Implants and Sinus-Inlay Graft in a 1-Stage Procedure in Severely Atrophied Maxillae: Prosthodontic Aspects in a 3-year Follow-up Study

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The aim of this 3-year prospective study was to evaluate the prosthetic treatment in 2 groups of maxillary edentulous patients with similar age and gender distribution: a study group of 39 patients treated with intra-sinus block bone grafts and implants in a 1-stage procedure, and a control (reference) group of 37 patients treated with implants and no grafting. In the study group, bone volumes were regarded as insufficient for implant treatment unless a bone grafting procedure was performed (posterior alveolar bone height was less than 5 mm). Self-tapping Nobel Biocare implants were used in both groups of patients. In the study group, 35 fixed partial dentures and 4 overdentures were placed, and in the control group 34 fixed partial dentures and 3 overdentures were placed. All patients were followed for at least 3 years. The 3-year follow-up examination included examination of a number of clinical parameters as well as the type of abutment and evaluation of stability of prosthesis retention screws and abutment screws. During the follow-up period, 2 patients were lost from the study group and 4 patients from the control group, giving a total of 70 patients available for examination after 3 years (8% dropout rate). Both the amount of plaque and gingival bleeding were significantly lower in the study group than in the control group. The presence of attached gingiva was 25% in the study group and 35% in the control group. The number of angulated abutments was significantly higher in the study group than in the control group. There was no significant difference in the number of prosthetic complications in the 2 groups of patients. Neither was there any significant difference in prosthesis screw or abutment screw stability between the 2 groups. The type of abutment did not significantly influence the stability of prosthesis retention screws or abutment screws in either of the groups. However, prosthesis screw stability was significantly greater than abutment screw stability in both groups of patients. It can be concluded that the prosthetic outcome was similar in the 2 groups of patients, regardless of whether or not a bone grafting procedure was used. (INT J ORAL MAXILLOFAC IMPLANTS 2001;16:668–674)

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There is well-recorded documentation of the effects of prosthetic rehabilitation on osseointegrated implants in both the maxilla and the mandible.[1,2] The implant success rate can be expected to be lower when the amount of bone and the bone density are lower, especially in the posterior part of the maxilla.[3,4] Bone grafting procedures have been developed to increase bone volume in patients with advanced alveolar resorption and insufficient bone volume for implant placement. A number of different methods for grafting the maxilla have been developed during the last 10 years.[5–12] Simultaneous bone grafting and implant placement

(a 1-stage procedure) is a frequently used grafting technique, as it does not increase the treatment time compared to the standard protocol. It has been proven to be both a safe and predictable method.[13]

Follow-up studies on maxillary grafted patients have not mentioned the prosthetic outcome of treatment, and no study has been reported that mainly emphasizes the outcome of prosthetic treatment on patients receiving bone grafts.[14,15] However, bone grafting techniques may influence both the design of prostheses and the choice of abutment (standard versus angulated), which have been discussed recently.[13,16]

The surgical aspects of this prospective 3-year study were reported by Johansson et al.[17] The aim of this study was to evaluate the outcome of prosthetic rehabilitation after 3 years in patients receiving implants placed in a 1-stage procedure with intrasinus block bone grafts compared to patients receiving implants placed in only maxillary bone by the standard protocol. The choice of abutments and complications received special attention.

MATERIALS AND METHODS

This study comprised a total of 76 patients with edentulous maxillae referred to the Department of Prosthetic Dentistry at the Public Dental Service, St Erik Hospital, Stockholm, Sweden, for implant treatment. According to specific inclusion criteria, the patients were divided into 2 groups: a study group (39 patients) and a reference group (37 patients).[17] All patients in the study group (8 male, 31 female, with a median age of 56 years [range 40 to 77]) received implants in a 1-stage sinus-inlay block graft procedure.[10,11] The reference group comprised 37 patients (10 males, 27 females), with a median age of 68 years (range 38-86), and they received implants in maxillary bone alone according to the standard protocol.[1] Self-tapping Nobel Biocare implants (Göteborg, Sweden) were used in both groups of patients. The 2 groups differed as to the remaining bone quantity, measured according to Cawood and Howell.[18] The study group was classified in the posterior maxillary regions as Class 5 or 6, and the reference group was, in general, Class 3 or 4. At second-stage surgery, healing abutments were placed, and 2 weeks later the prosthodontist replaced these with individually selected definitive abutments before the impression was made.

