Implant Rehabilitation for Extremely Atrophic Maxillae (Cawood Type VI) with Le Fort I Downgrafting and Autogenous Iliac Block Grafts: A 4-year Follow-up Study

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Purpose: *The aim of this 4-year retrospective follow-up study was to investigate treatment outcomes, including implant survival rate and marginal bone loss, in patients with maxillary Cawood type VI atrophy pattern who underwent Le Fort I downgrafting and iliac block augmentations for implant rehabilitation.* ***Materials and Methods:*** *Retrognathic edentulous Class III patients with severe maxillary resorption (Cawood VI) were enrolled. Reconstructive procedures performed included Le Fort I maxillary osteotomy, iliac block grafting, labial sulcoplasties, and dental implant placement. Panoramic radiographs were used to assess marginal bone loss. The Nobel Biocare Replace and GMI Frontier dental implant systems and fixed partial dentures were used for dental rehabilitation. Statistical analyses were made using NCSS 2007 statistical software, with significance set at $P < .05$.* ***Results:*** *Ten patients (six men and four women) with a mean age of 50.4 ± 12.55 years underwent maxillary osteotomy (advancement: 9 ± 1.4 mm; inferior repositioning: 8 ± 1.0 mm) and iliac block sandwich grafting (posterior ilium: n = 3; anterior ilium: n = 7) from 2009 to 2015. Nine patients were treated with a two-stage protocol. The mean graft healing period was 5.9 ± 0.73 months. A total of 98 implants were placed, 80 in maxillae and 18 in mandibles. The Nobel Biocare Replace system was used in two patients (n = 29 implants) and GMI Frontier system was used in eight patients (n = 69 implants). Implant numbers in the maxilla were: 6 implants in 2 patients, 8 implants in 6 patients, and 10 implants in 2 patients. The mean follow-up period was 47.8 ± 3.4 months. The success rate was 93.75%, with a 6.25% fail ratio (n = 9 implants) at a follow-up of 4 years. Marginal bone resorption was 1.8 ± 1.0 mm at the postoperative year 1 and 3.75 ± 0.85 mm at postoperative year 4. Marginal resorption in the 8-implant group was found to be higher than that in the 6-implant group and 10-implant group at the postoperative year 1 ($P = .045$, $P = .026$, $P < .05$, respectively).* ***Conclusion:*** *Le Fort I osteotomy and simultaneous iliac block grafting (downgrafting) is a valuable option for implant rehabilitation in extremely atrophic maxillae (Cawood VI). It showed a high survival rate (93.75%) at 4 years of follow-up in this study.* INT J ORAL MAXILLOFAC IMPLANTS 2016;31:1415–1422. doi: 10.11607/jomi.4740

Keywords: *atrophy, graft, iliac, implant, Le Fort I osteotomy, maxilla*

Implant placement in the severely atrophic maxilla is challenging. In severe maxillary atrophy, categorized as having type V and type VI resorption patterns according to the Cawood and Howell classification,[1] the vertical, transverse, and sagittal interarch relationships are unfavorable due to multidimensional resorption in long-term edentulism.[2]

As the maxilla undergoes resorption, the alveolar ridge becomes narrower and shorter. The anterior maxillary wall migrates dorsally and superiorly, thus forming a knife-edge ridge.[3] The posterior maxillary ridge and alar base loses its cancellous component in the Cawood type VI resorption pattern. This phenomenon usually leaves a residual maxillary base with a crestal bone height of 1 to 2 mm.[4]

The Le Fort I maxillary osteotomy with interpositional bone grafts, also known as the maxillary downgrafting procedure, allows simultaneous skeletal correction and bony augmentation by means of forward and/or downward repositioning of the maxilla,[2,4–6] as opposed to other augmentation techniques (onlay bone

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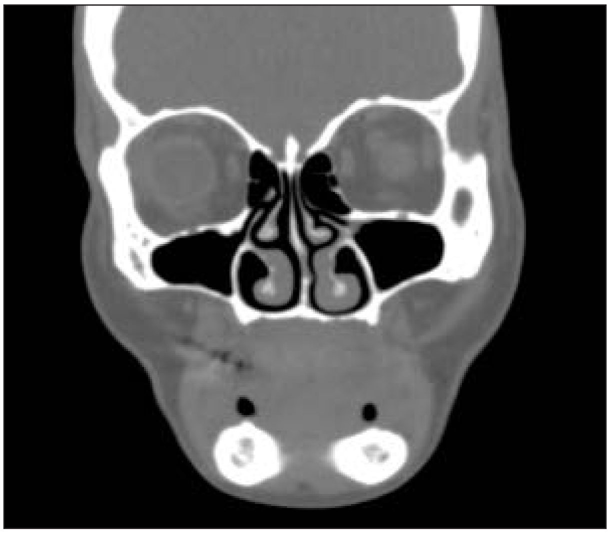

