Indian Journal of Otolaryngology and Head & Neck Surgery (2026) 78:289–296
https://doi.org/10.1007/s12070-025-06123-x

ORIGINAL ARTICLE

Clinical and Functional Outcomes of ZIP Flaps in Oral Squamous Cell Carcinoma

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Received: 14 May 2025 / Accepted: 18 September 2025 / Published online: 18 October 2025

Abstract

To evaluate the clinical outcomes and feasibility of the Zygomatic Implant Perforated (ZIP) flap technique for the primary reconstruction of Brown Class 2 maxillary defects in oral squamous cell carcinoma (OSCC), focusing on early dental rehabilitation, flap viability, and long-term quality of life. This retrospective study was conducted at Sri Shankara Cancer Hospital, Bangalore, from January 2023 to June 2024. Five patients—four with primary OSCC and one with a secondary defect—underwent infrastructure maxillectomy with immediate reconstruction using a radial forearm free flap combined with zygomatic implant placement. Virtual surgical planning sessions guided resection margins and implant positioning. A temporary prosthesis was placed intraoperatively and replaced with a definitive one after completion of adjuvant therapy. Quality of life was assessed using the UW-QOL v4 questionnaire at 1, 6, and 24 months. All flaps survived with no need for re-exploration. The facial artery and cephalic vein were the most commonly used recipient vessels. The four primary OSCC cases underwent timely radiation and achieved successful prosthetic integration. The secondary case experienced an orbital floor breach, which was later repaired with titanium mesh. UW-QOL scores showed consistent improvement across functional and psychosocial domains, with most patients achieving near-complete recovery by 24 months. No cases of peri-implantitis or donor site morbidity were noted. The ZIP flap technique is a reliable option for single-stage reconstruction of low-level maxillary defects, enabling early fixed dental rehabilitation with sustained functional and aesthetic outcomes. Its use is best reserved for non-irradiated, primary cases, where vascular integrity and tissue quality support optimal results.

Keywords Maxillary defect · Oral squamous cell carcinoma · ZIP flap · Zygomatic implant · Reconstructive surgery · Head and neck cancer

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Introduction

Oral squamous cell carcinoma (OSCC) involving the maxilla comprise less than 6% of all head and neck cancers, yet they present significant challenges in terms of resection and reconstruction due to their anatomical complexity and functional implications [1]. Among these, Brown Class 1 and 2 defects are the most frequently encountered, with Class 2 defects extending superiorly to the infraorbital rim and resulting in oronasal communication, alveolar bone loss, and significant facial deformity [1].

Management of Class 2 maxillary defects has traditionally involved obturators for prosthetic closure or free tissue transfer for structural separation and volume replacement [2, 3]. While both options restore form and function to some extent, the inability of obturators to provide stable long-term outcomes in irradiated or extensive defects remains

a major limitation [4]. Moreover, resection and soft tissue reconstruction alone do not address one of the most critical determinants of post-treatment quality of life—dental rehabilitation.

The Zygomatic Implant Perforated (ZIP) flap, first described by Butterworth et al. in 2017, presents a paradigm shift by combining microvascular free flap reconstruction with simultaneous placement of zygomatic implants to facilitate early prosthetic dental loading [5]. A subsequent series of 35 cases demonstrated that this technique can achieve stable, aesthetic, and functional rehabilitation even in patients requiring postoperative radiotherapy [6]. Despite promising results, the technique remains underutilized, partly due to its technical complexity and the need for seamless integration between surgical and prosthodontic teams.

Reconstruction of low-level maxillary defects must address not only oronasal separation but also the restoration of oral function and aesthetics—goals that are often compromised when dental rehabilitation is delayed or omitted [7]. Concerns regarding flap vascularity, implant exposure, and the feasibility of immediate loading continue to deter widespread adoption of ZIP flaps, particularly in centers without in-house prosthodontic planning or virtual surgical planning (VSP) capabilities [8].

In this article, we present our institutional experience using radial forearm free flaps in combination with zygomatic implants for the reconstruction of Brown Class 2 maxillary defects. We outline the surgical technique, emphasize the intraoperative modifications critical to flap and implant integration, and evaluate long-term outcomes using validated quality-of-life metrics [9].

