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Case Report

From atrophy to accuracy: A breakthrough in maxillary reconstruction

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Abstract

Bone resorption with age presents challenges in treating edentulous patients, as even perfectly crafted Removable Partial Dentures (RPD) often fail over time. Prefabricated dental implants, while preferred, fall short of addressing significant bone loss and individual needs in cases like hypoplastic or edentulous maxillae. Patient-specific implants (PSIs) overcome these limitations, offering zero-nil accuracy and unmatched precision. This case report explores our experience using PSIs in a hypoplastic and edentulous maxilla, focusing on detailed preoperative diagnosis, precise surgical techniques, and evaluating postoperative outcomes, including patient satisfaction.

Keywords: Maxillary atrophy, Edentulous maxilla, Bone loss, Patient-specific implants, Osseointegration, Maxillary reconstruction, Implant rehabilitation

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1. Introduction

An atrophic maxilla results from bone loss in the upper jaw due to factors like aging, tooth loss, periodontal disease, and sinus enlargement, complicating implant placement.

Traditional techniques like bone grafting, sinus lifting, and ridge augmentation rely on a two-stage surgical protocol, which is intricate and prone to complications. Prefabricated implants often lack stability, demand extensive adjustments, and perform poorly in severe atrophy, trauma, or post-tumour cases, emphasizing the need for customized solutions.

Patient-specific implants (PSI) in maxillofacial surgery are meticulously custom–designed implants relative to the unique and specific anatomical variation of each patient. These are different from prefabricated conventional implants in providing an unequivocally ideal fit, distinctive to each patient, and are considered to be very useful in complex cases with bone loss and structural deficiencies that cannot be successfully addressed with conventional implant techniques.[1]

This case report features a patient with an atrophic maxilla, which was successfully managed using Patient-Specific Implants (PSI), leveraging advanced imaging and customization to address the unique anatomical challenges, ensuring optimal functional and aesthetic outcomes.

2. Case Presentation

A 46-year-old male patient presented to the Oral and Maxillofacial Surgery (OMFS) Outpatient Department (OPD) with a chief complaint of missing teeth in relation to the maxillary right posterior region for the past 1.5 years. The patient had no relevant possibly complicating medical history, any known allergies, or bleeding disorders. The patient had undergone a therapeutic extraction a year ago in relation to the right upper posterior region.

On general examination, the patient appeared conscious and coherent and well-oriented with time and place, vitals appeared to be stable.

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Figure 1: Intraoral view highlighting adequate mouth opening, poor oral hygiene, and gingival recession. Partial edentulism in relation to the maxillary right posterior region is encircled

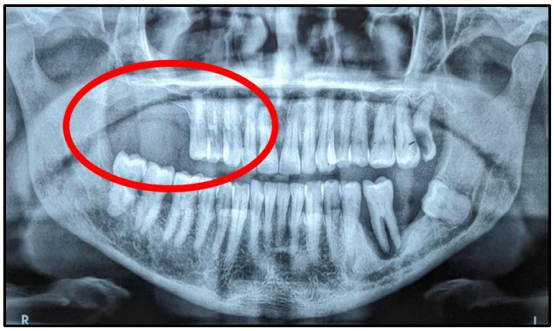

Figure 2: Preoperative Orthopantomogram (OPG) highlighting the region of severe maxillary atrophy with partial edentulism in the right maxillary posterior region.

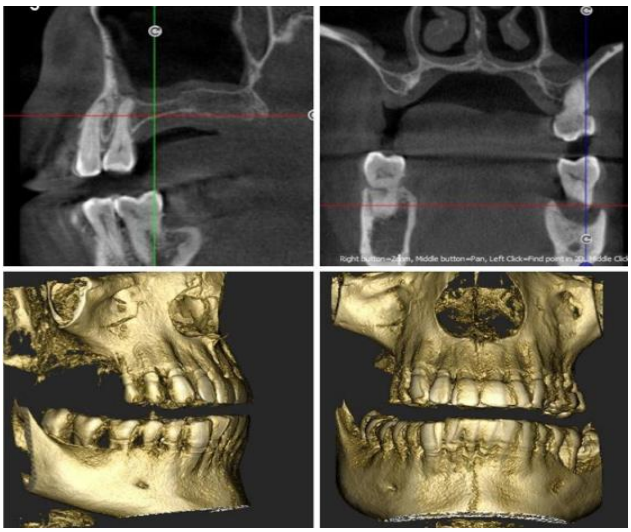

Figure 3: High-resolution computed tomography (HRCT) in coronal and sagittal sections (highlighted in yellow) along with a 3D-reconstructed HRCT image (highlighted in red), depicting extensive bone resorption and anatomical constraints for conventional implant placement.

