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Image Report

Minimalistic reconstruction of exposed skull in a complex craniovertebral polytrauma

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ABSTRACT

Background: In stable craniovertebral injuries complicated by polytrauma, rigorous spinal immobilization is essential for neuroprotection. Scalp and forehead reconstruction in these circumstances are safest when performed under local anesthesia, maintaining cervical immobilization.

Case Description: A sizeable 10 × 6.5 cm forehead defect was reconstructed utilizing regenerative principles under local anesthesia and sedation in a 54-year-old woman. After adequate debridement of gangrenous soft tissues, exposed outer skull bones were trephined, forehead defect covered with a synthetic biomaterial, and the patient was discharged thereafter. Granulating neodermis regenerated within the biomaterial over the next 6 weeks. Weekly platelet-rich plasma injections along the wound margins facilitated wound regeneration. Dimensions reduced by two-thirds to 6.5 × 3.5 cm with wound regeneration and contraction, while granulating neodermis covered the remaining skull-bones. Split skin-grafting over the neodermis ensured satisfying long-term results, with similar color, texture, soft-tissue thickness, and sensation. Multiple occipitocervical, spinal, scapular, and rib fractures healed well with strict immobilization.

Conclusion: Good long-term results were achieved with significantly reduced dangers, complications, hospitalization, and costs than traditional reconstructive flap surgeries. Minimalistic reconstruction utilizing tissue engineering and regenerative medicine principles appears beneficial for patients with grave spinal injuries.

Keywords: Biodegradable temporising matrix, Craniovertebral injury, Forehead reconstruction, Minimally invasive reconstruction, Platelet-rich plasma

INTRODUCTION

Complicated anatomy of the skull base and cervical spine significantly challenge proper diagnosis and treatment of craniovertebral injuries.[4] Even in stable occipitocervical injuries, adequate neuroprotection becomes difficult with associated polytrauma involving other anatomical areas.[8] General anesthesia in such cases requires extreme caution, as even small and momentary lapses may have catastrophic consequences. Reconstructing soft-tissue defects in such patients with traditional reconstructive flaps under general anesthesia necessitate re-positioning the patient and maneuvering the cervical spine repeatedly, which can potentially deteriorate existing neurotrauma.[5] Therefore, reconstructions maintaining strict spinal immobilization under minimal anesthesia would potentially benefit these patients maximally. Described here is a novel method of using regenerative principles to reconstruct a large forehead defect complicated by craniovertebral polytrauma under local anesthesia, while rigorously maintaining spinal immobilization.

CASE PRESENTATION

Craniovertebral polytrauma

A 54-year-old woman was transferred to our neurosurgical intensive care from another hospital after surviving a high-speed automobile collision 2 days earlier. Computed tomograms revealed diffuse axonal injury of the brain along with concomitant craniovertebral fractures, including fractures over the right occipital condyle, seventh cervical vertebrae foramen transversarium anterior wall, and seventh cervical right lateral mass – lamina junction. Furthermore, fractures involving both scapulae, second to sixth ribs, and fifth dorsal vertebrae were observed in addition to bilateral pulmonary contusions and left hemothorax. Over the scalp, she had large degloving injuries with grease and road dirt sticking to the wounds. Debridement and primary closure of the degloved scalp tissues were initially performed by the treating neurosurgeon. The patient was stabilized in intensive care and closely monitored for her cranial, cervical, and pulmonary injuries. Taylor's brace and Philadelphia collar were applied after her relatives preferred conservative management.

Minimalistic reconstruction

After the amelioration of life-threatening medical conditions, a plastic surgical referral was received for managing the necrosed degloved skin over her left forehead. Proper counseling of different options for forehead reconstruction followed. Finally, we decided to perform smaller surgeries under minimal anesthesia, while strictly maintaining her spinal immobilization with a collar and brace. Under sedation and local anesthesia, necrotic areas were debrided along the demarcation margins, resulting in a 10 cm × 6.5 cm forehead and scalp defect, including 9 cm × 5 cm area of barren skull bones without any periosteal cover [Figure 1]. Outer vault of the skull was trephined at least 1 cm apart until punctate bleeding was visible from the underlying diploe [Figure 2]. Thereafter, platelet-rich plasma (PRP) was obtained by centrifuging venous blood and injected along the margins of the wound. Finally, a bi-layered polyurethane biomaterial acting as a tissue scaffold (Biodegradable Temporising Matrix; PolyNovo Ltd., Australia) was placed over the defect and sutured in place [Figure 3]. The patient remained comfortable during the entire procedure, barely feeling any pain or discomfort, and was discharged the next day. She was followed up weekly when gradual tissue regeneration was visible within the scaffold [Figure 4]. PRP was injected in small aliquots around the wound under topical anesthesia in the clinic.