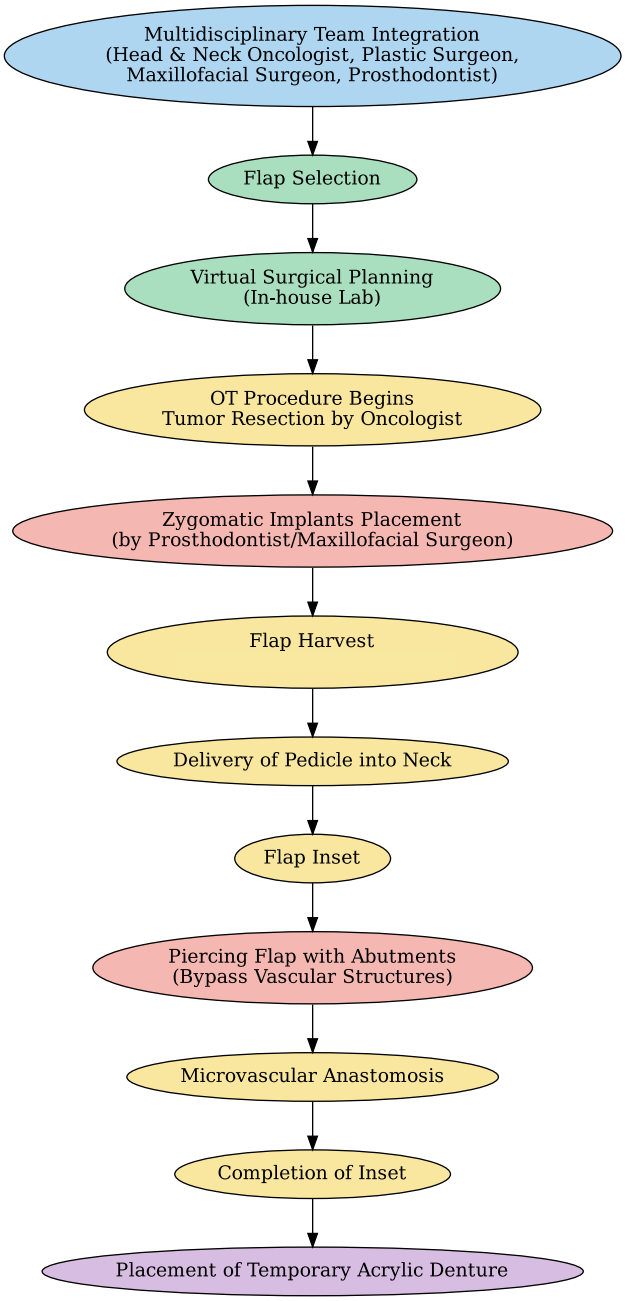

Fig. 1 Workflow of the study

Subjects and Methods

This retrospective study was conducted in the Department of Head and Neck Surgical Oncology at Sri Shankara Cancer Hospital and Research Center, Bangalore, between January 2023 and July 2024. Patients with OSCC requiring infrastructure maxillectomy and expressing a desire for dental rehabilitation were evaluated for ZIP flap reconstruction. The workflow of the study is given in Fig. 1.

Multidisciplinary Workflow

Once the oncological evaluation confirmed the need for infrastructure maxillectomy, a multidisciplinary team comprising a head and neck surgical oncologist, a plastic reconstructive surgeon, and a prosthodontist was assembled. Multiple virtual surgical planning (VSP) sessions were conducted in an in-house VSP lab to develop and refine the surgical plan. Preoperative CT imaging and anatomical considerations guided precise maxillectomy planning and optimal zygomatic implant placement. These collaborative sessions enabled the team to anticipate surgical challenges and optimize outcomes.

Flap Selection and Planning

The radial forearm free flap was selected as the reconstructive option of choice, harvested from the non-dominant forearm. Preoperative Allen's test was used to confirm vascular adequacy of the donor limb. A critical component of

Table 1 Demography of the patients and complications involved

Case	Age	Gender	Diagnosis	Defect (Brown's classification)	Surgery	Arterial anastomosis	Venous anastomosis	Complications
1	45	Male	OSCC	Class 2	Infrastructure Maxillectomy	Facial Artery	Cephalic Vein to EJV, Vena Comitans to IJV	None
2	56	Male	OSCC	Class 2	Infrastructure Maxillectomy	Facial Artery	Cephalic Vein to EJV, Vena Comitans to IJV	None
3	63	Male	OSCC	Class 2	Infrastructure Maxillectomy	Facial Artery	Cephalic Vein to EJV, Vena Comitans to IJV	None
4	51	Female	OSCC	Class 2	Infrastructure Maxillectomy	Facial Artery	Cephalic Vein to EJV, Vena Comitans to IJV	None
5	66	Female	Secondary Reconstruction Post-Infrastructure Maxillectomy)	Class 2	Zygomatic Implant Reconstruction	Superficial Thyroid Artery	Cephalic Vein to EJV, Vena Comitans to IJV	Orbital Floor Injury (Repaired with Titanium Mesh)