In the study group, 36 patients were provided with standard gold/acrylic resin fixed partial dentures (FPD) and 3 patients received overdentures. In the reference group, 33 patients received gold/acrylic resin FPD and 4 patients received overdentures.[19] The latter were placed because of an insufficient number of implants or because load factors were regarded as unfavorable. In attaching the prostheses, a torque controller (DFE 020, Nobel Biocare) was used to tighten the prosthesis retention screws with 10 Ncm of torque. Prosthesis retention screws were retightened 2 weeks later. The abutment screws in grafted implants were generally tightened manually with the use of a counter-grip. The abutment screws in implants placed in native maxillary bone were tightened with 20 Ncm by use of the torque controller.

One week after the prostheses were seated, a baseline documentation was made which included clinical parameters and a radiographic examination. Thereafter, the patients were examined annually for 3 years. At the 3-year follow-up, the prostheses were removed to confirm osseointegration. Observations were focused on individual implant stability, and the following observations were recorded according to the protocol.

- The type(s) of abutment used was noted.
- Prosthesis and abutment screw stability was assessed by using a modification of the California Dental Association's (CDA) quality evaluation criteria.[20,21] The stability was rated as satisfactory in groups R/S (where R = excellent and S = acceptable) and as not acceptable in T/V (T and V = not acceptable).
- Complications and adjustments to the prostheses seen or made during the observation period and at the 3-year follow-up examination were noted. Adjustments made to the prostheses as a result of implant losses were not included.
- The presence or absence of plaque on the buccal, lingual, mesial, and distal surfaces of the abutments was recorded according to the Visible Plaque Index (VPI) as suggested by Ainamo and Bay.[22]
- The presence or absence of bleeding (Bleeding Index [BI]) in the marginal gingiva was recorded using a periodontal measuring probe (CP-12, Hu-Friedy, Chicago, IL, USA).
- The number of occlusal contacts was noted using a GHM occlusion pilot foil (Hanel-GHM Dental GmbH, Nurtingen, Germany). The occlusion was treated the same in both groups.
- The length (in mm) of the posterior distal extensions of the prosthesis exposed to occlusal loads was measured.
- The presence or absence of attached gingiva in relation to each abutment was noted.
- The color of the mucosa on the alveolar ridge beneath the prostheses was graded according to Bergendal.[23]

Table 1 Types of Abutments and Implant Positions Recorded at the 3-year Check-up

	Implant position*							
Group/abutment	**R4**	**R3**	**R2**	**R1**	**L1**	**L2**	**L3**	**L4**
Study group								
Standard	7	19	27	29	27	25	20	5
Angulated	3	8	9	6	9	8	5	0
Reference group								
Standard	2	22	27	26	25	26	19	3
Angulated	0	1	2	2	3	2	2	0

*R4–R1 = fourth implant on right side of midline – first implant on right side of midline; L4–L1 = fourth implant on left side of midline – first implant on left side of midline.

Statistics

The relationship of abutment screw stability, grouped as R/S and T/V in the study and reference groups to standard and angulated abutments (A, S) was analyzed by means of the chi-square test. The same test was used to analyze the relationship of PI and BI in the 2 groups. Fisher's exact test was used to compare prosthesis screw stability (R/S and T/V) between the study group and the reference group and to analyze whether the choice of abutment (angulated vs. standard) significantly influenced prosthesis screw stability (R/S, T/V) in the study group or reference group. The same test was used to analyze whether the choice of abutment (angulated/standard) had influenced abutment screw stability (R, S, T, V) in the study or reference groups. To analyze the relationship between prosthesis screw stability (R/S, T/V) and abutment screw stability (R/S, T/V), McNemar's test was used in both the study and reference groups. A value of $P < .05$ was required for statistical significance.

