# Survival Analysis of Endosseous Implants in Grafted and Nongrafted Edentulous Maxillae

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***Purpose:*** *The aim of this study was to analyze and compare the survival rates of endosseous implants placed in the edentulous maxillae of patients in whom bone augmentation was undertaken prior to or in conjunction with implant placement with survival rates in patients who did not undergo bone augmentation.* ***Materials and Methods:*** *This study included 2 retrospective patient groups: the graft group, which included 64 patients with 437 implants, and the nongraft group, which included 118 patients with 683 implants. The patients were treated consecutively between 1990 and 1996. In addition, the retrospective patient groups were also followed prospectively using a standardized clinical and radiographic study design.* ***Results:*** *The implant survival rate was 75.1% for the graft group and 84.0% for the nongraft group after a mean follow-up of 5 to 6 years, a statistically significant difference. However, there was no difference with regard to the prosthesis survival rate, and after reoperation, more grafted patients had a fixed prosthesis at the end of the study (87.5% versus 85.3%). Implant failure appeared to be related to the original jawbone volume in the anterior regions. In the premolar region, where the inlay graft technique was used, the implant survival rate for the graft group was comparable to that of the nongraft group. The graft group had significantly more failures than the nongraft group in the incisor region, but not in the canine, premolar, or molar regions.* ***Discussion:*** *The majority of implant failures occurred before loading. Occlusal overload during the healing period may have been a causative factor.* ***Conclusions:*** *The overall implant survival rate was lower in grafted maxillae than in nongrafted maxillae after a mean of 5 to 6 years of follow-up. Analysis revealed that jawbone volume in the anterior regions at the start of treatment was directly related to implant survival rates in both groups: the greater the volume, the higher the survival rate. Moreover, the implant survival rate was similar in grafted posterior edentulous maxillae of classes V and VI and in nongrafted posterior edentulous maxillae of classes III and IV.*
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**Key words:** *bone augmentation, bone graft, dental implants, edentulous maxilla, endosseous implants, maxillary sinus*

The use of endosseous implants is currently a routine treatment modality for prosthetic reconstruction of the edentulous maxilla, and acceptable long-term results have been presented in patients with sufficient bone volume.[1–3] However, increased failure rates have been experienced in situations with inadequate bone volume and/or low bone density in edentulous patients and especially in those for whom an overdenture has been the final prosthetic solution.[3–5] The severely atrophied maxilla constitutes a challenging therapeutic problem, since bone augmentation is required to enable placement of a sufficient number and length of implants. A variety of bone augmentation procedures using autogenous bone have been described in the literature, eg, onlay bone grafting, grafting to the floor of the nose and the maxillary sinuses, and interpositional bone grafting in conjunction with a Le Fort I osteotomy procedure.

The literature reporting on results from grafting procedures using autogenous bone is extensive but not conclusive, because of the fact that different techniques, donor sites, implant systems, healing

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**Table 1 Distribution of Patients in Treatment Groups with Regard to Gender, Age, and Follow-up Period**

| Treatment group | No. of patients | Male/ female | Mean age (y) (SD) | Age range (y) | Follow-up period (mo) | Follow-up period range (mo) |
|---|---|---|---|---|---|---|
| Graft group | 64 | 22/42 | 56.7 (8.58) | 31–74 | 68.9 | 27–100 |
| Nongraft group | 118 | 72/46 | 63.6 (7.92) | 44–79 | 75.8 | 36–111 |

