Digital Rehabilitation of Severe Post-Traumatic Anterior Alveolar Ridge Deficiency Using Customized Patient-Specific Implants: A Case Report

Abstract

Background: Rehabilitation of anterior maxillary and mandibular teeth loss with severe alveolar ridge deficiency is a major dental challenge. Endosseous implants require sufficient bone volume, but post-traumatic ridge defects often need staged ridge augmentation before implant placement. Patient specific implants (PSI) offer an alternative by bypassing grafting and shortening rehabilitation time.

Materials and Methods:

A 26-year-old male with pan-facial fracture 6 months prior, treated conservatively, presented with missing maxillary and mandibular anterior teeth. Clinical and radiographic exams revealed severe horizontal and vertical alveolar ridge deficiency with inadequate bone for endosseous implants.

Results:

Customized PSIs provided a promising alternative for severe post-traumatic alveolar ridge defects where endosseous implants are unfeasible, enabling immediate or early fixed rehabilitation.

Keywords: Patient specific implant, PSI, alveolar ridge deficiency, rehabilitation, ridge augmentation, endosseous implant.

Introduction

High-velocity facial trauma often causes extensive teeth and alveolar bone loss, complicating rehabilitation which requires multidisciplinary planning. Endosseous implants need adequate bone volume for osseointegration.3 Severe horizontal and vertical ridge deficiencies typically require staged augmentation like autogenous grafts, guided bone regeneration, distraction osteogenesis, or block grafting. These procedures increase treatment time, morbidity, cost, and discomfort.1

Digital planning and additive manufacturing now enable customized titanium PSIs designed to fit the patient's alveolar anatomy and basal facial skeleton, avoiding extensive augmentation and shortening treatment duration.2

Case Description:

A 26-year-old male presented with missing maxillary and mandibular anterior teeth and difficulty chewing after a road traffic accident-causing pan-facial trauma treated conservatively. Patient’s consent was taken for the further treatment. Extraoral exam showed healed scars without asymmetry. Intraoral exam revealed:

- Missing maxillary and mandibular anterior teeth
- Severe horizontal and vertical alveolar ridge deficiency
- Thin, knife-edge ridges in maxilla and mandible
- Right side scissor molar bite

Patient prioritized fixed replacement with shortest treatment time.

Fig 1: Pre-operative intraoral photograph showing edentulous anterior maxillary and mandibular ridge with sever horizontal and vertical alveolar deficiency.

Radiographic Examination:
CT scan showed severe vertical and horizontal alveolar ridge loss, inadequate bone for endosseous implants, and healed fractures with no active pathology.

Treatment Options Discussed:

- Tooth-supported fixed partial denture (FPD)
- Guided bone regeneration with staged endosseous implant
- Removable prosthesis
- Customized PSI

Patient declined bone augmentation and FPD due to prolonged treatment, donor site morbidity, multiple surgeries, delayed aesthetics, and harm to natural teeth.

Materials and Methods

Patient Assessment:
Clinical and radiographic evaluation included a high-resolution CT scan for residual bone volume and intraoral optical scan for mucosal and dentition registration. DICOM and STL data were merged via virtual surgical planning software to create a 3D virtual skull model.2

Virtual Surgical Planning and Implant Design:
PSIs were designed to adapt to facial skeletal pillars:

- Maxillary implant with fixation wing to anterior maxilla and nasal spine, two transmucosal posts for prosthesis support.
- Mandibular implant with inverted Y shape fixed to mandibular symphysis, two transmucosal posts for prosthesis.

Fabrication:

Implants fabricated from medical-grade Ti-6Al-4V using selective laser melting (SLM). A full-scale stereolithographic (STL) bio model was 3D printed for trial fitting, confirming perfect bone adaptation and prosthetic positioning.2,5

The prosthesis was cement-retained zirconia with roughened abutment surfaces for mechanical retention and polished submucosal implant surfaces to minimize plaque and promote soft tissue health.

Fig 2: 3D-printed stereolithographic bio-model demonstrating trial fit and adaptation of maxillary and mandibular patient-specific implants on the skeletal framework.

