Implant Survival Rates of Maxillary Sinus Augmentation: a Literature Review of Graft Materials

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Abstract

Purpose: By reviewing literature on the subject, we compared the survival rate of implants placed in various graft materials used for maxillary sinus augmentation.

Materials and Methods: The search protocol used the Pubmed electronic database, with a time limit from 1998 to 2009. Keywords such as 'sinus lift,' 'sinus augmentation,' 'sinus floor elevation,' 'sinus graft,' 'bone graft,' 'implants,' 'oral implants,' and 'dental implants' were used, alone and in combination, to search the database. We selected articles and divided them into three groups by type of graft materials: Group 1. Autogenous bone group: autogenous bone alone; Group 2. Combined bone group: autogenous bone in combination with bone substitutes; and Group 3. Substitute group: bone substitutes alone or bone substitute combinations.

Results: We selected 37 articles concerning a total of 2,257 patients and 7,282 implants; 417 implants failed. The total implant survival rate (ISR, %) was 94.3%. In Group 1, 761 patients and 2,644 implants were studied; 179 implants failed and the ISR was 93.2%. In Group 2, 583 patients and 1,931 implants were studied; 126 implants failed and the ISR was 93.5%. In Group 3, 823 patients and 2,707 implants were studied; 112 implants failed and the ISR was 95.9%.

Conclusion: Implants inserted in grafts composed of bone substitutes alone or in grafts composed of autogenous bone in combination with bone substitutes may achieve survival rates better than those for implants using autogenous bone alone ($P < 0.05$).

Key words: Implant survival rate, Maxillary sinus augmentation

Introduction

Bone quality in the posterior maxilla is poor, and pneumatization of the maxillary sinus and a insufficiency in the vertical alveolar height after tooth loss may limit the placement of implants.[1-3] To resolve these problems, various methods, such as onlay graft, veneer graft, bone graft after performing LeFort I osteotomy simultaneously, and maxillary sinus augmentation, have been introduced.[4-6] The maxillary sinus augmentation has been reported to be comparable to the success rate of implants placed in the edentulous posterior maxilla with a sufficient height. The maxillary sinus augmentation have been accepted as predictable and common method clinically.[7]

Maxillary sinus augmentation using autogenous bone was introduced by Boyne and James in 1980,[6] and since then, various bone substitutes have been used. Among maxillary sinus graft materials, autogenous bone has been considered the gold-standard. Autogenous bone has advantages of excellent bone regeneration potential, biocompatibility, and absence of immune response. However, its use can be restricted by the morbidity of donor graft site, infection, resorption of grafted bone, and the difficulty in

obtaining a sufficient bone intraorally.[8,9] Thus variety of allobone, xenobone, and synthetic bone have recently been introduced. Many studies are ongoing to assess the outcomes of bone graft materials in maxillary sinus augmentation

In this study, the prognosis and success rate of implants using various graft materials in the maxillary sinus lift were examined through literature reviews.

Materials and Methods

Research papers listed in the Pubmed database from 1998 to 2009 using the terms 'sinus lift,' 'sinus augmentation,' 'sinus floor elevation,' 'sinus graft,' 'bone graft,' 'implants,' 'oral implants,' and 'dental implants,' alone or in combination, were searched and collected.

Articles were selected according to the following inclusion criteria. 1) A lateral approach to the maxillary sinus was used, 2) limited to cases placing implants in humans, 3) limited to studies of bone grafts in more than 20 cases, 4) root-form implants was used, 5) mean follow-up time was more than 12 months after implant loading, and 6) the implant survival rate was clearly calculated data reported in the paper.

Reviews and technical reports were excluded. Also papers from same group of authors, with very similar databases of patients, materials, methods and outcomes, were excluded.

The collected papers were organized and divided to three groups based on the type of bone graft materials used.

- Group 1. Autogenous bone group; this group used only autogenous bone.
- Group 2. Autogenous bone + bone substitutes group; this group used autogenous bone in combination with bone substitutes.
- Group 3. Bone substitutes group; this group used bone substitutes alone or bone substitute combinations.