times, and implant placement approaches (simultaneous or delayed placement) have been used.[2,6,7] Adell and colleagues[8] presented 5-year follow-up results with an onlay bone grafting technique using iliac bone and simultaneous placement of implants. They reported a survival rate of approximately 72%, which is consistent with the findings of other authors.[3,9–12] It has been suggested that a delayed approach, where the bone graft is allowed to heal prior to implant placement, ought to result in higher implant survival.[13,14] However, clinical follow-up studies using a delayed approach have not consistently shown better results than studies in which a simultaneous approach was used.[15,16] Bone augmentation of the floor of the maxillary sinuses is a frequently used method, since the implant survival rate in the sinus inlays has been high.[17–20] However, high failure rates have also been reported.[21] The outcome of using interpositional bone grafts in conjunction with a Le Fort I procedure, originally described by Keller and coworkers[22] and Sailer,[23] can be positive. Using this technique, Nystrom and colleagues[24] demonstrated a survival rate of 95% after 3 years. Lekholm and coworkers[15] reported on a 3-year retrospective, multicenter study of bone grafting and implants with an overall implant survival rate of approximately 80%. A literature review by Esposito and colleagues[7] reported a pooled failure rate of 15% after 3 years of loading in edentulous and partially edentulous patients. The efficacy of bone grafting in comparison to conventional implant treatment is not well known because of the paucity of published comparative studies.

The aim of this study was to analyze the clinical outcome of implant treatment in patients with edentulous maxillae treated with or without bone grafts by the same team.

## MATERIALS AND METHODS

### Subjects

The study included 216 patients with edentulous maxillae, including 34 who were later withdrawn from the study, treated with endosseous implants with or without bone augmentation at the Division of Oral and Maxillofacial Surgery, Maxillofacial Unit, Specialisttandvården, Länssjukhuset, Halmstad, Sweden. All patients were consecutive admissions treated by 3 surgeons between January 1, 1990, and December 31, 1996. The choice of treatment was based on the amount of bone available for implant placement as determined by clinical and radiographic presurgical examinations. Routine implant treatment was commenced if the remaining bone volume was evaluated as adequate. Patients with severe atrophy underwent a bone augmentation procedure using autogenous bone grafts either prior to or in conjunction with implant placement.

The department's policy was to introduce an implant treatment plan to all patients regardless of any physiologic or anatomic limitations.

*Graft Group.* This group included 64 patients, 22 men and 42 women, with a mean age of 56.7 years (Table 1). Because of advanced horizontal and vertical bone loss of the alveolar processes, as well as extensive pneumatization of the maxillary sinuses, the patients were considered to have insufficient bone volume for routine implant treatment. A 1-stage grafting technique was used from 1990 to 1994, and a 2-stage grafting technique was used from 1994 to 1996. The goal of the treatment was to provide the patients with a fixed prosthesis. The posterior maxillary regions of all 64 patients were classified as Class V or VI using the system of Cawood and Howell.[25] Regarding the area anterior to the maxillary sinus, 41 patients were classified as Class V or VI and 22 patients as Class III or IV; information on 1 maxilla was lacking (Table 2).

*Nongraft Group.* One hundred eighteen patients, 72 men and 46 women with a mean age of 63.6 years (Table 1), were judged from clinical and radiographic examinations to have sufficient bone volume for implants to support a fixed prosthesis (Table 2). Overdenture treatment was planned for 9 patients, and the remaining 109 were to be provided with a fixed prosthesis.

### Surgery

*Bone Grafting.* Bone augmentations were performed under general anesthesia with nasal endotracheal intubation supplemented with infiltration of local

**Table 2 Distribution of Patients in Treatment Groups with Regard to Jawbone Volume in the Anterior and Posterior Maxilla***

| Treatment group | No. of patients | | Classes I–II | | Classes III–IV | | Classes V–VI | |
|---|---|---|---|---|---|---|---|---|
| | A | P | A | P | A | P | A | P |
| Graft group | 63 | 64 | 0 | 0 | 22 | 0 | 41 | 64 |
| Nongraft group | 112 | 118 | 24 | 14 | 75 | 88 | 13 | 16 |

*According to Cawood and Howell.[25]
A = anterior; P = posterior.

