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FROM FRAGMENTATION TO RESTORATION: OUR JOURNEY IN TITANIUM MESH CRANIOPLASTY

Plastic Surgery

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ABSTRACT

Background: Cranioplasty is a vital surgical procedure for repairing cranial defects, enhancing both functional and cosmetic outcomes. Titanium mesh has emerged as a preferred material due to its biocompatibility, strength, and adaptability. **Methods:** A retrospective observational study was conducted on 25 patients who underwent titanium mesh cranioplasty at a tertiary care centre between January 2020 and December 2023. Patient demographics, etiology, defect characteristics, timing of cranioplasty, surgical, complications, and satisfaction levels were analysed. Outcomes were assessed at three and six months postoperatively, with satisfaction measured using the Visual Analog Scale (VAS). **Results:** The cohort included 14 males (56%) and 11 females (44%) with a mean defect size of 12 × 10 cm. No intraoperative or postoperative complications, such as infection, hematoma, or mesh extrusion, were observed. At six months, most patients reported high satisfaction (VAS ≥6). Outcomes were favourable for both primary (68%) and secondary (32%) cranioplasties. **Conclusion:** Titanium mesh is a safe and effective material for cranioplasty, offering excellent functional and cosmetic results with a low complication profile. Its adaptability and durability make it suitable for both early and delayed reconstructions.

KEYWORDS

Cranioplasty, Titanium mesh, Cranial defects, Visual analogue score

INTRODUCTION

Cranioplasty, the surgical repair of cranial defects, is a critical procedure performed to restore the integrity of the skull following conditions such as traumatic brain injury, ischemic stroke, tumour resection, or infections that lead to the removal of bone flaps. Cranioplasty also plays a key role in improving both the functional and cosmetic aspects of the patient, which can significantly impact their quality of life.

Historically, a variety of materials have been used for cranioplasty, ranging from autologous bone grafts to synthetic materials such as polymethyl methacrylate (PMMA), hydroxyapatite, and titanium mesh.[1] While autologous bone is often considered the gold standard due to its biocompatibility and minimal rejection risk, it carries significant limitations, including the risk of resorption, infection, or deformity over time.[2]

Titanium mesh is widely recognized for its strength, biocompatibility, and favourable properties in reconstructive surgery. It provides robust protection to the underlying brain while maintaining low rates of infection and rejection. Additionally, titanium's flexibility allows for easy intraoperative moulding, making it ideal for tailoring to the unique shape and size of individual cranial defects.[3]

Despite the growing popularity of titanium mesh, there remain concerns regarding its long-term performance, including the potential for delayed complications such as infection, extrusion, and issues related to the aesthetic appearance of the repaired skull.[4]

In this study, we aim to present our institutional experience with titanium mesh cranioplasty over a series of 25 patients, highlighting the clinical outcomes, complications, and patient satisfaction over a six-month follow-up period. This study also offers insights into the advantages and limitations of titanium mesh cranioplasty in various clinical settings, supporting its role as a preferred material for repairing cranial defects.

Methods

This retrospective observational study was conducted at a tertiary care centre in department of Plastic and Reconstructive surgery. The study included 25 patients who underwent titanium mesh cranioplasty between Jan 2020 and Dec 2023.

Inclusion Criteria

- Underwent cranioplasty using titanium mesh for reconstruction of cranial defects.
- Had a documented follow-up of at least six months.
- More than 10 years of age at the time of surgery.

Exclusion Criteria

- They underwent cranioplasty with materials other than titanium mesh.
- They had incomplete follow-up data or a follow-up period of less than six months.
- They experienced active infections or other conditions contraindicating cranioplasty at the time of surgery.

Data were retrospectively collected from the institution's electronic medical record system. The following specific parameters were included:

- Age and gender distribution of the patient population.
- Presence of comorbidities such as diabetes mellitus and hypertension
- The cause of the cranial defect was categorized into road traffic accidents, infarct, tumours, and electrical burns
- The size of the cranial defect (measured in cm).
- Laterality of the defect.
- Anatomical site of the defect.
- The timing of cranioplasty was classified as either primary (mesh cranioplasty was done immediately after the decompressive crainectomy) or secondary (failed autologous bone graft followed by mesh cranioplasty).
- The interval between decompressive craniectomy and cranioplasty.
- Any intraoperative complications, such as dural tears, bleeding, or difficulties in mesh placement.
- Postoperative complications, including infection, implant rejection, hematoma formation, wound dehiscence, or neurological deterioration.

