



# Management of Comminuted Frontal Depressed Fracture Using Split Calvarial Graft: A Novel Technique

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## Abstract

Frontal depressed fracture generally results from high-speed motor vehicle accidents. The frontal fractures can be closed or open depending upon the involvement of the overlying skin. Frontal fracture can be comminuted if the bone is broken in at least two or more places. Because of the proximity of the frontal bone to critical structures like the frontal sinus, frontal dura with underlying brain parenchyma, and orbit with its content, an injury resulting in a frontal depressed fracture can result in a multitude of clinical symptoms. If not addressed promptly with an experienced team, these fractures can result in cerebrospinal fluid leak, osteomyelitis of the frontal bone, meningitis, and ocular and olfactory dysfunction with poor cosmetic outcomes. Thus, repairing the frontal depressed fracture should be considered a priority. The standard practice is to elevate the depressed fracture and repair any dural defect. In case of a comminuted fracture, elevation is not possible, and we generally remove the fracture pieces and repair the defect using titanium mesh. In this case report, we propose a novel technique of repair of the defect using a split calvarial graft, which is fashioned after separating the outer table from the inner table of the posterior frontal bone. This technique reduces the theoretical risk of infection and is cost-effective as our procedure does not require any external implant in cranioplasty.

## Keywords

- ▶ depressed fracture
- ▶ split graft
- ▶ calvarium
- ▶ CSF leak
- ▶ repair

## Introduction

Frontal bone fracture often involves the frontal sinus, comprising around 5% of all maxillofacial injuries.<sup>1</sup> Their location and proximity to vital structures such as orbit and intracranial contents make these fractures an essential entity for management. Depressed fracture in this region is often the result of high-energy blunt traumatic impact. Depressed fracture is often classified into open and closed based on the integrity of the overlying scalp. *Comminuted fractures* are fractures in which bone is broken in at least two or more places and are often the result of high-impact traumas. Open

depressed fracture often requires surgical management. Closed fracture with depth of fracture segment below the inner table requires surgical management. The standard teaching is to elevate the depressed fracture or implant cranioplasty in case of comminuted fracture. In this article, we present a close comminuted frontal depressed fracture involving the outer and inner table of the frontal sinus that underwent repair using a split cranial graft taken from the posterior margin of the frontal bone. It is a novel technique that does not require the placement of a foreign material like titanium mesh to replace the comminuted fracture segment,

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thus decreasing the risk of infection. Also, in a developing country like the Indian subcontinent, it is a cost-effective method.

### Case Description

A 43-year-old gentleman presented to our center with a history of road traffic accident, a two-wheeler rider collision with another two-wheeler, following which he was unconscious for approximately 30 minutes, and there was a history of nasal bleeding. There was no calvarial defect; however, his skin over the frontal bone was necrosed (►Fig. 1). He was evaluated with a computed tomography (CT) scan of the head, which showed a comminuted frontal depressed fracture involving both the outer and inner tables of the frontal sinus (►Fig. 2). There was no parenchymal injury to the brain on the CT scan. He was evaluated with CT cisternography, given doubtful cerebrospinal fluid (CSF) rhinorrhea; however, no defect was noted. Since the depressed fracture segment was extending below the inner table of the calvarium, the patient was planned for surgical management. We planned the patient for the elevation of the frontal depressed fracture and reconstruction at the same sitting using a split calvarial graft

taken from the posterior margin of the frontal bone. The necrosed skin over the forehead was excised, and a partial-thickness skin graft was performed with the help of a plastic surgery team. During the postoperative period, the patient recovered well and did not develop any fresh complaints. The postoperative CT scan of the head showed good calvarial defect repair without any obvious disfigurement (►Fig. 3).