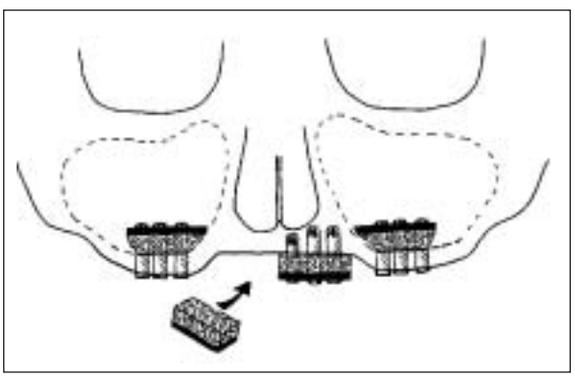

**Fig 1** One-stage grafting technique.

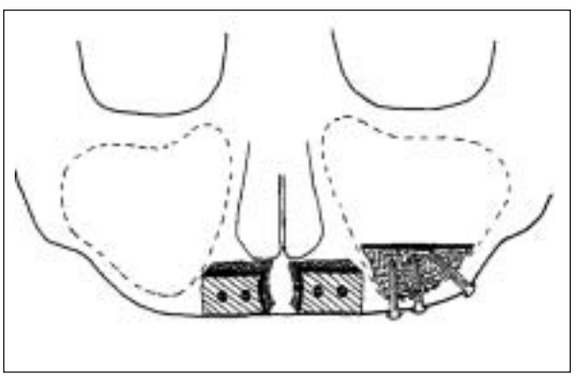

**Fig 2** Two-stage grafting technique.

anesthetic agents, with a vasoconstrictor for hemostasis. Patients were routinely given benzyl penicillin (3 g) and metronidazole (0.5 g) preoperatively. All 64 patients received corticocancellous bone blocks harvested from the iliac crest, as previously described by Isaksson and Alberius.[9] A 40- to 50-mm bony lid, encompassing the iliac crest and attached only to the inner periosteum, was tilted medially, and bone blocks of approximately 40 × 10 × 10 mm were harvested. The medial cortical layer of the iliac bone was left intact. The intraoral approach for the maxilla was made by a circumvestibular incision along the vestibular sulcus from the region of the maxillary right first molar to the maxillary left first molar. The alveolar crest was subsequently exposed by raising a palatal pedicle mucoperiosteal flap.

To establish optimal soft tissue coverage and to avoid wound dehiscence, the onlay technique sometimes required a more labially positioned incision.

The surgical techniques used have previously been described in detail.[26,27] When the onlay bone graft technique was used, the grafts were positioned inferior and/or lateral to the alveolar ridge, whereas in the inlay graft technique, the bone blocks were positioned in contact with the floor of the maxillary sinus. Great effort was made to place the cancellous surface of the bone graft in close contact with the maxillary bone. In the first 40 consecutive patients, in whom a 1-stage grafting technique was used,[12] fixation of the bone grafts was obtained by the immediate placement of endosseous implants (Brånemark Implant System; Nobel Biocare, Göteborg, Sweden) (Fig 1). In the 24 patients in whom the 2-stage grafting technique[28] was performed, the bone grafts were fixed with titanium osteosynthesis screws 7 to 15 mm in length and 2 mm in diameter (Martin, Tüttlingen, Germany) (Fig 2). The wound closure was made with continuous, absorbable 4-0 sutures (Monocryl; Ethicon, Norderstedt, Germany). The patients were prescribed antibiotics to be taken for 1 week postoperatively.

