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Titanium Mesh versus Autologous Bone Graft Cranioplasty

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ABSTRACT

Objective: To compare the efficacy of titanium mesh to autologous bone grafting in cranioplasty and assessing complications like seroma and abscess formations and subjective measures of pain.

Study Design: Comparative cross-sectional study

Place and Duration of Study: Neurosurgery Department, Combined Military Hospital, Rawalpindi Pakistan from Aug 2017 to Dec 2018.

Methodology: Twenty patients (Women=12, Men=8) were randomly assigned to Titanium Mesh (TM) group and 20 patients (Women=7, Men=13) to Autologous Bone Graft (ABG) group. All were subjected to cranioplasty using Titenium Mesh and Autologous Bone Graft procedures to assess cranial seroma and abscess formation and pain.

Results: Comparison of pain on day 3 showed 7(35%) patients in titenium mesh group experienced pain compared to 14(70%) patients in the autologous bone graft group, which was statistically significant (p<0.001). Similarly, a comparison on day 7, revealed that pain in the titenium mesh group reduced to 5(25%) patients compared to 11(55%) patients in the autologous bone graft group, which again was statistically significant (p<0.001). Four(20%) patients in titenium mesh group and 7(35%) patients in autologous bone graft group developed seroma on day 3 and the difference was significant (p<0.001). Two(10%) patients in titenium mesh group and 5(25%) patients in autologous bone graft group developed abscess, which was significantly different (p<0.001).

Conclusion: Cranioplasty using titenium mesh is better than autologous bone graft because complications like seroma, abscess and pain are attenuated in surgical cohorts.

Keywords: Abscess formation, Autologous bone graft, Cranioplasty, Post-op pain, Seroma formation, Titanium mesh.

How to Cite This Article: *Shamim B, Khan AA, Mushtaq MJ, Abbasi AS, Ahmed A, Shahzadi M. Titanium Mesh versus Autologous Bone Graft Cranioplasty. Pak Armed Forces Med J 2023; 73(Suppl-1): S140-143. DOI: https://doi.org/10.51253/pafmj.v73iSUPPL-1.3467*

INTRODUCTION

Cranioplasty is a surgical procedure that repairs a defects and deformity of the skulls. In this surgical procedure cranial vault defect is restored following decompressive craniectomy carried out for traumatic brain injury, ischemic or haemorrhagic disease, and after removal of cranial tumours. Apparently a simple, easy and routine surgical procedure, cranioplasty is associated with a high complication rates, reported in 41% of cases.[1] In addition, 25-76% cranioplasty patients require additional surgical procedures to correct these complications, with a mortality rate over 3% of cases.[2,3] Most common complications include post-op infections, autologous bone flap resorption, and hematoma/ seroma formation etc. Other possible complications are wound dehiscence, seizures, hygroma, and poor cosmetic results.[4] Complications associated with cranioplasty depends on many factors including duration between bone decompression and cranial reconstruction, materials used for reconstruction, experience of the surgeon, age and conditions of patients.[5,6] Complications after cranioplasty are more frequent in male and old patients,[6,7] however some complications may result from cranial locations that are convex like sub-occipital and bi-frontal cranium.[7,8] Cranial defects can be closed using different materials including natural material, like the skull bone of the patient (autologous bone graft), or alloplastic materials, like ceramics, acrylic resin (poly methyl methacrylate), titanium, and others etc. Job Janszoon van Meekeren, in 1668 used canine bone to repair a cranial defect in a Russian man.[9] The next advancement in cranioplasty took place in the late 19th Century with experimental ground breaking work in bone grafting leading to autografts that became popular in the early 20th Century for cranioplasty. Twentieth Century wars leading to head injuries, among other, provided impetus to search for alternative metals and plastics to cover large cranial defects. Poly methyl methacrylate (PMMA) was introduced in 1940, and is still the most common material used today for this purpose. Research in cranioplasty was then directed at improving the ability of the host to regenerate bone using titanium plates and in 2014, a

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Received: 13 Mar 2020; revision received: 02 Sep 2020; accepted: 08 Sep 2020

team of surgeons at Johns Hopkins introduced pericranialonlay cranioplasty to improve outcomes and minimize complications with cranial surgeries.[10] The objective of this study was to compare the efficacy of Titanium Mesh (TM) to Autologous Bone Grafting in cranioplasty and assess seroma, abscess and pain at post-op phase. Since Neurosurgery Ward, Combined Military Hospital, Rawalpindi serves as tertiary care center for military personnel and civilians from Rawalpindi, Islamabad, Northern areas and AJK, Pakistan, an assessment of cranioplasty types need to be carried out that would determine effective, efficient, and resource-saving protocol for patient care and management.

METHODOLOGY

The comparative cross-sectional study was conducted at the Department of Neurosurgery, Combined Military Hospital, Rawalpindi Pakistan, from August 2017 to December 2018. Permission from Hospital Ethical Committee was obtained (IERB No. 11/10/19 dated 21st Oct 2019), and a written informed consent was taken from all patients included in the study. The sample size was calculated by WHO sample size calculator, keeping Level of significance (α)= 10%, Power of test (1-β)=80%, Anticipated population proportion (P)=60%.

Inclusion Criteria: Patients aged 20-60 years received craniotomy for Traumatic Brain Injury (TBI) were included in the study.

Exclusion Criteria: Patients having chronic diseases like diabetes mellitus, chronic renal failure, bleeding disorders, immuno-compromised, pregnancy and ischemic heart diseases were not included in the study.