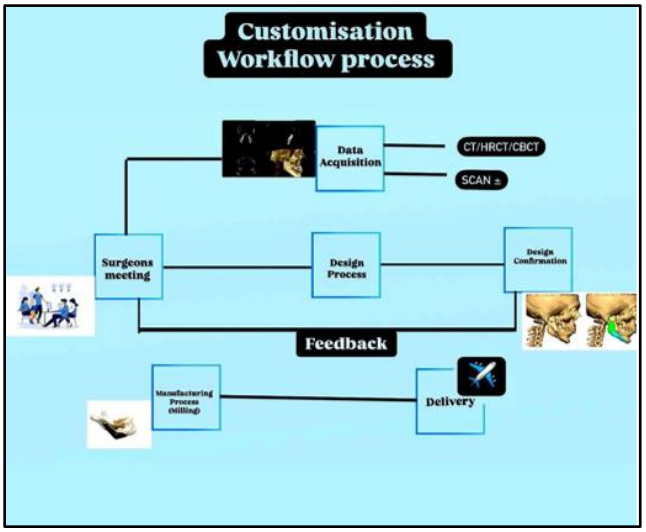

Figure 4: Depicts workflow for the digital planning and fabrication of patient-specific implants using CTARS technology.

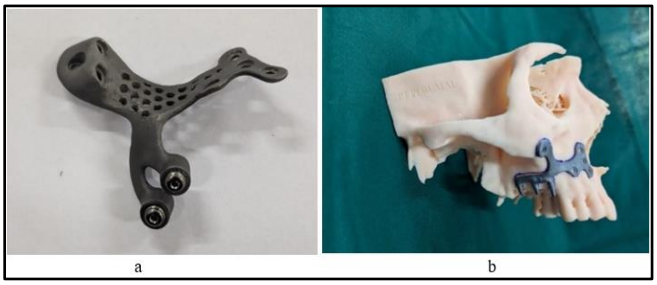

Figure 5: Titanium PSI design with **endosseous support** (a) Isolated view, (b) Trial fit on stereolithographic maxillary model.

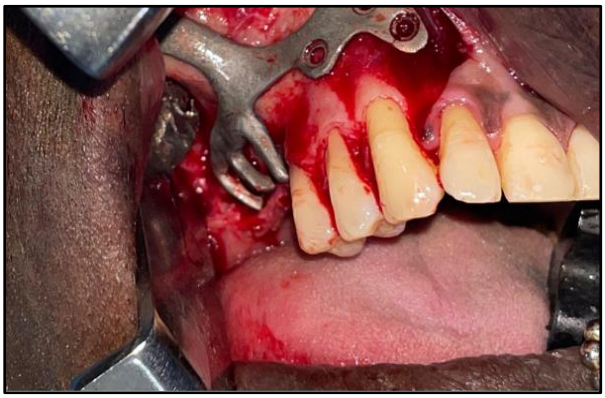

Figure 6: Depicts bone trimming performed in the right posterior maxillary region, using an alveolar platform guide.

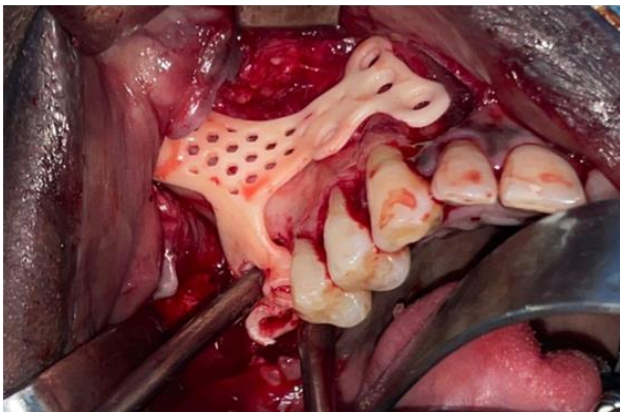

Figure 7: Shows the placement of the patient-specific implant (PSI) template following position verification in the right posterior maxillary region.