RESULTS

During the follow-up period, 2 patients were lost in the study group (39 patients) because of multiple implant failures. In the reference group (37 patients), 4 patients were lost during the follow-up period; 3 died and 1 lost her prosthesis as a result of multiple implant failures. Therefore, a total of 70 patients (study group, 37 patients; reference group, 33 patients) were available to be followed during the 3-year follow-up period, which corresponds to an 8% dropout rate. The dropouts were not included when prosthetic complications were recorded.

A total of 207 abutments were placed in the study group. Of these, 48 (23%) were angulated (Table 1). In the reference group, 162 abutments in total were placed and 12 (7%) of these were angulated (Table 1). The number of angulated abutments was significantly higher ($P < .05$) in the study group than in the control group.

There was no significant difference ($P > .05$) in prosthesis retention screw stability between the study and the reference groups, and prosthesis retention screw stability was good in both groups (Table 2). Abutment screw stability did not differ significantly ($P > .05$) between the 2 groups either (Table 3); nor was the prosthesis retention screw or abutment screw stability correlated ($P > .05$) to the use of standard or angulated abutments in either of the groups. However, prosthesis retention screw stability was significantly ($P < .05$) better than abutment screw stability in both groups of patients.

Prosthetic complications or adjustments included tooth fractures, loss of screw access fillings, or adjustments of the attachment system in patients with overdentures (Table 4). No difference was seen between the 2 groups. The presence of attached gingiva was 25% in the study group, compared with 35% in the reference group (Table 5). Both VPI and BI were significantly lower ($P < .05$) in the study group than in the reference group (Table 6). On the other hand, stomatitis, the number of occlusal contacts, and length of the posterior extensions were evenly distributed between the groups (Table 6).

Table 2 Stability of Prosthesis Retention Screws Recorded at the 3-year Check-up Using a Modification of the CDA Quality Evaluation Criteria[21]

	Implant position*							
Group/stability	**R4**	**R3**	**R2**	**R1**	**L1**	**L2**	**L3**	**L4**
Study group								
R	10	27	34	32	34	29	23	5
S	0	0	2	3	2	4	2	0
T	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0
Reference group								
R	2	18	23	25	24	19	15	1
S	0	4	6	2	3	8	6	2
T	0	1	0	1	0	1	0	0
V	0	0	0	0	1	0	0	0

*R4–R1 and L4–L1 = fourth implant–first implant on right and left sides of midline.

Table 3 Stability of Abutment Screws Registered at the 3-year Check-up Using a Modification of the CDA Quality Evaluation Criteria[21]

	Implant position*							
Group/stability	**R4**	**R3**	**R2**	**R1**	**L1**	**L2**	**L3**	**L4**
Study group								
R	7	16	17	19	22	21	15	2
S	2	7	14	11	11	8	7	2
T	1	3	3	4	0	3	2	1
V	0	1	2	1	3	1	1	0
Reference group								
R	0	11	17	16	17	14	10	1
S	2	8	8	8	7	7	4	1
T	0	3	4	4	4	5	2	1
V	0	1	0	0	0	2	5	0

*R4–R1 and L4–L1 = fourth implant–first implant on right and left sides of midline.