- Follow-up assessments were conducted at three months and six months post-surgery. Patients were evaluated for any signs of complications or neurological decline.
- Patient satisfaction was assessed using the Visual Analog Scale (VAS) at six months, with patients asked to rate their satisfaction with the procedure on a scale of 0 to 10 (0 indicating no satisfaction and 10 indicating maximum satisfaction).

Surgical Procedure:

- All cranioplasty procedures were performed under general anaesthesia.
- Incision was taken at the previous incision scar site, depending on the site of the defect scalp flap was raised at subgaleal level.
- The defect size was measured and titanium mesh was cut according to the dimension, contoured and fixed to the adjacent bone with 1.5mmx4mm or 1.5mmx6mm titanium screws.
- Open tube drain was placed and skin was closed with non absorbable polyamide suture 3 0. Compressive dressing was done with crepe bandage.
- Dressing was done on POD 3, and tube drain was removed.
- Suture removal was done on POD 10.
- The operative time was recorded for each case.

Fig 1: Subgaleal dissection with Titanium mesh insitu, intraoperative moulding of the mesh, immediate post-operative results.

Statistical Analysis

Data were analysed using descriptive statistics. Percentages were used to represent categorical variables such as gender, comorbidities, etiology of cranial defects, laterality of defects, and timing of cranioplasty. Continuous variables, such as defect size, operative time, and the interval between decompressive craniectomy and cranioplasty, were presented as means with standard deviations (SD).The VAS results were categorized into low satisfaction (0–3), moderate satisfaction (4–6), and high satisfaction (7–10).

Results

The study included 25 patients who underwent titanium mesh cranioplasty at our institution and the population was composed of 14 males (56%) and 11 females (44%).

Fig 2: Mean age

Four patients (16%) had a history of diabetes mellitus and seven patients (28%) had a history of hypertension.

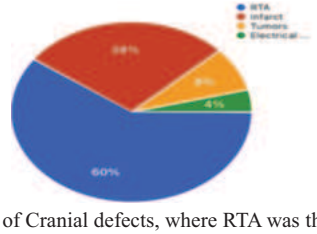

Fig:3 Etiology of Cranial defects, where RTA was the most common cause.

Twelve patients (48%) had defects on the right side and thirteen patients (52%) had on the left side. The mean size of the cranial defect was 12 cm × 10 cm.

The most common anatomical site for the cranial defects was the fronto-temporo-parietal region followed by:

- Fronto-temporo-parietal: 19 patients (76%)
- Frontal: 2 patients (8%)
- Parietal: 4 patients (16%)

The majority of patients underwent primary cranioplasty, with the procedure performed within three months following decompressive craniectomy:

- Primary cranioplasty: 17 patients (68%)
- Secondary cranioplasty: 8 patients (32%)

The mean interval between decompressive craniectomy and cranioplasty was 10 months for the secondary cranioplasty group, with the longest interval being 18 months. The mean operative time for the cranioplasty procedures was 103 minutes (ranging from 85 to 130 minutes). No significant difference in operative time was observed between primary and secondary cranioplasties. None of the patients experienced any intraoperative complications, such as dural tears, bleeding, or difficulties in mesh placement.

Follow-up assessments were conducted at three months and six months after the cranioplasty.

- Three-Month Follow-up:
  - No patients experienced postoperative complications, including wound infection, hematoma, or cerebrospinal fluid leakage.
  - All patients reported satisfactory wound healing and had no signs of mesh displacement or skin dehiscence.
- Six-Month Follow-up:
  - Similar to the three-month follow-up, no postoperative complications were observed at the six-month mark.
  - No cases of infection, titanium mesh extrusion, or neurological decline were noted. All patients maintained stable neurological function, and no adverse events such as seizures or new neurological deficits occurred.

At the six-month follow-up, patient satisfaction was assessed using the Visual Analog Scale (VAS), with a score range of 0 (no satisfaction) to 10 (maximum satisfaction).

