ORIGINAL RESEARCH PAPER

Volume - 10 | Issue - 06 | June - 2021 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

HAZARDS OF TITANIUM MESH CRANIOPLASTY – OUR EXPERIENCE

Neurosurgery

Dr. S. I. Sadique Associate Professor, Dept. of Neurosurgery, Bangur Institute of Neurosciences, I.P.G.M.E & R, Kolkata, India.

Dr. Md. Shahbaz Alam Associate Professor, Dept. of Anaesthesia, Teerthankar Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India.

Dr. Md. Shahid Alam* Senior Resident, Dept. of Neurosurgery, Bangur Institute of Neurosciences, I.P.G.M.E & R, Kolkata, India. *Corresponding Author

ABSTRACT

INTRODUCTION: Titanium is biologically inert, hard, rigid, strong, durable, light-weight, resistant to infection, easy to handle and relatively inexpensive, hence frequently used as the material of choice for cranioplasty. But at the same time there is significant rate of complications, most commonly infection, poor cosmesis, hematoma, headache, seizure and implant exposure necessitating re-operation and implant removal.

MATERIALS AND METHODS: The present study was conducted in the department of neurosurgery, Bangur Institute of Neurosciences(B.I.N), Kolkata & SSKM Hospital, IPGME & R, Kolkata from January 2019 to December 2020. The study design was non-randomized prospective observational study. The period of study was 2 years. The sample size was 30.

OBSERVATIONS AND RESULTS: Total 30 patients underwent cranioplasty. Their mean age was 38 years (range, 20-62 years) with a male:female ratio of 3:2. Ten patients developed postoperative complications, making a cranioplasty complication rate of 33.34%. Out of 10 patients, 5 (50%) required further surgical procedure including 4 cases of cranioplasty removal, the overall removal rate of 13.34%. Overall mortality was nil.

CONCLUSION: Titanium mesh cranioplasty though a very common procedure used for correction of craniectomy skull defect is not totally free from complication. Our present study analyse the various causative factors which may lead to complications and implant failure. We have to be very judicious in the use of materials and other modalities used for skull defect repair depending upon the current materials available, the patient's general condition, co-morbidity, their economic status and modality of surgery.

KEYWORDS

Cranioplasty, Titanium mesh, Implant exposure, Post-operative complications.

INTRODUCTION:

Cranioplasty is the surgical repair of the cranial defect caused due decompressive craniectomy done for various etiology like traumatic brain injury, malignant cerebral infarction, tumor surgery. It avoids cosmetic deformity, reduces the vulnerability of unprotected brain tissues and prevent cognitive decline, or improve cognition in those with neurological deficit secondary to a cranial defect. Considering the immunological compatibility, the re-implantation of the patient's own bone flap is usually the material of choice. But age, difficulties with storage, timing of surgery and anatomical conditions can lead to the loss of the bone flap in a large number of cases.[1,2] Three main nonbiological materials, polymethylmethacrylate (PMMA), hydroxyapatite (HA) and titanium mesh are currently used widely. Titanium is biologically inert, hard, rigid, strong, durable, light-weight, resistant to infection, easy to handle and relatively inexpensive, hence frequently used as the material of choice for cranioplasty. But at the same time there is significant rate of complications, most commonly infection, poor cosmesis, hematoma, headache, seizure and implant exposure necessitating re-operation and implant removal. The latest review of titanium cranioplasty found that the overall complication rate was 26.4% and titanium plate removal rate was 10.3%.[3] The exposed implant rate in titanium cranioplasty was reported as 13.9%.[4]

MATERIALS AND METHODS:

Study design and setting

The present study was conducted in the department of neurosurgery, Bangur Institute of Neurosciences(B.I.N), Kolkata & SSKM Hospital, IPGME & R, Kolkata from January 2019 to December 2020. Ethical clearance to carry out the study was obtained from the ethical committee of the Institute. The study design was non-randomized prospective observational study. The period of study was 2 years. Study cases were included in the first year and were followed-up in the consecutive year. The sample size was 30. All the patients undergoing titanium cranioplasty during the study period regardless of aetiology were included in the study. All patients who did not undergo surgical intervention, had a non-titanium cranioplasty, lack of clinical follow-up were excluded. Pre-operative 3D rendered reconstructions of computerized tomographic images of the skull were done.