Table 4 Prosthetic Complications During the Follow-up Period, as Noted at the 3-year Check-up (n = No. of Implants)

Complications	**Study group (n = 207)**	**Reference group (n = 162)**
Tooth fractures	10	9
Esthetic problems	1	0
Correction of occlusion	2	0
Adjustments of labial flange	1	0
Loss of screw access filling	7	6
Gingivectomy	2	0
Fistulae	1	1
Activated attachments	7	5
New male spring-pins (attachment)	4	7

Table 5 Absence or Presence of Attached Gingiva on the Buccal Side of Implants in Different Positions, Noted at the 3-year Check-up

Group/attached gingiva	Implant position*							
	R4	R3	R2	R1	L1	L2	L3	L4
Study group								
Absent	4	2	9	6	10	13	6	1
Present	6	25	27	29	26	20	19	4
Reference group								
Absent	1	11	10	6	7	10	9	2
Present	1	12	19	22	21	18	12	1

*R4–R1 and L4–L1 = fourth implant–first implant on right and left sides of midline.

Table 6 Clinical Parameters Recorded at the 3-year Follow-up Examination

Group	Presence of plaque (VPI)	Presence of bleeding (BI)	Stomatitis (grade)				Occlusal contacts/ patient	Prosthesis type		Posterior extension	
			0	1	2	3		FPD	OD	Right	Left
Study group (n = 37)	8%	1%	21	10	3	2	7.5	32	4	9 mm	10 mm
Reference group (n = 33)	13%	9%	15	8	4	3	7.4	26	4	11 mm	12 mm

TN: FPD = fixed partial denture; OD = overdenture.

DISCUSSION

This study provides the prosthetic experiences of patients in a carefully monitored prospective 3-year follow-up study of those who had prostheses supported by implants placed in sinus-inlay bone grafts. The surgical results were reported in 1999 by Johansson and coworkers.[17] Dropouts during the study period were few (8%) and specified.

In the study group, patients received implants using a 1-stage sinus-inlay block graft, which means that opportunities to place the implants in an ideal vertical position were limited, necessitating a more palatal angulation of the implants. This tendency was also seen in the anterior region and in the non-grafted alveolar process, since minimal alveolar bone was found not only in the lateral areas of the maxilla but also in the anterior regions. Furthermore, the implants were placed without surgical guides, and the surgeons concentrated mainly on finding optimal bone volumes to obtain adequate implant stability. One-stage sinus-inlay grafts have also been shown by others to involve a greater number of skewed-position implants, necessitating an increased use of angulated abutments to facilitate minimal buccolingual width of the prosthesis.[13] For these reasons, the number of angulated abutments was significantly ($P < .05$) higher in the study group than in the control group.

No difference was seen in the stability of the prosthesis retention screws and abutment screws when comparing the 2 groups of patients. But stability of the prosthesis retention screws was significantly better ($P < .05$) than that of the abutment screws in both groups of patients. These results correspond to findings by Smedberg and associates[24] but contradict findings of Kallus and Bessing.[21] One explanation for this could be that in the present study, as well as in that of Smedberg and associates,[24] a torque controller was used not only when the patients received their prostheses, but also when the prosthesis retention screws were retightened 2 weeks later.[24]

In this study, the prosthesis retention screws were mechanically tightened (10 Ncm), but the abutment screws on grafted implants were usually tightened manually without the use of counter-grip, so as not to jeopardize the osseointegration of the implants. It is well known that stability increases with time, especially in compromised sites as analyzed with resonance frequency. In most instances, stability of both the prosthesis retention screws and the abutment screws was acceptable. However, stability of the abutment screws was less than satisfactory (T and V ratings) in 12.5% of the abutments in the study group and 19.1% of the abutments in the reference group. However, this had no observable, clinical implications at the time of clinical check-ups.

