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Evaluation of Cranioplasty in Pediatric Patients: A Single-Center Experience

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Abstract

Background: Cranioplasty is a well-known neurosurgical technique used for repairing cranial defects. It is performed to protect the brain, restore its appearance, and reverse the altered cerebral physiology. There is an ongoing debate on the best material and timing for cranioplasty in pediatric patients.

Aim of Study: The present study aimed to evaluate the results of cranioplasty with various materials in pediatric patients.

Patients and Methods: A retrospective study was conducted at a single center on pediatric patients who had undergone cranioplasty with any material from January 2020 to December 2021. A total of 54 consecutive cranioplasties in 46 patients were studied. Data on the patient's gender, age, cause of skull defect, implant type, number of cranioplasties done per patient, cosmetic outcome, wound healing, complications, and complications management were documented. The follow-up interval ranged from 24–36 months.

Results: The cranioplasty procedure did not result in any mortality. Six (30%) out of 20 patients with autologous graft cranioplasty developed complications; Two cases experienced complications of subcutaneous surgical emphysema at the site where the rib graft was taken, while four cases had graft resorption and required a second surgery using titanium mesh. Six (17.6%) out of 34 cases of synthetic graft cranioplasty developed complications; Two cases of infection in acrylic cranioplasty were successfully treated with antibiotics, and four cases of acrylic cranioplasty underwent cracking and fragmentation into pieces then reoperated using titanium mesh.

Conclusion: Pediatric patients have a higher incidence of experiencing spontaneous resorption with autologous bone grafts. Patients above 5 years can safely undergo cranioplasty using synthetic material. Acrylic cranioplasty provides a safe and effective option for centers with limited facilities, but the long-term efficacy of acrylic material should be studied in a more comprehensive study.

Key Words: *Cranioplasty – Skull defect.*

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Introduction

ARCHEOLOGICAL findings show cranioplasty has been practiced since 7000 BC, with a wide range of non-biological and biological materials like bone flaps, cork, and metals used for reconstruction to offer neuroprotection **[1].** Meekeren was the first to report a successful cranioplasty using a bone graft. in 1668, using a portion of the cranium from a deceased dog. Nonetheless, it wasn't until 1821 that the initial autologous bone graft cranioplasty was documented and attributed to Walther, who substituted the bone plug after the trephination procedure **[1,2,3].**

Craniectomy is frequently done in adult and pediatric patients who have traumatic brain injury (TBI) and elevated intracranial pressure (ICP) that does not respond to medical treatment **[4].**

Most skull defects are due to trauma, infection, tumors, elective removal, growing fractures, bone disorders, and congenital malformations. Loss of the cranium results in aesthetic and functional deficiencies. Without the cranium, atmospheric pressure directly affects the scalp and dura, leading to

Abbreviations:

ICP : Intracranial pressure
TBI : Traumatic brain injury
CT : Computerized tomography
MRI: Magnetic resonance angiography.

the closing of the subarachnoid space and lowering brain perfusion pressure. Consequently, some patients develop "syndrome of the trephined", a condition marked by intense headache, dizziness, excessive fatigability, weak memory, irritability, epilepsy, discomfort, and psychiatric issues *[5,6]*.

The goal of the cranioplasty procedure is to create a long-lasting, secure, structural repair of the skull, which is then covered by healthy skin. This aims to reduce the psychological issues of patients, enhance their quality of life, and promote better social adjustment *[7,8]*. The replacement of the cranium serves not only as a cosmetic and protective procedure but also has the potential to restore the changed physiological condition that arises after craniectomy. It can also reverse the altered physiological state, irregularities in cerebral blood flow, dynamics of cerebrospinal fluid, and observable neurological abnormalities *[9,10,11]*.

In pediatric patients, the skull is continually growing and the bone shape is constantly evolving, which means there are certain limitations on the materials that can be used for cranial vault reconstruction. Additionally, a thinner scalp and improved long-term survival rates further limit appropriate available bone graft options *[12]*. Cranioplasty materials used in children should be able to accommodate skull growth, have long-term durability, and exhibit high resistance to late infection *[4]*.

Three main categories of materials used for cranioplasty: Organic, synthetic-organic, and inorganic *[13]*.

Cranioplasty materials of organic origin consist of autografts (harvested from the same individual), allografts (bone grafts from another individual), and xenografts (taken from another species) *[13]*.

Synthetic-organic materials ("biomaterials") are manufactured natural bone minerals or proteins found in the human body. Examples include hydroxyapatite and bone morphogenic protein *[13]*. Autologous bone and biomaterials are the two major sources of cranial reconstruction in adults and children.

Inorganic substances do not have biological activity. These include methyl methacrylate, silicone, porous polyethylene, titanium mesh, and bioactive glass *[13]*.

In recent years the medical practice has been implemented with modern computer technologies for manufacturing of individual implants to reconstruct skull defects based on spiral computed tomography data *[7]*. The ideal cranioplasty material should be radiolucent, infection-resistant, non-conductive of temperature, resistant to biomechanical processes, malleable to fit defects with complete closure, affordable, and readily available for use *[14]*.