Table 2 University of Washington Quality of Life (UW-QOL v4) Composite score of all the patients during first, second and the third follow up

Case	Gender	1 month after surgery	6 months Post-treatment	24 months Post-treatment
1	Male	81.25	87.5	89.58
2	Male	81.25	89.58	91.66
3	Male	81.25	89.58	91.66
4	Female	71.16	89.58	91.66
5	Female	51.16	72.91	79.16

the planning process was ensuring a minimum of 2 cm spacing between implant abutments to avoid compression of the flap vasculature, maintain tissue perfusion, and ensure stable prosthetic integration. The flap was harvested approximately 3 cm wider than the defect to account for the soft tissue compression that occurs during abutment perforation.

Surgical Technique and Inset

After the vascular pedicle was delivered into the neck, the flap was carefully inset into the maxillary defect. Zygomatic implant abutments were then pierced through the flap under direct vision, taking care not to disrupt vascular structures such as the flap pedicle and cephalic vein. This step was crucial to maintaining flap viability. Microvascular anastomosis was performed after abutment placement, and flap viability was confirmed intraoperatively using the prick test.

Prosthetic Rehabilitation

A temporary acrylic prosthesis was placed over the zygomatic implant abutments at the time of reconstruction. This interim denture facilitated early restoration of oral function and aesthetics and was retained during the course of adjuvant radiotherapy. A definitive implant-supported prosthesis was provided approximately 6 months later, following the completion of radiation therapy.

Results

A total of five cases of ZIP flap reconstructions were performed, with a minimum follow-up period of 2 years. Four patients underwent primary surgery for OSCC, all of whom required postoperative radiation therapy. The fifth case involved a secondary reconstruction in a patient who had previously undergone infrastructure maxillectomy 10 years prior and later presented for dental rehabilitation (Table 1).

None of the patients required surgical re-exploration. The most commonly used arterial pedicle was the facial artery. For venous drainage, the cephalic vein was anastomosed to the external jugular vein (EJV), and the vena comitantes of the radial forearm flap pedicle were connected to a tributary of the internal jugular vein (IJV). All four primary OSCC cases had uneventful postoperative courses, completed radiation therapy within the prescribed time frame, and subsequently underwent successful delivery of definitive dental prostheses.

In the secondary reconstruction case, zygomatic implant placement was complicated by an inadvertent breach of the orbital floor. The patient developed enophthalmos, and postoperative imaging confirmed a fracture of the orbital floor. This was corrected 4 months later using titanium mesh reconstruction, which resolved both diplopia and enophthalmos.

University of Washington Quality of Life (UW-QOL v4)

Quality of life was assessed at 1, 6, and 24 months postoperatively using the University of Washington Quality of Life version 4 questionnaire. A progressive and consistent improvement was observed across functional and psychosocial domains for all five patients (Table 2).

At the 1-month postoperative follow-up, the mean UW-QOL score was 73.41. Individual scores ranged from 51.16

to 81.25, with patient 5 (secondary reconstruction) reporting the lowest value. Domains such as chewing, swallowing, and speech showed moderate impairment, while mood, anxiety, and shoulder function remained relatively unaffected.

By the 6-month follow-up, the mean UW-QOL score increased to 85.03. Four patients (patients 1–4) recorded scores of 87.5 or higher, and patient 5 improved significantly to 72.91. Functional domains including chewing and swallowing demonstrated marked recovery, with improved articulation and dietary consistency observed in clinical follow-up.

At 24 months, the mean score further increased to 88.64, indicating stable long-term rehabilitation. Patients 2, 3, and 4 achieved scores of 91.66, reflecting near-complete functional restoration. Patient 1 recorded 89.58, while patient 5 continued to show progressive gains, reaching 79.16, despite the prior orbital floor complication. Mild residual deficits in taste and saliva production were noted in all patients, aligning with expected outcomes post-radiation.

