
Le Fort I Osteotomy with Interpositional Bone Grafts and Implants for Rehabilitation of the Severely Resorbed Maxilla: A 2-Stage Procedure

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A surgical procedure for the rehabilitation of severely resorbed maxillae is described. Twenty-five patients, made up of a development group of 5 and a routine group of 20, were treated with Le Fort I osteotomy using interpositional bone grafts from the iliac crest and, in a second stage, titanium implants. Altogether, 181 Brånemark implants were placed, and the patients were followed for up to 5 years. The implant survival rate for the development group was 60.0% after 5 years. Life table analysis for the routine group showed a 5-year survival rate of 85.6%. Twenty-two patients received fixed prostheses and 2 received overdentures. One patient lost all implants and was rehabilitated with a prong denture. (INT J ORAL MAXILLOFAC IMPLANTS 1999;14:571-578)

Key words: bone graft, implants, maxillary osteotomy, two-stage procedure

Osseointegration of implants using the Brånemark System (Nobel Biocare AB, Göteborg, Sweden) has proven to be reliable for 28 years. As long as bone volume is sufficient, the reported implant survival rates lie between 85 and 100%.¹⁻⁴ Maxillary implants have a somewhat higher failure rate than mandibular implants. In the severely resorbed mandible, there is still the possibility of placing implants between the mental foramina, whereas in the resorbed maxilla the amount of bone available for implant placement is reduced and often inadequate. Autogenous onlay bone grafts have been used to increase bone volume in the maxilla. The donor site has often been the iliac crest,⁵ but smaller bone grafts can be harvested from the mandible.⁶⁻⁷

Controlled clinical studies using a standardized methodology have reported survival rates between 75% and 85%.⁸⁻¹⁰ Survival rates essentially depend on the handling of soft and hard tissues, as well as postoperative care and prosthetic loading. In patients with a normal sagittal relation between the jaws, onlay bone grafts may be suitable, but when the sagittal discrepancy is large, the inclination of the implants may be too unfavorable for a satisfactory result.

Maxillary Le Fort I osteotomies have long been routine in orthognathic surgery, and use of the method in the edentulous patient seems natural. Keller et al¹¹ and Sailer¹² were the first who reported on the use of maxillary osteotomy for bone grafting and implant rehabilitation. Several publications have reported on the use of the method, either with direct implantation or 2-stage surgery.¹³⁻¹⁸ The aim of the present study was to prospectively evaluate the combined treatment with a Le Fort I osteotomy and simultaneous bone grafting with later placement of endosseous implants.

Materials and Methods

From 1990 to 1997, 25 patients received maxillary osteotomies with interpositional bone grafts prior to implant placement. The study included 17 females

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Patient age range (y)	Ridge anatomy			
	Type III	Type IV	Type V	Type VI
30 to 40		2		
40 to 50				
50 to 60		1	3	1
60 to 70	4	2	4	6
70 to 80			1	1

Type III = width < 2 mm, height 12 to 15 mm; Type IV = width 3 to 4 mm, height 4 mm; Type V = width 3 to 4 mm, height 4 mm; Type V = height 2 mm; Type VI = height 1 mm. No patients had Type I or Type II ridge anatomy.

Duration of denture wear (y)	Ridge anatomy			
	Type III	Type IV	Type V	Type VI
Less than 10	1		4	
10 to 20	2	3	4	
20 to 30	2		1	4
30 to 40		1		
More than 40		1	1	2

Type III = width < 2 mm, height 12 to 15 mm; Type IV = width 3 to 4 mm, height 4 mm; Type IV = width 3 to 4 mm, height 4 mm; Type V = height 2 mm; Type VI = height 1 mm. No patients had Type I or Type II ridge anatomy.