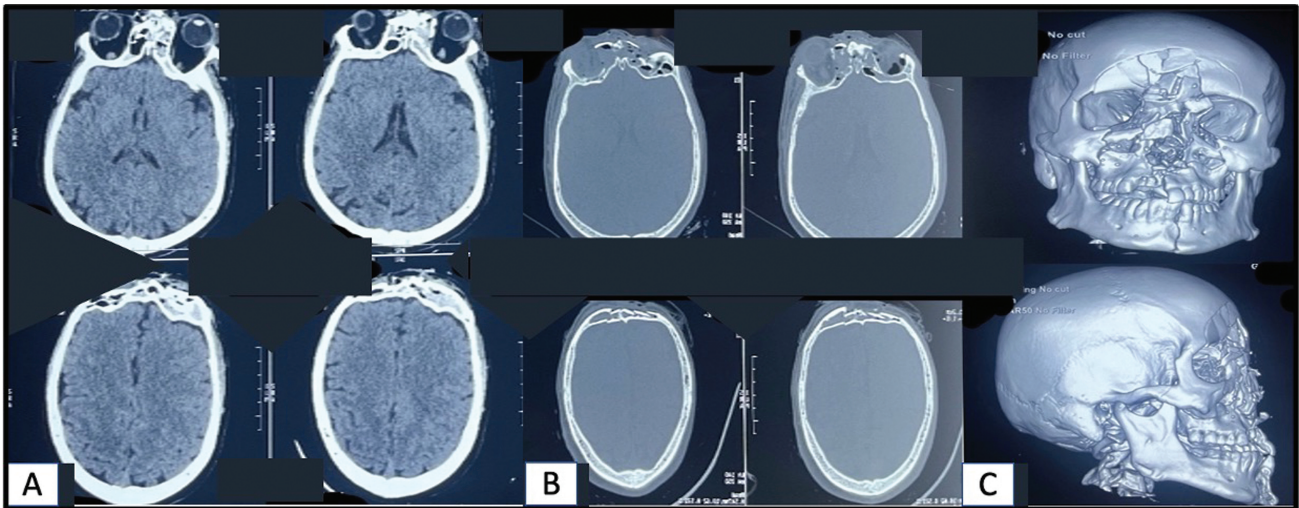
### Surgical Technique

The patient was positioned supine with slight extension. First, our plastic surgery colleague debrided the necrosed skin. We marked a standard bicoronal skin flap extending from one tragus to another and curving in the midline behind the hairline. The surgical part was painted and draped with aseptic precautions. After raising the mucocutaneous flap, we could visualize the frontal bone, which was fractured into multiple pieces (►Fig. 4). A bifrontal craniotomy was performed, and the fractured segments of the frontal bone were removed. It should be noted that the craniotomy was extended posteriorly, just anterior to the coronal suture. A larger-sized craniotomy could provide an appropriate split calvarial graft, which will help repair the defect. The area of