Postoperative quality of life was assessed using the UW-QOL version 4 questionnaire at 1 month, 6 months, and 24 months. Each domain was evaluated and reported as a score from 0 to 100, with higher scores indicating better function or fewer symptoms. The analysis showed progressive improvement across both functional and psychosocial domains.

At the 1-month follow-up, patients experienced moderate impairment in functional domains. The chewing domain had the lowest mean score of 41, reflecting difficulties with mastication immediately post-surgery. Swallowing (mean: 50) and speech (mean: 55) were similarly affected. Taste and saliva had mean scores of 46 and 48, respectively. In contrast, psychosocial domains showed relatively preserved function: mood scored 75, anxiety scored 78, and shoulder function scored 82, indicating minimal impact on psychological well-being or donor site morbidity in the early postoperative period (Fig. 2).

By 6 months, functional scores improved substantially. Chewing rose to a mean score of 72 and swallowing improved to 79. Speech reached 81, showing restoration of oral communication. Taste and saliva also improved (mean: 62 and 68, respectively), although not yet normalized. Psychosocial recovery continued, with appearance, recreation, mood, and anxiety all achieving scores above 85, reflecting enhanced self-image and social reintegration (Fig. 3).

At the 24-month evaluation, near-complete recovery was observed across most domains. Chewing, swallowing, and speech all reached scores above 90 (mean scores: 91, 94, and 92, respectively). Taste and saliva continued to show mild persistent deficits, with mean scores of 74 and 76, respectively, consistent with expected post-radiation effects. Psychosocial domains stabilized with high scores: mood (93), appearance (90), recreation (92), and anxiety

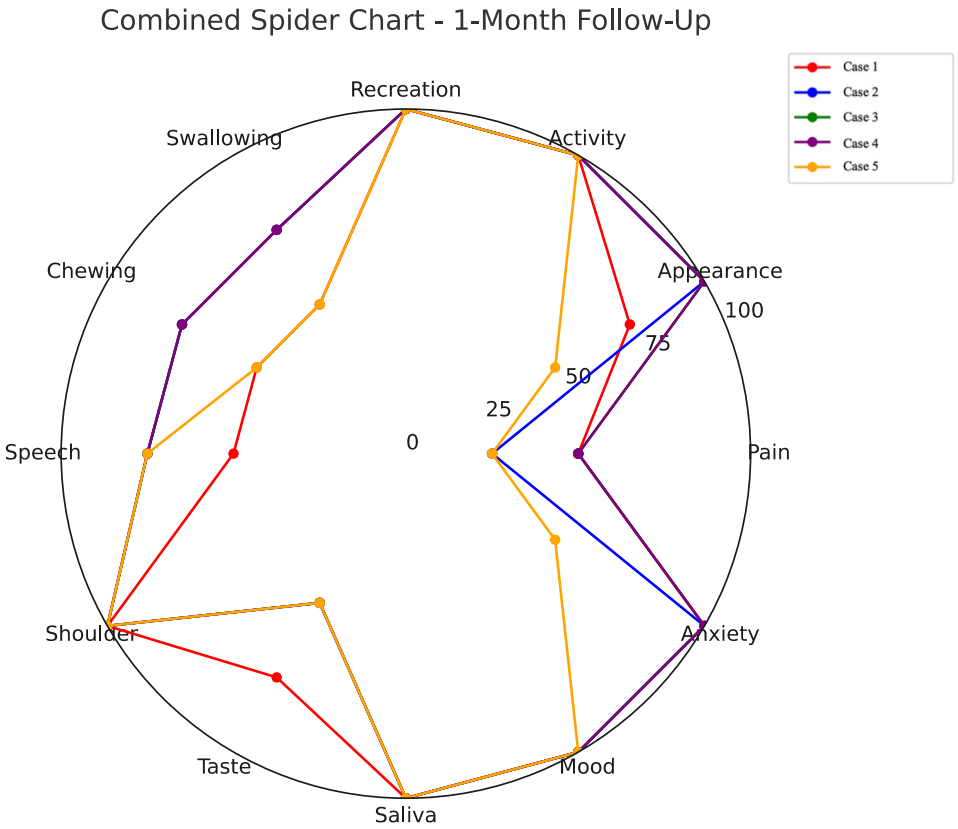

Fig. 2 Spider chart showing all the twelve domains of during University of Washington Quality of Life (UW-QOL v4) first follow-up i.e., 1 month