and 8 males. The mean age was 56 years (range 38 to 77). The mean age of the male patients was 56, and the mean age of the female patients was 63. Two females were between 30 and 40 years of age, 1 was between 40 and 50, 2 were between 50 and 60, 10 were between 60 and 70, and 2 were between 70 and 80 years of age. The male patients were distributed as follows: 3 between 50 and 60, 4 between 60 and 70, and 1 between 70 and 80 years of age. Six of the patients were followed for 7 years, six for 4 years, four for 3 years, four for 2 years, three for 1 year, and two for less than 1 year. Twenty patients were followed for more than 2 years. The first 5 patients were considered a development group and the final 20 patients were considered a routine group. The implant rehabilitation was performed in 2 stages, beginning with the grafting procedure. After 3 to 4 months, the second-stage operation was carried out with removal of osteosutures and plates. At this time, the implants were placed (Brånemark System). Abutments were connected 6 months later. The number of implants placed in each patient varied between 6 and 8, depending on the amount and quality of the bone. In all, 181 implants were placed.

The indications for a Le Fort I osteotomy with bone grafting have been severe atrophy of the alveolar process, with a height of the alveolar process under the sinus and nasal cavities between 1 and 4 mm, excluding conventional implant placement; but also a sagittal discrepancy between the maxilla and mandible preventing acceptable orientation of the implants, thus creating an unfavorable loading situation. An anatomic index, modified from Cawood and Howell¹⁹ for description of bone volume (I to VI), was used to identify suitable patients for this type of procedure (Tables 1 and 2). Most patients (21) were in the anatomic classifications 4, 5, and 6 (Table 1). A trend relating duration of denture wearing and crestal resorption was also noticed (Table 2).

Exclusion Criteria. Only patients with severe systemic diseases preventing general anesthesia and the demanding surgical procedure were excluded from the study. From 1990 to 1997, 2 patients were excluded from treatment for these reasons.

Patients with smoking habits were instructed to stop smoking 9 months before the bone graft operation. In this patient material, 3 were smokers. All 3 ceased smoking before operation but started

Table 3 Systemic Health and Smoking Habits with Respect to Patient Age

Patient age range (y)	Health condition/smoking habits			
	Systemic diseases*	Smoker (less than 10 cigarettes/day)	Heavy smoker	Somatically healthy
30 to 40	1			1
40 to 50	1			
50 to 60		2	1	4
60 to 70	6			9
70 to 80	1			2

*Includes allergy, hormonal disorders, heart and blood pressure disorders, etc.

again some months later (Table 3). Smoking was regarded as a relative contraindication, but none of these patients were excluded.

Surgical Procedure. Surgery was carried out in a 2-stage procedure. A Le Fort I osteotomy was initially performed according to the orthognathic surgical concept, with a vestibular incision in the anterior extending from the right premolar region to the left premolar region. The buccal aspects of the maxillary sinus wall and the nasal aperture were surgically exposed. The junction between the maxillary tuberosity and the pterygoid process was then identified. In these extreme situations, there is often only a thin bony wall to the sinus cavity; thus it is easy to accidentally perforate into the sinus before the bony junction. The nasal mucosa in these atrophic situations appears to be thin and very adherent to the nasal bony floor. The dissection and lifting of the nasal mucosa was thus considerably more difficult compared to the patients who normally undergo orthognathic surgery. However, it was considered important to keep the mucosa intact to prevent communication between the nasal cavity and bone graft. Accidental lacerations were sutured to maintain a soft tissue roof for the graft. Following osteotomies of the nasal septum and lateral nasal walls, the maxilla was gently downfractured using mainly digital forceps, sometimes combined with Rowe & Killey's disimpaction forceps. After downfracturing, the maxilla was further mobilized and carefully repositioned anteriorly to the planned position. Experience has shown that a maximal forward repositioning is about 10 mm. The vertical height was corrected at the same time, with rotation of the maxilla inferiorly. The bone graft was harvested from the iliac crest and os ilium, almost always with the maximum volume possible, without risking a fracture at the donor site.