Fig 1 Preoperative coronal computed tomography slice demonstrates the extent of atrophy to the basal maxillary bone (Cawood type VI atrophy).

grafts,[2,7,8] maxillary sinus elevation without nasal floor grafting,[4,9] and guided bone regeneration[4]).

Downgrafting of the maxilla is a reliable and predictable technique to reconstruct severely atrophic maxillae with a Cawood VI resorption pattern.[3,5,6,8–12] More esthetic results with an enhanced midface profile and better lip support can be achieved with this method.[12,13]

The aim of this retrospective study was to assess peri-implant marginal bone loss and survival rates of dental implants placed in downgrafted maxillae with autogenous interpositional iliac bone grafts harvested from the anterior and posterior ilium.

MATERIALS AND METHODS

Patients and Methods

This retrospective study sample was derived from the records of edentulous patients with extremely atrophic maxillae who were referred to two of the authors (A.V. and S.B.) for dental implant rehabilitation using Le Fort I downgrafting and implant placement between 2009 and 2015.

Patients were included based on the following criteria: American Society of Anesthesiology (ASA) I and II score, significant skeletal maxillary retrusion, increased interarch distance, severe bony loss of alveolar ridges, healthy maxillary sinuses, and difficulty wearing a traditional denture. Exclusion criteria were tobacco use, severe renal and liver disease, previous history of radiotherapy in the head and neck region, chemotherapy, noncompensated diabetes, autoimmune diseases, poor oral hygiene, and noncompliant patients.

Preoperative computed tomography scans of maxillofacial skeletons were obtained from all patients to evaluate bone atrophy and perform surgical simulation with Simplant software (Materialise). Maxillary repositioning was simulated virtually using the "osteotomy wizard" option of the software to measure maxillary advancements and inferior repositioning at the sagittal and coronal planes. The ethical committee of Marmara University (Istanbul, Turkey) approved the retrospective study (file no. 2015/68).

Reconstructive Surgery

All patients received general anesthesia with nasotracheal intubation. All received 10 mL of local anesthesia with epinephrine in the maxillary vestibule. A 2.0-mm Kirschner wire was inserted as a glabellar pin to control inferior repositioning of the maxillae. The distance between the glabellar pin and anterior nasal spine was measured with a caliper before maxillary downfracture. The amount of maxillary inferior repositioning was adjusted according to a preoperative analysis done with the software. Le Fort I osteotomies were performed using a piezoelectric surgical system (NSK Variosurg 2) and downfractured with finger pressure at the anterior nasal spine. Downfractured maxillae were advanced using a Stromeyer bone hook anchored at the incisive channel from the nasal side. A caliper adjusted to the preoperative parameters of software planning was used to control anterior repositioning. No particular attention was paid to preserve the antral mucosa, but full attention was given to keep the nasal mucosa intact. Therefore, the lacerated or detached nasal mucosa was repaired primarily with 4-0 resorbable monofilament sutures. A two-team approach was preferred for harvesting bone from the anterior ilium to reduce the intraoperative time and ischemic period of the osteotomized maxilla and the grafts. Harvested iliac bone block grafts were wrapped with a saline-soaked gauze.

The autologous grafts taken from the anterior and posterior ilium were shaped to fit between caudal and cranial segments. Posterior iliac grafts were sculpted into a horseshoe shape to engage lateral walls of maxillary osteotomies. The downgrafted maxillae were stabilized with 1.0-mm profile microplates (Trimed, Elektron Medikal). All remaining spaces between the downfractured maxilla and the bone blocks were filled with autogenous particulated bone (Figs 1 to 9).

Antibiotic prophylaxis was started 2 days before the surgeries and continued for 7 days after surgery. Nonsteroidal analgesics were administered after surgery. Postoperative instructions included a soft diet for 2 weeks and appropriate oral hygiene with 0.2% chlorhexidine mouthrinse. Sutures were removed 7 to 10 days after surgery.