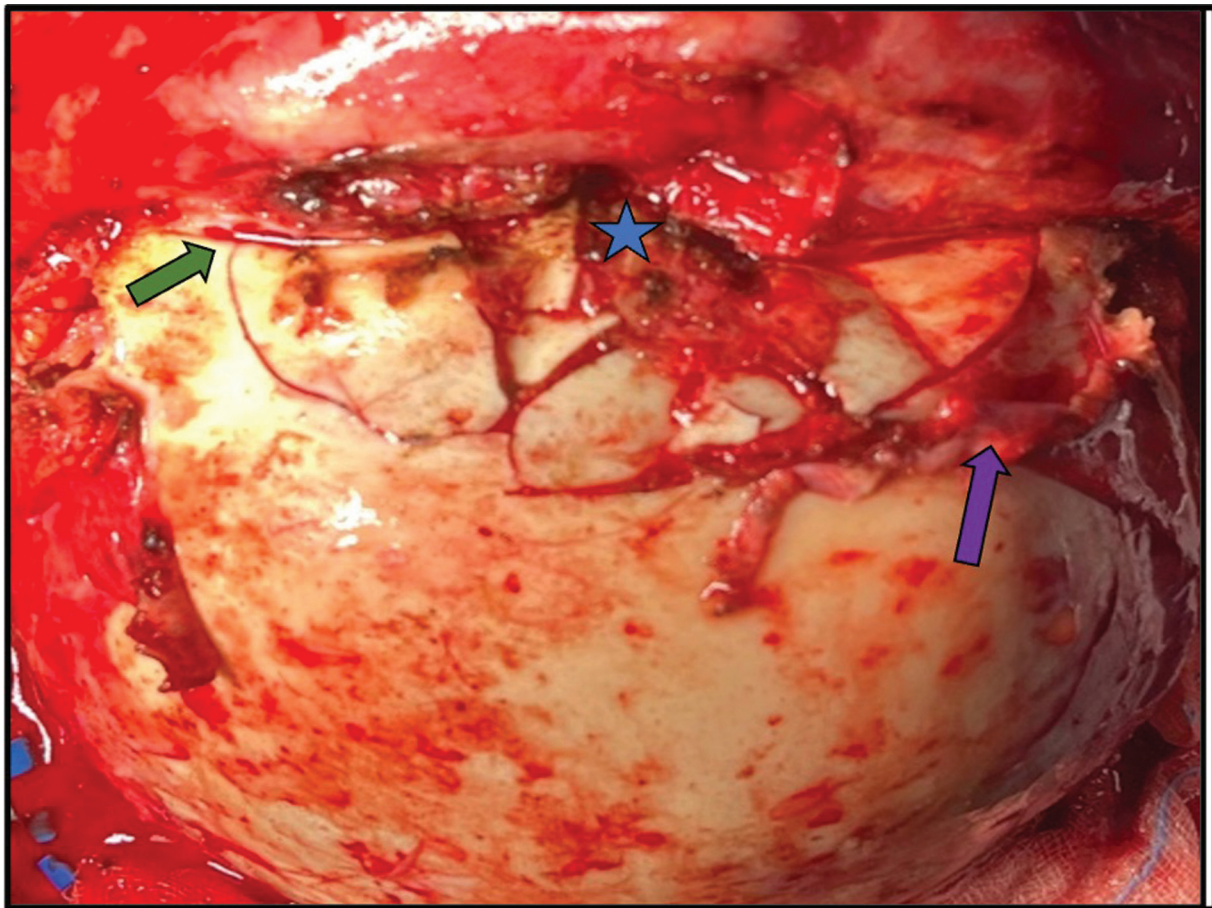


**Fig. 1** A preoperative clinical photograph of the patient showing necrosed skin over the forehead with significant skin blackish discoloration.





**Fig. 2** (A, B) The radiology of the patient shows a preoperative noncontrast computed tomography (NCCT) of the brain (both parenchymal and bone window), depicting the frontal depressed fracture with involvement of both outer and inner table of frontal sinus along with hemosinus. There was no pneumocephalus or associated intracranial injury. (C) Three-dimensional formatted CT images of the head showing frontal comminuted depressed fracture.