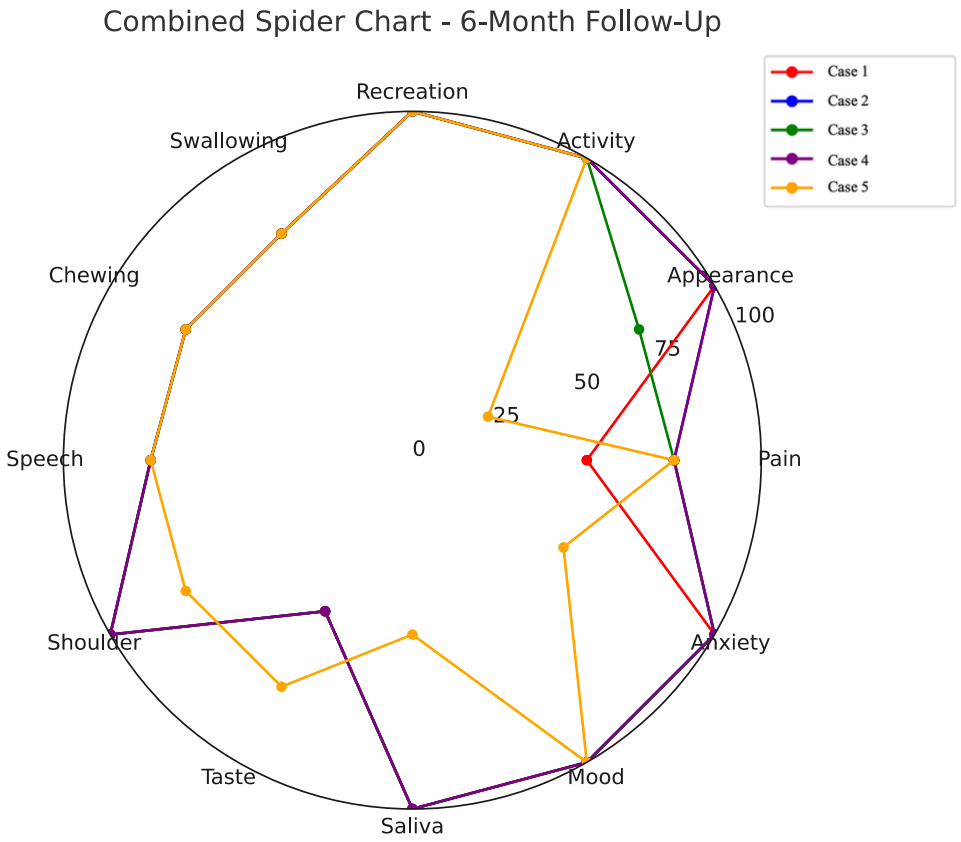

Fig. 3 Spider chart showing all the twelve domains of during University of Washington Quality of Life (UW-QOL v4) second follow-up i.e., 6 months

(94). The shoulder domain remained unaffected throughout (mean: > 90 at all time points), reaffirming minimal donor site morbidity associated with radial forearm flap harvest (Fig. 4).

These domain-wise improvements underscore the effectiveness of the ZIP flap in restoring critical functions such as mastication, speech, and swallowing while maintaining psychological well-being and donor site function. Persistent mild deficits in taste and saliva production were noted, which are commonly reported post-maxillectomy and adjuvant therapy (Figs. 5, 6).

Discussion

Locally advanced maxillary defects, particularly Brown Class 2 defects following infrastructure maxillectomy, present a unique challenge due to their functional and aesthetic complexity. These resections disrupt the oral-nasal interface and often require adjuvant radiotherapy, necessitating a reconstructive strategy that not only achieves defect closure but also enables reliable dental rehabilitation and long-term tissue stability. The ZIP (Zygomatic Implant Perforated) flap technique addresses these critical needs by combining microvascular soft tissue reconstruction with immediate zygomatic implant placement for prosthetic rehabilitation [5].

Traditionally, rehabilitation following maxillectomy involved prosthetic obturation, but this often resulted in poor stability, functional compromise, and significant psychosocial burden—especially in irradiated or large-volume defects [4]. The ZIP flap approach allows for a single-stage solution wherein oronasal separation, soft tissue restoration, and implant integration are achieved concurrently, streamlining the patient's recovery pathway and enabling faster reintegration into daily life [5].