Contraindications for cranioplasty include the presence of infection, untreated hydrocephalus, and brain swelling. Cranioplasty complications may differ and involve autologous bone resorption which is more common in children than adults, infection, fluid collections, hematomas, and plate failure *[15]*.

Patients and Methods

This retrospective study was conducted on patients who underwent cranioplasty in the Department of Neurosurgery, Benha University Hospital in the period between January 2020 and December 2021. 46 patients who underwent a total of 54 consecutive cranioplasty procedures were studied. The patients' age ranged from 5 to 16 years. There were 14 girls and 32 boys. Data on the patient's gender, age, cause of skull defect, implant type, number of cranioplasties done per patient, cosmetic outcome, wound healing, complications, and complications management were documented. The follow-up interval ranged from 24–36 months.

Acrylic implants were used in 10 cases of bony destruction with tumors, and in 5 patients with post-traumatic skull defect. A titanium mesh was utilized in 4 patients who had wound infection and needed a craniectomy after undergoing a craniotomy for a space-occupying lesion, in 4 patients with post-traumatic skull defect, in 4 patients with bone resorption following cranioplasty with rib graft, and split calvarial graft, and in 4 patients complicated with acrylic fragmentation. Rib grafts were used in 4 patients with post-traumatic skull defect and 8 cases following infection. Split calvarial grafts were used in 8 post-traumatic patients. Own craniotomy bone flap was used in 3 patients with decompressive craniectomy.

Technical notes:

The first step in all procedures is good exposure of the skull defect, preparation of the dura by freeing any dehiscence, repairing any defects, and fashioning dural tackup stitches around the edges of the skull defect. At the end of the procedure, we use a subgaleal drain for 48 hours.

For split calvarial bone graft a flap was done, exposure, preparation, and measurement of the defect area, the designed cranioplasty bone flap was harvested and split through the diploe with an oscillating saw into two layers with the inner table covering the donor site, and the outer table covering the skull defect.

The rib graft was harvested through an inframammary skin incision where about 5-6cm of the osseous parts of 2 ribs (Usually 5^{th} and 6^{th} ribs) are separated from the chondral part by bone cutting. The rib was divided into two halves through its thickness and fixed to the edges of the defect by sutures.

The bone flap used in 3 patients' craniotomy procedures was stored in the abdominal subcutaneous tissue and later reused to cover the defect.

In acrylic cranioplasty, the acrylic mixture is molded into a plate with a thickness that matches the skull and is molded to match the defect. Next, Multiple holes are created in the plate, and they are positioned before hardening to be manually compressed to fit the edges of the skull. Continuous irrigation with saline containing gentamycin is employed to prevent the exothermic reaction and to serve as an antiseptic.

In cranioplasty with titanium mesh, after fixing the mesh to the skull with screws, we used to stretch the pericranium with sutures over the edge of the mesh as we thought that this technique eliminate the risk of pressure necrosis on the thin, scarred pediatric scalp.

Results

There was no mortality from the cranioplasty procedure. We had 2 cases of infection with wound discharge following acrylic cranioplasty but resolved with wound toilet and antibiotics. Two cases of subcutaneous surgical emphysema at the rib graft donor site were resolved without intervention. Reoperation was performed using titanium mesh for four cases of graft resorption. One case of subdural fluid collection was observed in one patient, treated conservatively, and resolved during follow-up. Cosmetic outcome was rated according to feedback from parents in addition to clinical follow-up.

Table (1): Summarize the different variables and outcome in our study.

Variable	Number
Median age (years)	(5-16)
Sex:	
Male	32 (69.6%)
Female	14 (30.4%)
Etiology of bone defect:	
Tumor	10
Infection	12
Trauma	24
Resorbed cranioplasty	4
Fragmented acrylic implant	4
Material used in cranioplasty:	
Split calvarial graft	8
Rib graft	12
Acrylic	15
Titanium mesh	16
Own craniotomy bone flap	3
Number of cranioplasties:	
1	38
2	8 4 (Graft resorption) + 4 (Fragmented acrylic implant)
Mean follow-up period	(24-36) months
Complications:	
Infection	2
Subcutaneous surgical emphysema	2
Graft resorption	4
Subdural fluid collection	1
Fragmentation of acrylic implant	4
Cosmetic outcome:	
Excellent	32
Good	16
Poor	2

Illustrative Cases

Case (1):

A fifteen-year-old female presented with scalp swelling causing cosmetic disfigurement, A CT brain with bone window and MRI brain revealed a dermoid cyst with an underlying skull defect. The mass was totally excised en block and immediate acrylic cranioplasty was performed (Fig. 1).