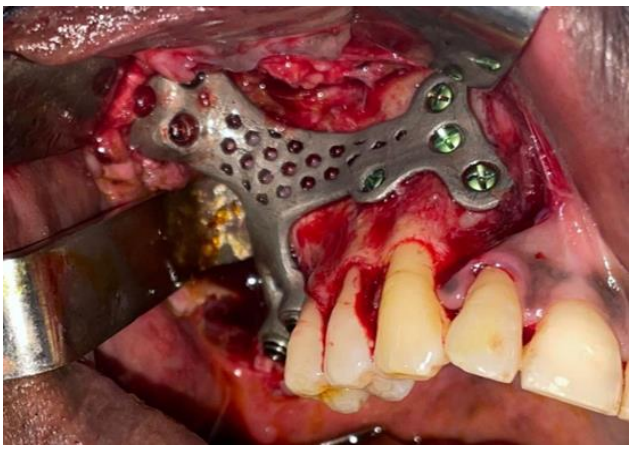

Figure 8: Visualises the patient-specific implant (PSI) positioned in the right posterior maxilla and stabilized using titanium screws

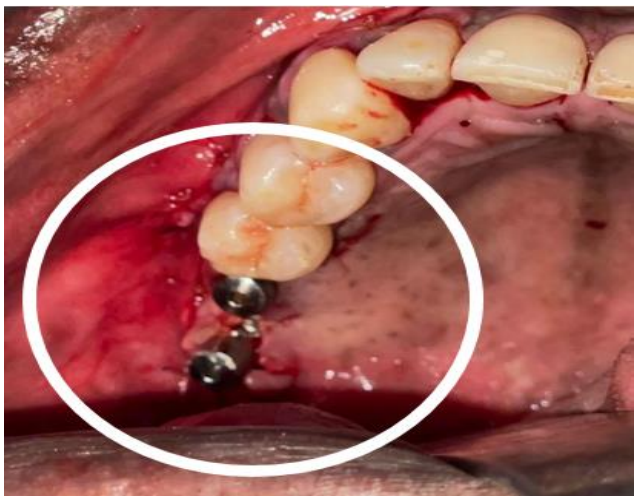

Figure 9: Depicts the final stabilization of the patient-specific implant (PSI) with a healing abutment in the right posterior maxilla.

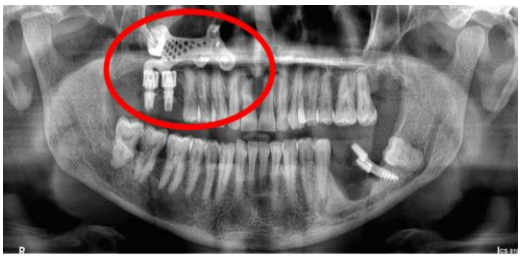

Figure 10: Postoperative orthopantomogram (OPG) highlighting successful osseointegration of the patient-specific implant (PSI) in the right posterior maxillary region.

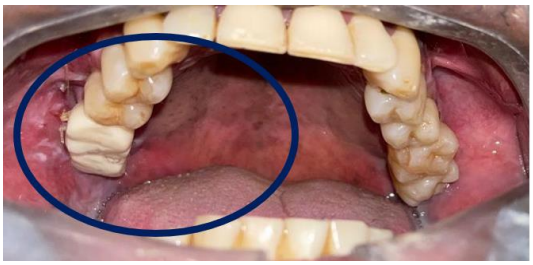

Figure 11: Postoperative intraoral picture depicts successful prosthetic rehabilitation in the posterior maxillary region after the patient-specific implant (PSI) placement.