*Implant and Abutment Surgery.* For graft-group patients in whom a 2-stage procedure was used, the osteosynthesis screws were removed after a healing period of 4 to 7 months (mean 4.9) to enable implant placement. In total, 1,120 Brånemark implants (Nobel Biocare), 6 to 18 mm long and 3.75 to 5 mm in diameter, were placed (Table 3). Abutment connection was performed after a healing time of 5 to 12 months (mean 8.8) in the graft group and 5 to 14 months (mean 7.0) in the nongraft group.[29]

## Prosthodontics

Conventional dentures were relined 1 to 3 weeks after bone grafting and/or implant surgery and at abutment connection. Fabrication of gold/acrylic resin fixed prostheses and overdentures using a bar

**Table 3 Distribution of Implants with Regard to Number, Length, and Diameter**

| | | 6 mm | 7 mm | | 8 mm | 10 mm | | | 13 mm | | 15 mm | 18 mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Group** | **Total** | **5** | **3.75** | **4** | **5** | **3.75** | **4** | **5** | **3.75** | **4** | **3.75** | **3.75** |
| Graft group | 437 | 0 | 1 | 10 | 1 | 45 | 32 | 4 | 162 | 14 | 165 | 3 |
| Nongraft group | 683 | 1 | 3 | 2 | 0 | 130 | 27 | 0 | 282 | 3 | 231 | 4 |
| Lost implants in both groups (%)* | 281/1120 (19.5) | 1/1 (100) | 4/16 (20) | | 1/1 (100) | 58/234 (24.8) | | | 95/461 (20.1) | | 57/396 (14.4) | 2/7 (28.6) |

*Implant failures/implants placed.

and clips followed the standard procedures for the Brånemark System as described elsewhere.[29]

### Examinations and Follow-up

Data were collected from the time of bone augmentation or implant placement until the last follow-up and analyzed retrospectively. All patients were contacted for a further prospective follow-up examination. Of 216 patients, 185 presented and subsequently underwent clinical and radiographic examination according to the prospective follow-up protocol. Three patients were excluded because of combined infection and dehiscence of the wound related to a nonresorbable membrane. The follow-up period ranged from 27 to 111 months from the day of implant placement, with a mean of 68.9 months (5 years and 9 months) for the graft group and 75.8 months (6 years and 4 months) for the nongraft group (Table 1). The following parameters were obtained from patient records and recorded: age and gender, jawbone volume classified according to Cawood and Howell,[25] type of bone graft and grafting technique, type and number of implants placed, implants lost, implant position(s), marginal bone level(s), reoperation information, and prosthetic outcome.

### Radiographic Examination

The retrospective radiographic examinations had not been performed consistently at the time of the abutment connection surgery and at the annual check-ups. Radiographs used in this study were taken at the prospective follow-up. An intraoral radiographic paralleling technique[30] was utilized at the time of the prospective patient follow-up. The distance from a reference point on the implant to the most apical marginal bone level at the mesial and distal surfaces of each implant. Linear measurements were performed to the nearest millimeter. The reference point used was the junction between the implant and the abutment.

Preoperative classification according to Cawood and Howell[25] was done retrospectively with the help of lateral and panoramic radiographs. Lateral radiographs were used to determine the bone height in the anterior maxilla. Panoramic radiographs were used for the classification of bone height in the posterior maxilla. A bone height of 5 mm or less was considered Class V or VI, a bone height of 6 to 12 mm was considered Class III or IV, and a bone height of 12 mm or more was considered Class I or II.

### Statistics

Life table analyses were performed to calculate the cumulative survival rate (CSR) for the implants. The Wilcoxon rank sum test was used to test differences in implant survival rates between the nongraft group and the graft group, with the relative frequency of implant loss in each patient as the calculation unit. The Wilcoxon rank sum test was used to test the differences between the groups in specific regions (incisor, canine, premolar, and molar), with the implant as the unit. The chi-square test was used to compare the nongraft group and the graft group and with respect to a variety of explanatory variables. The level of statistical significance was set at 5%.