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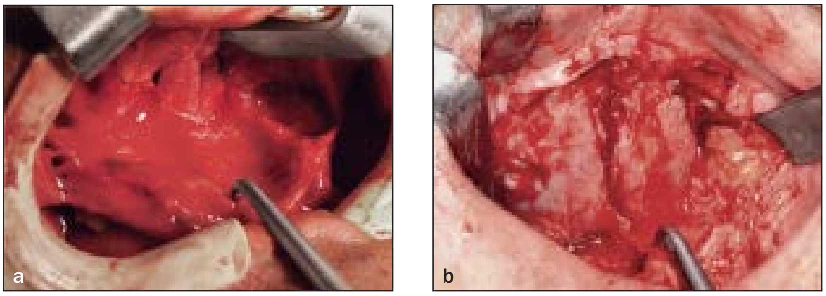

Fig 2 *(a)* Completed Le Fort I osteotomy (patient 2). The resorbed maxilla is very thin and prone to unfavorable palatal fracture. *(b)* The nasal mucosa should be dissected with great caution to avoid postoperative graft infection (patient 6).

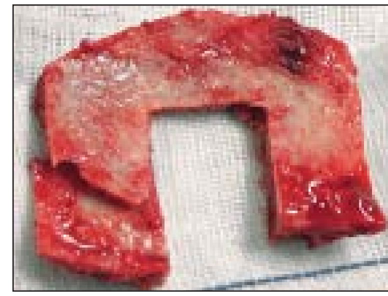

Fig 3 A posterior iliac block graft carved in a horse-shoe shape.

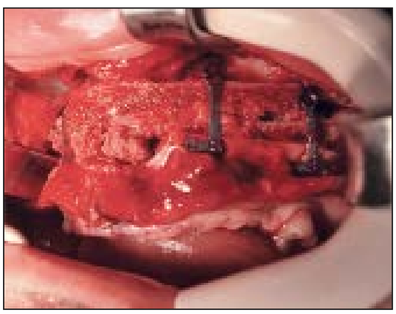

Fig 4 Intraoperative view of the completed downgrafting. The maxilla was advanced 10 mm and repositioned 9 mm inferiorly. Horse-shoe sandwich grafting was performed with 1.0-mm profile micro osteosynthesis plates (Trimed Micro System).

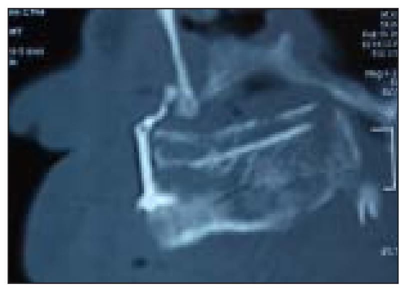

Fig 5 Postoperative computed tomography scan confirms osseous reconstruction over 15 mm.

Fig 6 Implant placement after 6 months (Nobel Biocare Replace System).

Fig 7 Final ceramic fixed partial dentures.

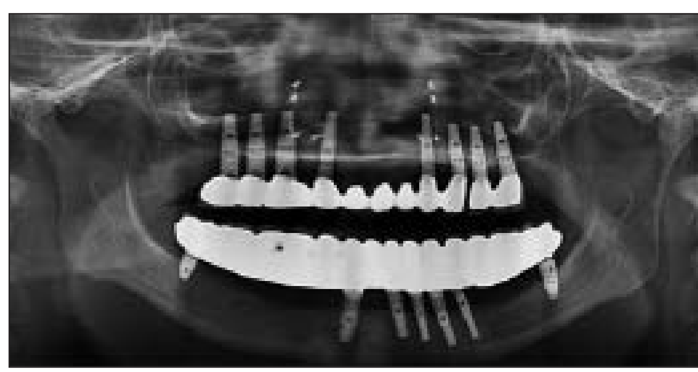

Fig 8 One-year postoperative panoramic radiograph.

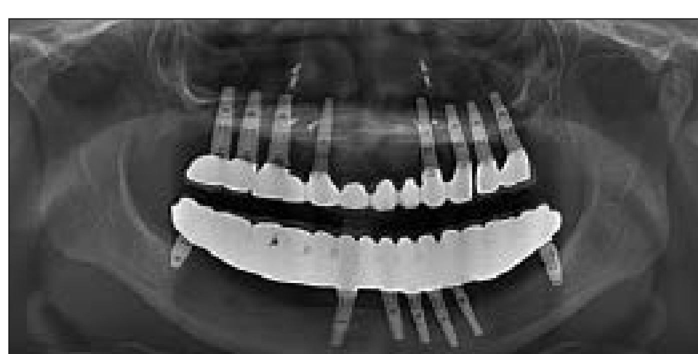

Fig 9 Four-year postoperative panoramic radiograph.