Statistical analysis was performed using statistical software. SSPS (statistical package for the social science); Chi-square test was used to determine statistical significance among between groups. Difference were considered significant at P value < 0.05.

Results

Through this search, 37 papers were selected and classified according to the year of publication (Table 1). In these reports, 7,282 implants were placed in a total of 2,257 patients; 417 implants failed, and the overall success rate of implants was 94.3%. The first, autogenous bone group included 15 papers; 2,644 implants were placed, 179 implants failed, and the success rate of implants was 93.2%. The second group, using autogenous bone in combination with bone substitutes, included 10 papers. The substitutes mixed with autogenous bone were deproteinized bovine bone (Bio-Oss®; Geistlich Pharma, Wolhusen, Switzerland), hydroxyapatite (HA; Berkeley Advanced Biomaterials, Berkeley, CA, USA), demineralized freeze-dried bone allograft (DFDBA; Musculoskeletal Foundation, Holmdel, NJ, USA), Dentsply/Friadent/Ceramed, (Mannheim, Germany), tricalcium phosphate (TCP), and BioPlant HTR (Replacement Therapy Materials, Mechelen, Belgium). In the autogenous bone in combination with bone substitutes group, 1,931 implants were placed, 126 implants failed, and the success rate was 93.5%. The third bone substitutes group, using used bone substitutes alone or bone substitute combinations, included 16 papers. Bone substitutes included Bio-Oss®, DFDBA, freeze-dried bone allograft (FDBA; Musculoskeletal Foundation) and Dentsply/Friadent/Ceramed, TCP, calcium sulfate, phyconic + fluro, marine algae, β-TCP (Cerasorb; Curasan AG, Kleinostheim, Germany), Bio-Oss® + DFDBA, Bio-Oss® + PRP (Platelet-Rich Plasma; SmartPrep, Harvest Technologies, Norwell, MA, USA), HA + DFDBA, HA + fibrin glue, and HA + PRP. In Group 3, 2,707 implants were placed, 112 implants failed, and the success rate was 95.9% (Fig. 1, Table 2).

Discussion

Many different materials have been used to augment the maxillary sinus for the placement of implants. The criteria for selection of the graft

Table 1. Articles selected according to criteria

	Article	Graft material	No. of patients	No. of cases	No. of implants	No. of lost implants	Implant survival rate (%)
1	Block *et al.* (10)	A	16	27	73	3	95.9
2	Fugazzotto &Vlassis (11)	B/C/D/E/	153	194	433	15	96.5
3	Kaptein *et al.* (12)	A + F	88	132	388	46	88.1
4	Van Den Bergh *et al.* (13)	A	42	62	161	0	100.0
5	Watzek *et al.* (14)	A/A + F/F	20	40	155	6	96.1
6	Buchmann *et al.* (15)	A	50	75	167	0	100.0
7	De Leonardis & Pecora (16)	G	57	65	130	2	98.5
8	Keller *et al.* (17)	A	37	58	139	20	85.6
9	Khoury (18)	A	216	216+	467	28	94.0
10	Lekholm *et al.* (19)	A	55	82	280	53	1.1
11	Peleg *et al.* (20)	A + C	63	63+	160	0	100.0
12	Lorenzoni *et al.* (21)	B	32	42	98	7	92.9
13	Van Den Bergh *et al.* (22)	C	24	30	69	0	100.0
14	Wannfors *et al.* (23)	A	40	80	150	24	84.0
15	Bahat & Fontanessi (24)	A + B/A + F	62	83	313	23	92.7
16	Raghoebar *et al.* (25)	A	99	182	392	32	91.8
17	Tawil & Mawla (26)	B	29	30	61	9	85.2
18	Engelke *et al.* (27)	A + E	83	118	211	11	94.8
19	Philippart *et al.* (28)	A	18	25	58	5	91.4
20	Rodriguez *et al.* (39)	B + H	15	24	70	5	92.9
21	Stricker *et al.* (30)	A	41	66	183	1	99.5
22	Valentini & Abensur (31)	B + C/B	59	78	187	10	94.7
23	Hallman & Zetterqvist (32)	F + I	50	71	218	12	94.5
24	Itiurriaga *et al.* (33)	A	58	79	223	0	100.0
25	Hallman & Nordin (34)	A + B	20	30	108	15	86.1
26	Hatano *et al.* (35)	A + B	191	191	361	21	94.2
27	Schwarz-Arad *et al.* (36)	A/A + B/A + C/B	70	81	209	9	95.7
28	Butz & Huys (37)	A + J	20	22	56	0	100.0
29	Ewers (38)	K	118	209	614	27	95.6
30	Simunek *et al.* (39)	L	24	24+	45	1	97.8
31	Karabuda *et al.* (40)	B/M	91	91+	259	11	95.8
32	Becktor *et al.* (41)	A	61	61+	180	2	98.9
33	Minichetti *et al.* (42)	C/C + F	56	56+	136	3	97.8
34	Bornstein *et al.* (43)	A + C/A + E	56	59	100	2	98.0
35	Chaushu *et al.* (44)	D	28	28+	72	4	94.4
36	Sbordone *et al.* (45)	A	28	39	70	4	94.3
37	Torres *et al.* (46)	F + H	87	144	286	6	97.9
Total			2,257	2,957+	7,282	417	94.3