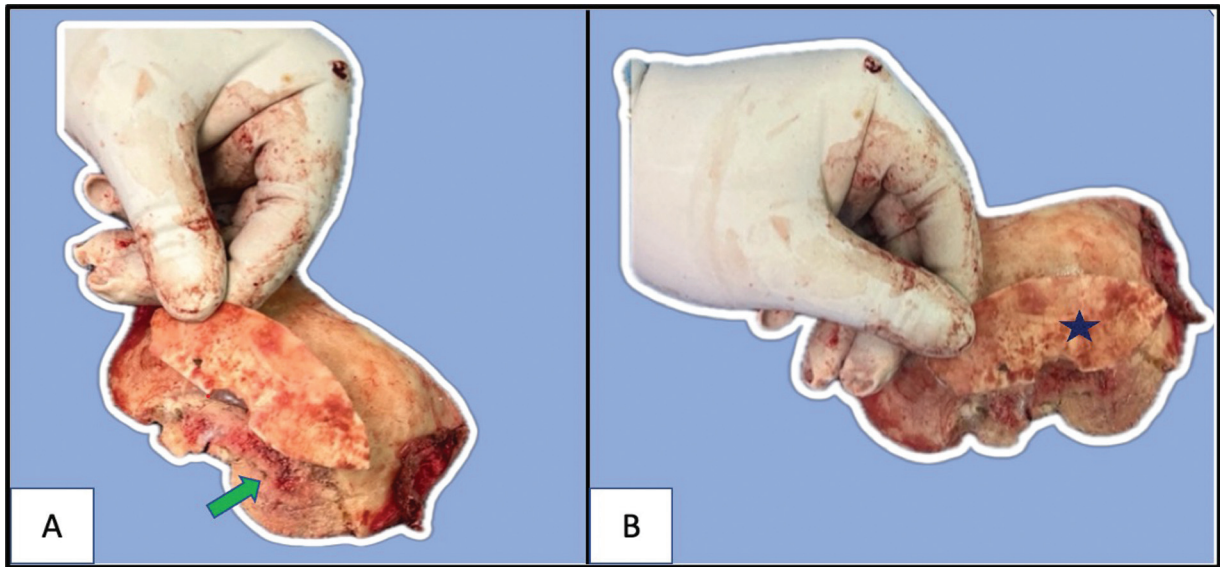


**Fig. 3** The intraoperative image noticed after elevating the myocutaneous flap. We can see the comminuted depressed fracture of the frontal bone with multiple fragments of variable size. The *purple arrow* shows the mucosa of frontal sinus bulging out after compression by the fracture fragments of the frontal bone. The *blue star* marks the area of the glabella with comminuted fracture fragments. The *green arrow* marks the fracture line involving the supraorbital ridge.

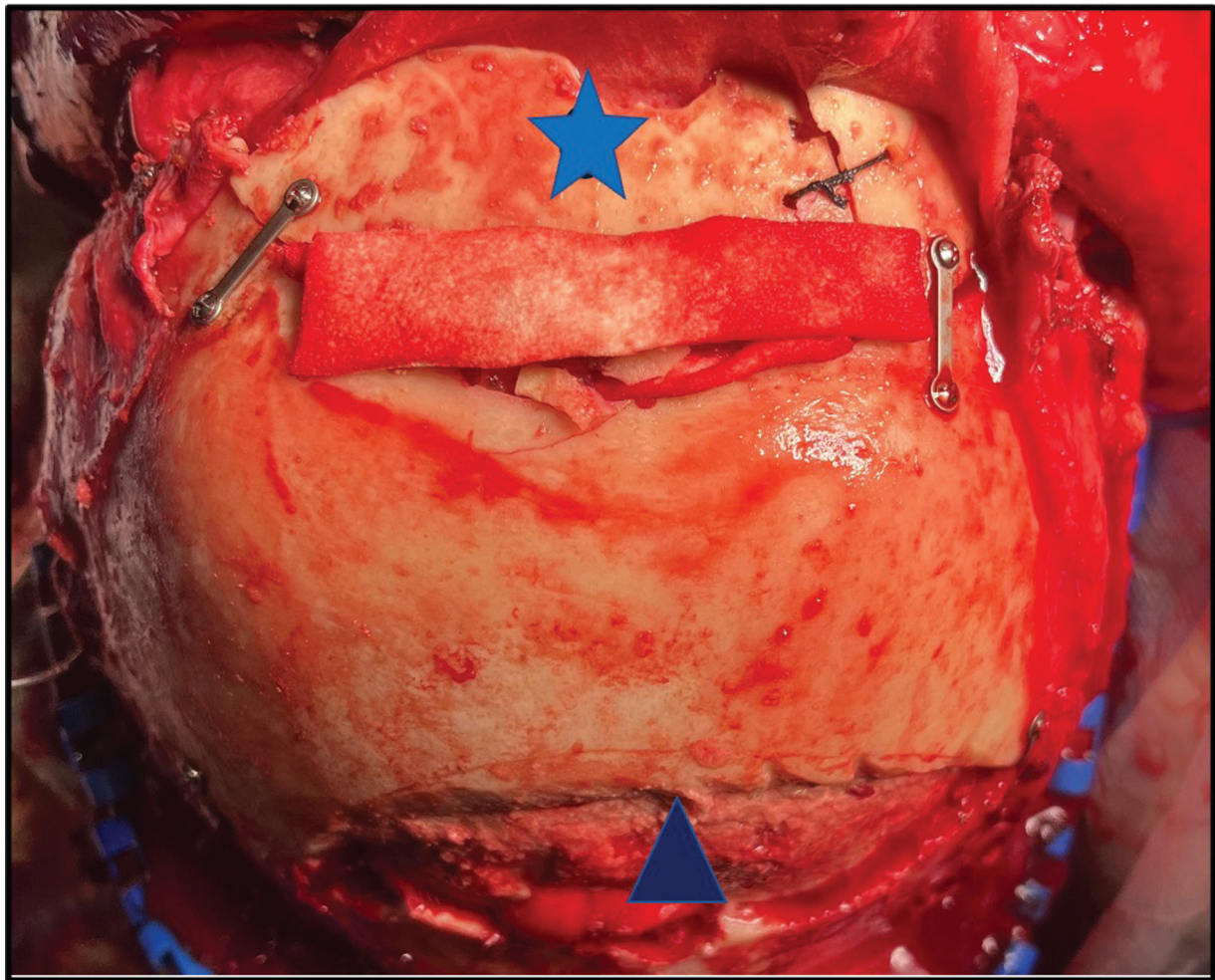
depressed fracture was meticulously measured, and the craniotomy defect that appeared after removing the fractured segments was calculated on the CT console (GE