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Implant Surgery

The second-stage surgery involved dental implant insertion and labial sulcoplasties. Both procedures were performed under general anesthesia. All healing caps were inserted at the end of the second operation.

Prosthetic Treatment

All patients were rehabilitated with full-arch implant-supported fixed ceramic prostheses. Mandibular fixed partial dentures were seated on multiunit screw-retained abutments. Maxillary fixed partial dentures were fabricated using cement-retained abutments. The patients were followed up with annual clinical examinations and panoramic radiographs.

Statistical Analyses

Statistical analysis was performed for clinical data on maxillary procedures with NCSS 2007 statistical software (Number Cruncher Statistical System). Descriptive analysis (mean, standard deviation [SD], and median [interquartile range]), and the Wilcoxon (for repeating measurements), Kruskal-Wallis (for group comparisons), and Dunn multiple comparison tests were run to compute subgroup comparisons. The level of significance was set at $P < .05$.

RESULTS

Ten patients (mean ± SD age, 50.4 ± 12.55 years; four men and six women) with ASA I and II scores underwent reconstructive Le Fort I osteotomy and interpositional iliac block grafting (downgrafting) using anterior and posterior iliac block grafts between 2009 and 2015. The mean follow-up period was 47.8 ± 3.4 months.

The mean maxillary advancement was 9 ± 1.4 mm and inferior repositioning was 8 ± 1.0 mm. Mean operation time for maxillary downfracturing was 25.5 ± 7.16 minutes. Two patients had a fracture of the palatal transversal suture during the downfracture procedure. Successful advancement of the maxilla was achieved in those two cases after completion of pterygomaxillary separation with Tessier mobilizers.

Bone blocks from the anterior (n = 7) and posterior iliac crests (n = 3) were harvested according to the required augmentation volume. A seroma formed at the posterior iliac harvest site (n = 1), which was managed with compression bandage and drainage. The antibiotic regimen was started, and included amoxicillin and clavulanic acid (2 g/day orally) 2 days before surgery twice a day (Augmentin BID 1,000 mg tablet, Glaxo SmithKline), and intravenous cephazoline sodium during surgery and 2 g/day after surgery for 10 days. The mean hospitalization period was 3 ± 0.7 days for all patients. Two patients continued oral amoxicillin and clavulanic acid 2 g/day for 1 week after surgery. Mean graft healing period was 5.9 ± 0.73 months.

A total of 98 dental implants (Nobel Biocare Replace [two patients; n = 29 implants] and GMI Frontier [eight patients; n = 69 implants]) were inserted in the maxilla and mandible. A two-stage protocol was used for the remaining nine patients. One patient underwent simultaneous insertion of the GMI Frontier implant system with one-stage osseous reconstruction (Le Fort I osteotomy/posterior iliac graft). A total of 80 implants (64 GMI Frontier and 16 Nobel Biocare Replace) were inserted in the maxillae. Eighteen implants (5 GMI Frontier and 13 Nobel Biocare Replace) were placed in the mandibles. Implant numbers in the maxilla were as follows: 6 implants in 2 patients (patients 1 and 2), 8 implants in 6 patients (patients 3 to 8), and 10 implants in 2 patients (patients 9 and 10). Three patients requested removal of the osteosynthesis hardware at the second stage. Polyvinyl silicon impressions were taken 3 weeks after the healing caps were placed.

All patients reported positive feedback, including full satisfaction with facial changes and well-functioning fixed partial prosthetic restorations.

Survival Rate

The success rate of maxillary implants in this study was 93.75%, and failure rate was 6.25% (n = 9 implants) at the 4-year follow-up. Five maxillary implants in three patients failed after the insertion of healing caps. Four mandibular implants failed because of poor hygiene. Two implants failed in a patient who underwent reconstruction with anterior iliac grafts and three implants failed in a patient treated with posterior iliac grafts.

