Maxillary Sinus Grafts for Endosseous Implant Placement: A Literature Review

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• Abstract

This study sought to evaluate the effect of the type of grafts used in sinus lifting. A review of literature through MEDLINE search covering the period 1980 ~ 2006 was performed. After screening, this study was narrowed down to 2,452 patients receiving sinus lift grafts wherein 7,151 implants were placed. In this study, the types of grafts used in sinus augmentation were autogenous bone, allogenic bone, corticocancellous block bone, and various alloplastic materials. The success rate varied from 69% to 100% depending on the graft material type. The highest success rate was reported for the autogenous bone, with high success rates recorded for the most part in most studies.

• Keywords : sinus lift, sinus graft, autogenous bone, allogenic bone, alloplastic material

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Introduction

An important aspect of dental implant treatment is to provide long-term, safe anchorage for prosthesis[1-7]. The maxillary sinus is a living tissue wherein resorption and deposition occur continuously; thus, its shape and location can change over time. In the maxillary molar area, bone resorption caused by early tooth extraction can cause the maxillary sinus to expand. The maxillary sinus volume can also be increased by pneumatization of the inferior border, allowing the alveolar crest to approach the maxillary sinus. Since this is disadvantageous for implant placement, maxillary sinus grafts have been developed to improve osseointegration for implant placement.

Boyne and James[9] reported maxillary sinus floor elevation with autogenous bone grafts when the resorption of the alveolar bone is minimal, and the anteroposterior relationship is normal with regard to the maxillary sinus floor elevation as the technique introduced by Tatum[8]. A lateral approach for maxillary sinus floor elevation was later introduced by Tatum (1986)[8], with a modified method developed by Wood and Moore[10]. In these procedures, compensating for insufficient alveolar bone height entailed the use of various bone graft materials separately and in combination including autogenous bone, allogenic bone, xenogenic bone, and synthetic bone; many complications have been reported, however[11] (Table I).

Table I. Intraoperative, early-postoperative, and late-postoperative complications and sequelae following sinus bone grafts

Complications	Sequelae
Intraoperative	
Bleeding	Obstruction of ostium
Tear in buccal flap	Inadequate bone grafting
Perforation of sinus membrane	Damage to adjacent teeth
Early post-operative	
Wound dehiscence	Acute infection
Bleeding	Loss of graft material
Exposure of membrane	Failure of implant
Parenthesia of infra-orbital nerve	Oro-antral fistula
Late post-operative	
Loss of graft material	Invasion of soft tissue to bony window
Failure of implant	Cyst in maxillary sinus
Oro-antral fistula	Chronic maxillary sinusitis
Migration of implant	Chronic infection
Sequelae due to inadequate bone grafting	Chronic pain

This study reviewed reports on patients who underwent maxillary sinus floor elevation to overcome the problem of insufficient residual bone volume for implant placement in the maxillary molar area and assessed the prognosis after implant placement according to the material used for the maxillary sinus bone graft.

Materials and methods

A Medline search was conducted using the keywords "sinus augmentation" and "bone materials," yielding 213 articles related to maxillary sinus floor elevation surgery published between 1980 and 2006; of these, 47 articles met the study criteria.

The types of graft materials reported in literature were subdivided (Table II). The selected reports were analyzed with emphasis on the types of graft materials and the success rate of implants.

Results

We reviewed 47 papers describing the placement of 7,152 implants in 2,452 patients. The use of various bone graft

Table II. Graft Types

A. Block
Non-vascularized
Iliac
Calvarium
Rib
Mandible: symphysis
Maxilla: tuberosity
Source unknown
B. Particulate
1. Autogenous
Iliac
Tibia
Mandible: ramus and coronoid process
2. Alloplastic plus allogenic: HA + DFDB
3. Autogenous plus allogenic: iliac + DFDB
4. Autogenous plus alloplastic: iliac + HA, Source unknown + HA

HA, hydroxyapatite; DFDBA, demineralized freeze-dried bone allograft.