Company). After marking the graft size on the frontal craniotomy bone flap, the split calvarial bone graft was crafted by separating the outer table of the bone flap from





**Fig. 4** (A) The intraoperative image depicts the photograph of the split calvarial graft where the outer table is separated from the inner table (green arrow) of the posterior frontal bone flap. (B) We used a combination of drill, chisel, and hammer for fashioning and designing the split calvarial bone graft of desired size (black star).

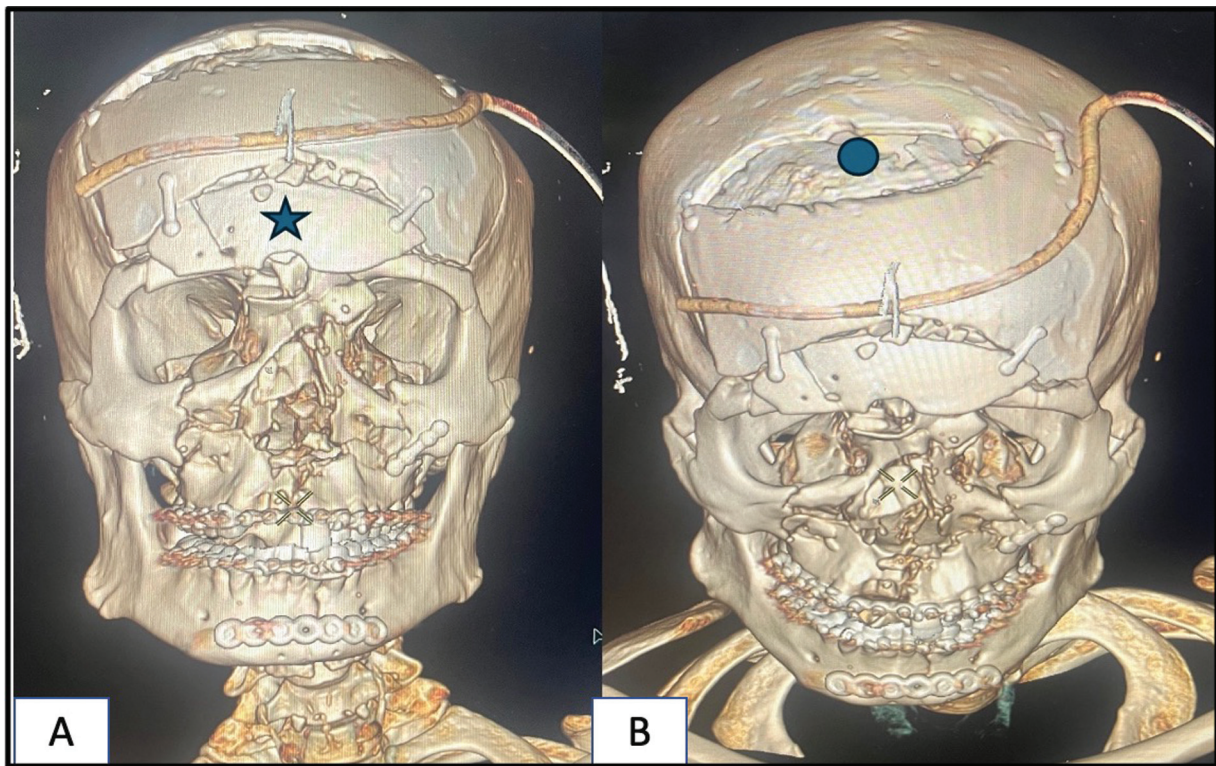


**Fig. 5** The intraoperative image with repair of frontal depressed fracture using split calvarial bone graft. After removal of the fractured fragments, the defect was repaired by using the outer table (blue star), which was separated from the inner table (blue triangle) of the posterior frontal bone. The autologous graft was fixed at the anterior margin by using nonabsorbable sutures and titanium miniplates and screws.





**Fig. 6** The postoperative clinical photograph showing healthy status of the full-thickness skin graft that was used to repair the skin defect of the forehead.



**Fig. 7** (A, B) The postoperative three-dimensional formatted image showing good repair of frontal comminuted depressed fracture using the outer table (*blue star*) separated from the inner table (*blue circle*) of the posterior frontal bone just anterior to the coronal suture. The tube of the minivac system can be noticed traversing through the wound cavity under the scalp.



**Fig. 8** The follow-up clinical photographs after 6 weeks suggest good cosmetic appearance. The *yellow arrow* indicates the line of full-thickness graft uptake and the *red arrows* indicate the healed stitch line of bicoronal skin flap.

the inner table using a C-1 bit of Midas Rex high-speed drill system, chisel, and hammer (►**Fig. 5**). This ensured minimal bone loss and helped design the flap of the desired shape. This split calvarial graft was fixed using magnetic resonance imaging (MRI) compatible titanium plates and screws (►**Fig. 6**). After calvarial reconstruction, the plastic surgery team excised the necrosed skin. The skin defect was repaired using a full-thickness graft from the right groin region. The surgical incision was closed in layers, and a suction catheter connected to a minivac suction container was inserted. The postoperative period was uneventful, and the CT scan done on the second postoperative day suggested an excellent alignment of the split calvarial graft (►**Fig. 7**). The operative wound was healthy, and the sutures in the graft area were removed after 3 weeks. The clinical photographs after 6 weeks suggest a good cosmetic appearance and no

wound-related complications (►**Fig. 8**). He resumed his normal activities as a farmer and is in regular follow-up visits.

## Discussion

The most common cause of frontal fracture is high-energy impact to the upper third of the face, which is mainly seen in motor vehicle accidents. Other causes include assault with blunt or penetrating objects, falls from height, industrial accidents, and high-impact sports/contact sports injuries like martial arts and boxing injuries.<sup>2</sup> Our patient had a history of high-velocity two-wheeler injury. Since this region hosts a variety of critical structures, including the frontal sinus, cribriform plate of the ethmoid, dura, frontal lobe, orbit, globe, and facial bones, the fracture of the frontal bone



could present in many ways. Forehead laceration associated with frontal depression is a hallmark clinical presentation. It is also commonly associated with periorbital edema and ecchymosis. CSF leak, meningitis, and decrease in sensorium and seizure episodes suggest parenchymal intracranial injury. Diplopia, impaired visual acuity, and restricted ocular movements suggest injury to the orbit.<sup>3,4</sup> In our patient, there was necrosis of the skin over the forehead with a frontal depressed fracture. There was a suspected dural defect leading to CSF rhinorrhea. However, he was neurologically intact without any associated ophthalmological features.