## RESULTS

### Implant and Bone Graft Stability

*Graft Group.* Sixty-five (14.9%) of 437 implants placed were lost during the healing period and abutment connection surgery. Seventeen (3.9%) failed before abutment connection surgery. Between abutment connection surgery and definitive prosthetic loading, another 35 implants (8.0%) were lost. Five patients lost all their implants (n = 32) within 4 months after abutment connection surgery. At the time of prosthetic loading the total number of lost implants was 100 (22.9%). Nine implants were lost after loading, including 3 implants lost in the first year after loading, for a CSR of 75.1% after a mean follow-up period of 68.9 months (5 years and 9 months). Calculated from the date of abutment connection surgery, the percentage of functioning implants was 88.2%, and calculated from the date of definitive prosthetic loading, the percentage of functioning implants was 97.3% (Table 4a).

**Table 4a Distribution of Failed Implants in the Graft Group**

| | Before abutment surgery | At abutment surgery | Before loading of prosthesis | Observation period after loading of prosthesis (y) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| No. of implants surveyed | 437 | 420 | 373 | 338 | 313 | 296 | 256 | 238 | 187 | 89 | 17 |
| No. of implants failed in interval | 17 | 48 | 35 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| Interval failure rate (%) | 3.9 | 11.4 | 9.4 | 0.9 | 0.6 | 0.7 | 0.8 | 0 | 0 | 0 | 0 |
| Cumulative failure rate (%) | 3.9 | 14.9 | 22.9 | 23.6 | 24.0 | 24.5 | 24.9 | 24.9 | 24.9 | 24.9 | 24.9 |

**Table 4b Distribution of Failed Implants in the Nongraft Group**

| | Before abutment surgery | At abutment surgery | Before loading of prosthesis | Observation period after loading of prosthesis (y) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| No. of implants surveyed | 683 | 680 | 628 | 588 | 584 | 562 | 514 | 472 | 370 | 209 | 101 | 29 |
| No. of implants failed in interval | 3 | 52 | 40 | 4 | 6 | 1 | 1 | 2 | 0 | 0 | 0 | 0 |
| Interval failure rate (%) | 0.4 | 7.6 | 6.4 | 0.7 | 1.0 | 0.2 | 0.2 | 0.4 | 0 | 0 | 0 | 0 |
| Cumulative failure rate (%) | 0.4 | 8.1 | 13.9 | 14.5 | 15.4 | 15.5 | 15.7 | 16.0 | 16.0 | 16.0 | 16.0 | 16.0 |

The study data showed no statistical difference between the 1-stage and the 2-stage grafting groups. The 2 groups have therefore been treated as one in subsequent statistical analyses.

*Nongraft Group.* Fifty-five (8.1%) of 683 implants were lost through the end of the healing period (ie, before or at abutment connection surgery). Four patients lost all their implants (n = 21) within 4 months of abutment connection. At the time of prosthetic loading the total number of lost implants for this group was 95 (13.9%). After 1 year of loading with fixed prostheses or overdentures, another 4 implants had been lost. After a mean follow-up period of 75.8 months (6 years and 4 months) the CSR was 84.0%. Calculated from the date of abutment connection surgery, the percentage of functioning implants was 91.4%, and calculated from the date of definitive prosthetic loading, the percentage of functioning implants was 97.6% (Table 4b).

Statistically, the 2 groups were comparable for the majority of variables. However, there was a statistically significant difference ($P$ = .007) between the 2 groups in relative frequency of implant loss per patient. There were differences between the 2 groups in gender, implant position, and diameter which, although not statistically significant, should be considered.

## Implant Position and Implant Length

The implant failure rate was evaluated in relation to implant position and type of bone in both groups (Tables 5a and 5b). Implants placed in onlay grafts had a higher failure rate (37.0%) than implants placed in inlay grafts (24.9%).The failure rates of implants placed in nongrafted sites were very similar in the graft and nongraft groups (16.0% and 16.8%, respectively). Implants placed in inlay grafts in the premolar region had a failure rate of 22.1%, which was similar to the failure rate of implants in the same region of the nongraft group (20.6%). Longer implants in both groups tended to have lower failure rates, as seen in Table 3.