Surgical technique

Titanium mesh repair was the sole cranioplasty technique used. Peri-operative antibiotics, betadine soaks and post-operative sub-galeal free drainage were routinely applied.

Analysis

After written informed consent the following variables were recorded in all patients: demography, indication for primary surgery, interval between craniectomy and titanium cranioplasty, complications, Glassgow Coma Scale both pre and post-cranioplasty and need for further surgery.

STATISTICAL ANALYSIS

Data was analysed using SPSS version 16.0. A p value of less than or equal to 0.05 was considered statically significant.

OBSERVATIONS AND RESULTS:

Total 30 patients underwent cranioplasty in the first year of study period who were followed for the next 1 year. Their mean age was 38 years (range, 20-62 years) with a male:female ratio of 3:2. The commonest primary procedure requiring cranioplasty was decompressive craniectomy for trauma (n=22). All cranioplasty was done in the range of 3-6 months from the primary surgery. All cranioplasties in our series were single titanium mesh constructed intraoperatively. The primary pathologies in this study are shown in **Table 1**.

Table 1. Primary pathologies leading to titanium cranioplasty.

Sl. NO.	Primary pathology	No. of patients	Percentage(%)
1	Decompressive craniectomy (trauma)	22	73.34
2	Tumor Surgery	08	26.67

Ten patients developed postoperative complications, making a cranioplasty complication rate of 33.34%. Out of 10 patients, 5 (50%) required further surgical procedure including 4 cases of cranioplasty removal, the overall removal rate of 13.34%.

Table 2. shows the timing, severity of complications. 'Mild' complications were those that were self-limiting and resolved with conservative management. 'Moderate' complications required a

period of sustained medical management and monitoring and 'Severe' complications required critical care and further surgery. Infection was the most common complication (n=4) giving an overall infection rate of 13.34%. The second most common complication was Implant exposure (n=3, 10%). Patients who underwent implant removal for implant exposure had wound washout, debridement followed by simple wound closure as shown in **Figure 1.** Post-operatively these patients were treated with systemic treatment followed by oral antibiotic therapy. Seizure and hemiparesis that developed in 1 study case resolved after implant removal. There was no mortality in the study group.

Table 2. Type and incidence of complications following titanium cranioplasty.

Sl. No.	Severity of complications	Early complications (n = 7, 23.34%)	Late complications (n = 3, 10%)
1	Mild (n=4, 13.34%)	Wound infection – resolved with conservative management (n = 4)	
2	Moderate (n=1, 3.34%)	CSF leak requiring intervention (n = 1)	
3	Severe (n=5, 16.67%)	Extradural haematoma – evacuation done (n = 1) Seizure with hemiparesis requiring implant removal (n = 1)	Implant Exposure requiring implant removal (n = 3)

FIGURE : 1. A – Photograph showing exposed titanium mesh. **B –** Per-op photograph showing tissue dissection with exposed mesh. **C –** Post-op photograph showing removed exposed mesh with intact duramater with hair growth at skin-dura junction. **D –** Photograph showing cranial defect after mesh removal with hair growth at wound site.

DISCUSSION:

It is widely believed that all foreign materials, including metallic implants, allografts, and non-vascularized autografts, can decrease antibiotics effectiveness via increased bacterial adherence and biofilm formation.[5] This is because antibiotics, phagocytes and various humoral immune responders cannot reach bacteria through the biofilm. Staphylococcus epidermidis adheres much more easily to stainless steel than to titanium.[6] Titanium alloy surfaces are thought to minimize bacterial adhesion and thereby lower the rate of infection. The titanium mesh cage has been used even at sites of infection in some cases with septic spondylitis.[7] Ischaemic scalp lesions due to insufficient tissue perfusion can also be a cause of scalp ulceration.[8] Titanium mesh should be removed if exposed through skin in post-op follow-up. Takumi et al. reported a reconstruction procedure using a vascularized calvarial flap for intractable scalp ulcers associated with cranial implants that didn't involved removing the entire prosthesis.[9] It is very important to preserve the balance of the scalp-galea-calvarium network with its mutual blood supply systems.[10]