The gold standard for diagnosing frontal fracture (depressed or linear/nondepressed) is non-contrast-enhanced high-resolution computed tomography (HRCT) with thin cuts.<sup>5,6</sup> The axial section provides the presence and degree of fracture displacement. The coronal section provides information regarding the floor of the frontal sinus and the roof of the orbit. Sagittal reconstruction enhances visualization of nasofrontal outflow tract (NFOT) injuries and displacement of the outer and inner frontal sinuses. In a head CT scan, we should look for signs that suggest intracranial injury, like pneumocephalus and coup (frontal) countercoup (occipital) contusions. Three-dimensional reformatted images help visualize external contour deformities of the frontal bone.<sup>7</sup> In our patient, plain noncontrast CT (NCCT) of the brain showed a comminuted frontal depressed fracture involving both the outer and inner tables of the frontal sinus (→Fig. 2.). There was no parenchymal injury on the CT scan. He was evaluated with CT cisternography, given doubtful CSF rhinorrhea; however, no apparent bony defect or extravasation of dye was noticed in the paranasal sinuses or the base of the skull.

In our patient, there was the presence of a comminuted depressed fracture with involvement of overlying skin and frontal sinus, which made him prone to delayed CSF leak, frontal bone osteomyelitis, meningitis, brain abscess, residual forehead contour defects, and deformities. Since the head CT scan showed depression of the fracture segments below the inner table of the calvarium, the patient was planned for surgical intervention in the form of elevation of the depressed fracture and repair of the overlying skin. The standard for depressed fracture is the elevation of the depressed segment. However, in the cases with comminuted frontal depressed fractures, it is usually not possible to elevate the multiple fracture segment and achieve the desired surgical and cosmetic outlook. Removing the multiple fractured segments and repairing the defect with titanium mesh cranioplasty is prudent in these cases. However, placing a foreign body increases the surgery cost, and there is a theoretical risk of infection. Also, if the edges of the titanium mesh are not fixed properly, it can erode the overlying thin skin of the forehead. Thus, we propose a novel method of repair and reconstruction of the frontal depressed fracture using the split calvarial graft taken from the posterior frontal bone. The posterior frontal

bone, just anterior to the coronal suture, is thick, facilitating the splitting of the outer table from the inner table of the bone flap. We recommend placing an outer table over the defect created by discarding the fracture segments. The natural contour of the outer table of the frontal bone gives a good cosmetic appearance besides the robust strength of the bone flap. The edges of the bone flap are fixed using nonabsorbable silk sutures to provide a rigid approximation with the craniotomy margins. Since the bone graft used is autologous, this method greatly reduces the risk of infection. Also, it should be noted that this method is cost-effective as we are not using an external implant like titanium mesh, as well as plates and screws for fixation. In a developing country like India, this dramatically reduces the surgery cost and thus can be recommended for optimal utility of resources in emergency settings and situations with financial constraints.

## Conclusion

Management of frontal depressed fractures becomes challenging because of the nature of high-energy impact injury and its proximity to the paranasal sinuses and orbital and intracranial structures. The conventional procedure of depressed fracture elevation and reconstruction using mesh cranioplasty has limitations. We are proposing a novel method of repair using split calvarial graft, which is ready for use in emergency settings. This cost-effective method has a reduced risk of infection and imposes no additional financial burden to the patient.

## Funding

None.

## Conflict of Interest

None declared.

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