In the incisor region, significantly more failures occurred in the nongraft group than in the graft group ($P$ = .004). No significant differences were found in the canine, premolar, or molar regions.

## Jawbone Volume

The implant failure rate in relation to jawbone volume is shown in Tables 6a and 6b. The outcome of implant treatment in anterior edentulous maxillae appeared to be related to the original jawbone volume (Table 6a). As shown in Table 6b, in the posterior region, the failure rate for implants in the nongraft group placed in bone classes III or IV was similar to the failure rate for implants in the graft group placed in bone classes V or VI.

## Reoperation

*Graft Group.* Fourteen patients required additional bone graft and/or implant surgery before treatment with a definitive implant-supported restoration. Seven patients underwent a second graft procedure with additional implant placement. Seven other patients were treated with supplementary implant placement. A total of 43 additional implants were placed.

**Table 5a Distribution of Failed Implants in the Graft Group with Regard to Placement in Type of Bone and Tooth Region**

| | Incisor | | | Canine | | | Premolar | | | Molar | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | F | P | % | F | P | % | F | P | % | F | P | % | F | P | % |
| 1-stage | | | | | | | | | | | | | | | |
| Inlay graft | 0 | 0 | 0 | 7 | 17 | 41.2 | 21 | 85 | 24.7 | 14 | 44 | 31.8 | 42 | 146 | 28.8 |
| Onlay graft | 2 | 5 | 40 | 4 | 4 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 7 | 57.1 |
| Residual bone | 10 | 55 | 18.2 | 7 | 44 | 15.9 | 1 | 8 | 12.5 | 0 | 0 | 0 | 18 | 107 | 16.8 |
| Total | 12 | 60 | 20 | 16 | 63 | 25.4 | 22 | 93 | 23.7 | 14 | 44 | 31.8 | 64 | 260 | 24.6 |
| 2-stage | | | | | | | | | | | | | | | |
| Inlay graft | 0 | 0 | 0 | 4 | 29 | 13.8 | 12 | 64 | 18.8 | 4 | 10 | 40 | 20 | 103 | 19.4 |
| Onlay graft and residual bone | 19 | 52 | 36.5 | 6 | 22 | 27.3 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 74 | 33.8 |
| Total | 19 | 52 | 36.5 | 10 | 51 | 19.6 | 12 | 64 | 18.8 | 4 | 10 | 40 | 45 | 177 | 25.4 |
| Total | 31 | 112 | 27.7 | 26 | 114 | 22.8 | 34 | 157 | 21.7 | 18 | 54 | 33.3 | 109 | 437 | 24.9 |

F = no. failed; P = no. placed.

**Table 5b Distribution of Failed Implants in the Nongraft Group with Regard to Tooth Region**

| Tooth region | No. failed | No. placed | Percent failed |
|---|---|---|---|
| Incisor | 43 | 305 | 14.1 |
| Canine | 32 | 212 | 15.1 |
| Premolar | 34 | 165 | 20.6 |
| Molar | 0 | 1 | 0 |
| Total | 109 | 683 | 16.0 |

*Nongraft Group.* Eleven patients received a total of 26 additional implants. Three of these patients also required a graft procedure.

### Prosthesis Stability

*Graft Group.* Of the 64 patients, 56 (87.5%) received a fixed prosthesis. Three patients were treated with an overdenture and 5 with a complete denture. Twelve of these patients received additional implant surgery. Of these 12, 10 received fixed prostheses, 1 received an overdenture, and 1 received a complete denture. Of the 56 full-arch prostheses, all (100%) were stable throughout their observation periods.

*Nongraft Group.* Of 118 patients included, 93 (78.8%) received a fixed prosthesis, 21 an overdenture, and 4 a complete denture. Five patients were treated with additional implant surgery; of these patients, 4 received fixed prostheses and 1 received an overdenture. Of the 93 fixed prostheses, all (100%) were stable at the end of the study period.