From a reconstructive standpoint, there has been longstanding concern among plastic surgeons about compromising flap vascularity during implant perforation. However, our experience reaffirms that strategic implant spacing (≥2 cm) and a widened flap harvest (3–4 cm beyond the template) preserve perfusion and allow for safe integration of abutments without ischemic complications. This deviates from conventional low maxillary in setting strategies where tight flaps were preferred to avoid redundancy or intraoral tenting [8]. Interestingly, early prosthetic loading using an acrylic denture seems to further stabilize the flap by functioning as an internal stent, reducing the risk of palatal fistula formation—a known complication with infrastructure maxillectomy reconstructions using radial forearm free flaps [6].

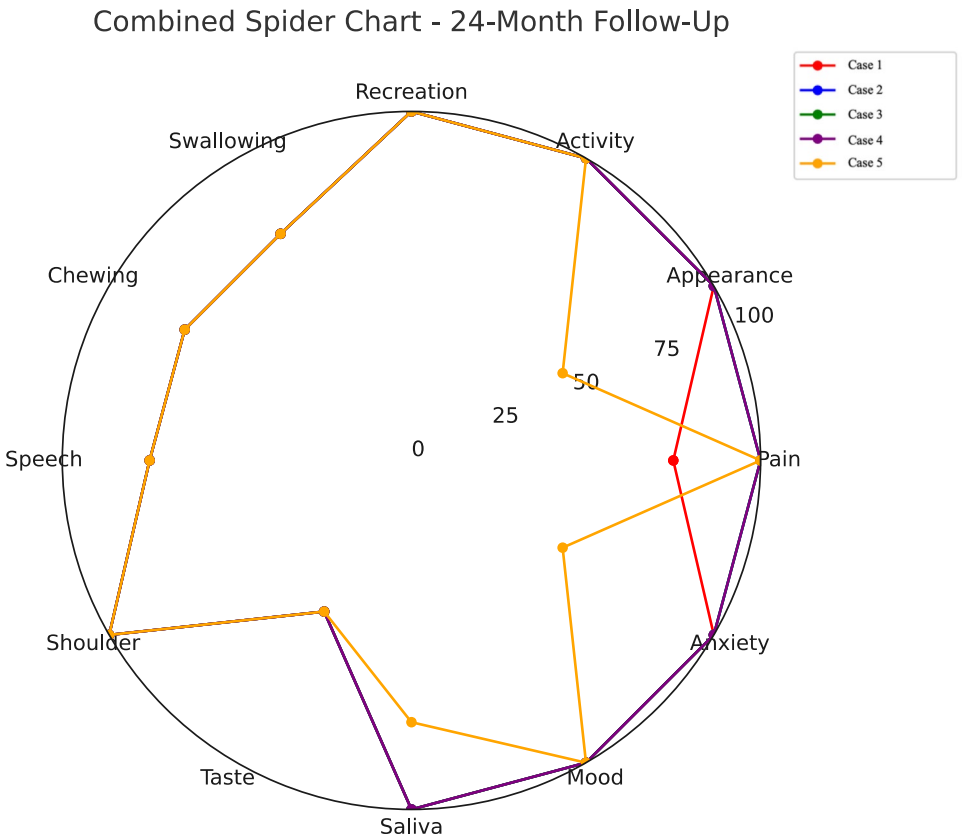

Fig. 4 Spider chart showing all the twelve domains of during University of Washington Quality of Life (UW-QOL v4) third follow-up i.e., 24 months