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Table III. Longitudinal reports on sinus elevation

Author	Patient No.	Site No.	Implant No.	Graft material	Type of implant	Perforation	Length of study	Success rate (%)
Boyne & James[9] (1980)	11			Au (hip)				
Tatum[8] (1986)				Au				
Misch[13] (1987)		170		TCP+DMB +blood			6 M	
Smiler & Holmes[14] (1987)	4	5	12	porous HA particles	endosteal root form		26-97 M	
Wood & Moore[18] (1988)	2	2	5	Au (ramus, coronoid)				100%
Kent & Block[15] (1989)	11	18	44	Au (hip)	HA-coated endosseous implant (Cakitek)	small (no Tx.) large (graft)	16-30 M	100%
Whittaker et al.[16] (1989)	1	1	4	osteogen+DMB +cortical bone				100%
Jensen et al.[17] (1990)	11	18	44	Au (hip)			46 M	75%
Hall & McKenna[18] (1991)	15	30		Au (hip)				90%
Hirsch & Ericsson[19] (1991)				Au (chin)				
Wagner[20] (1991)		63		osteogen +blood				
Jensen & Sindet-Pedersen[21] (1991)	26	31	107	Au (chin)			6-32 M	93.5%
Smiler et al.[22] (1992)	36	66	198	porous HA			10-12 M	95%
Smiler et al.[22] (1992)		21	56	Bio-oss+DMB (3:1)			10-12 M	95%
Smiler et al.[22] (1992)	106			osteogen+blood +collagen			10-12 M	95%
Smiler et al.[22] (1992)	72	81		osteogen +DMB			10-12 M	95%
Tidwell et al.[23] (1992)	48	48	267	Au+HA	HA-coated IMZ endosseous implant	Explanation of treatment necessity based on a 5 mm standard	23-39 M	93.3%
Loukota et al.[24] (1992)	7		27	Au (hip)		Perforation in 1 case (no symptoms)	22-24 M	
Jensen et al.[25] (1992)	15	26	74	Auto-radiated mineralized cancellous bone, DFDB				69%
Block & Kent[26] (1993)	32	51	173	Au (hip)		Failure due to a large Tear at 1 graft site	36 M	100%
Block & Kent[26] (1993)	32	51	173	18 cases of Au (iliac bone) ZB+DFDBA (1:1) 33				75%
Tolman[27] (1993)		20		Au (hip)				93%
Small et al.[28] (1993)	27	45	111	DMB+porous HA		No perforation		100%
Lozada et al.[29] (1993)	120	69	298	Au+Al+Ap				85%
Raghoebar et al.[30] (1993)	25	47	93			Perforation at 8 sites (5 Failures)	16M	94.2%
Raghoebar et al.[30] (1993)	25	47	86	Au (hip)				100%
Raghoebar et al.[30] (1993)	25	47	6	Au (symphysis)				
Raghoebar et al.[30] (1993)	25	47	1	Au (tuber)				100%
Moy et al.[31] (1993)	5		19	Porous HA, DFDB Symphysis				89.4%
Keller et al.[32] (1994)	20	23	66	Au (hip)	Branemark		15 Y	92%
Chiapasco & Ronchi[33] (1994)	30	43	124	Au+HA				93.5%
Jensen et al.[34] (1994)	98	128 (sinus) 34 (nasal)	291	Au		Perforation at 45 sites (19 Failures)	12-58 M	93.5%
Misch & Pietsh[35] (1994)	20	20	148	Au (iliac bone) (block)	Branemark, Nobelpharma swedevent, Dentsply			97.9%
Zinner & Small[36] (1996)	50	57	215	DMB+ porous HA			5 Y	98.6%
Olson et al.[37] (1997)	27	42	102	Au (14/22/57) DFDB (4/4/8), HA+DFDB (1:1) (9/12/29), Au+DFDB (3/4/8)	30 HA-coated cylinders, 43 HA-coated cylinders 10-16mm, 60 implants, 13mm, 35 implants (34%) 16mm, 7implants (8%)		3-12 M	99.0%
Peleg et al.[38] (1998)	20	20	55	Au (symphysis) +DFDBA			26.4 M (15-39)	100%
van den Bergh et al.[39] (1998)	42	62	161	Au	ITI screw	Perforation type (2nd stage)	1-6 Y at 3 sites (no failures)	100%
Peleg et al.[40] (1999)	63	63	160	Au (symphysis) +DFDBA	HA-coated integral cylindrical imp. (Sulzer Calcitek)		2-4 Y	100%
Khoury[41] (1999)	216	216	467	Au (symphysis, retromolar)	IMZ (Frident), Branemark (Nobel Biocare), Frialit-2 (Frident)	Perforation at 51 sites (14 failures, 28 implants)	2 Y	94%