Surgical Procedure:

Under general anaesthesia, full-thickness flaps raised exposing boneDuring elevation of the palatal mucoperiosteal flap, the incision was intentionally placed slightly palatal to the alveolar crest, with anterior extension into the incisive region, rather than directly over the crest. This approach was adopted to preserve the integrity of the crestal tissues and facilitate adequate soft tissue coverage of the patient-specific implant (PSI). Two small perforations were created in the palatal flap to allow passive accommodation of the vertical abutment components of the PSI.

During flap adaptation, inadvertent tearing of the palatal flap occurred around the perforation sites, resulting in partial loss of the flap margin and preventing tension-free primary closure. To reconstruct the soft tissue defect, a free gingival graft was harvested and secured over the exposed area. Although the graft demonstrated partial survival, incomplete graft takes resulted in persistent exposure of a limited area of the roughened abutment surface. The patient was managed conservatively with regular clinical follow-up for one month. Throughout the observation period, no clinical evidence of implant mobility, infection, peri-implant inflammation, or other biological complications was observed. However, complete epithelialization of the exposed surface was not achieved.

After one month, the intervening soft tissue bridge was surgically excised to establish a definitive prosthetic emergence profile. During the prosthetic phase, the residual palatal metal framework exposure was effectively masked by extending the palatal contour of the definitive prosthesis using tissue-coloured acrylic resin, thereby restoring soft tissue continuity, improving aesthetics, and facilitating oral hygiene maintenance.

Placement and Fixation:

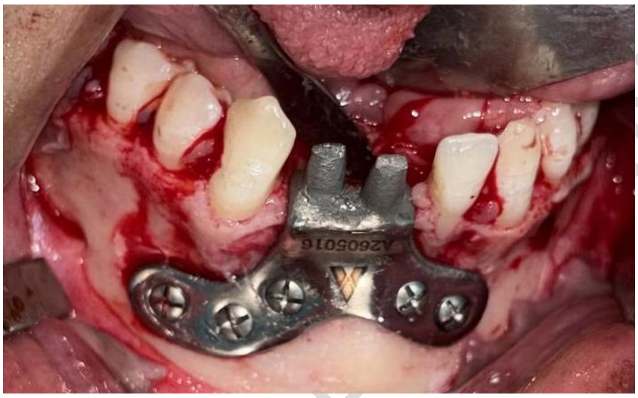

Fig 3: Intra-operative view showing mandibular inverted-Y patient-specific implant rigidly fixed to the symphysis with 2.0mm screws

Fig 4: Intra-operative view showing maxillary patient-specific implant with fixation wing secured to the anterior nasal spine region using 1.5mm screws

Sterile titanium PSIs showed precise self-location fit and were fixed rigidly using 1.5 mm screws in maxilla and 2.0 mm screw in mandible through predesigned holes.

Flaps were repositioned and sutured around transmucosal posts with resorbable sutures.

Results:

Fig 5: Occlusal view of definitive cement-retained zirconia prosthesis

Fig 6: Intra-oral view of definitive prosthesis

PSIs showed excellent adaptation and stable primary fixation without intraoperative modification. Healing was uneventful except localized palatal flap dehiscence. Despite partial graft survival and soft tissue exposure, no infection, implant mobility, or peri-implant inflammation occurred. The exposed area remained healthy. Definitive cement-retained zirconia prostheses with palatal acrylic extensions restored soft tissue contour and aesthetics. At follow-up, the patient had satisfactory function, phonetics, aesthetics, occlusal stability, acceptable hygiene, and no prosthetic or mechanical complications. Patient reported high satisfaction with outcomes.