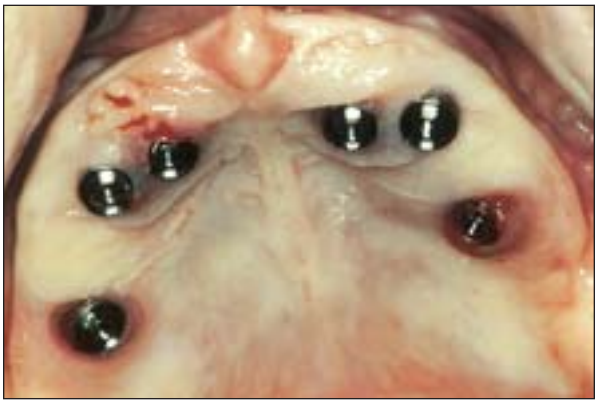

Fig 1 Occlusal view showing the position of the implants in a patient in the study group.

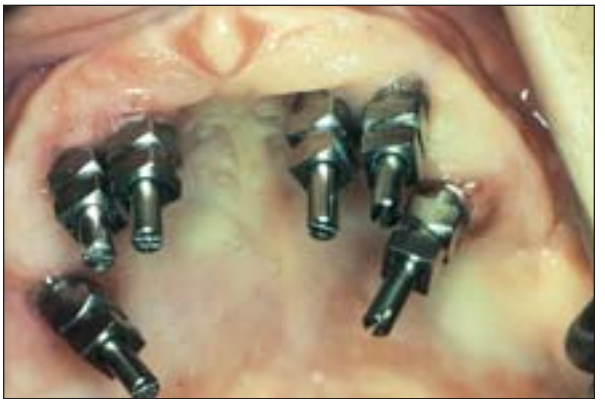

Fig 2 Occlusal view showing the palatal angulation of the posterior implants in a patient in the study group before the impression for a definitive prosthesis was made.

The prosthesis design in the study group was slightly different from that of the control group because of a more palatal angulation of the posterior implants and a more buccal angulation of the anterior implants. This resulted in prostheses with a greater buccolingual width in the study group (Figs 1 to 3). Despite this, an equal distribution of prosthetic technical complications was seen in the 2 groups (Table 4).

Although implants in the study group often had a less-than-optimal position, there was only a minor difference between the 2 groups in the frequency of attached gingiva connected with the implants (Table 5). The frequency of attached gingiva was obviously not affected by the difference in the level of alveolar resorption measured according to Cawood and Howell between the 2 groups of patients either.[18] The sinus-inlay bone graft procedure used in the study group did not change the external alveolar morphology or the overlying soft tissues.

The clinically recorded parameters showed significantly reduced plaque and bleeding within the study group compared to the reference group at the 3-year follow-up examination. This might be explained by the higher motivation of grafted patients to maintain good oral hygiene, although the prostheses in the study group had a somewhat atypical design, with greater buccolingual width complicating optimal oral hygiene. As to loading factors, neither the average number of occlusal contacts per patient nor the length of posterior extensions differed between the 2 groups of patients.

Fig 3 Occlusal view of a fixed partial denture of a patient in the study group showing the extended buccolingual width of the fixed partial denture resulting from the palatal angulation of the posterior implants.

CONCLUSION

This 3-year follow-up study of bone-grafted patients demonstrated results that compare favorably with the results of a reference group treated using a conventional approach. The treatment provided in both groups was acceptable over the 3-year period.

REFERENCES

1. Adell R, Eriksson B, Lekholm U, Brånemark P-I, Jemt T. A long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
2. Albrektsson T, Dahl E, Enbom L, et al. Osseointegrated oral implants: A Swedish multicenter study of 8139 consecutively inserted Nobelpharma implants. J Periodontol 1988; 59:287–296.
3. Esposito M, Hirsch J-M, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (I) Success criteria and epidemiology. Eur J Oral Sci 1998;106:527–551.