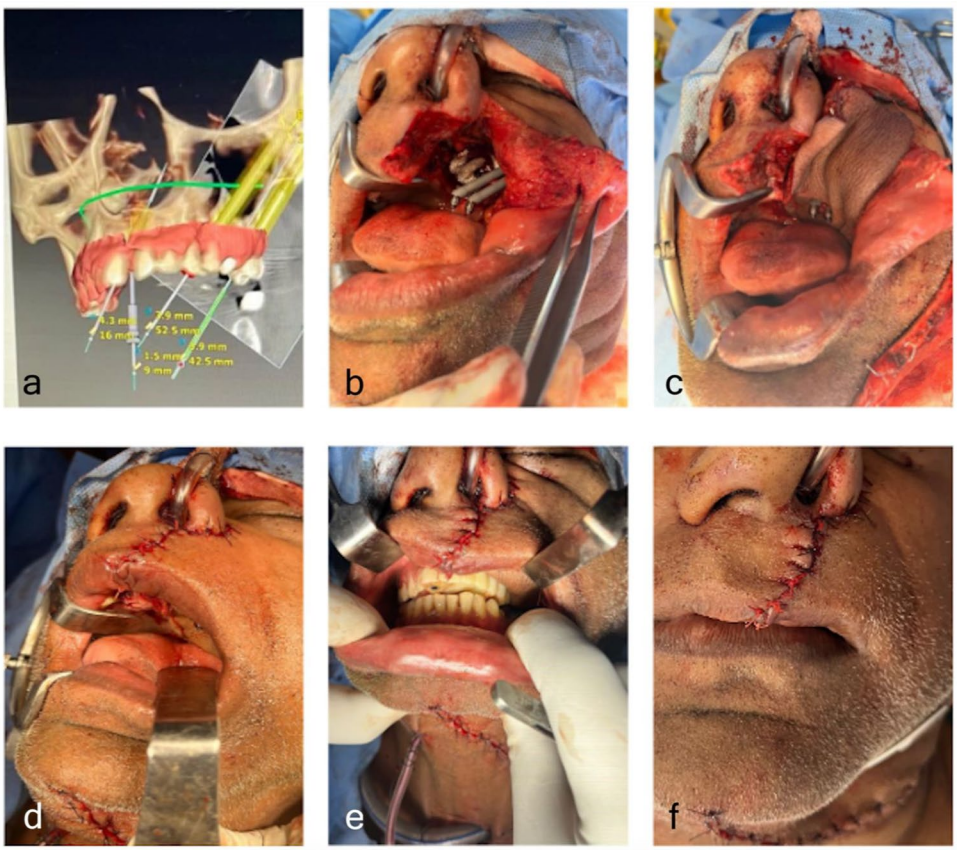

Fig. 5 **a** Virtual surgical planning showing preoperative implant positioning, **b** showing zygomatic implants in situ, **c** showing the Flap pierced with Zygomatic Implants, **d** complete inset of the flap, **e** placement of the acrylic denture over the abutments, showing good occlusion, **f** post operative picture showing good contour after skin closure

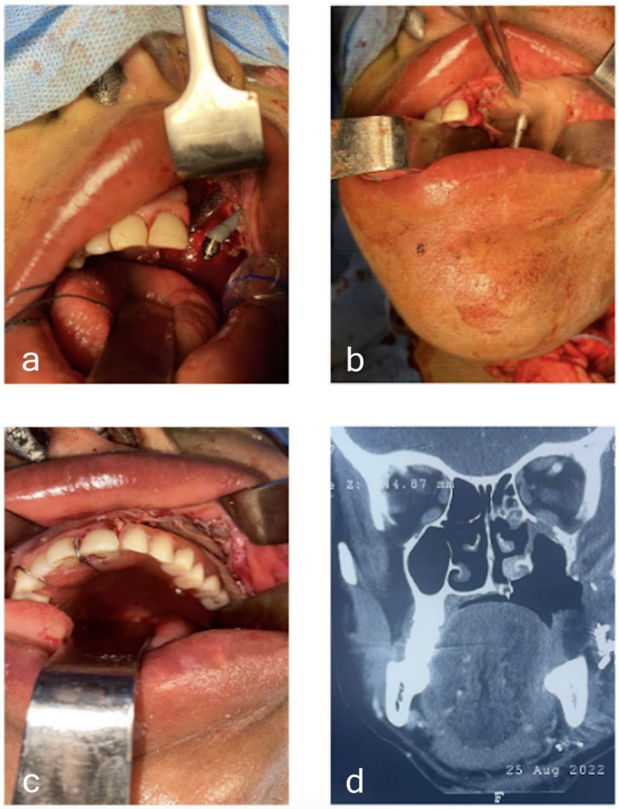

Fig. 6 **a** Showing zygomatic implants insitu, **b** showing the Flap pierced with Zygomatic Implants, **c** placement of the acrylic denture over the abutments, **d** Orbital floor defect noted after Zygomatic implant insertion in a secondary ZIP flap

Among various donor sites, the radial forearm free flap remains our preferred choice due to its thin, pliable skin paddle and long, reliable vascular pedicle, which are particularly advantageous for maxillary reconstruction. Compared to anterolateral thigh (ALT) flaps, which are variable in thickness and perforator-dependent, the radial forearm flap offers a uniform skin thickness, facilitating better contouring, reduced risk of abutment burial, and predictable flap survival [10, 11]. Furthermore, its long pedicle eliminates the need for vein grafting in most cases, simplifying microsurgical execution and reducing operative morbidity (Tables 3, 4).