RESULTS

Removal of the outer semi-permeable film layer after 5 weeks showed significant wound regeneration and contraction,

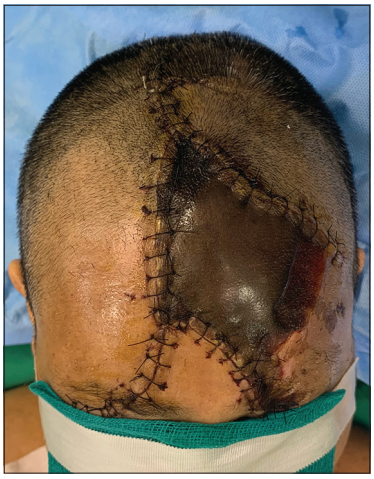


Figure 1: A 54-year-old female presented with gangrenous soft tissues over the forehead following an extensive polytrauma.

Figure 2: Debridement along demarcation margins was followed by trephination of the outer skull bones (black arrows).

Figure 3: An absorbable bi-layered polyurethane biomaterial was sutured onto the forehead defect sized 65 cm^2 under minimal anesthesia.

shortening the wound dimensions to 6.5 cm × 3.5 cm. Thus, wound areas had reduced substantially by approximately two-thirds, from 65 cm^2 initially to 23 cm^2 eventually, with granulating neodermis formation within the inner scaffold [Figure 5]. A thick split-skin graft was harvested from the thigh and applied over the raw area under sedation and local anesthesia, which took completely within a week. Her brace and collar were not removed anytime during the operative procedures or anesthesia. 6 months postoperatively, the patient had a near-normal appearance over her forehead [Figure 6]. The grafted wound had similar color, texture, soft-tissue thickness, and good return of sensation when compared to the surrounding healthy forehead. Several fractures involving her skull base, cervical spine, thoracic spine, and ribs healed conservatively after maintaining strict immobilization and did not require surgical intervention. The patient expressed deep satisfaction with the treatment process, with final results surpassing her expectations [Table 1].

Figure 4: 2 weeks later, granulation ingrowth was observed within the scaffold overlying the periosteum (white arrow), while the scaffold overlying the bone was avascular (black arrow).

Figure 5: 6 weeks postoperatively, progressing tissue regeneration and wound contraction within the scaffold shortened the wound area to 23 cm^2.

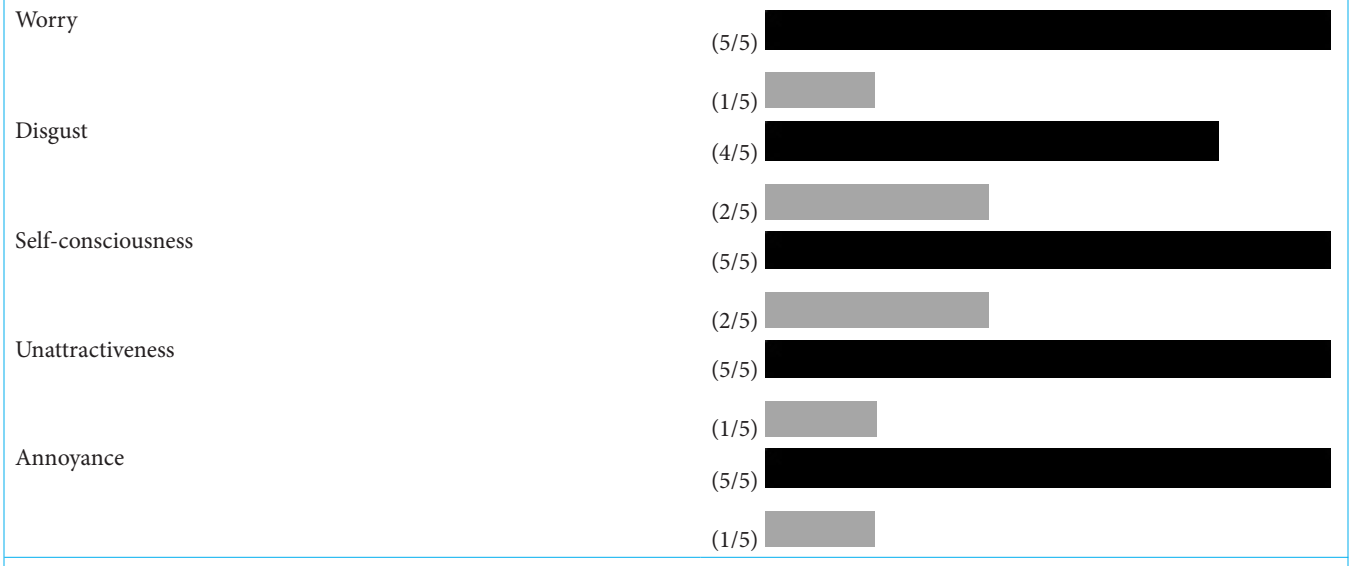
DISCUSSION

Occipital condylar fractures are potentially dangerous and require careful attention in unconscious patients.[8] Meticulous assessment of associated transverse ligament injury is crucial.[4] Surgical fixation is preferred if the transverse ligament is avulsed or grossly injured, making the fracture unstable; and if the atlas and axis are fractured simultaneously.[11] Otherwise, stable non-displaced traumatic occipital condylar fractures usually heal well without complications after strict neck immobilization in a Philadelphia collar.[4] Any laxity in neck immobilization during the next few months may cause significant lifelong disability or even death.[5,8]