Marginal Bone Resorption (MBR)

Mean peri-implant MBR was 1.8 ± 1.0 mm at postoperative year 1 and 3.75 ± 0.85 mm at postoperative year 4. In all patients, the 4-year follow-up MBR scores were higher (Table 1). All 4-year follow-up comparison scores were significant at $P < .05$ (Table 1). The MBR scores at postoperative year 1 revealed significance among the 6-implant, 8-implant, and 10-implant groups ($P = .007$) (Table 2). The MBR in the 8-implant group was found to be higher than that in the 6- and 10-implant groups at postoperative year 1 ($P = .045$, $P = .026$, $P < .05$, respectively). No difference was found between the 6- and 10-implant groups ($P = .976$) (Table 3).

DISCUSSION

Implant survival rates in reconstructed maxillae with free bone grafts range from 67% to 97%.[10] Accordingly, the survival rate of implants in downgrafted maxillae ranges from 76%[5] to 97%[2,14] (Table 4). Temporary

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Table 1 Descriptive Data[a]

Patient	Age (y)/sex	Site, iliac graft	Maxillary osteotomy (min)	Graft healing (mo)	Implants (n)	Follow-up (mo)	Mean SD ± 1-year MBR/median (IQR)	Mean ± SD 4-year MBR/ median (IQR)	P
1	55/M	Ant	20	5	6	50	1.17 ± 0.41/1 (1–1.25)	3.5 ± 1.05/3.5 (2.75–4.25)	.003
2	61/M	Ant	35	6	6	48	1.67 ± 0.82/1.5 (1–2.25)	3 ± 1.55/2 (2–5)	.025
3	43/F	Post	36	6	8	51	1.25 ± 0.46/1 (1–1.75)	3 ± 1.31/3 (2–4)	.002
4	58/M	Ant	25	6	8	49	2 ± 0.93/2 (1–3)	4 ± 1.31/4 (3–5)	.0001
5	28/F	Post	25	7	8	45	3 ± 0.76/2 (2.25–3.75)	5 ± 0.93/5 (4–6)	.005
6	29/M	Post	22	5	8	52	2.25 ± 1.28/2 (1–3.75)	4.5 ± 1.77/4.5 (3–6)	.0001
7	56/M	Ant	18	6	8	40	1.13 ± 0.35/1 (1–1)	2.5 ± 0.93/2.5 (2–3)	.008
8	60/F	Ant	20	5	8	46	4 ± 1.07/4 (3.25–5)	4.5 ± 0.93/4.5 (4–5)	.033
9	56/M	Ant	35	7	10	48	1.6 ± 0.7/1.5 (1–2)	3 ± 0.67/3 (2.75–3.25)	.00
10	58/F	Ant	19	6	10	49	1.4 ± 0.52/1 (1–2)	4.5 ± 1.18/5 (3–5.25)	.0001

[a]Mean and median (IQR) marginal bone loss (in millimeters) at the 1-year and 4-year follow-up.
Significance ($P < .05$) was found in all patients at the 4-year follow-up.
SD = standard deviation; MBR = marginal bone resorption; IQR = interquartile range; Ant = anterior; Post = posterior.

Table 2 Group Comparisons

	1-year follow-up		4-year follow-up		
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	P*
6-implant group	1.42 ± 0.67	1 (1–2)	3.25 ± 1.29	3 (1–2)	.0001
8-implant group	2.27 ± 1.3	2 (2–4.75)	3.92 ± 1.47	4 (3–5)	.0001
10-implant group	1.5 ± 0.61	1 (1–3)	3.75 ± 1.21	3 (1–3)	.0001
P	.007		.333		

*Kruskal-Wallis test, with significance at $P < .05$.
IQR = interquartile range.

Table 3 Multiple Comparison Test For Marginal Bone Loss Values Among Groups with 6, 8, and 10 Implants

	P value* at 1-year follow-up
6-implant group vs 8-implant group	.045
6-implant group vs 10-implant group	.976
8-implant group vs 10-implant group	.026

*Dunn multiple comparison test, significance at $P < .05$.

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Table 4 Brief Review of Studies Describing Le Fort I/Iliac Downgrafting Procedures