### Radiographic Examination

For the graft group, the marginal bone level was on average 3.3 mm (SD: 2.18) from the reference point after a mean follow-up of 68.9 months (Fig 3). For the nongraft group, the marginal bone level was on average 2.9 mm (SD: 1.98) from the reference point after a mean follow-up of 75.8 months (Fig 3).

### Withdrawals

Of a total of 216 patients and 1,357 implants, 34 patients (15.7%) with 237 implants (17.5%) were withdrawn. In the graft group, 19 patients with 133 implants were withdrawn—3 due to infection and dehiscence of the wound related to the use of a nonresorbable membrane, 3 due to poor health, 7 because they moved from the area, and 6 due to death. In the nongraft group, 15 patients with 104 implants were withdrawn—6 because they moved from the area, 7 due to poor health, and 2 due to death.

## DISCUSSION

The present study compared the clinical outcome of implant treatment in 64 grafted maxillae with that in 118 nongrafted ones. A statistically significant lower CSR was demonstrated for the graft group (75.1%) than for the nongraft group (84%) after a mean follow-up of 5 to 6 years. In spite of this, similar percentages of patients in the 2 groups received a fixed prosthesis (71.8% versus 75.4%), and after reoperation, more grafted patients (87.5%) than nongrafted patients (78.8%) still had fixed prostheses in function at the end of the study. Since a fixed prosthesis was the desired outcome in the treatment of both groups, a better long-term result was seen in the graft group, although more surgery was needed. However, for various reasons, in 9 of the nongrafted patients, an overdenture was the planned final

**Table 6a Distribution of Failed Implants with Regard to Jawbone Volume and Tooth Region in the Anterior Maxilla**

| | Incisor | | | Canine | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| **Classification*** | **F** | **P** | **%** | **F** | **P** | **%** | **F** | **P** | **%** |
| Graft group | | | | | | | | | |
| Classes I and II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Classes III and IV | 6 | 35 | 17.1 | 3 | 52 | 5.8 | 9 | 87 | 10.3 |
| Classes V and VI | 20 | 63 | 31.7 | 17 | 52 | 32.7 | 37 | 115 | 32.2 |
| Nongraft group | | | | | | | | | |
| Classes I and II | 1 | 70 | 1.4 | 4 | 41 | 9.8 | 5 | 111 | 4.5 |
| Classes III and IV | 31 | 192 | 16.1 | 18 | 133 | 13.5 | 49 | 325 | 15.1 |
| Classes V and VI | 9 | 24 | 37.5 | 9 | 22 | 40.9 | 18 | 46 | 39.1 |

*According to Cawood and Howell.[25]
F = no. of implants failed; P = no. of implants placed.

**Table 6b Distribution of Failed Implants with Regard to Jawbone Volume and Tooth Region in the Posterior Maxilla**

| | Premolar | | | Molar | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| **Classification*** | **F** | **P** | **%** | **F** | **P** | **%** | **F** | **P** | **%** |
| Graft group | | | | | | | | | |
| Classes I and II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Classes III and IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Classes V and VI | 26 | 138 | 18.8 | 15 | 49 | 30.6 | 41 | 187 | 21.9 |
| Nongraft group | | | | | | | | | |
| Classes I and II | 0 | 21 | 0 | 0 | 1 | 0 | 0 | 47 | 0 |
| Classes III and IV | 36 | 141 | 25.5 | 13 | 32 | 40.6 | 49 | 173 | 28.3 |
| Classes V and VI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*According to Cawood and Howell.[25]
F = no. of implants failed; P = no. of implants placed.

restoration. Excluding these 9 patients, the prosthesis stability rate in the remaining 109 patients was 85.3% at the end of the follow-up period, which was similar to that in the graft group.