- VAS score of 6: Reported by the majority of patients (n = 14, 56%)
- VAS score of 7–8: Reported by 8 patients (32%)
- VAS score of 9–10: Reported by 3 patients (12%)

The patients generally expressed satisfaction with the cosmetic outcome, the feeling of cranial protection, and the overall quality of life post-cranioplasty.

Fig 4: Post RTA at 6 months of follow up

Fig 5: Post RTA with significant deformity correction.

Fig 6: Post HTN infarct craniectomy, good improvement in terms of morbidity and patient satisfaction seen.

Fig 7: Post RTA, immediate post op results.

The results of this study demonstrate the effectiveness and safety of titanium mesh cranioplasty for the reconstruction of moderate to large cranial defects, with a favourable complication profile and high patient satisfaction over a six-month follow-up period.

DISCUSSION

Several studies have highlighted the efficacy and safety of titanium mesh cranioplasty.For example, a study by Gooch et al. (2009) reported that titanium mesh cranioplasty is associated with a low incidence of infection and other complications, with most patients experiencing satisfactory outcomes[5]. The authors noted that the absence of intraoperative complications is consistent with the findings of our study, which also reported no intraoperative complications and favourable outcomes at 3 and 6 months follow-up. This underscores the low complication profile of titanium mesh cranioplasty, making it a reliable choice for both primary and secondary cranioplasty procedures. The ability to contour and shape the mesh intraoperatively allows for precise fitting, ensuring optimal coverage of cranial defects and excellent cosmetic outcomes.

Titanium mesh has emerged as one of the most widely used materials for cranioplasty, primarily due to its strength, flexibility, and biocompatibility. Autologous bone grafts, while often considered the gold standard, are prone to complications such as bone resorption, infection, and deformity over time.

Common complications associated with cranioplasty, such as, hematoma formation, CSF leakage, or mesh extrusion, were not encountered in our study. This may be attributed to several factors, including meticulous surgical technique, careful patient selection, and appropriate postoperative care.

Infection remains one of the most feared complications in cranioplasty, particularly when synthetic materials are used. Studies report infection rates ranging from 4% to 15% depending on the material when placed in a clean and sterile environment, presents a low risk of infection, consistent with other studies that have reported infection rates as low as 1% to 5% with titanium.

The mean operative time for titanium mesh cranioplasty, as reported in our study (103 minutes), aligns with findings from other studies. Honeybul et al. (2013) found that titanium mesh allows for relatively straightforward and efficient reconstruction, with operative times typically ranging from 60 to 120 minutes depending on the complexity of the defect and the surgical approach used[6]. The mean defect size in our study (12x10 cm) is comparable to those reported in the literature, where titanium mesh has been successfully used to repair defects of similar or larger dimensions.

The operative time in our study was relatively short (mean duration of 103 minutes), which may also contribute to the favourable outcomes, as shorter operative times are generally associated with reduced complication rates.

In our study, patients reported a VAS score of 6 at 6 months, indicating moderate satisfaction with both the cosmetic and functional results of the procedure. This is consistent with findings from Park et al. (2016), who observed high levels of patient satisfaction following cranioplasty with titanium mesh. Their study highlighted that patients experienced improvements in both aesthetic and functional outcomes, contributing to an overall positive impact on quality of life[7].

One of the major concerns for patients undergoing cranioplasty is the cosmetic result, as the cranial defect can have a significant impact on appearance and self-esteem. Titanium mesh is particularly well-suited for achieving satisfactory cosmetic outcomes, as it can be moulded to closely match the contours of the skull.[8] In our study, patient satisfaction was high, with most patients reporting a VAS score of 6 or higher at the six-month follow-up.

The radiolucent nature of titanium allows for clear postoperative imaging, which is beneficial for monitoring any potential complications or changes in the reconstructed area.[9] the absence of major complications in our study at 3 and 6 months is in line with other studies that have demonstrated the low complication rate associated with titanium mesh cranioplasty.[10]

In our study, 68% of the patients underwent primary cranioplasty, while 32% underwent secondary cranioplasty. Despite the difference in timing, the outcomes were similarly favourable in both groups, with no significant differences in complication rates or patient satisfaction. However, it is important to note that the decision to perform primary or secondary cranioplasty should be based on individual patient factors, including the risk of infection, the presence of comorbidities, and the status of the surgical wound.[11]

Study Limitations

Despite the favourable outcomes reported in this study, there are several limitations. The sample size is relatively small, with only 25 patients included. The follow-up period of six months, while adequate for assessing short-term outcomes, does not allow for the evaluation of long-term complications. Future studies with larger sample sizes and longer follow-up durations are needed to confirm the durability and long-term safety of titanium mesh in cranioplasty.