Extraoral evaluation revealed no evident facial asymmetry, with bilateral temporomandibular joint functions appearing normal. On intraoral examination, the patient demonstrated adequate mouth opening; however, oral hygiene maintenance was significantly compromised. Generalized gingival recession was observed, along with partial edentulism in relation to the 16, 17 regions. The mandibular occlusal plane and dentition appeared intact and properly aligned. (**Figure 1**)

Soft tissue examination revealed no ulceration or erythema. The patient was subjected to thorough radiological investigations, including Orthopantomogram (OPG) (**Figure 2**) and High-Resolution Computed Tomography (HRCT). (**Figure 3**) All routine blood and biochemical tests were performed concurrently, yielding results within the normal range. The patient was thoroughly informed about treatment options, including Conventional Dental Implants, Zygomatic Implants, and Patient-Specific Implants (PSIs). After consideration, the patient opted to go with PSIs.

The patient was then educated about the suitability and advantages of patient-specific implants (PSIs), highlighting their precision and ease of application, particularly for addressing the atrophic maxilla as in his case. Following a comprehensive evaluation of all relevant factors, a treatment plan was designed to incorporate patient-specific implants for the rehabilitation of the right posterior maxilla. The patient was advised oral prophylaxis and had undergone procedural oral prophylaxis prior to the treatment. After rigorous radiological analysis using OPG and HRCT, patient-specific implants were customized for the patient's atrophic posterior maxilla.These implants were fabricated using titanium—a

material renowned for its exceptional biocompatibility and durability, making it a cornerstone in prosthetic development since its early use enabling precision and customization for both medical and dental applications. The manufacturing process was supported by advanced technology and specialized software from the Centre for Technology-Assisted Reconstructive Surgery (CTARS), enabling precision and customization. (**Figure 5**)

Considering the protocols for the fabrication of Patient-Specific Implants, we proposed custom-designed maxillary implants featuring an innovative design that incorporates endosseous support zones to facilitate optimal osseointegration and enhance implant stability**.** (**Figure 5**)

2.1. Surgical procedure

Routine investigations were completed, and the reports were obtained. Anaesthesia fitness was assessed, and the patient was classified as ASA II (American Society of Anaesthesiologists Physical Status Classification System), making him suitable for surgery under general anaesthesia.

Under aseptic conditions, right naso-endotracheal intubation was performed, and general anaesthesia was successfully induced and maintained. The patient was prepared, following standard surgical painting and draping protocols. Local anaesthesia was administered by infiltrating 2% lignocaine with adrenaline into the right buccal vestibule.

A crevicular incision was performed with a No. 15 blade, from the 12-15 region and was extended as an anterior releasing incision distal to 12. The mucoperiosteal flap was elevated using a No. 9 Molt's periosteal elevator, providing a clear view of the right pyriform rim, the right zygomatic body, and the right zygomatic buttress region.

Using a guide for alveolar platform creation, bone trimming was performed with a 701 bur**.** (**Figure 6**) After verifying its position, a patient-specific implant (PSI) template was placed (**Figure 7**) The implant was inserted into the right posterior maxilla and secured with titanium screws for stable fixation. Specifically, two screws (2.0 mm x 6 mm) and four screws (2.0 mm x 8 mm) were placed in the posterior maxillary region**.** (**Figure 8**)

Throughout the procedure, thorough irrigation with betadine and saline was performed. Periosteum scoring was completed to enhance tissue adaptation. Cover screws were removed, and healing abutments were placed into the implant slots**.** (**Figure 9**) The site was irrigated again to ensure optimal cleanliness before securely closing the surgical area with 3-0 monocryl sutures. This marked the successful completion of the surgery.

The patient was prescribed routine postoperative analgesics and antibiotics for five days and advised to follow up at the OMFS Outpatient Department after one week.

During the follow-up visit, the healing abutments were reviewed and removed, and the prosthetic phase was initiated. (**Figure 10**)

Soft tissue adaptation and implant platform integrity were verified. Following initial healing, the patient-specific implant (PSI) framework was placed, and the abutment was separately connected to ensure precise fit and optimal load distribution, a practice that enhances biomechanical efficiency. A custom impression was taken to accurately capture peri-implant soft tissue contours, facilitating the fabrication of a cement-retained metal ceramic crown. Although PSIs are compatible with both cement- and screw-retained restorations, a cement-retained option was chosen in this case due to favorable implant angulation and the high esthetic demands of the region, as it eliminates visible screw access holes. The crown was luted using a Resin-Modified Glass Ionomer Cement (RMGIC), and excess cement was carefully removed to prevent peri-implantitis, as residual cement is a known risk factor for such complications. This approach optimized passive fit, esthetics, and functional stability.[3]This marked the successful completion of the PSI-based rehabilitation, restoring both function and aesthetics. (**Figure 11**)