Table 4 University of Washington Quality of Life (UW-QOL v4) Composite score of all the patients during first, second and the third follow up

Case	Gender	1 month after Surgery	6 months Post-treatment	24 months Post-treatment
1	Male	81.25	87.5	89.58
2	Male	81.25	89.58	91.66
3	Male	81.25	89.58	91.66
4	Female	71.16	89.58	91.66
5	Female	51.16	72.91	79.16

Immediate placement of zygomatic implants at the time of resection and reconstruction has previously been approached with caution in irradiated fields. However, available literature and our own outcomes suggest that with meticulous virtual planning and adequate soft tissue support, osseointegration can be reliably achieved without increased risk of peri-implantitis [5, 6]. All four of our primary cases, despite undergoing postoperative radiotherapy, demonstrated stable integration and successful transition to definitive prostheses without flap or implant-related complications.

The use of a temporary prosthesis, fabricated from radiolucent acrylic, adds functional and psychological benefits by maintaining oral function during radiation therapy and allowing patients to adapt gradually. In addition, it permits intraoperative handling and re-exploration, if needed, without compromising the implant site or soft tissue flap. Its radiolucency ensures it does not interfere with the precision of IMRT planning or delivery [12].

Functional recovery, as measured by the UW-QOL questionnaire, showed steady and predictable improvement. At 1 month, patients exhibited moderate impairment in chewing, speech, and swallowing but maintained stable scores

Table 3 Demography of the patients and complications involved

Case	Gender	Diagnosis	Defect (Brown's classification)	Surgery	Arterial anastomosis	Venous anastomosis	Complications
1	Male	Oral Squamous Cell Carcinoma	Class 2	Infrastructure Maxillectomy	Facial Artery	Cephalic Vein to EJV, Vena Comitans to IJV	None
2	Male	Oral Squamous Cell Carcinoma	Class 2	Infrastructure Maxillectomy	Facial Artery	Cephalic Vein to EJV, Vena Comitans to IJV	None
3	Male	Oral Squamous Cell Carcinoma	Class 2	Infrastructure Maxillectomy	Facial Artery	Cephalic Vein to EJV, Vena Comitans to IJV	None
4	Female	Oral Squamous Cell Carcinoma	Class 2	Infrastructure Maxillectomy	Facial Artery	Cephalic Vein to EJV, Vena Comitans to IJV	None
5	Female	Secondary Reconstruction Post-Infrastructure Maxillectomy)	Class 2	Zygomatic Implant Reconstruction	Superficial Thyroid Artery	Cephalic Vein to EJV, Vena Comitans to IJV	Orbital Floor Injury (Repaired with Titanium Mesh)

in mood and anxiety. By 6 months, there was significant recovery in oral function, and by 24 months, all domains except taste and saliva approached near-normal scores. This highlights the potential of the ZIP flap to support both short-term and long-term functional reintegration [9].

When compared to other reconstructive strategies—such as the Alberta Reconstructive Technique [13] or jaw-in-a-day protocols [14]—which may involve delayed prosthetic loading or additional donor sites, the ZIP flap offers a streamlined, predictable, and prosthodontically driven workflow that is particularly well-suited for oncologic patients who require timely radiation and functional restoration.

In our experience, the only significant complication occurred in the single secondary reconstruction case, where previous surgery and altered anatomy likely contributed to the orbital floor injury. This highlights the importance of careful planning and cautious application in previously irradiated or second-intent reconstructions, where tissue quality may be compromised [6]. All primary reconstruction cases had excellent outcomes, supporting the ZIP flap's reliability in appropriately selected patients.

Conclusion

The ZIP flap represents a reliable and effective technique for the primary reconstruction of low-level maxillary defects, offering the dual benefits of immediate soft tissue reconstruction and early dental rehabilitation. Our experience demonstrates that perforating the flap to accommodate zygomatic implant abutments does not compromise vascularity and may, in fact, enhance implant stability and prosthetic integration. In appropriately selected, non-irradiated primary cases, the ZIP flap provides predictable, durable functional and aesthetic outcomes. However, its application in previously irradiated fields or in secondary reconstructions warrants caution, as these settings are associated with increased risk of complications and compromised tissue healing.

Funding No funding received.

Data Availability Data is available with the corresponding author and shall be made available with considerable request.

Declarations

Conflict of interest No competing interests.

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