Discussion

This case highlights successful rehabilitation of severe post-traumatic anterior alveolar ridge deficiency with customized titanium PSIs. Conventional endosseous implants require adequate bone, often necessitating staged augmentation procedures associated with long treatment times, morbidity, and higher costs.1,2,3 Many patients decline these options. Digital advances allow precise virtual planning and CAD/CAM fabrication of customized implants conforming to patient anatomy, reducing intraoperative adjustments and improving surgical and prosthetic precision. Unlike root-form implants, PSIs gain stability from basal cortical bone and skeletal buttresses, making them suitable for severe ridge deficiencies without bone augmentation. The implant design featured roughened transmucosal abutments for cement retention and polished submucosal surfaces to reduce bacterial adhesion and promote soft tissue health, critical for long-term success. Soft tissue management remains challenging. In this case, flap tearing caused dehiscence and partial graft survival, but the implant remained stable with no complications, suggesting limited soft tissue exposure can be managed conservatively with careful hygiene and follow-up. Prosthetic replacement of soft tissue deficiency with tissue-coloured acrylic improved aesthetics and hygiene access. Compared to conventional staged rehabilitation, customized PSIs eliminate bone grafting, reduce surgeries, morbidity, and treatment duration, providing early fixed restoration—important for young trauma patients desiring rapid rehabilitation.8

However, PSIs require advanced planning, precise manufacturing, multidisciplinary collaboration, and careful soft tissue management. Long-term clinical data are limited; further studies are needed to validate survival, tissue stability, and outcomes.

Conclusion

Customized patient-specific titanium implants provide a predictable, minimally invasive alternative for rehabilitating severe post-traumatic anterior alveolar ridge defects when conventional implants are unfeasible. Digital workflows enable precise implant adaptation, stable fixation, and early fixed prosthetic rehabilitation without extensive bone augmentation. Despite soft tissue challenges, implant stability and satisfactory functional and aesthetic results were achieved. Customized PSIs represent a valuable option for selected patients avoiding morbidity and prolonged treatment of conventional augmentation. Larger studies with long-term follow-up are needed to confirm clinical predictability and survival.

REFERENCES

1. (lorencin, 2024)Albash Z, Hnaino E, Khalil A. Dental implant placement with simultaneous localized ridge augmentation using L-shaped titanium mesh in the esthetic zone: a case report. J Surg Case Rep [Internet]. 2024;2024(3):rjae185. Available from: http://dx.doi.org/10.1093/jscr/rjae185
2. Digital workflow for customized titanium subperiosteal implants in atrophic jaws. Clin Implant Dent Relate Res [Internet]. 2023;25(3):310–20. Available from: http://dx.doi.org/10.1111/cid.13145
3. Ueda N, Takayama Y, Yokoyama A. Minimization of dental implant diameter and length according to bone quality determined by finite element analysis and optimized calculation. J Prosthodont Res [Internet]. 2017;61(3):324–32. Available from: http://dx.doi.org/10.1016/j.jpor.2016.12.004
4. Reddy MRH, Ummadisingh L, Fatima S. Customised patient-specific implants in maxillofacial reconstruction after mucormycosis: A case series. J Maxillofac Oral Surg [Internet]. 2025;24(4):1115–21. Available from: http://dx.doi.org/10.1007/s12663-025-02656-4
5. Selective laser melting of Ti 6Al 4V for patient specific craniofacial implants. J Biomed Mater Res B Apl Biomatter [Internet]. 2020;108(5):2105–14. Available

from: http://dx.doi.org/10.1002/jbm.b.345672020;108(5):2105–14. Available from: http://dx.doi.org/10.1002/jbm.b.345676

6. Kim Y-K, Ku J-K. Guided bone regeneration. J Korean Assoc Oral MaxillofacSurg [Internet]. 2020;46(5):361–6. Available from: http://dx.doi.org/10.5125/jkaoms.2020.46.5.361
7. Brás VM. Patient Specific Implant – A reliable alternative to atrophic maxillas. J Dent Oral Sci [Internet]. 2020; Available from: http://dx.doi.org/10.37191/mapsci2582-3736-3(1)-068
8. Korn P, Gellrich N-C, Jehn P, Spalthoff S, Rahlf B. A new strategy for patient-specific implant-borne dental rehabilitation in patients with extended maxillary defects. Front Oncol [Internet]. 2021;11:718872. Available from: http://dx.doi.org/10.3389/fonc.2021.718872