(A) (B) (C)

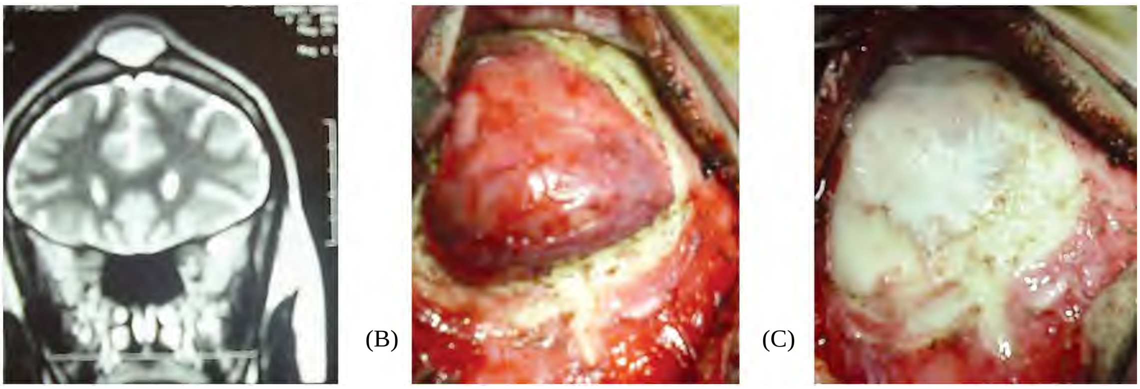

Fig. (1): (A) Coronal T2 weighted MRI showing the dermoid cyst and skull defect. (B) Intra-operative image showing the cyst. (C) The view after appliction of acrylic.

Case (2):

A six years old boy presented with a right frontal skull defect after a history of trauma, acrylic cranioplasty was done after molding the acrylic into a thin plate and creating of multiple holes aiming at preventing collection and infection (Fig. 2).

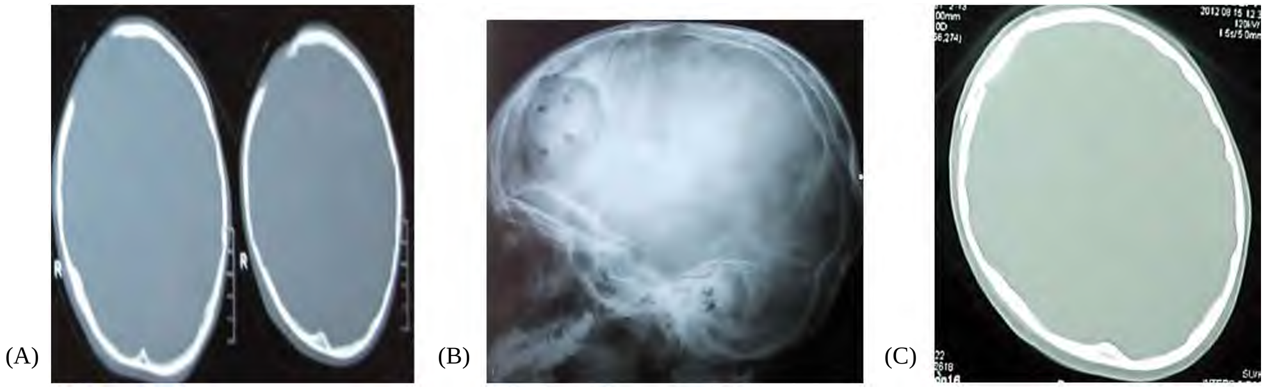

Fig. (2): (A) The bone window of CT brain axial cuts showing right frontal skull defect. (B) X-ray skull lateral view showing closure of the defect with acrylic " the created holes in the acrylic plate are appearant" (C) Post-operative CT after cranioplasty.

Case (3):

A six-year-old boy subjected to a post-traumatic skull defect two years ago was treated with a rib graft that was almost completely resorbed six months after surgery with a recurrence of the defect. We closed the defect with titanium mesh with satisfactory results on follow-up (Fig. 3).