The cortical bone was modeled to fit into the sinus recesses and the anterior part of the nasal cavity. Cancellous bone was packed around the cortical pieces to fill the spaces completely. The grafts were then secured with wire sutures, 2 on each side and 1 in the anterior region (Figs 1a to 1e). After checking the sagittal and horizontal relationships to the mandible, the maxilla was secured with 1 miniplate (1.5 mm) on each side and 4 screws in each plate. The vestibular incision was closed with continuous sutures, and a postoperative antibiotic regimen was initiated (Kävepenin, Astra AB, Södertälje, Sweden), 4 g/day for 10 days. The maxilla and bone graft were then left to heal for 3 to 4 months before the second-stage operation. During the second-stage procedure, plates, screws, and wire sutures were removed and implants were placed using a guide splint to achieve the desired optimal positioning. This operation was done under local anesthesia (Xylocain-Adrenalin 2%, Astra, Södertälje, Sweden) combined with preoperative sedation (Stesolid, Dumex, Copenhagen, Denmark), 15 to 20 mg as a single dose.

Healing after implant placement extended over 6 months. Abutment connection was also done under local anesthesia, and healing abutments were used normally. After suture removal, prosthodontic treatment was begun.

Prosthetic Procedure. While the surgical treatment was carried out by the same surgical team for all patients, prosthetic treatment was provided by several clinicians, including both specialists and general practitioners. The aim was to use a temporary acrylic resin prosthesis primarily during the first postoperative 6 months to somewhat reduce the loading on the implants. Furthermore, patient expectations for the definitive restoration may be

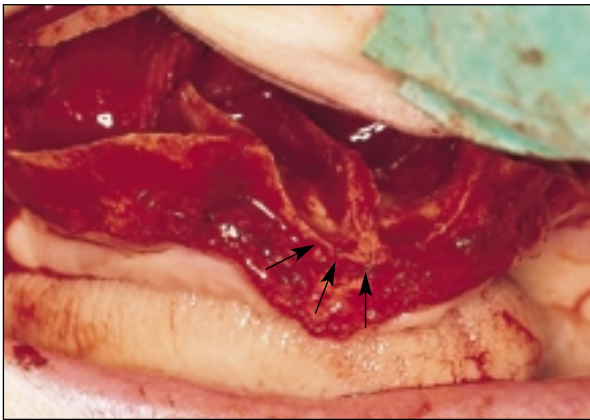


Fig 1a Maxillary osteotomy with downfracture of a severely resorbed maxilla in a 54-year-old female.

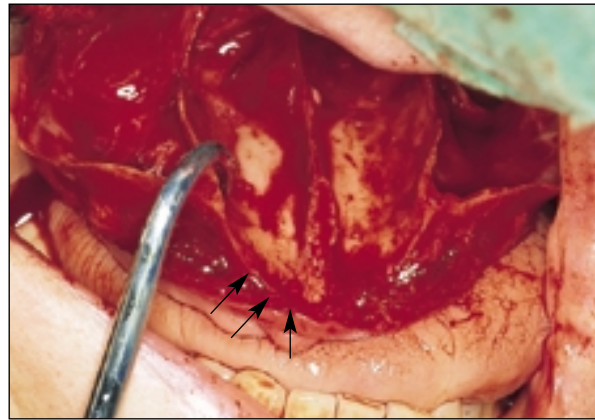


Fig 1b Nasal mucosa should be carefully resected from the nasal floor and the sinus mucosa should be gently removed from the antral recesses.

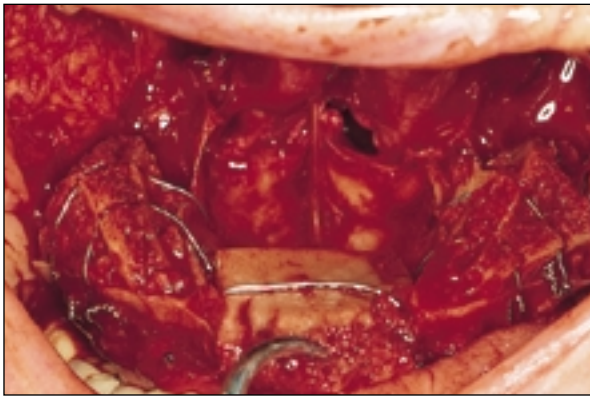


Fig 1c Bone grafts from the hip, both cortical and cancellous, are attached into the sinus recessus and the anterior part of the maxilla.

