Management of Malunited Depressed Frontal Bone Fracture With Onlay Corticocancellous Anterior Iliac Crest Bone Graft With Titanium Mesh

Akhilesh Kumar Singh1, Nishtha Chauhan1,*, Naresh Kumar Sharma1, Mehul Shashikant Hirani1 and Arjun Mahajan1,1

Abstract
Frontal bone is fractured following high-velocity injuries such as road traffic injuries or assaults. At times, the intervention can get delayed to avoid grave intracranial injuries resulting in malunion of the fracture which may later become an aesthetic concern to the patient. Many alloplastic materials and autogenous grafts can be used to reconstruct the defect to replace lost and damaged anatomical bone structures, to renew their original function, and at the same time, to restore the aesthetics. We opted to go for an autogenous graft secured with a titanium mesh which gave us a better outcome.

Keywords
Dental auxiliaries, dentistry, oral and maxillofacial surgery, other health specialties

Received: 16 January 2022; Revised: 27 February 2022; Accepted: 07 March 2022

Introduction
The frontal bone is the most frequently fractured cranial bone in craniofacial trauma patients and accounts for 37% of cranial fractures. Isolated Le Fort 1 fractures have significant association with frontal bone fracture.1 The frontal bone consists of 3 parts, the squamous part which is the largest and forms majority of the forehead, supraorbital margins, and the superciliary arch. The frontal bone is more protected from traumatic events due to the prominence of the nasal pyramid which protects the naso-orbital region as well. It can withstand around 800 to 1,600 pounds of force, thus conferring resistance against most forms of traumatic injury.2 Most common causes of frontal bone fractures are road traffic accidents followed by physical assaults and sports-related injuries. There are various modalities available for reconstruction of frontal bone defects. We report a case of malunited depressed frontal bone fracture managed with onlay corticocancellous anterior iliac crest graft bone with titanium mesh.

Case Discussion
A 35-year-old male patient reported to the outpatient department of the Unit of Oral and Maxillofacial Surgery of our Institute with complaints of depression over forehead for more than 2 months (Figure 1A). He gave history of road traffic accident that took place 2 months back. Patient was admitted under neurosurgery and was treated conservatively without any surgical intervention. His medical history was noncontributory. On examination, he had a defect measuring about 4×3×2 cm over his glabella region without any visible pulsations (Figure 1B).

On palpation, it had well-defined smooth margins without any crepitus and tenderness at present. Preoperative computed tomography (CT) was advised and it showed frontal bone fracture with outer table involved (Figure 2). Neurosurgery clearance was done and patient was planned to camouflage the defect with autogenous onlay corticocancellous iliac crest graft stabilized with 1.5 mm titanium mesh under general anesthesia. X-ray pelvis was advised to rule any metabolic previous fracture or osteomyelitis at the donor site.

1 Division of Oral and Maxillofacial Surgery, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India.

Corresponding author:
Nishtha Chauhan, Division of Oral and Maxillofacial Surgery, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. E-mail: chauhannishtha04@gmail.com

Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (http://www.creativecommons.org/licenses/by-nc/4.0/) which permits nonCommercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (https://us.sagepub.com/en-us/nam/open-access-at-sage).
Surgical Procedure

Patient was operated under general anesthesia. After proper scrubbing of operating field and draping, 2% lignocaine with 1:2,00,000 adrenaline was infiltrated in the area to achieve vasoconstriction. Surgical site was exposed through Bicoronal approach (Figure 3). After proper exposure of defect site, it was reconstructed with autogenous iliac crest graft. Anterior corticocancellous iliac graft was harvested by trap door approach technique (Figure 4). The harvested graft was contoured in the defect site and stabilized with 1.5 mm titanium mesh (Figure 5). The surgical site was irrigated and drain was placed and closure done in layers with 3-0 vicryl and 3-0...
Various autografts such as cranium, scapula, fascia, sternum, ileum, tibia, and costochondral grafts are used which are protected previously by boiling in water, autoclaving, freezing, and covering in abdominal fat. Allografts was first used by Morestein in 1915 but was not popular due to higher infectivity rates and graft rejection. Nonmetal alloplasts used are celluloids, methyl-methacrylate, hydroxyapatite, polyethylene, silicon, chorale, ceramic, and Cortoss™. Titanium, gold, silver, platinum, tantalum and vitallium alloys. Among them titanium is the most biocompatible and widely used.