A: autogenous bone, B: Bio-Oss, C: demineralized freeze-dried bone allograft (DFDBA), D: freeze-dried bone allograft (FDBA), E: tricalcium phosphate (TCP), F: hydroxyapatite (HA), G: calcium sulphate, H: platelet-rich plasma (PRP), I: fibrin glue, J: BioPlant HTR, K: marine algae, L: phycogenic material + fluorohydroxyapatite, M: Cerasorb

Table 2. Implant survival rates according to the graft materials

Group	No. of paper	No. of patients	No. of implats	No. of implant failures	Implant survival rate (%)
Group 1	15	761	2644	179	93.2
Group 2	10	583	1931	126	93.5
Group 3	16	823	2707	112	95.9
Total		2257	7282	417	94.3

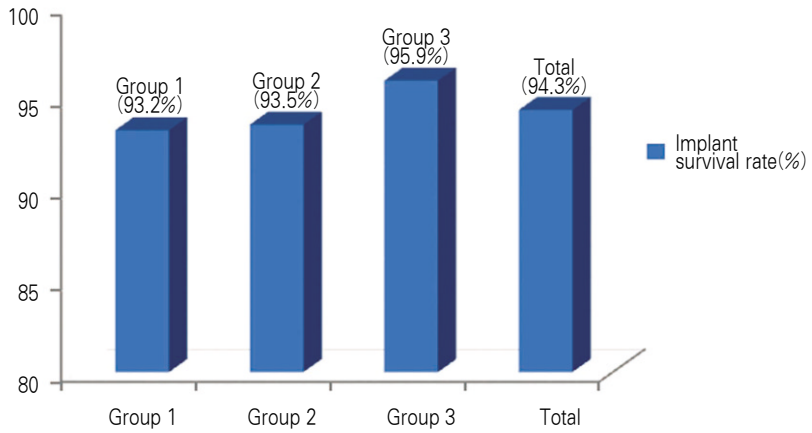

Fig. 1. Implant survival rates according to graft material.
- Group 1. Autogenous bone group; this group used only autogenous bone.
- Group 2. Autogenous bone + bone substitutes group; this group used autogenous bone in combination with bone substitutes.
- Group 3. Bone substitutes group; this group used bone substitutes alone or bone substitute combinations.

include[47]: 1) the ability to produce bone in the sinus by cellular proliferation from viable transplanted osteoblasts or by osteoconduction of cells along the graft surface, 2) the ability to produce bone by osteoinduction, 3) the ability of the initially formed bone to remodel into mature lamellar bone, 4) the maintenance of the mature bone over time without loss, 5) the ability to stabilize the implants, 6) the low infection rate, 7) the easy availability, 8) the low antigenicity, and 9) high level of reliability.