The superiority of autologous bone is not clear and some authors consider it inferior as it is prone to osteolysis and infection. Acrylic (PMMA) is light weight, cheap, radiolucent and can be moulded intra-operatively. Complication rates for PMMA have been reported as high as 24%.[11] For large sized defect pre-formed cranioplasties may be preferred, including HA ceramics and titanium. HA achieves minimal tissue reaction, increased bone repair, good osteointegration and osteoconductivity but lack resistance to mechanical stress and may easily break. Ceramic achieves osteointegration similar to acrylic, but lacks sufficient durability. Titanium is relatively cheap, bioacceptable but may not be a good option in cases of bad skin viability (such as after multiple operations or radiotherapy).[12,13,14]

In our study, we reported an absolute complication rate of 33.34%. The figure is comparable with several studies in the literature.[14-19] 50% of complications were severe requiring further surgery or intensive care. The commonest complication was wound infection at the rate of 13.34%. This is in keeping with published study on titanium mesh cranioplasty.[15,16,18,20,21,22,23] Plate removal rate was 13.34% and implant exposure accounted for 10% of these cases. This is consistent with recently published studies.[21,22] We found only 1 case of seizure and contralateral hemiparesis developing after cranioplasty, though such complications has not been mentioned in previous literature. It may be probably due to development of a large pseudomeningoceles which in our case was rectified by doing a lumbo-peritoneal shunts to reduce the CSF pressure after the removal of cranioplasty mesh, hence reducing the size of the pseudomeningocele and later performing cranioplasty gave good results. In some cases there may be a large ventriculocele formation through a large calvarial defect. In such cases prior VP shunting and then craniplasty may be done.

Recent studies shows that we have other options such as Carbon fiber reinforced polymer(CFRP) and Polyetheretherketone(PEEK), which are the biocompatible materials that provide high strength and radiolucency for post-operative imaging and can be used as a replacement for currently available implant materials with improved safety and efficacy. In a series of 29 patients, not a single CFRP plate had to be removed.[24] The computer assisted design (CAD)/ computer assisted modeling (CAM) PEEK implants for cranioplasty are gaining access in calvarial reconstruction recently.[25]

CONCLUSION:

Titanium mesh cranioplasty though a very common procedure used for correction of craniectomy skull defect is not totally free from complication. Our present study analyse the various causative factors which may lead to complications and implant failure. We have to be very judicious in the use of materials and other modalities used for skull defect repair depending upon the current materials available, the patient's general condition, co-morbidity, their economic status and modality of surgery.

REFERENCES:

1) Grant GA, Jolley M, Ellenbogen RG, Roberts TS, Gruss JR, Loeser JD: Failure of autologous bone-assisted cranioplasty following decompressive craniectomy in children and adolescents. J Neurosurg 100 (2 Suppl Pediatrics):163–168, 2004
2) Matsuno A, Tanaka H, Iwamuro H, Takanashi S, Miyawaki S, Nakashima M, et al: Analyses of the factors inflencing bone graft infection after delayed cranioplasty. Acta Neurochir (Wien) 148:535–540, 2006
3) Mukherjee S, Thakur B, Haq I, Hettige S, Martin AJ: Complications of titanium cranioplasty—a retrospective analysis of 174 patients. *Acta Neurochir* (*Wien*) 156: 989–998; discussion 998, 2014
4) Thien A, King NK, Ang BT, Wang E, Ng I: Comparison of polyetheretherketone and titanium cranioplasty after decompressive craniectomy. *World Neurosurg* 83: 176–180, 2015
5) A.G. Gristina, C.D. Hobgood, L.X. Webb, Q.N. Myrvik, Adhesive colonization of biomaterials and antibiotic resistance, Biomaterials 8 (6) (1987) 423 –426.
6) S. Arens, U. Schlegel, G. Printzen, W.J. Ziegler, S.M. Perren, M. Hansis, In fluence of materials for fixation implants on local infection. An experimental study of steel versus titanium DCP in rabbits, J Bone Joint Surg Br 78 (4) (1996) 647 –651.
7) P. Korovessis, T. Repantis, P. Iliopoulos, A. Hadjipavlou, Bene ficial influence of titanium mesh cage on infection healing and spinal reconstruction in hematogenous septic spondylitis: a retrospective analysis of surgical outcome of twenty- five consecutive cases and review of literature, Spine (Phila Pa 1976) 33 (21) (2008) E759 –E767.
8) P. Korovessis, T. Repantis, P. Iliopoulos, A. Hadjipavlou, Bene ficial influence of titanium mesh cage on infection healing and spinal reconstruction in hematogenous septic spondylitis: a retrospective analysis of surgical outcome of twenty- five consecutive cases and review of literature, Spine (Phila Pa 1976) 33 (21) (2008) E759 –E767.
9) I. Takumi, M. Akimoto, One-stage reconstruction using a vascularized calvarial flap for intractable scalp ulcers in relation with cranial implants without removing the whole prosthesis, Neurosurg. Rev. 32 (3) (2009) 363 –368 (discussion 368).
10) C.B. Cutting, J.G. McCarthy, A. Berenstein, Blood supply of the upper craniofacial skeleton: the search for composite calvarial bone flaps, Plast. Reconstr. Surg. 74 (5) (1984) 603 –610.
11) Im SH, Jang DK, Han YM, Kim JT, Chung DS, Park YS (2012) Long-term incidence and predicting factors of cranioplasty infection after decompressive craniectomy. J Korean Neurosurg Soc 52:396–403
12) Aydin S, Kucukyuruk B, Abuzayed B, Sanus GZ (2011) Cranioplasty: review of materials and techniques. J Neurosci Rural Pract 2:162–167
13) Gooch MR, Gin GE, Kenning TJ, German JW (2009) Complications of cranioplasty following decompressive craniectomy: analysis of 62 cases. Neurosurg Focus 26:E9
14) Sobani ZA, Shamim MS, Zafar SN, Qadeer M, Bilal N, Murtaza SG, E n a m S A , B a r i M E (2 0 1 1) Cranioplasty after decompressive craniectomy: an institutional audit and

PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

analysis of factors related to complications. Surg Neurol Int 2:123
15) Chang V, Hartzfeld P, Langlois M, Mahmood A, Seyfried D (2010) Outcomes ofcranial repair after craniectomy. J Neurosurg 112:1120–1124
16) Moreira-Gonzalez A, Jackson IT, Miyawaki T, Barakat K, DiNick V (2003) Clinical outcome in cranioplasty: critical review in long-term follow-up. J CraniofacSurg 14:144–153
17) Sahuquillo J, Arikan F (2006) Decompressive craniectomy for the treatment of refractory high intracranial pressure in traumatic brain injury. Cochrane Database Syst Rev 1:CD003983, updated May 2008
18) Sanan A, Haines SJ (1997) Repairing holes in the head: a history of cranioplasty. Neurosurgery 40:588–603
19) Segal DH, Oppenheim JS, Murovic JA (1994) Neurological recovery after cranioplasty. Neurosurgery 34:729–731
20) Aydin S, Kucukyuruk B, Abuzayed B, Sanus GZ (2011) Cranioplasty: review of materials and techniques. J Neurosci Rural Pract 2:162–167
21) Hill C S, Luoma A M, Wilson S R, Kitchen N (2012) Titanium cranioplasty and the prediction of complications. Br J Neurosurg 26:832–837
22) Stephens FL, Mossop CM, Bell RS, Tigno T Jr, Rosner MK, Kumar A, Moores LE, Armonda RA (2010) Cranioplasty complications following wartime decompressive craniectomy. Neurosurg Focus 28:E3
23) Wiggins A, Austerberry R, Morrison D, Ho KM, Honeybul S (2013) Cranioplasty with custom- made titanium plates—14 years' experience. Neurosurgery 72:248–256
24) Saringer W, Nobauer-Huhmann I, Knosp E: Cranioplasty with individual carbon fire reinforced polymere (CFRP) medical grade implants based on CAD/CAM technique. Acta Neurochir (Wien) 144:1193–1203, 2002
25) Scolozzi P, Martinez A, Jaques B: Complex orbito-fronto-temporal reconstruction using computer-designed PEEK implant. J Craniofac Surg 18:224–228, 2007