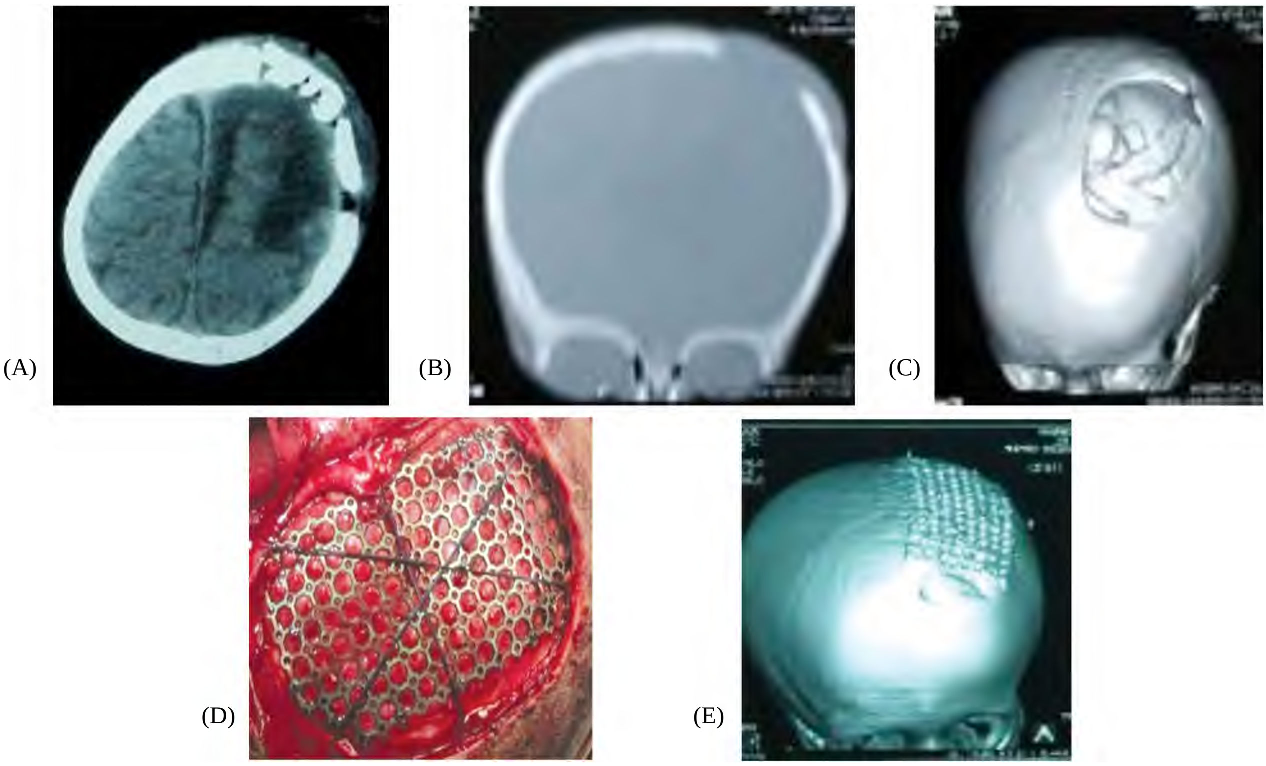

Fig. (3): (A) CT brain axial cut showing reconstruction of left parietal skull defect with rib graft. (B) Bone window of CT brain "coronal view" showing recurrence of the skull defect due to resorption of rib graft. (C) CT 3D reconstruction demonstrating the defect and remaining part of the graft. (D) Intraoperative image showing the titanium mesh in place , note sutures stretching the perioteom over the edge of the mesh that avoid erosion of the scalp over the mesh edges. (E) Follow-up CT 3D reconstruction revealing adequate skull reconstruction.

Case (4):

A sixteen years old male patient presented with post-traumatic skull defect treated with split calvarial graft cranioplasty (Fig. 4).

Fig. (4): (A) Pre-operative CT bone window of axial cuts showing the skull defect. (B) Intra-operative image showing splitting of skull bone into two layers through the diploe. (C) Post-operative CT showing closure of the defect and correction of the deformity.

Case (5):

A nine-year-old boy presented with skull osteomyelitis secondary to scalp abscess, treated with drainage of the abscess and debridement of the infected bone followed by an adequate course of systemic antibiotics. Six months later, upon family request, the patient was subjected to autologous cranioplasty using a rib graft (Fig. 5).

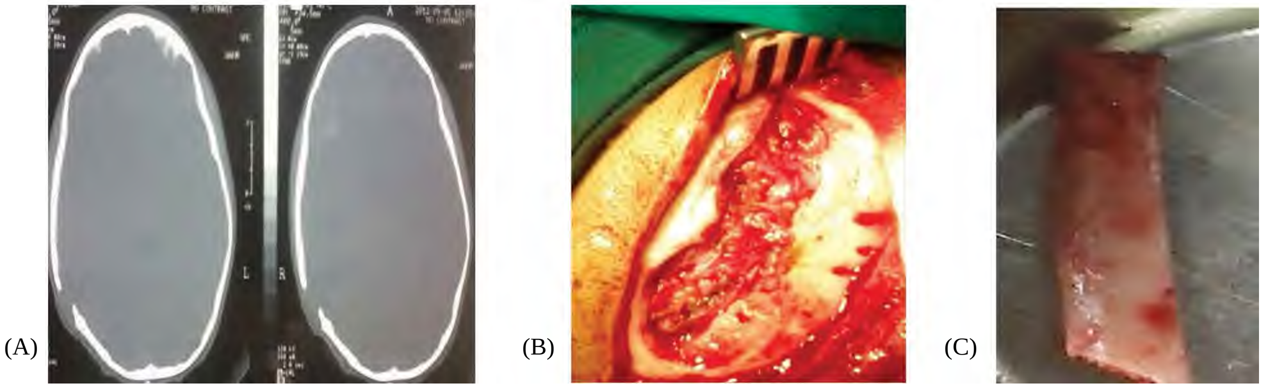

Fig. (5): (A) Pre-operative CT showing the defect. (B) Intra-operative imge of the defect with freshening of edges. (C) Image of the rib grft used for cranioplasty.

Discussion

There needs to be more data regarding the long-term outcomes of different cranioplasty materials in the pediatric cases. It is difficult to reach obvious conclusions from these studies due to lacking long-term results, and only small sample sizes were used **[4]**.

