Cranioplasty

- Bone Graft Expansion in Cranioplasty Using a Split-Bone Technique
- Cranioplasty After Removal of a Meningioma With Skull Invasion: A Technical Case Report
- The Effectiveness of Combined Mirror Therapy and Contralateral Controlled Functional Electrical Stimulation Therapy in a Stroke Patient With Upper Limb Motor Paralysis: A Case Report
- Rural Health: What can and cannot be done in an isolated rural neurosurgical unit
- Pre- and post-cranioplasty hydrocephalus in patients following decompressive craniectomy for ischemic stroke: a systematic review and meta-analysis
- Intractable subdural effusion after decompressive craniectomy for traumatic brain injury: A case report
- Timing Matters: A Comprehensive Meta-Analysis on the Optimal Period for Cranioplasty After Severe Traumatic Brain Injury
- Therapeutic Strategies for Retention of Cranioplasty Titanium Mesh After Mesh Exposure

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Cranioplasty is a surgical intervention to repair cranial defects, frequently performed in neurosurgery.

It is one of the oldest known neurosurgical procedures, dating from the year 3000 B. C., when the Paracas Indians in Peru performed procedures to correct large cranial defects.

Archeologic findings proved that the use of inorganic materials for cranioplasty had begun before the organic materials [1)].

Decompressive craniectomy (DC) is a surgical procedure, that is followed by cranioplasty surgery. DC is usually performed to treat patients with traumatic brain injury, intracranial hemorrhage, cerebral infarction, brain edema, skull fractures, etc. In many published clinical case studies and systematic reviews, cranioplasty surgery is reported to restore cranial symmetry with good cosmetic outcomes and neurophysiologically relevant functional outcomes in hundreds of patients. In this review article, we present a number of key issues related to the manufacturing of patient-specific implants, clinical complications, cosmetic outcomes, and newer alternative therapies. While discussing alternative therapeutic treatments for cranioplasty, biomolecules and cellular-based approaches have been emphasized. The current clinical practices in the restoration of cranial defects involve 3D printing to produce patient-specific prefabricated cranial implants, that provide better cosmetic outcomes. Regardless of the advancements in image processing and 3D printing, the complete clinical procedure is time-consuming and requires significant costs. To reduce manual intervention and to address unmet clinical demands, it has been highlighted that automated implant fabrication by data-driven methods can accelerate the design and manufacturing of patient-specific cranial implants. The data-driven approaches, encompassing artificial intelligence (machine learning/deep learning) and E-platforms, such as publicly accessible clinical databases will lead to the development of the next generation of patient-specific cranial implants, which can provide predictable clinical outcomes. STATEMENT OF SIGNIFICANCE: Cranioplasty is performed to reconstruct cranial defects of patients who have undergone decompressive craniectomy. Cranioplasty surgery improves the aesthetic and functional outcomes of those patients. To meet the clinical demands of cranioplasty surgery, accelerated designing and manufacturing of 3D cranial implants are required. This review provides an overview of biomaterial implants and bone flap manufacturing methods for cranioplasty surgery. In addition, tissue engineering and regenerative medicine-based approaches to reduce clinical complications are also highlighted. The potential use of data-driven computer applications and data-driven artificial intelligence-based approaches are emphasized to accelerate the clinical protocols of cranioplasty treatment with less manual intervention and shorter intraoperative time [2)]

Indications

see Cranioplasty Indications.

Contraindications

see Cranioplasty contraindications.

Timing

see Cranioplasty timing.

Classification

Ultra-early cranioplasty (defined here as <30 days from the original craniectomy)

Conventional cranioplasty for some (defined here as >30 days from the original craniectomy)

Early Cranioplasty (defined here as <60-90 days from the original craniectomy)

The pediatric patient for this procedure is distinct from the adult one because of the growing skulls and thinner bones of the calvarium. A paucity of data on the outcomes of this procedure in the pediatric population has been identified repeatedly.

Wagas et al conducted a retrospective cohort study to investigate the outcomes in a pediatric population that underwent cranioplasty after craniectomy at a institute in a developing-world country. The cohort showed no association of complication rate or cosmetic outcomes with the timing of cranioplasty, area of skull defect, type of implant used, or method of storage [3)].

Materials

see Cranioplasty materials.