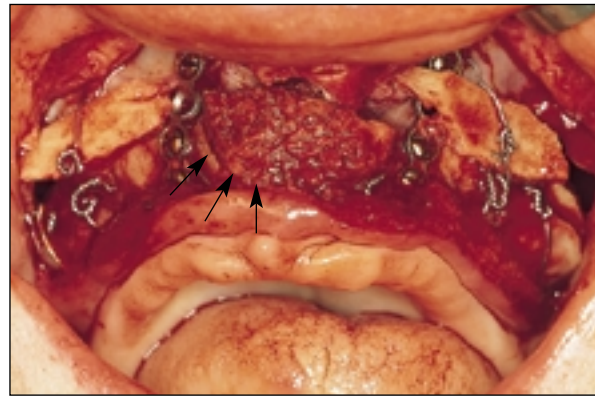


Fig 1d After repositioning the maxilla with bone plates, bridging bone grafts are secured over the osteotomy regions.



Fig 1e Four months of healing reveal a well-integrated and remodeled bone graft.

more reasonable if implant loss occurs during the first postoperative period. The desired prosthetic treatment for all patients was a fixed prosthesis.

Radiographic Examination. Classification of the bony anatomy of the alveolar process was made based on lateral radiographs and tomography of the maxilla prior to operation. The height of the alveolar process in 21 of the patients did not exceed 4 mm, and in many patients (16) it was

between 1 and 2 mm. In a couple of patients, the alveolar crest in the anterior region was relatively high but knife-edged (Figs 2a and 2c). Patients were followed up annually after implant placement with both clinical and radiographic examinations (Figs 2b and 2d). Radiographic examination, including tomography and lateral radiographs for evaluation of bone graft resorption and stability of maxillary repositioning, will be presented subsequently.

Fig 2a (Left) Radiograph of a 48-year-old female patient with a sagittal discrepancy between the jaws after resorption of the entire maxillary alveolar process.

Fig 2b (Right) Radiograph of the same patient 5 years after rehabilitation with interpositional bone transplants and implants, as well as anterior repositioning of the maxilla.

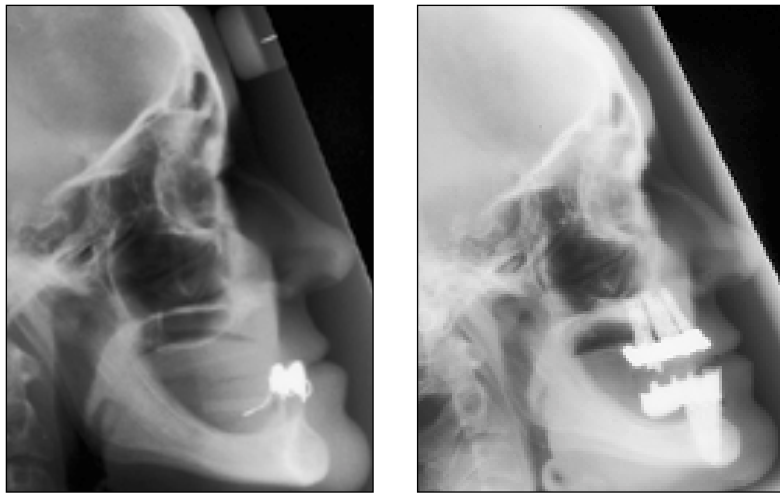


Fig 2c Tomographic views of the antrum recess before bone grafting.