4. Esposito M, Hirsch J-M, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (2) Etiopathogenesis. Eur J Oral Sci 1998;106: 721–764.
5. Breine U, Brånemark P-I. Reconstruction of alveolar bone. Scand J Plast Reconstr Surg 1980;14:23–48.
6. Wood RM, Moore DL. Grafting of the maxillary sinus with intraorally harvested autogenous bone, prior to implant placement. Int J Oral Maxillofac Implants 1988;3:209–214.
7. Kent JN, Block MS. Simultaneous maxillary sinus floor bone grafting and placement of hydroxylapatite-coated implants. J Oral Maxillofac Surg 1989;47:238–242.
8. Raghoebar GM, Brouwer TJ, Reintsema H, van Oort RP. Augmentation of the maxillary sinus floor with autogenous bone for the placement of endosseous implants. J Oral Maxillofac Surg 1993;51:1198–1203.
9. Nyström E, Kahnberg KE, Gunne J. Bone grafts and Brånemark implants in the treatment of severely resorbed maxilla: A 2-year longitudinal study. Int J Oral Maxillofac Implants 1993;8:45–53.
10. Keller EE, Eckert SE, Tolman DE. Maxillary antral and nasal one-stage inlay composite bone graft: Preliminary report of 30 recipient sites. J Oral Maxillofac Surg 1994;52: 438–447.
11. Loukota RA, Isaksson S, Linnèr ELJ, Blomqvist JE. A technique for inserting endosseous implants in the atrophic maxilla in a single stage procedure. Br J Oral Maxillofac Surg 1992;30:46–49.
12. Isaksson S, Ekfeldt A, Alberius P, Blomqvist J-E. Early results from reconstruction of severely atrophic (class VI) maxillas by immediate endosseous implants in conjunction with bone grafting and Le Fort I osteotomy. Int J Oral Maxillofac Surg 1993;22:144–148.
13. Wannfors K, Johansson B, Hallman M, Strandkvist T. A prospective randomized study of 1- and 2-stage sinus inlay bone grafts, 1-year follow up. Int J Oral Maxillofac Implants 2000;15:625–632.
14. Köndell PÅ, Nordenram Å, Moberg LE, Eliasson S, Nyberg B. Reconstruction of the resorbed edentulous maxilla using autogenous rib grafts and osseointegrated implants. Clin Oral Implants Res 1996;7:286–290.
15. Van der Bergh JPA, ten Bruggenkate CM, Krekeler G, Tuinzing DB. Sinus floor elevation and grafting with autogenous iliac crest bone. Clin Oral Implants Res 1998;9:429–435.
16. Blomqvist JE, Alberius P, Isaksson S. Sinus inlay bone augmentation. Comparison of implant positioning after one-or two-staged procedures. J Oral Maxillofac Surg 1997;55: 804–810.
17. Johansson B, Wannfors K, Ekenbäck J, Smedberg J-I, Hirsch J-M. Implants and sinus-inlay bone grafts in a 1-stage procedure on severely atrophied maxillae: Surgical aspects of a 3-year follow-up study. Int J Oral Maxillofac Implants 1999;14:811–818.
18. Cawood JI, Howell RA. A classification of the edentulous jaws. Int J Oral Maxillofac Surg 1988;17:232–236.
19. Lothigius E, Smedberg J-I, De Buck V, Nilner K. A new design for a hybrid prosthesis supported by osseointegrated implants: Part 1. Technical aspects. Int J Oral Maxillofac Implants 1991;6:80–86.
20. California Dental Association. Quality Evaluation for Dental Care. Guidelines for the Assessment of Clinical Quality and Professional Performance. Los Angeles: California Dental Association, 1977.
21. Kallus T, Bessing C. Loose gold screws frequently occur in full-arch fixed prostheses supported by osseointegrated implants after 5 years. Int J Oral Maxillofac Implants 1994;9: 169–178.
22. Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. Int Dent J 1975;25:229–235.
23. Bergendal T. Treatment of Denture Stomatitis. [thesis]. Stockholm: Karolinska Institute, 1992.
24. Smedberg J-I, Nilner K, Frykholm A. A six-year follow-up study of maxillary overdentures on osseointegrated implants. Eur J Prosthodontics Restorative Dent 1999;7:51–56.