The ideal properties of cranioplasty materials are as follows:

Discussion

Cranioplasty is primarily performed for esthetic purposes. Along with esthetic result for patient psychology, cranioplasty decreases the chances of epilepsy as per literature. Ideal waiting period is 3 to 6 months or till 1 year if surgical site is infected. This ensures that the patient is neurologically stable, thus reduces the chances of graft site infection.

Figure 5. Autogenous Graft Contoured in the Defect Site and Fixed With 1.5 mm Titanium Mesh.

Figure 6. Postoperative 3 Months Follow-up.
1. It must fit the defect and achieve complete closure
2. Radiolucency
3. Resistance to infections
4. Not diluted with heat
5. Strong to biomechanical processes
6. Easy to shape
7. Not expensive
8. Ready to use

Not a single material satisfies all the given criteria.

In our institution, the preferred graft is anterior iliac corticocancellous graft.

The cortical cancellous iliac graft is more porous in nature, more rapidly revascularized but at the same time has more chances to get resorbed. The autografts having higher chances of resorption when combined with alloplastic mesh retains the contour of the bone even in case of complete resorption of autograft, which is the most important advantage of combination of autograft and alloplast.

Technique of harvesting the iliac crest graft is classified as follows:

1. Trapdoor technique
2. Splitting technique (Wolfe Kawamoto)
3. Window technique
4. Trephine technique

Among these, window technique allows for a stable graft with little quality of manipulation and is generally contoured to fit the desired special defect.

Disadvantage of iliac graft is its porous nature and high vascularity which causes early resorption. Methylmethacrylate is the most commonly used material for cranioplasties because of its adaptation, good radiates less heat, and adherence to dura with no reaction to underlying layers but it needs structural support to prevent breakage. Hydroxyapatite and chorale increase the bone repair but it is very brittle and needs protection from trauma till osseointegration is complete. Polyethylene easy shapeable build with heat made this material popular. Cortoss™ (Orthovita®) is a new synthetic bone void filler that contains bis-glycidyl-methylmethacrylate, bisphenol (a polyethylene glycol diether dimethyl acrylate), triethylene glycol dimethyl acrylate monomer, and bioactive glass ceramic. Cortoss has lower rate of inflammation but no direct vascular invasion. Noble metals are outdated because of their high cost, tantalum due to headaches caused by high heat conduction ability. Titanium is hard to shape, but relatively cheaper, bio acceptable, and radiolucent after mixing with other metals.

The frontal bone is the most frequently fractured cranial bone in craniofacial trauma patients and accounts for 37% of cranial fractures. Prevalence of frontal bone injuries based on injury mechanism road traffic accident (RTA) (65.1%) being most common, fall (18.8%), sports (4.7%), fight (6.04%), work related (1.34%), and other (4%). Motor vehicle accidents are the most common cause followed by assaults and sports-related injuries. Depressed skull fractures are indicated for elevation if the defect is more than 10 mm and in the presence of brain injury. Frontal bone contour defects result in marked facial deformity which becomes an esthetic concern.

Amongst various classifications of frontal bones fractures, 2 most important are as follows:

1. Based on vertical and horizontal lines
   - Type 1 fractures are isolated to the frontal sinus without a vertical trajectory (34.2%).
   - Type 2 fractures are vertically oriented and extend into the orbit but not the frontal sinus (15.4%).
   - Type 3 fractures are vertically oriented and extend into the frontal sinus but not the orbit (6%).
   - Type 4 fractures are vertically oriented and extend into ipsilateral frontal sinus and orbit (18.8%).
   - Type 5 fractures extend into the frontal sinus and into the orbit on both sides of the face or the contralateral side of the face (25.5%).