In maxillary sinus augmentation, autogenous bone is considered the preferred material for bone regeneration. Autogenous bone contains osteogenic cells that has an osteogenic potential and bone morphogenetic proteins (BMP) that induce osteoblasts with bone-forming potential and growth factors, and plays the role of the osteoconductive scaffold required for the process of new bone formation.[6] Additionally, autogenous bone is not immunogenic.[48]

Allogeneic bone used as graft material is prepared from bone harvested from cadavers and treated by freeze-drying or by demineralization plus freeze drying. The mineralized freeze-dried bone retain certain osteoconductive qualities.[49] Urist[50] first prepared decalcified freeze-dried allogeneic bone and reported their osteoconductive capacity. The demineralized bone may result fibrous connective tissue or cartilage rather than bone in the sinus floor.[51] While Van den Bergh *et al*. reported that satisfactory results were obtained in cases with maxillary sinus lifts using demineralized freeze-dried bone (DFDB).[23]

The xenogenic Bio-Oss® is an inorganic material prepared by harvesting bovine bone, removing organic substances by treating with ethylenediamine, and sterilizing. Its crystal structure, morphology, and physical characteristics are similar to human cancellous bone. Bio-Oss® forms new bone through the osteoconduction process.[6,52,53] The xenogenic Bio-Oss® can be regarded as an appropriate material in maxillary sinus augmentation for implant placement because slow resorption as physiologic remodeling.[48]

The allogeneic or xenogeneic bone have the possible transmission of AIDS and infection via contaminated blood and tissues, and the risk of the infection with diseases from different species have been pointed out.[54,55] Thus, recently, alloplastic bone with excellent biocompatibility has been developed and is widely used as bone substitute materials. Advantages of synthetic bone include that it can be readily prepared and stored, clinical application is easy, and the risk of cross-infection is absent.[55-57] It does not have osteoinductive potential, but acts as a scaffold for

ingrowth of bone due to osteoconduction. Presently used synthetic bone graft materials include hydroxyapatite, bioglass, bioceramic, polymer, calcium carbonate, and tricalcium phosphate.[58-61]

Medical risk factors seem to contribute to implant loss in patients who smoke, in post menopausal patients receiving estrogen replacement, and in patients with a history of antral sepsis.[17] moreover, in sinus augmentation procedures the implant's survival rate appears to be more influenced by the residual bone height or by tobacco than by the type of bone graft.[46] And the highest failure rates are associated with "severely resorbed" ridges, poverty of blood supply presumably is the cause.[24]

No significant difference between the quality of newly formed bone tn the cases of the one-stage and the two-stage sinus lift has been found.[39] But, two-stage technique presented seems to be kept to be optibal because the crucial region is denuded only minimally duringimplant placement.[14,19, 23]

Perforation of the sinus membrane does not compromise the osseointegration process or the success of dental implants placed in the augmented maxillary sinus. However, a sealed sinus environment is important for optimal healing conditions after sinus lifting and implant placement surgery, and the size of membrane perforation is the most important factor in postponing of abandoning the augmentation and implant insertion.[40]

Conclusion

We attempted to identify the published studies reporting survival rates for implants placed in augmented maxillary sinuses. The success rates of the bone substitutes group (Group 3; ISR: 95.9%) and autogenous bone + bone substitutes group (Group 2; ISR: 93.5%) were comparable or superior to the autogenous bone group (Group 1; ISR: 93.2%) ($P < 0.05$). Based on the studies examined, the bone substitutes alone had similar or better than autogenous bone in combination with bone substitutes and autogenous bone alone in maxillary sinus augmentation.

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원고 접수일 2010년 03월 22일
게재 확정일 2010년 06월 21일

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Paper received 22 March 2010
Paper accepted 21 June 2010