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Table III. Longitudinal reports on sinus elevation

Author	Patient No.	Site No.	Implant No.	Graft material	Type of implant and length	Perforation	Length of study	Success rate (%)
van den Bergh et al.[42] (2000)	24	30	69	DFDB	ITI full body screw implant: rough surface	6 perforations (DFDBA)	10 M	100%
Yildirim et al.[43] (2001)	12	13	36	Bio-oss Au	Branemark system implant			
Pinholt[44] (2003)	25		158	Au (iliac+ mandible)	Branemark system implant (78): machined surface ITI (80) : SLA surface		20-67 M	B: 81% I: 98%
Stricker et al.[45] (2003)	41		183	Autogenous bone	SLA surface (ITI)	Perforation under 2mm →fibrin glue	20-67M 15-40M	100%
Hatano et al.[46] (2004)	191		361	Au: (Bio-oss)= 2:1			10 Y	94.2%
Andreana et al.[47] (2004)	6	6	14	Cerasorb+ DFDBA (capset)	3.7*13: Paragon24. 7*10: Paragon23. 75*10: Biolock23. 75*10: Biolock 3.75*10: Nobel		12-30M	100%
Deporter et al.[48] (2005)	70		104	bovine hydroxyapatite	Endpore implant (Innova)			98%
Zijderveld et al.[49] (2005)	10	16	41	beta-calcium phosphate (Cerasorb) Au (chin bone)	ITI full body: screw type			100%
Butz & Huys[50] (2005)	20	22	56	Synthetic graft (Bioplant HTR)			7 Y	
Hallman et al.[51] (2005)			108	Au + deproteinized bovine bone →(20:80)			3 Y	86%
Peleg et al.[52] (2006)	731	2132		Au + xeno + allobone	Screw type (1374) HA-coated cylinder (758)		9 Y	97.9%
Lindenmuller & Lambrecht[53] (2006)	80		201	Autogenous bone ceros 82 Algi pore	ITI (98%), Frialit (80%)			92%
Qin et al.[54] (2006)	122		157	Auto + xeno + allobone	Length: 8-11mm			100%
Maiorana et al.[55] (2006)	34		37	Alloplastic + xenogenic	Flialit-2			97.3%

Au, autogenous bone graft; Al, allogenic bone; Ap, alloplastic materials; osteogen, HA resorb; DMB, demineralized bone; xeno, xenogenic bone; DFDBA, demineralized freeze-dried bone allograft; tuber, maxillary tuberosity; HA, hydroxyapatite; Y, years; M, months; Perfo, Perforation.

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materials and implants was reported, and the success rate varied from 69% to 100% depending on the graft material types. The follow-up periods varied from zero to ten years. The highest success rate was reported for autogenous bone. The success rate of using autogenous bone grafts was high; ditto for the success rates of using synthetic bone and mixture of autogenous and allogenic bone.

Different types of implants and graft materials were used; high success rates were reported in most studies (Table III).

Discussion

In this review, we examined the effects on the success of the implants by the types of bone graft materials used in maxillary sinus grafts and the complications that developed during maxillary sinus floor elevation.

During the maxillary sinus floor elevation procedure, several complications may arise including hemorrhage in the membrane and bony window, but this can typically be managed by cauterization. The maxillary sinus may also become perforated. In particular, if the membrane becomes perforated, it may be repaired by utilizing a collagen membrane. Thus, careful control is needed to avoid such injuries.

To ensure the complete healing of the graft materials, patients should advise to wait for a minimum of 14 months prior to implant placement. According to an analysis of maxillary sinus bone grafts during the 1996 Sinus Graft Consensus Conference[12], 79 (48%) out of the 164 failures were due to complications during surgery; among said complications, 38 (48%) were associated with the perforation of the maxillary sinus membrane. Triplett and Schow[56] recommended the use of block bone instead of particle types for cases involving perforation measuring more than 5mm[32]. Jensen et al[34] reported that the perforation of the maxillary sinus membrane occurred in 35% of the cases; among those cases involving transplanted autogenous bones, there were no reported instances of infection.