Direct Consequences

Intracranial pressure (ICP) is a crucial factor that we need to take into account in all major pathophysiological changes of the brain after decompressive craniectomy (DC) and cranioplasty (CP). The purpose of a study was to check ICP values before and after cranioplasty and its relation to various parameters (imaging, demographics, time of cranioplasty, and type of graft) as well as its possible relation to postsurgical complications. The authors performed a prospective study in which they selected as participants adults who had undergone unilateral frontotemporoparietal DC and were planned to have cranioplasty. Intracranial pressure was measured with fiber-optic sensor in the epidural space and did not affect cranioplasty in any way.Twenty-five patients met the criteria. The mean vcICP (value change of ICP) was 1.2 mm Hg, the mean ΔICP (absolute value change of the ICP) was 2.24 mm Hg and in the majority of cases there was an increase in ICP. The authors found 3 statistically significant correlations: between gender and ΔICP, Δtime (time between DC and CP) and vcICP, and pre-ICP and ±ICP (quantitative change of the ICP).Male patients tend to develop larger changes of ICP values during CP. As the time between the 2 procedures (DC and CP) gets longer, the vcICP is decreased. However, after certain time it shows a tendency to remain around zero. Lower pre-ICP values (close to or below zero) are more possible to increase after bone flap placement. It seems that the brain tends to restore its pre-DC conditions after CP by taking near-to-normal ICP values [4)].

Complications

see Cranioplasty complications.

Technique

see Cranioplasty technique

Review

2017

A PubMed, Google Scholar, and MEDLINE search adhering to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines included studies reporting patients who underwent DC and subsequent cranioplasty in whom cerebral hemodynamics were measured before and after cranioplasty.

The search yielded 21 articles with a total of 205 patients (range 3-76 years) who underwent DC and subsequent cranioplasty. Two studies enrolled 29 control subjects for a total of 234 subjects. Studies used different imaging modalities, including CT perfusion (n = 10), Xenon-CT (n = 3), single-photon emission CT (n = 2), transcranial Doppler (n = 6), MR perfusion (n = 1), and positron emission tomography (n = 2). Precranioplasty CBF evaluation ranged from 2 days to 6 months; postcranioplasty CBF evaluation ranged from 7 days to 6 months. All studies demonstrated an increase in CBF ipsilateral to the side of the cranioplasty. Nine of 21 studies also reported an increase in CBF on the contralateral side. Neurological function improved in an overwhelming majority of patients after cranioplasty.

This systematic review suggests that cranioplasty improves CBF following DC with a concurrent improvement in neurological function. The causative impact of CBF on neurological function, however, requires further study [5].

Case series

Cranioplasty case series.

Cranioplasty surgical technique

Cranioplasty surgical technique.

1)
Sanan A, Haines SJ. Repairing holes in the head: A history of cranioplasty. Neurosurgery. 1997;40:588–603.
2)
Thimukonda Jegadeesan J, Baldia M, Basu B. Next-generation personalized cranioplasty treatment. Acta Biomater. 2022 Dec;154:63-82. doi: 10.1016/j.actbio.2022.10.030. Epub 2022 Oct 19. PMID: 36272686.
3)
Waqas M, Ujjan B, Hadi YB, Najmuddin F, Laghari AA, Khalid S, Bari ME, Bhatti UF. Cranioplasty after Craniectomy in a Pediatric Population: Single-Center Experience from a Developing Country. Pediatr Neurosurg. 2016 Dec 8. [Epub ahead of print] PubMed PMID: 27926912.
4)
Tsianaka E, Singh A, Drosos E, Fountas K. Direct Consequences of Cranioplasty to the Brain: Intracranial Pressure Study. J Craniofac Surg. 2021 Nov-Dec 01;32(8):2779-2783. doi: 10.1097/SCS.0000000000007945. PMID: 34727479.
5)
Halani SH, Chu JK, Malcolm JG, Rindler RS, Allen JW, Grossberg JA, Pradilla G, Ahmad FU. Effects of Cranioplasty on Cerebral Blood Flow Following Decompressive Craniectomy: A Systematic Review of the Literature. Neurosurgery. 2017 Mar 29. doi: 10.1093/neuros/nyx054. [Epub ahead of print] PubMed PMID: 28368505.