3. Discussion

The atrophic maxilla, characterized by significant bone loss, poses challenges for traditional implant placement. Alexandre Amir Aalam et al. emphasize that multiple factors must be evaluated to determine appropriate treatment options for atrophic maxillae.[4]

Ramninder Bawa et al. have elaborated on the significance and versatility of Maxillofacial Patient-Specific Implants and how PSIs address both reconstructive and aesthetic needs. These implants correct volume loss, deformities, and asymmetries while supporting procedures such as trauma reconstruction, osteotomies, orthognathic surgeries, and Temporomandibular Joint (TMJ) replacements. PSIs are particularly advantageous for patients with unsatisfactory outcomes from conventional implants or unique contour defects.[5]

Even though titanium implants have been used solemnly as a trustworthy novel source, newer materials have also come to stabilize the PSI field as preference for PSIs increases from day to day. Secondary to Ti, cobalt-chromium (Co-Cr) are used owing to their increased wear resistance but are evidently less biocompatibility appealing. Zirconia (Zr), which is highly preferred for radiolucent dental prostheses, is used but as an optional material since it's very brittle and cannot sustain load-bearing stress. PEEK is also a radiolucent synthetic material biocompatibility similar to bone but not commonly used in dentistry. Other bioresorbable materials like polycaprolactone are used as temporary implants and their strength is lower and are not indicated for complex cases. Bioactive glass is a recent one which integrates with

the natural bone and is also of use in low stress-bearing areas.[6]

Designed with advanced imaging technologies like 3D imaging, high-resolution computed tomography (HRCT), or cone-beam computed tomography (CBCT), PSIs achieve a precise fit customized to individual anatomy. This precision enhances stability, reduces grafting requirements, and facilitates the rehabilitation of complex cases, marking a significant advancement in implantology.[7]

CAD/CAM technology has further improved PSIs by enabling rapid, customized implant design and fabrication. These advancements allow for single-stage reconstruction, minimize donor site morbidity, and bring implantology closer to providing ideal patient-specific solutions.[8]

Esposito et al. highlights the potential of PSIs in treating the atrophic maxilla. Their work explores immediate or early loading protocols to reduce treatment time and stresses the importance of long-term follow-up to identify complications such as sinusitis. Similarly, Jehn et al. report favourable therapeutic outcomes with PSIs, noting their comparable effectiveness to conventional implants in improving Oral Health-Related Quality Of Life (OHRQoL).[9-10]

Since PSIs have been introduced recently, long-term clinical data remains limited, highlighting the need for further research. Comparative trials should assess their efficacy, particularly in cases of severely atrophic maxillae and as retainers for obturators in maxillectomy patients. Such studies will be crucial in establishing PSIs as a viable alternative to traditional bone augmentation techniques.[11]

By eliminating intraoperative modifications, enhancing accuracy, and accelerating recovery, PSIs revolutionize implantology. Their customization, functionality, and aesthetic integration offer superior support, retention, and durability, making them an advanced alternative to conventional implants.

4. Conclusion

Edentulism, whether partial or complete, poses a significant challenge, especially in an era where both aesthetics and functionality are prioritized. As demand for personalized treatments rises, Patient-Specific Implants (PSIs) offer a precise solution in surgical implantology. Unlike traditional implants, PSIs address issues like poor bone quality and density, providing a precise fit for patients with bone loss. Utilizing advanced imaging technologies like CBCT/HRCT and 3D printing, PSIs are custom-designed for optimal biomechanical integration, enhancing both functionality and aesthetics. This innovative approach represents a major advancement in surgical implantology.

5. Conflict of Interest Statement

None.

6. Funding Statement

None.

7. Ethical Approval & Patient Consent

All clinical images included in this report are fully anonymized and do not reveal the patient's identity. However, informed patient consent was obtained, ensuring compliance with ethical standards.

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