Cranioplasty is a surgical procedure to repair cranial defects or deformities that are left behind after a previous operation or injury. Nowadays there are many different techniques and materials that can be used in the repair of cranial defects. Surgeons' preferences for various implant materials for cranioplasty differ based on factors like their training, personal experiences, the traditions of the units they work in, and the resources available **[16]**. Some surgeons prefer using autologous bone grafts while others prefer synthetic materials, each material has advantages and disadvantages and until now it is unclear which material provides the best overall result. In our study, we present the outcome of cranioplasty in pediatric patients using different materials and techniques.

Choosing the best cranioplasty implant for pediatric patients is difficult because of various patient factors such as continuous skull growth, bone healing, tissue reaction, potential implant migration, breakage, congenital conditions, and varying infection risks [17].

Autologous bone grafting is still the method of choice at many centers in the world acquiring widespread popularity even with progression into the 21th century [18].

Advantages of autologous bone graft include high biocompatibility, absent risk of disease transmission, easy return of the former cranial contour, allowed remolding of cranial bone and continuous growth, easily accepted by the host, reintegrated into the cranium and cost-efficiency [19].

Disadvantages include donor site morbidity and, the bone flap resorbs at a high rate, leading to structural breakdown [14,20].

Symptomatic bone resorption is described as a defect that raises concerns about potential brain damage or creates a cosmetic issue unacceptable to the family or treating physicians [11]. In our study; the resorption rate of autologous bone flap was 8.7%. Reported rates of autologous bone flap resorption vary in the literature; Grant et al. [11] reported a 50% resorption rate, Gruber et al. [21] reported a 33.3% resorption rate, Piedra et al. [22] found a 29.5% resorption rate, and Posnick et al. [23] reported 7.4% resorption rate. A recent systematic review revealed that the reabsorption rates in published studies varied from 30% to 80%, with a 20% graft failure rate, especially when the banked bone was utilized [1,4,24].

Predictors of bone flap resorption are young age, thin skull, large bone defect, an underlying contusion, and fragmentation of the explanted bone graft [11,25]. The method of bone flap preservation was suggested to be a risk factor as the bone matrix may be destroyed by freezing or autoclaving [26]. Recently, investigators proved a low resorption rate in frozen autologous bone flaps in contrast to autoclaving which is not routinely performed [27]. Revision cranioplasty is typically very effective in pediatric patients experiencing bone flap resorption. With higher success rates with custom synthetic implants than with autologous split-thickness bone grafts [28].

Replacement of the original bone removed during craniectomy is optimal as it is readily available, avoids other graft or foreign materials, guarantees a low infection rate, and reintegrates well in the maturing skull [16,29]. This bone can be preserved either by cryopreservation, autoclaving, or by placement in a subgaleal or subcutaneous abdominal pocket. Several research studies have confirmed the effectiveness, minimal infection risk, and affordable price of storing a cranioplasty flap in the subcutaneous pouch of the abdominal wall [30,31,32]. Drawbacks include difficult storage either due to limited facilities or in children with reduced abdominal subcutaneous tissue and failure of shape matching especially in delayed cranioplasty due to new bone formation at the edges of the defect [16].

We used the decompressive craniectomy technique in 3 traumatic cases who underwent cranioplasty using their own craniectomy flap stored in the abdominal subcutaneous tissue without complications.

Autogenous split calvarial graft is easily harvested from the same operating site, of enhanced survival, volume available with favourable contour and simplified reconstruction of the donor site reducing morbidity but It is challenging to perform a calvarial graft in children due to the diploic bone's limited differentiation [11,29,33].

The advantages of rib graft include its availability and ability to regenerate (neovascularization, osteoclastic activity, and subsequent bone formation), and minimal blood loss. Splitted rib is easily fixed, more elastic conforming easily to the calvarial contour [8,34]. Drawbacks of the procedure include extended surgery time, significant resorption, shape irregularities, and the need for multiple ribs in cases of large defects [35,36].

We used autologous bone graft in 20 patients with 30% reported complications including two cases that experienced complications of subcutaneous surgical emphysema at the site where the rib graft was taken resolved spontaneously, while four cases had graft resorption and required a second surgery using titanium mesh.

Throughout history, synthetic options like metals, ceramics, plastics, and more recently, resorbable polymers and biomaterials, have been used when autograft reconstruction is not possible due to factors like severe bony fragmentation, bone graft resorption, infection, and limited donor site options. [37,38]. The use of synthetic materials is not ideal before the age of 5 years because the absence of growth potential causes them to be unable to adjust to the developing neurocranium [39].

Methyl methacrylate is the most frequently used material in cranioplasty because of its advantages which are low cost, biologically inert, lightweight, and has no magnetic properties or thermal conductivity. It is as strong as bone and can be easily molded during surgery to fit contour defects. Additionally, it does not cause interference with computed tomography or magnetic resonance imaging studies. [29,40], but its main disadvantage is the exothermic reaction that occurs during the polymer setting, potentially causing thermal damage to the underlying brain tissue. To mitigate this temperature increase, the surgeon can irrigate the implant with cold saline as it sets and place layers of wet cotton between the acrylic and dura. Other reported complications are infection and breakage [5,36,39].