Author(s)	Patients (n)	Reconstructive procedure	Implants (n)	Failure (n)	Success (%)	Follow-up (y)
Sailer (1989)[6]	5	Le Fort I/iliac graft, sulcoplasty	35	0	100	–
Isaksson et al (1993)[29]	12	Le Fort I/iliac graft	59	4	76.3	1–2
Cawood et al (1994)[28]	12	Le Fort I /iliac graft +HA			95	–
Krekmanov (1995)[11]	35	Le Fort I /sinus elevation/iliac graft	225	9	86.6	4
Li et al (1996)[24]	20	Le Fort I /sinus elevation/iliac graft	139	5	82	2
Watzinger et al (1996)[13]	14	Le Fort I sinus elevation/iliac graft	76	0	88.1	2.5
Kahnberg and Vannas-Löfqvist (2006)[14]	25	Le Fort I /sinus elevation/iliac graft	181	6	85.6	5
Stoelinga et al (2000)[21]	15	Le Fort I/ anterior iliac graft + HA	92	6	91.3	1–8
Yerit et al (2004)[19]	35	Le Fort I /iliac graft + HA	324	9	91.1	6.3–4.8
Clayman (2006)[25]	8	Le Fort I/iliac graft	41	4	83	3.7
Chiapasco et al (2007)[2]	9	Le Fort I/anterior iliac	281	5	82.9	10
Nyström et al (2009)[5]	6	Le Fort I/anterior iliac graft	167	24	85	11–16
Grecchi et al (2009)[3]	1	LeFort I/femur/anterior iliac graft	84	2	97.6	1.5
van der Mark et al (2011)[10]	10	LeFort I/anterior iliac graft	54	3	94	2–3
Pieri et al (2012)[15]	6	LeFort I/anterior iliac graft	50	2	96	2
Soehardi et al (2015)[12]	25	Lefort I/iliac graft	141	4	75.9	5–18

or prolonged ischemia of the downgrafted maxilla and free iliac block grafts is responsible for late graft resorption and osseointegration failures as well.[2] Graft resorption after the downgrafting procedure has a stable period after 1 year without further resorption.[15]

The higher survival rate (93.75%) seen in the present study may have strongly contributed to the absence of a long intraoperative ischemic period. The two-team approach contributes noticeably to decreased operative time and should be used whenever possible. Reported failure rates could be credited mostly to inappropriate graft handling conditions,[16] which include maintenance of iliac block grafts in the wrong medium for long periods, inadequate stability/fixation of grafts, premature implant loading, short healing time after teeth extractions, use of oversized grafts, and a short postoperative period after graft transfer.[16]

The choice between one-stage and two-stage implant placement in downgrafted cases is still a matter of clinical controversy. The rate of successful osseointegration is higher when implants are placed using a two-stage protocol.[17] Two-stage procedures have a better survival rate, with 88% success, whereas single-stage procedures have a success rate of 79%.[18] Immediate implantation is advantageous, with fewer surgical procedures required, and benefit from synchronized healing of sandwich iliac grafts, implants, and osteotomized maxilla.[11,18–20] However, the two-stage treatment offers better graft healing, placement of implants with proper angulations, and increased survival rate.[21,22]

Mean MBR scores measured at the first and fourth years (1.8 ± 1.0 mm; 3.75 ± 0.85) in the present study demonstrate scores similar to those reported in other studies, in which MBR scores increased gradually at the measuring intervals during follow-ups.[2,4,5,7,15,21] The success rate of 93.7% obtained with this retrospective 4-year follow-up study is coincident with reported success rates of two-stage implant reconstruction (Table 4).

No consensus has been reached on the healing period for harvested bone block grafts, with a great diversity of consolidation periods seen, ranging from 3 to 12 months. Although 5 to 6 months was considered to be the shortest required period,[12,15] lengthy consolidation periods were also reported.[2,19]

Primary implant stability is an essential factor for achieving predictable results with an immediate loading protocol in the grafted maxillae. The proper insertion protocol in these cases mandates nontapping, limited countersinking, and underpreparing of an intrabony implant socket. Implant-specific features (screw type, rough surface, minimal length of 10 mm) and occlusion-related factors (exclusion of oblique and/or horizontal forces, cross-arch splinting, reduction of cantilevers) are the other important issues contributing to success.[4]

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At least six or eight implants are recommended for maxillary downgrafted cases. However a consensus is lacking on that issue because of various personal choices.[11,19–21] The use of longer implants (> 13 mm) is recommended to engage the entire height of the iliac block grafts from the crestal side.[2,11,19–22] Insertion torque of 30 N is recommended for convenient apical fixation of an implant inserted in a bone block, unless a cascade of ischemia, infection, and implant failure may follow in any absence of primary stability.