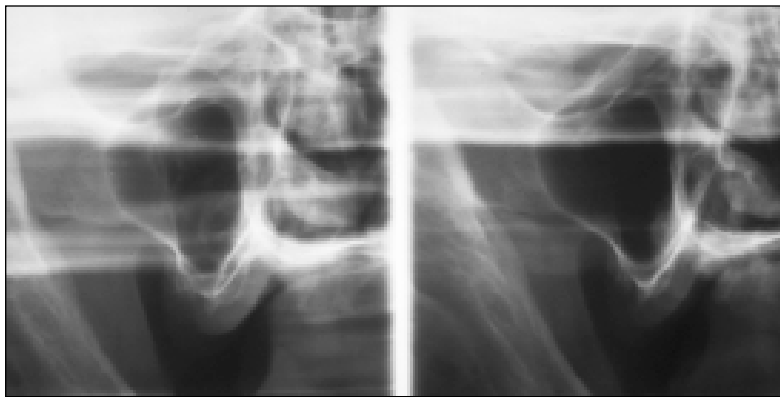


Fig 2d Tomography of the same region after grafting.

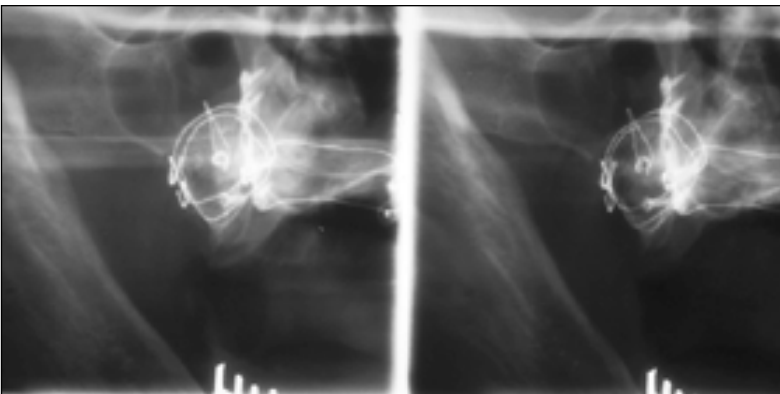


Table 4 No. of Implants Lost with Respect to Time and Patient Age and Sex

Patient age (y)/sex	Time of implant loss						
	Abutment connection	Initial prosthetic treatment	< 6 mo after abutment connection	1 y after abutment connection	2 y after abutment connection	3 y after abutment connection	4 y after abutment connection
Male							
50 to 60				2	2	1	
60 to 70	4	1					
70 to 80	2						
Female							
50 to 60	3	2		2			
60 to 70		1	2	3	1		2
70 to 80		1		1			

Results

Healing after the grafting procedure was initially uncomplicated and no dehiscences were noted. Pain in the iliac crest was common in all patients during the first 1 to 2 weeks, with varying difficulties with walking. In 6 patients, sinus infections were evident, and in 2 patients an exploration was made to remove loose bone fragments. However, all healed after treatment. The second-stage operation with implant placement was uncomplicated, as was abutment connection.

Implant losses occurred during different phases of rehabilitation (Table 4). In all, 30 of 181 implants were lost. When the different time periods were analyzed, it could be seen that 14 implants were lost at abutment connection or during initial prosthetic treatment, and the remaining 16 were lost between 1 and 4 years after implant placement. The implant losses were concentrated in a relatively small number of patients (15 implants lost in 3 patients), and in 14 patients no implants were lost. In the development group (5 patients followed for 5 years), 12 implants were lost, for a survival rate of 60.0%. In the routine group (20 patients followed up to 5 years), 18 implants were lost. For this group, life table analysis reveals a 5-year survival rate of 85.6% (Table 5).