Titanium is widely used for cranioplasty because of its strength, good resistance to infection, biocompatibility, malleability, good cosmetic results, and suitability for postoperative imaging techniques **[41,42]**.

Wound infection is common. We had 2 cases (4.3%) of infection with wound discharge following acrylic cranioplasty but resolved with wound toilet and antibiotics. Reported rates of infection vary in the literature; Choi et al. **[43]** reported 5.3% of wound infection, Ma et al. **[44]** reported 5.1% of wound infection in implant material, and Frassanito et al. **[45]** reported 5.3% of wound infection (all following cranial implant).

In our study synthetic graft was used in 30 patients with good cosmetic outcomes Methyl methacrylate was used in 20 patients with satisfactory cosmoses in most of them achieved with 2 reported wound infection resolved with antibiotics. We used titanium mesh in 10 patients with no reported complications.

Conclusion:

Pediatric patients have a higher incidence of experiencing spontaneous resorption with autologous bone grafts. Synthetic materials can be safely utilized in cranioplasty for patients above 5 years. In centers with limited resources, acrylic cranioplasty is a safe and effective method, but the long-term efficacy of acrylic material should be studied in a more comprehensive study.

Declaration of patient consent: Patient's consent is not required as patients' identity is not disclosed or compromised.

Ethics approval and consent to participate: This study was approved by the Ethical Committee of Scientific Research, Faculty of Medicine, Benha University under the number (RC 8-7-2024).

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Conflicts of interest: There are no conflicts of interest.

References

1- ABU-GHNAME A., BANUELOS J., OLIVER J.D., VYAS K., DANIELS D. and SHARAF B.: Outcomes and Complications of Pediatric Cranioplasty: A Systematic Review. Plast. Reconstr. Surg., 144 (3): 433e-443e, 2019.

2- SHAH A.M., JUNG H. and SKIRBOLL S.: Materials used in cranioplasty: A history and analysis. Neurosurg Focus, 36: E19, 2014.

3- VITERBO F., PALHARES A. and MODENESE E.: Cranioplasty: The autograft option. J. Craniofac. Surg., 6: 80–83, 1995.

4- KLIEVERIK V.M., MILLER K.J., SINGHAL A., HAN K.S. and WOERDEMAN P.A.: Cranioplasty after craniectomy in pediatric patients-a systematic review. Childs Nerv Syst., 35 (9): 1481-1490, 2019.

5- AZMI A., LATIFF A.Z. and JOHARI A.: Methyl methacrylate cranioplasty. Med. J. Malaysia, 59 (3): 418-421, 2004.

6- CHO K.C., PARK S.C., CHOE I.S. and SEO D.H.: Safety and efficacy of early cranioplasty after decompressive craniectomy in traumatic brain injury patients. Journal of Korean Neurotraumatology Society, 7: 74-77, 2011.

7- EOLCHIIAN S.A.: Complex skull defects reconstruction with CAD/CAM titanium and polyetheretherketone (PEEK) implants. Zh Vopr Neirokhir Im N N Burdenko., 78 (4): 3-13, 2014.

8- SAHOO N.K., ROY I.D. and RANGARAJAN H.: Cranioplasty in children with split rib graft. MJAFI, 67 (1): 83–85, 2011.

9- SUZUKI N., SUZUKI S. and IWABUCHI T.: Neurological improvement after cranioplasty. Analysis by dynamic CT scan. Acta Neurochir (Wien), 122: 49–53, 1993.

10- WINKLER P.A., STUMMER W., LINKE R., et al.: Influence of cranioplasty on postural blood flow regulation, cerebrovascular reserve capacity, and cerebral glucose metabolism. J Neurosurg., 93: 53–61, 2000.

11- GRANT G.A., JOLLEY M., ELLENBOGEN R.G., ROBERTS T.S. and GRUSS J.R.: Failure of autologous bone-assisted cranioplasty following decompressive craniectomy in children and adolescents. J. Neurosurg., 100 (2 Suppl Pediatrics): 163-168, 2004.

12- FEROZE A.H., WALMSLEY G.G., CHOUDHRI O., LORENZ H.P., GRANT G.A. and EDWARDS M.S.: Evolution of cranioplasty techniques in neurosurgery: Historical review, pediatric considerations, and current trends. J. Neurosurg., 123 (4): 1098-1107, 2015.

13- SALAM A.A., IBBETT I. and THANI N.: Pediatric cranioplasty: A review. Interdiscip Neurosurg., 13: 59-65, 2018.

14- SHAH A.M., JUNG H. and SKIRBOLL S.: Materials used in cranioplasty: A history and analysis. Neurosurgical focus, 36(4):E19, 2014.

15- LANG S. and GRADY M.S.: Surgical Management of Major Skull Defects and Potential Complications. In: Quiñones-Hinojosa A (ed.). SCHMIDEK & SWEET: Operative Neurosurgical Techniques. 6th ed, Philadelphia, W.B. Saunders Co., Vol. 2, 140: 1607-1610, 2012.

16- JOSAN V.A., SGOUROS S., WALSH A.R., DOVER M.S., NISHIKAWA H. and HOCKLEY A.D.: Cranioplasty in children. Child's Nervous System, 21: 200–204, 2005.

