window sinus elevation procedures. Survival rates were similar for both longer and shorter implants (99.5% and 99.0%, respectively).

Conclusion

In summary, comparable and desirable outcomes were achieved for all patients with an RBH <3mm, regardless of implant placement technique. The strength of these findings lies in the broad representation of implant size and width across 4 different sinus lift procedures.

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Tables

Table 1- Characteristics of patients in each implant treatment group.

	Implant treatment group				
Characteristic	B-1 (n=19)	B-2 (n=23)	L-1 (n=17)	L-2 (n=12)	P
Age, years (mean±SD)	55.91±5.06	51.86±13.46	53.52±10.97	55.74±6.60	.813
Implants per patient, n (%)					
1	16 (84.2)	17 (73.9)	11 (64.7)	3 (25)	
2	2 3 (15.8)	5 (21.7)	6 (35.3)	8 (66.7)	
3	3 0 (0.0)	1 (4.4)	0 (0.0)	0 (0.0)	
4	4 0 (0.0)	0 (0.0)	0 (0.0)	1 (8.3)	
Total treatment, days (mean±SD)	270.27±114.99	401.43±117.32	263.00±63.02	458.87±139.98	<.01

*****_B-1 = 1-stage bone-added osteotome sinus floor elevation procedure (BAOSFE) with simultaneous implant placement, B-2 = 2-stage BAOSFE with delayed implant placement, L-1 = 1-stage lateral window sinus lifting with simultaneous implant placement, L-2 = 2-stage lateral window sinus lifting with delayed implant placement, SD = standard deviation._

Table 2- Characteristics of implants and implant sites in the 4 treatment groups

	Implant treatment group				
Characteristic	B-1 (n=22)	B-2 (n=28)	L-1 (n=23)	L-2 (n=23)	p
Position of implant, n (%)					.29
Pre-molar	5 (22.7)	4 (13.8)	5 (21.7)	1 (4.3)	
Molar	17 (77.3)	24 (85.7)	18 (78.3)	22 (95.7)	
Implant length, n (%)					<.01
8.5 mm	14 (63.4)	3 (10.7)	1 (4.3)	0 (0.0)	
10.0 mm	7 (31.8)	9 (32.1)	8 (34.7)	13 (56.5)	
11.5 mm	1 (4.5)	16 (57.1)	11 (47.8)	9 (39.1)	
13.0 mm	0 (0.0)	0 (0.0)	3 (13.0)	1 (4.3)	
Implant width, n (%)					.586
3.25 mm	2 (9.1)	2 (7.1)	1 (4.3)	0 (0)	
4.00 mm	3 (13.6)	8 (28.6)	8 (34.7)	7 (30.4)	
5.00 mm	17 (77.3)	18 (64.2)	14 (60.1)	16 (69.6)	
Measurements, Mean±SD					
RBH, pre-treatment, mm	2.78±0.45	2.16±0.73	2.27±1.14	1.28±0.77	<.01
Graft healing time, months		7.59±1.99		9.73±2.11	.069
Bone height gain of 1st sinus lifting, mm		5.43±2.21		8.44±2.72	<.01

**B-1 = 1-stage BAOSFE with simultaneous implant placement, B-2 = 2-stage BAOSFE with delayed implant placement, Bone height gain of 1st sinus lifting = the gain of bone height was measured after graft healing of 1st sinus augmentation and prior to the implant placement in 2-stage surgery groups (B-2, L-2), Graft healing time = time between 1st sinus augmentation and implant placement in 2-stage surgery groups (B-2, L-2), L-1 = 1-stage lateral window sinus lifting with simultaneous implant placement, L-2 = 2-stage lateral window sinus lifting with delayed implant placement, RBH = residual bone height, SD = standard deviation, Total bone height gain = the gain of bone height was measured when all treatments were complete.*