The antibiotic regimen is crucial to prevent graft infections related to sinonasal flora. Infections are the main cause of graft loss and implant failures.[11,12,17–22] Generally, wide-spectrum antibiotics are preferred and continued for 6 to 10 days.[2,15] Preservation of the nasal mucosa is an important factor to reduce graft infection/resorption in such cases.[11,19,20] Total removal of antral mucosa from the nasal base with aggressive curettage increases the success rate significantly.[10,13,24–26] Unnoticed remnants of sinus mucosa during surgery have the potential to form sinus entrapment cysts.[21]

Bilateral sinus elevation with piezoelectric surgery is recommended for the maxillary downgrafting procedure to avoid graft infections caused by antral flora.[23] However, the technique is challenging and vulnerable to tears in largely pneumatized atrophic maxillae. This is because the antral mucosa is thin and susceptible to perforations during sinus elevation and maxillary downfracture. Moreover, the antral mucosa has to be reflected through a larger bony window with that technique, which may cause stress concentrated at the weakened sinus wall during downfracture and easily lead to undesired palatal fractures.

Fracture of transversal suture of the palatal bone may be a complication.[26] Extra difficulty may be encountered in completing the downfracture procedure and advancing the maxilla with the fractured palate to the planned anterior position. The two-piece fractured maxillary segment is susceptible to aseptic necrosis (the descending palatal artery is usually clipped/tied), insufficient fixation with skeletal instability, and long-term relapse.[26] The importance of harvesting one-piece horseshoe block grafts comes across in such complications, because the thick iliac block graft allows safe fixation of the fractured palatal segments.

A sinus elevation procedure combined with autogenous symphysis grafts or percutaneous harvested iliac strips was recommended (when the crestal bone was shorter than 4 or 6 mm) 6 months before a Le Fort I downgrafting/iliac block reconstruction to achieve primary implant stability and reinforce palatal bone to prevent fractures.[27] The total rehabilitation period exceeds 1 year with this technique, which may not sound reasonable to a typical implant recipient.

CONCLUSIONS

The survival rate of 93.7% in this 4-year follow-up retrospective study confirmed the clinical success of the maxillary Le Fort I downgrafting procedure for dental implant rehabilitation in extreme maxillary atrophic cases. This reconstruction option addresses all aspects of implant rehabilitation for patients with Cawood type VI resorption pattern.

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REFERENCES

1. Cawood JI, Howell RA. A classification of the edentulous jaws. Int J Oral Maxillofac Surg 1988;17:232–236.
2. Chiapasco M, Brusati R, Ronchi P. Le Fort I osteotomy with interpositional bone grafts and delayed oral implants for the rehabilitation of extremely atrophied maxillae: A 1-9-year clinical follow-up study on humans. Clin Oral Implants Res 2007;18:74–85.
3. Grecchi F, Zollino I, Parafioriti A, et al. One-step oral rehabilitation by means of implants' insertion, Le Fort I, grafts, and immediate loading. J Craniofac Surg 2009;20:2205–2210.
4. Marchetti C, Felice P, Lizio G, Rossi F. Le Fort I osteotomy with interpositional graft and immediate loading of delayed modified SLActive surface dental implants for rehabilitation of extremely atrophied maxilla: A case report. J Oral Maxillofac Surg 2009;67:1486–1494.
5. Nyström E, Nilson H, Gunne J, Lundgren S. Reconstruction of the atrophic maxilla with interpositional bone grafting/Le Fort I osteotomy and endosteal implants: A 11-16 year follow-up. Int J Oral Maxillofac Surg 2009;38:1–6.
6. Sailer HF. A new method of inserting endosseous implants in totally atrophic maxillae. J Craniomaxillofac Surg 1989;17:299–305.
7. Nyström E, Ahlqvist J, Gunne J, Kahnberg KE. 10-year follow-up of onlay bone grafts and implants in severely resorbed maxillae. Int J Oral Maxillofac Surg 2004;33:258–262.
8. Becktor JP, Isaksson S, Sennerby L. Survival analysis of endosseous implants in grafted and nongrafted edentulous maxillae. Int J Oral Maxillofac Implants 2004;19:107–115.
9. Del Fabbro M, Testori T, Francetti L, Weinstein R. Systematic review of survival rates for implants placed in the grafted maxillary sinus. Int J Periodontics Restorative Dent 2004;24:565–577.
10. van der Mark EL, Bierenbroodspot F, Baas EM, de Lange J. Reconstruction of an atrophic maxilla: Comparison of two methods. Br J Oral Maxillofac Surg 2011;49:198–202.
11. Krekmanov L. A modified method of simultaneous bone grafting and placement of endosseous implants in the severely atrophic maxilla. Int J Oral Maxillofac Implants 1995;10:682–688.
12. Soehardi A, Meijer GJ, Hoppenreijs TJ, et al. Stability, complications, implant survival, and patient satisfaction after Le Fort I osteotomy and interposed bone grafts: Follow- up of 5-18 years. Int J Oral Maxillofac Surg 2015;44:97–103.
13. Watzinger F, Ewers R, Millesi W, et al. Horseshoe Le Fort I osteotomy in combination with endosteal implants--a median-term follow-up study. Int J Oral Maxillofac Surg 1996;25:424–429.
14. Kahnberg KE, Vannas-Löfqvist L. Maxillary osteotomy with an interpositional bone graft and implants for reconstruction of the severely resorbed maxilla: A clinical report. Int J Oral Maxillofac Implants 2005;20:938–945.