17- STILL M.E.H., SAMANT S., ALVARADO A., NEAL D., GOVERNALE L.S. and CHING J.A.: Considerations for Choice of Cranioplasty Material for Pediatric Patients. Pediatr Neurosurg., 58 (1): 1-7, 2023.

18- REDFERN R.M. and PÜLHORN H.: Cranioplasty. Adv. Clin. Neurosci. Rehabil., 7: 32-24, 2007.

19- SON S., PARK C.W., KIM E.Y., KIM J.M. and YOO C.J.: Bone Resorption of Autologous Cranioplasty Following

Decompressive Craniectomy in Children-Case Report. Journal of Korean Neurotraumatology Society, 5 (2): 118-23, 2009.

20- ARNAUD E.: Advances in cranioplasty with osteoinductive biomaterials: Summary of experimental studies and clinical prospects. Childs Nerv. Syst., 16: 659-668, 2000.

21- GRUBER R., PETER R. and HORA J.: The prognosis of cranioplasty following large craniectomy in children. Z Kinderchir., 43: 375–383, 1988.

22- PIEDRA M.P., THOMPSON E.M., SELDEN N.R., RAGEL B.T. and GUILLAUME D.J.: Optimal timing of autologous cranioplasty after decompressive craniectomy in children. Clinical article. J. Neurosurg. Pediatr., 10: 268–272, 2012.

23. POSNICK J.C., GOLDSTEIN J.A., ARMSTRONG D. and RUTKA J.T.: Reconstruction of skull defects in children and adolescents by the use of fixed cranial bone grafts: long-term results. Neurosurgery, 32 (5): 785-791, 1993.

24- FRASSANITO P., MASSIMI L., CALDARELLI M., TAMBURRINI G. and DI ROCCO C.: Bone flap resorption in infants. J. Neurosurg. Pediatr., 13 (2): 243–4, 2014.

25- BROMMELAND T., RYDNING P.N., PRIPP A.H. and HELSETH E.: Cranioplasty complications and risk factors associated with bone flap resorption. Scandinavian journal of trauma, resuscitation and emergency medicine, 23 (1): 1-7, 2015.

26- ITOH Y.: Clinicopathological study of cranioplasty using freeze preserved autogenous skull [in Japanese]. J. Tokyo Med. Coll., 49: 550-564, 1991.

27- IWAMA T., YAMADA J., IMAI S., SHINODA J., FUNAKOSHI T. and SAKAI N.: The use of frozen autogenous bone flaps in delayed cranioplasty revisited. Neurosurgery, 52: 591-596, 2003.

28- BOWERS C.A., RIVA-CAMBRIN J., HERTZLER D.A. II and WALKER M.L.: Risk factors and rates of bone flap resorption in pediatric patients after decompressive craniectomy for traumatic brain injury. Clinical article. J. Neurosurg. Pediatr., 11: 526–532, 2013.

29- KOENIG W.J., DONOVAN J.M. and PENSLER J.M.: Cranial bone grafting in children. Plast. Reconstr. Surg., 95: 1–4, 1995.

30- BALDO S. and TACCONI L.: Effectiveness and safety of subcutaneous abdominal preservation of autologous bone flap after decompressive craniectomy: A prospective pilot study. World Neurosurg., 73: 552–556, 2010.

31- INAMASU J., KURAMAE T. and NAKATSUKASA M.: Does difference in the storage method of bone flaps after decompressive craniectomy affect the incidence of surgical site infection after cranioplasty? Comparison between subcutaneous pocket and cryopreservation. J. Trauma, 68: 183–187, 2010.

32- SHOAKAZEMI A., FLANNERY T. and MCCONNELL R.S.: Long-term outcome of subcutaneously preserved autologous cranioplasty. Neurosurgery, 65: 505–510, 2009.

33- AGRAWAL A. and GARG L.N.: Split calvarial bone graft for the reconstruction of skull defects. J. Surg. Tech. Case Report, 3: 13-6, 2011.

34- LONGACRE N. and DESTEFANO G.A.: Further observations of the behavior of autogenous split rib grafts in reconstruction of extensive defects of the cranium and face. Plast. Reconstr. Surg., 20: 281-96, 1957.

35- TAGGARD D.A. and MENEZES A.H.: Successful use of rib grafts for cranioplasty in children. Pediatr. Neurosurg., 34 (3): 149-155, 2001.

36- GOLDSTEIN J.A., PALIGA J.T. and BARTLETT S.P.: Cranioplasty: Indications and advances. Curr Opin Otolaryngol. Head Neck Surg., 21: 400–409, 2013.

37- YADLA S., CAMPBELL P.G., CHITALE R., MALTENFORT M.G., JABBOUR P. and SHARAN A.D.: Effect of early surgery, material, and method of flap preservation on cranioplasty infections: A systematic review. Neurosurgery, 68: 1124–1130, 2011.

38- BEEKMANS S.J., DON GRIOT J.P., and MULDER J.W.: Split rib cranioplasty for aplasia cutis congenita and traumatic skull defects: More than 30 years of follow-up. J. Craniofac. Surg., 18 (3): 594-597, 2007.