The average time from start of surgery until prosthesis placement was 12 months. In all but 3 patients, a fixed restoration was fabricated. One patient, although he had stable implants at abutment connection, lost 5 of 6 implants within 2 years after prosthesis connection. It was found that he was a heavy bruxer, and he was finally rehabilitated with a prong denture. Two patients received overdentures. Thus, 22 of 25 patients were rehabilitated with complete-arch superstructures.

Discussion

Indication for such surgical procedures as maxillary osteotomies with bone grafts and implants should be restricted to extremely resorbed jaws (Types IV–VI) according to the modified classification in this study. Results from the present study indicate that a Le Fort I osteotomy with interpositional bone grafts and implant placement after a healing period is a reliable procedure. The time sequence for implant losses was not uniform in its appearance. More than one third of the implant losses (14) occurred during abutment connection or during initial prosthetic rehabilitation. The remaining losses (16) occurred at different times following prosthetic treatment. It cannot be ignored that some of the implant losses could have been the result of loading forces on the implants or misfits of prostheses. It is suggested that initial loading of grated arches be moderated with acrylic resin in the superstructure to absorb some of the masticatory forces initially, because the bone graft is probably not completely matured until 1 to 2 years postoperatively.

When the number of implants lost in patients who have had the 5-year follow-up is considered (ie, the development group), it can be seen that implant losses were more pronounced, compared to the routine group, in the late follow-up periods, meaning that implant losses occurred 2, 3, and 4 years after implant placement. In these patients, prosthetic loading may have been one of the factors related to the failures. In the routine group, the patients followed for 3 to 5 years had implant losses before the 1-year follow up, which may indicate that the loading conditions were better. It is also notable that 3 patients had 50% of the implant losses (15/30). Two of these patients were in the development group. One was a habitual

Table 5 Life Table Analysis of Routine Group

Years followed	No. of implants at start of interval	Failed implants	Failure rate	Cumulative survival rate
Up to 1	151	18	14.4%	85.6%
Up to 2	99	0	0.0%	85.6%
Up to 3	76	0	0.0%	85.6%
Up to 4	38	0	0.0%	85.6%
Up to 5	6	0	0.0%	85.6%

bruxer and another was a heavy smoker. Smoking habits were regarded as a relative contraindication for treatment, and the 3 smokers in this material were instructed to stop 9 months before the first operation. However, they all admitted that they had started smoking again some months after the first operation.

The 2-stage procedure with delayed implant placement seems to be a safe procedure in the total maxillary osteotomy. Experimental data also point to the 2-stage procedure as the method of choice.²⁰ Although data from onlay grafts with simultaneous implant placement show survival rates of 77% to 87%,^{9,10} the incidence of complications has a more dramatic course. Another advantage to the maxillary osteotomy is the possibility of correcting horizontal as well as vertical discrepancies between the jaws, thus offering the surgeon optimal conditions for positioning the implants during the second stage.²¹

The time lapse from the initial operation to a fixed prosthesis fabrication was 12 months. That is double the time usually taken for a conventional implant prosthesis in the maxilla. For the moment, it does not seem feasible to decrease the healing time in this type of operation. Comparable studies report even longer healing periods for the bone graft.¹⁶ In this study, the mean healing time for the bone graft was 3.5 months and for the implants, it was 7 months. If the time for bone graft healing and remodeling is extended up to 6 to 8 months, part of the graft may be too resorbed for implant placement. Results of this study indicate that the timing of the different surgical procedures seems to be adequate. However, the optimal timing for placement of implants in grafted bone is currently not known.

The authors strongly believe that loading forces on the maxilla from the denture during healing of both the bone graft and implants may be hazardous. It is therefore recommended that the denture be used only for social purposes without functional mastication during these periods.

Conclusion

Experiences with maxillary osteotomy and interpositional bone grafts with implants in a 2-stage procedure encourage continuation with this type of rehabilitation in patients with severely or almost totally resorbed maxillae. However, caution must be taken with loading forces during the initial healing period and also when performing the prosthetic fabrication. Smoking habits may have a negative influence on the outcome of the treatment.

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