2. Based on depth of penetration of fracture line within skull base.
   - Depth A fractures involve the anterior table of the frontal bone with or without posterior table involvement and do not extend into the anterior cranial fossa (9.4%).
   - Depth B fractures involve the floor of the anterior cranial fossa (44.3%).
   - Depth C fractures involve the middle cranial fossa (22.8%).
   - Depth D fractures extend into the posterior cranial fossa (23.49%).

Considering all these options, the anterior corticocancellous iliac crest graft by window technique was considered suitable for the type 5 depth A type of frontal defect with only esthetic concern.

Conclusion

With various treatment modalities available for management of depressed frontal bone fractures, we opted for onlay corticocancellous anterior iliac crest bone graft with titanium mesh, which gave satisfactory postoperative results. Key points to remember are meticulous preoperative planning, neurosurgery consultation, and proper follow-up.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.
Statement of Informed Consent and Ethical Approval

Necessary ethical clearances and informed consent was received and obtained respectively before initiating the study from all participants.

ORCID iDs
Nishtha Chauhan https://orcid.org/0000-0001-8602-9709
Arjun Mahajan https://orcid.org/0000-0001-9475-9357

References
1. Gerbino G, Roccia F, Benech A, Caldarelli C. Analysis of 158 frontal sinus fractures: current surgical management and complications. J Craniomaxillofac Surg. 2000;28(3):133-139.
2. Meyyappan A, Jagdish E, Jeevitha JY. Bone cements in depressed frontal bone fractures. Ann Maxillofac Surg. 2019;9(2):407-410.
3. Rish BL, Dillon JD, Meirowsky AM, et al. Cranioplasty: a review of 1030 cases of penetrating head injury. Neurosurgery. 1979;4(5):381-385. doi:10.1227/00006123-197905000-00002.
4. Aydin S, Kucukyuruk B, Abuzayed B, Sanus GZ. Cranioplasty: review of materials and techniques. J Neurosci Rural Pract. 2011;2:162-167. doi:10.4103/0976-3147.83584.
5. Sanan A, Haines SJ. Repairing holes in the head: a history of cranioplasty. Neurosurgery. 1997;40(3):588-603. doi:10.1097/00006123-199703000-00033.
6. Prolo DJ, Oklund SA. The use of bone grafts and alloplastic materials in cranioplasty. Clin Orthop Relat Res. 1991;(268):270-278.
7. Blake DP. The use of synthetics in cranioplasty: a clinical review. Mil Med. 1994;159(6):466-469.
8. Robinson BT, Metcalfe D, Cuif AV, et al. Surgical techniques for autologous bone harvesting from the iliac crest in adults. Cochrane Database Syst Rev. 2018. doi:10.1002/14651858.CD011783.pub2.
9. Rosenthal AH, Buchman SR. Volume maintenance of inlay bone grafts in the craniofacial skeleton. Plast Reconstr Surg. 2003;112(3):802-811. doi:10.1097/01.PRS.0000069713.62687.F5.
10. Drosos GI, Babourda E, Magnissalis EA, Giatromanolaki A, Kazakos K, Verettas DA. Mechanical characterization of bone graft substitute ceramic cements. Injury. 2012;43(3):266-271. doi:10.1016/j.injury.2011.02.004.
11. Gosain AK. Hydroxyapatite cement paste cranioplasty for the treatment of temporal hollowing after cranial vault remodeling in a growing child. J Craniofac Surg. 1997;8(6):506-511. doi:10.1097/00001665-199711000-00017.
12. Abuzayed B, Tuzgen S, Canbaz B, Yuksel O, Tutunculer B, Sanus GZ. Reconstruction of growing skull fracture with in situ galeal graft duraplasty and porous polyethylene sheet. J Craniofac Surg. 2009;20(4):1245-1249. doi:10.1097/SCS.0b013e3181edf7f.
13. Barca I, Stroscio C, Cordaro R, Boschetti CB, Torre AD, Cristofaro MG. Reconstruction of comminuted frontal bone fracture with titanium plates and acrylic resin: report of two cases. Interdiscip Neurosurg Adv Tech Case Manag. 2020;23(3):100988.