Residual bone height prior to surgery is an important factor influencing the success or failure of implants. Implant removal can readily occur in cases of insufficient alveolar bone height, in which case a maxillary sinus floor bone graft should be performed. Jensen and Greer[57] reported a very low success rate in cases involving less than 3mm of bone as well as improved outcome with the use of grafts in cases of 7~9mm of bone. Within the maxillary sinus, two ~ four

Table IV. Success rates accoding to graft materials

Graft materials	No. of implants	3 years	5 years
AP	163	98%	98%
AP+X	125	98%	98%
AP+AL	563	93%	90%
AL	254	85%	85%
AL+X	199	80%	
AU (particulate)	264	93%	90%
AU+AP	331	91%	90%
AU+AL	124	82%	
	AU+AL+X	306	96%
AU+AL+AP	205	93%	93%

AP, alloplastic materials; X, xenogenic materials; AL, allogenic bone; AU, autogenous bone graft.

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15mm implants could be placed depending on the size of the maxillary sinus. Wheeler, et al[58] suggested the placement of 13mm implants after sinus bone graft for best results.

The three- and five-year cumulative success rates reported during the 1996 Sinus Graft Consensus Conference[12] are shown in Table IV. Many other graft materials have been used for maxillary sinus bone grafts[14,31,59-66], but autogenous bone harvested from the patient is considered ideal. In particular, autogenous bone is the best choice for areas of defective bone since it does not induce an immune response, and it has both osteoinductive and osteogenetic functions; hence its greater potential compared to allogenic bones. Note, however, that the adhesion of bones undergoing remodeling can be destroyed if load is applied during the healing periods[63]. Autogenous bone has the advantages of faster bone formation and remodeling including higher acceptability. Nonetheless, it has one obvious shortcoming: it requires a second surgical procedure. Typical donor areas include the iliac crest, ramus, maxillary tuberosity, and mandibular symphysis, and they have been used according to the type of powder, fragments, segments, and other shapes[9,10,18,25,30,67,68]. Ziccardi, et al recommend autogenous bone in cases where the residual alveolar crest is less than 2mm[68]. In cases of allogenic bone graft in the interior of the maxillary sinus, new bone formation is limited, typically occurring only in the vicinity of the maxillary sinus floor. In addition, insufficient hardness, abundant scar tissue, and long distance from the maxillary sinus floor reduce the viability of the bone[69].

For allogenic bone that has been decalcified and freeze-dried (DFDB), the level of bone morphogenic proteins varies depending on the preparation process; hence the varying osteoinductive potential. In fact, bone formation by osteoconduction rather than osteoinduction is likely. Note, however, that the use of a 1:1 mixture of autogenous and demineralized bone has been found to increase the volume of graft material and density of the transplanted cells. A synergistic response induced greater bone formation compared to the use of a single graft material[63]. Nonetheless, Holmes et al claimed that the risk of infection with DFDB was higher, and that more than twelve months may be required for the bone to mature enough to allow implant placement. Thus, DFDB is not the best choice for maxillary sinus floor elevation with implant placement.

The biocompatibility of xenogenic bones (e.g., Bio-Oss) and hydroxyapatite (HA) is an important factor. They provide sufficient space for new bone to grow as scaffold, and additional surgery is not required. Still, these materials lack osteoinductive properties, the risk of infection is higher, and their ability to withstand masticatory pressure following implant placement is unclear. Thus, these materials are used in combination in cases involving insufficient autogenous bone. For the osseointegration of implant to bone, autogenous bone should ideally be present in the vicinity of the implant. The filling of adjacent space with bone substitution materials is also recommended since they play a role in repairing alveolar bone defect.

Conclusions

Maxillary sinus elevation has been widely used in combination with bone grafting in cases of insufficient alveolar bone height for implant placement. Because of the structure of the maxillary sinus, however, many complications can occur during the procedure. The risk of such complications can be reduced if the procedure is understood completely and appropriate measures are taken. As reviewed in this paper, numerous graft materials have been used in maxillary sinus elevation. Autogenous bone was found to be associated with high implant success rate. A synergistic effect was also observed for autogenous bone mixed with other graft materials. Contact between bone and implant does not occur evenly in all areas. Thus, continued long-term clinical follow-up after implant placement is important. In addition, long-term follow-up is necessary to advance sinus elevation and to support posterior maxillary restorations.

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