39- BLUM K.S., SCBNEIDER S.J. and ROSCNBAL AD.: Methyl methacrylate cranioplasty in children long term results. Paediatric Neurosurg., 26: 33-5, 1997.

40- WHITMORE R.G., DANISH S.F. and GRADY M.S.: Cranioplasty. In: Winn HR (ed.). Youmans Neurological Surgery., 6th edition, Philadelphia, W.B. Saunders Co., Vol. 1, 32: 481-486, 2011.

41- CHANDLER C.L., UTTLEY D., ARCHER D.J. and MACVICAR D.: Imaging after titanium cranioplasty. Br. J. Neurosurg., 8: 409–414, 1994.

42- JOFFE J., HARRIS M., KAHUGU F., NICOLL S., LINNEY A. and RICHARDS R.: A prospective study of computer-aided design and manufacture of titanium plate for cranioplasty and its clinical outcome. Br. J. Neurosurg., 13: 576–580, 1999.

43- CHOI S.H., LEVY M.L. and MCCOMB J.G.: A method of cranioplasty using coralline hydroxyapatite. Pediatr Neurosurg., 29: 324–327, 1998.

44- MA I.T., SYMON M.R., BRISTOL R.E., BEALS S.P., JOGANIC E.F., ADELSON P.D., SHAFRON D.H. and SINGH D.J.: Outcomes of titanium mesh cranioplasty in pediatric patients. J. Craniofac. Surg., 29:99–104, 2018.

45- FRASSANITO P., MASSIMI L., TAMBURRINI G., BIANCHI F., NATALONI A., CANELLA V. and CALDARELLI M.: Custom-made hydroxyapatite for cranial repair in a specific pediatric age group (7-13 years old): A multicenter post-marketing surveillance study. Childs Nerv Syst., 34: 2283–2289, 2018.

تقييم جراحة ترقيع الجمجمة فى المرضى الأطفال:
تجربة مركز واحد

عملية إعادة تشكيل الجمجمة هى إجراء جراحى عصبى معتمد تستخدم لإصلاح تشوهات الجمجمة. يتم إجراؤها لحماية الدماغ، واستعادة مظهره، وعكس التغيرات فى فسيولوجيا المخ. هناك جدل مستمر حول أفضل مادة وتوقيت لعملية إعادة تشكيل الجمجمة فى المرضى الأطفال.

هدف الدراسة: تهدف الدراسة الحالية إلى تقييم نتائج عملية إعادة تشكيل الجمجمة باستخدام مواد مختلفة فى حالات المرضى الأطفال.

المرضى وطرق البحث: تم إجراء دراسة بأثر رجعى لمركز واحد على جميع المرضى الأطفال الذين خضعوا لعملية ترميم الجمجمة باستخدام أى مادة من يناير ٢٠٢٠ إلى ديسمبر ٢٠٢١ . تم دراسة مجموعة من ٥٤ عملية ترميم متتالية فى ٤٦ مريضًا. تم تسجيل البيانات حول جنس المريض، وعمره، وسبب عيب الجمجمة، ونوع الزرع، وعدد عمليات ترميم الجمجمة التى تم إجراؤها لكل مريض، ونتيجة التجميل، وشفاء الجرح، والمضاعفات، وإدارة المضاعفات. تراوحت فترة المتابعة بين ٢٤ و ٣٦ شهرًا.

النتائج: لم يحدث أى وفيات نتيجة لعملية ترقيع الجمجمة. وجد أن ستة من بين عشرين مريضًا (٣٠٪) تعرضوا لمضاعفات بعد عملية ترقيع الجمجمة باستخدام زراعة ذاتية؛ حيث عانت حالتان من مضاعفات انتفاخ جراحى تحت الجلد فى الموقع الذى تم أخذ الطعم منه، بينما عانت أربع حالات من امتصاص الطعم واحتاجت إلى جراحة ثانية باستخدام شبكة من التيتانيوم. تطورت مضاعفات فى ستة (١٧,٦٪) من أصل ٣٤ حالة من ترقيع الجمجمة الاصطناعى؛ تم علاج حالتين من العدوى فى ترقيع الأكريليك بنجاح باستخدام المضادات الحيوية، بينما تعرضت أربع حالات من ترقيع الأكريليك للتشقق والتفتت إلى قطع، ثم تم إعادة إجراء العملية باستخدام شبكة التيتانيوم.

الاستنتاج: يُظهر الطعم العظمى الذاتى معدلًا أعلى من الامتصاص التلقائى فى المرضى الأطفال ويمكن للمرضى الذين تتجاوز أعمارهم ٥ سنوات أن يخضعوا بأمان لعملية ترقيع الجمجمة باستخدام مواد اصطناعية. يوفر ترقيع الجمجمة الاكريليكى خيارًا آمنًا وفعالًا للمراكز ذات الإمكانيات المحدودة، ولكن يجب دراسة فعالية المواد الاكريليكية على المدى الطويل فى دراسة أكثر شمولاً.