Reconstructing large (>20 cm^2) forehead defects usually require sizeable loco-regional flaps or free tissue transfers. Loco-regional flaps, comprising substantial tissues from the adjacent forehead and scalp, are transposed, rotated, or advanced to cover the tissue defect. A wide flap-base with extensive dissection and undermining is necessary to preserve vascularity to the flap-edges.[3,10] Free tissue transfers, especially from the radial forearm and anterolateral thigh, are effective choices as well, utilizing superficial temporal artery and vein as recipient vessels.[9] Fenestrations over the outer layer of exposed skull bones until punctate bleeding is visualized from the underlying diploe results in granulation tissue coverage of the bones, followed by thin split-skin grafting later.[6] However, skull bones exposed for several weeks require frequent dressing changes and continuing medical supervision, with increased chances of infection and other complications.

Figure 6: Thick split skin grafting onto the granulating neodermis ensured satisfying long-term results.

Table 1: Patient outcomes assessment preoperatively and six months postoperatively. Severity of evoking specific emotions within the patient by the condition of the affected head/neck region on a scale of 1 to 5 (with 1 being the least and 5 the worst imaginable).



While performing loco-regional flaps and free tissue transfers, rotating and positioning the headneck junction are imperative several times to facilitate flap transfer and suturing.[3,10] These requirements contradict the primary objective of minimizing neck movements in patients with acute cervical spinal cord injury.[5] Managing the airway properly for during general anesthesia becomes remains critically important in these patients. For better neuroprotection, awake fibreoptic bronchoscope intubation and direct laryngoscopy with manual in-line immobilization may be necessary, while avoiding hypotension and depolarizing muscle relaxants during induction.[1] Overall, anesthetic care becomes complicated, intensive care may become necessary, and adequate neuroprotection may be jeopardized. Combined, all these factors substantially increase the duration of surgery and anesthesia, the chances of postoperative complications, and the overall treatment costs [Table 2].

Table 2: Key differences likely, while performing forehead reconstruction in a patient with craniovertebral injuries, with a large flap reconstructive surgery versus a minimalistic reconstructive approach.

Parameters	Large locoregional/ free flap surgery	Minimalistic reconstruction
Surgical duration	3–6 h	0.5–1 h
Anesthesia	General anesthesia	Local anesthesia and sedation
Surgical risks	High to very high	Minimal
Anesthetic risks	High to very high	Minimal
Expert post-op monitoring	Compulsory	Not necessary
Operative set-up requirements	Elaborate and costly	Basic
ICU requirements	Often	Almost never
Pain and morbidity	Severe	Negligible
Length of hospital stay	4–7 days	0-1 day
Overall costs	High to very high	Low
Spinal neuroprotection	Low	Very high

Platelets are anucleate derivatives of megakaryocytes that roam in the peripheral bloodstream for 7–10 days after migrating from the bone marrow. Activated, it releases several growth factors and cytokines for about 1 week, which possess angiogenic, mitogenic, and chemotactic properties. Autologous PRP is obtained after centrifuging the patient's venous blood to concentrate platelets, wherein platelet counts exceed 1-million/microliter, roughly 5 times the baseline values.[2] They contribute to vascularization and soft-tissue proliferation around the wound margins. Continuing PRP injections postoperatively at weekly intervals stimulate wound regeneration and wound contraction, thereby shortening the wound size.[2,12] Bi-layered polyurethane tissue scaffold protects an open wound from outside contamination and infection while stimulating faster neodermis regeneration within the inner layer of the scaffold. A thick split-skin graft is sufficient for final wound coverage over lush granulation tissue formation, which usually takes 5–8 weeks.[7]

CONCLUSION

Minimalistic reconstruction achieved an equivalent functional and aesthetic result when compared to reconstructive flap-

surgeries, but with significantly reduced dangers, chances of complications, and hospitalization, while lowering treatment costs. This case was performed at the height of the covid pandemic period, when regular hospital services were severely curtailed. In spite of limited available resources, it worked wonderfully and safely. It may become an apt model for reconstructing exposed skull-bones in the presence of significant craniovertebral injuries, especially in places and situations with limited medical resources.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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