CONCLUSION

Titanium mesh cranioplasty is a safe, effective, and cosmetically satisfying option for the reconstruction of moderate to large cranial defects. Titanium mesh offers several advantages, including biocompatibility, strength, and the ability to be easily contoured to individual cranial defects, making it a preferred material for cranioplasty. The operative times were relatively short, and the absence of intraoperative complications such as dural tears or bleeding further supports the ease of using this material. Titanium mesh should be considered a first-line option for cranial defect reconstruction, particularly in cases involving large or complex defects. The ability to use titanium mesh in both early and delayed cranioplasty settings also gives surgeons greater flexibility in managing patients who have undergone decompressive craniectomy. While this study highlights the short-term success of titanium mesh, further research with larger cohorts and longer follow-up periods is necessary to assess long-term outcomes and to compare its performance with other reconstructive materials.

REFERENCES

1. Sahoo NK, Tomar K, Sharma G, Singh V, Thakur S, and Dhillon MS. Cranioplasty: Review of materials and techniques. Indian J Neurotrauma. 2017; 14(2):109-115. Doi: 10.1055/s-0037-1610275.
2. Rosenthal G, Ng I, Moscovici S, et al. Polyetheretherketone implants for the repair of large cranial defects: A multi-center clinical series with 5 years of follow-up. J Neurosurg. 2014; 118(3):613-618. doi:10.3171/2014.11.JNS14727.
3. Wiggins A, Austerberry R, Morrison D, Kosmopoulos V, Sgouros S. Use of custom-made titanium cranioplasty plates for treating complex defects in infants and young children. J Neurosurg Pediatr. 2013; 12(1):34-40. doi:10.3171/2013.3.PEDS12468.
4. Honeybul S, Morrison DA, Ho KM, Lind CR. A randomized controlled trial comparing

autologous cranioplasty with custom-made titanium cranioplasty. J Neurosurg. 2017; 126(1):81-90. doi:10.3171/2015.11.JNS151301.
5. Gooch MR, Gin GE, Kenning TJ, German JW. Complications of cranioplasty following decompressive craniectomy: Analysis of 62 cases. Neurosurg Focus. 2009; 26(6):E9. doi:10.3171/2009.3.FOCUS0974.
6. Honeybul S, Morrison DA, Ho KM, Lind CR. A randomized controlled trial comparing autologous cranioplasty with custom-made titanium cranioplasty. J Neurosurg. 2017; 126(1):81-90. doi:10.3171/2015.11.JNS151301.
7. Park EK, Lim JY, Yun IH, Kim SH, Kim SW. Complications of cranioplasty using a titanium mesh: A retrospective study of 237 cases. J Korean Neurosurg Soc. 2016; 59(5):569-575. doi:10.3340/jkns.2016.59.5.569.
8. Schiffman JM, O'Shaughnessy KD, Baldwin JC, McCarthy JG. Long-term outcomes in cranial reconstruction with titanium mesh: A follow-up study. Plats Reconstr Surg. 2012; 130(2):333-339. doi:10.1097/PRS.0b013e318254b296.
9. Lethaus B, Kessler P, Wiltfang J, Howaldt HP, Heiland M, Schramm A. Comprehensive analysis of titanium mesh in cranioplasty: A 10-year single-center study. J Oral Maxillofac Surg. 2012; 70(5):e225-e232. doi:10.1016/j.joms.2011.09.045.
10. Huang G, Zheng Q, Lin D, et al. Analysis of complications following titanium mesh cranioplasty in patients with large cranial defects. Neurosurg Rev. 2020; 43(3):917-924. doi: 10.1007/s10143-019-01150-2.
11. Honeybul S, Morrison DA, Ho KM, Lind CR. A randomized controlled trial comparing autologous cranioplasty with custom-made titanium cranioplasty. J Neurosurg. 2017; 126(1):81-90. doi:10.3171/2015.11.JNS151301.