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15. Pieri F, Lizio G, Bianchi A, Corinaldesi G, Marchetti C. Immediate loading of dental implants placed in severely resorbed edentulous maxillae reconstructed with Le Fort I osteotomy and interpositional bone grafting. J Periodontol 2012;83:963–972.
16. Rasmusson L, Thor A, Sennerby L. Stability evaluation of implants integrated in grafted and nongrafted maxillary bone: A clinical study from implant placement to abutment connection. Clin Implant Dent Res 2012;14:61–66.
17. Ferri J, Dujoncquoy JP, Carneiro JM, Raoul G. Maxillary reconstruction to enable implant insertion: A retrospective study of 181 patients. Head Face Med 2008;4:1–9.
18. Sjöström M, Sennerby L, Nilson H, Lundgren S. Reconstruction of the atrophic edentulous maxilla with free iliac crest grafts and implants: A 3-year report of a prospective clinical study. Clin Implant Dent Relat Res 2007;9:46–59.
19. Yerit KC, Posch M, Guserl U, et al. Rehabilitation of the severely atrophied maxilla by horseshoe Le Fort I osteotomy (HLFO). Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97:683–692.
20. Lekholm U, Wannfors K, Isaksson S, Adielsson B. Oral implants in combination with bone grafts. A 3-year retrospective multicenter study using the Brånemark implant system. Int J Oral Maxillofac Surg 1999;28:181–187.
21. Stoelinga PJ, Slagter AP, Brouns JJ. Rehabilitation of patients with severe (Class VI) maxillary resorption using Le Fort I osteotomy, interposed bone grafts and endosteal implants: 1-8 years follow-up on a two-stage procedure. Int J Oral Maxillofac Surg 2000;29:188–193.
22. Keller EE, Tolman DE, Eckert S. Surgical-prosthodontic reconstruction of advanced maxillary bone compromise with autogenous onlay block bone grafts and osseointegrated endosseous implants: A 12-year study of 32 consecutive patients. Int J Oral Maxillofac Implants 1999;14:197–209.
23. Muñoz-Guerra MF, Naval-Gías L, Capote-Moreno A. Le Fort I osteotomy, bilateral sinuslift, and inlay bone-grafting for reconstruction in the severely atrophic maxilla: A new vision of the sandwich technique, using bone scrapers and piezosurgery. J Oral Maxillofac Surg 2009; 67:613–618.
24. Li KK, Stephens WL, Gliklich R. Reconstruction of the severely atrophic edentulous maxilla using Le Fort I osteotomy with simultaneous bone graft and implant placement. J Oral Maxillofac 1996;54:542–546.
25. Clayman L. Implant reconstruction of the bone-grafted maxilla: Review of the literature and presentation of 8 cases. J Oral Maxillofac Surg 2006;64:674–682.
26. Li KK, Stephens W. Fractures of the atrophic, edentulous maxilla during Le Fort I osteotomy. Int J Oral Maxillofac Surg 1996;25:430–432.
27. Muñoz-Guerra MF, Naval-Gías L, Capote-Moreno A. Le Fort I osteotomy, bilateral sinus lift, and inlay bone-grafting for reconstruction in the severely atrophic maxilla: A new vision of the sandwich technique, using bone scrapers and piezosurgery. J Oral Maxillofac Surg 2009;7:613–618.
28. Cawood JI,Stoeling PJ, Brouns JJ. Reconstruction of the severely resorbed (Class VI) maxilla. A two-step procedure. Int J Oral Maxillofac Surg 1994;23:219–225.
29. Isaksson S, Ekfeldt A, Alberius P, Blomqvist JE. 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 OralMaxillofac Surg. 1993;22:144–148.

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