Using the Cawood and Howell classification of bone anatomy, the majority of patients in the graft group belonged to classes V or VI prior to augmentation (64.1% in the anterior region and 100% in the posterior region), while most nongrafted patients were placed in classes III or IV (67% in the anterior region and 75% in the posterior region). Since the distribution of implant lengths was similar for both groups, it could be concluded that the grafting procedures resulted in a bone volume similar to that in the nongraft group. A higher implant failure rate was seen in the graft group in spite of this, which most likely could be related to the bone grafts' ability to integrate the implants. This may be explained by the grafts' biomechanical properties as well as the healing capacity of the bone. Another negative factor could be that the healing period for the bone graft was not long enough (mean: 4.9 months), resulting in immature bone graft quality and impaired osseointegration. In the posterior regions, where inlays into the maxillary sinus were used, the survival rates for the 2 groups were similar. It is possible that the residual alveolar crest below the maxillary sinus provided for good primary stability, which may explain the similar outcomes. High implant survival rates in inlay grafts have previously been reported.[13,20]

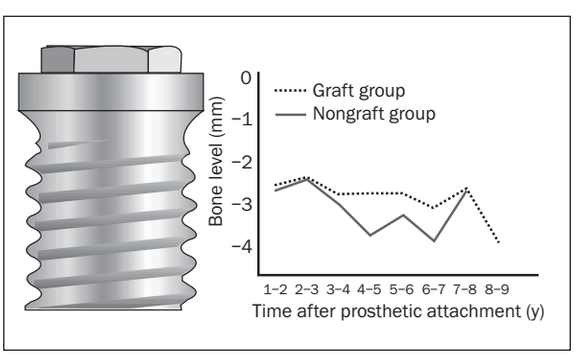


**Fig 3** Average bone level at last radiographic examination (mm below the reference point, which is represented by 0).

The majority of implant failures were early losses, since 92% of the grafted implant failures and 86% of the nongrafted implant failures occurred before loading. One causative factor for the early failures could have been occlusal overload during the healing period resulting in inadequate tissue response and impaired osseointegration. Denture stability and fit, occlusion, bite force, and opposing dentition may have a significant impact on load. In a recent publication,[31] opposing dentition was shown to correlate with implant failure in grafted patients; more failures occurred in patients with inadequate premolar and molar support. Another factor could be the abutment connection surgery, specifically rotational forces conveyed to the implant-bone interface associated with tightening of the abutment screws. This could have caused either immediate or delayed loss of the implants, especially considering the immature quality of the bone graft.

Within the graft group, the difference between the overall survival rates for 1-stage implants and 2-stage implants was not statistically significant. Where the inlay grafting technique was used, 2-stage implants had a lower survival rate than 1-stage implants; however, where the onlay grafting technique was used, 2-stage implants had a higher survival rate. Wannfors and coworkers[32] reported that the risk for implant failure using a 1-stage technique was double that for using a 2-stage technique. However, other authors have reported similar results with the 2 techniques.[15,16]

The radiographic follow-up demonstrated a similar mean marginal bone level for implants in both groups. After 5 years of follow-up, the marginal bone level was 3.3 mm from the abutment/implant junction in grafted patients and 2.8 mm in nongrafted patients. This indicates that the implants performed similarly in both groups during occlusal loading.

The policy of the maxillofacial unit has been to treat all patients regardless of any physiologic or anatomic limitations. This could be the explanation for the rather high implant failure rate in this study. However, because of the complexity of the cases treated, the failure rates should not be considered alarming. In general, the results are in agreement with those previously published by others.[3,8,13,15,18,33]

## CONCLUSION

The results of this investigation revealed a lower overall implant survival rate in grafted maxillae than in nongrafted maxillae after a mean of 5 to 6 years of follow-up. Analysis suggested that jawbone volume in the anterior of the maxilla at the start of treatment was directly related to implant survival rates in both groups, ie, the greater the volume, the higher the survival rate. Moreover, the implant survival rate in grafted posterior edentulous maxillae of classes V and VI was similar to that in nongrafted posterior edentulous maxillae of classes III and IV.

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