Twenty patients (Women=12, Men=8) randomly were assigned to titenium mesh Group and 20 patients (Women=7, Men=13) to autologous bone graft Group. Hospital registration number, name, age, gender, address and phone number (optional) were noted, and this information was kept confidential under lock and key with the principal investigator. General anesthesia was given to all the patients through Fentanyl, Propofol and Atracurium with dosage adjusted according to the weight of patient. Anesthesia was maintained with mixture of air, oxygen and Sevoflurane. Cranioplasty was done using Titanium Mesh for the titenium mesh Group and autologous bone graft cranioplasty for the autologous bone graft Group. All surgeries were performed by the same Neurosurgical team. Parenteral postoperative analgesia was given intravenously through Ketorolac (30mg) 8 hourly for 48 hours; and to control for post-op infection, intravenous Ceftriaxone (1g) 12 hourly was given for five days to both groups and were kept in hospital for at least seven days.

Postoperative (Post-op) pain was assessed and scored in both the groups using a visual analogue scale with 10mm line as point rating scale from 0-10, where 0 meant no pain and 10 as highest level of pain. This measurement was carried out at post-op day 3 and 7, where a score of 4 was considered significantly painful. In addition, we recorded pain for patients that required analgesics on day 3 and 7. Seroma was assessed on post-op day 3, and abscess on day 5. Patients were examined approximately after 14 days for a follow-up. All data was analysed by Statistical Package for Social Sciences (SPSS) version 14.0. Mean and standard deviation were calculated for quantitative variables like age. For categorical variables like gender, post-op pain, seroma and abscess formation, frequency was presented. Comparison of post-op pain, seroma formation and abscess formation was done using Chi-square test. *p*-value of <0.001 was considered as significant.

RESULTS

Twenty patients (Women=12, Men=8) were randomly assigned to Titanium Mesh (TM) Group (Mage 35.6±3.9 years) and 20 patients (Women=7, Men=13) to Autologous Bone Graft (ABG) Group (Mage 37.2±2.9 years). Comparison of pain on day 3 showed 7(35%) patients in titenium mesh Group experienced pain compared to 14(70%) patients in the autologous bone graft Group, which was statistically significant (p<0.001). Similarly, a comparison on day 7, revealed that pain in the titenium mesh Group reduced to 5(25%) patients compared to 11(55%) patients in the autologous bone graft Group, which again was statistically significant (p<0.001). Four (20%) patients in titenium mesh Group and 7(35%) patients in autologous bone graft Group developed seroma on day 3 and the difference was significant (p<0.001). Two (10%) patients in titenium mesh Group and 5(25%) patients in autologous bone graft group developed abscess, which was significantly different (p<0.001).

DISCUSSION

In many patients with severe neurological conditions, decompressive craniotomy serves as a life-saving procedure and requires bone closure either through bone flap replacement or its reconstruction with cranioplasty.[11] Cranial reconstruction provides protection to the underlying brain, improves neurological function by recovering cerebrospinal fluid (CSF) dynamics and cerebral blood flow, and cosmetically restore cranial contour.[11,12]

Table: Titanium Mesh versus Autologous Bone Graft Cranioplasty (n=20)

Parameters	Titenium Mesh Group	Autologous Bone Graft Group	*p*-value
Age	35.6±3.9	37.2±2.9	-
Gender			
Male Female	8(40%) 12(60%)	7(35%) 13(65%)	-
Pain on Day 03			
Positive Negative	7(35%) 13(65%)	6(30%) 14(70%)	<0.001
Pain on Day 07			
Positive Negative	5(25%) 15(75%)	11(55%) 9(45%)	<0.001
Analgesic Needed at Day 3			
Positive Negative	7(35%) 13(65%)	6(30%) 14(70%)	-
Analgesic Needed at Day 7			
Positive Negative	5(25%) 15(75%)	11(55%) 9(45%)	-
Seroma Formation			
Positive Negative	4(20%) 16(80%)	7(35%) 13(65%)	<0.001
Abscess Formation			
Positive Negative	2(10%) 18(90%)	5(25%) 15(75%)	<0.001

Cranioplasty seems like an easy and routine surgical procedure, but it is a high risk surgical procedure due to a high complication rate.[13] There are multiple factors which affect the outcome of the procedure for example time spent between decompression and reconstruction, implants/materials used for reconstruction, experience of the surgeon on cranial reconstruction, age and conditions of patients.[14] Complications associated with cranial reconstruction are high as compared to a routine neurosurgical operation e.g 15-41% versus 2-5%.[15] Moreover, another intervention may be required in 25-76% of patients with cranioplasty complications to correct the complications, which ultimately increase the mortality by over 3%. Complication rate is more in males and in elderly age group.[16] Rate of complication also depends upon the site of cranium i.e. whether the procedure has been performed on the convex surface, suboccipital region and bifrontal cranial region.[17] The most common complications associated with cranioplasty are infections, bone resorption, wound dehiscence, hematoma/seroma collection, seizures, hygromas and poor cosmetic results.[18]

Brommeland *et al.* in 2015 have demonstrated that surgical site infection (SSI) and bone flap resorption (BFR) were the two most common complications, affecting 8(9.2%) and 14(19.7%) patients, respectively following cranioplasty using bone grafting which can be compared to our results where 25% developed abscess post-operatively. Mukherjee *et al.* in 2014 demonstrated that titanium cranioplasty has high complication rate i.e., 26.4 % as compared to our study (10%) and the plate removal rate was 10.3%. The commonest complication was infection, which accounted for 69% of plate removals.[19] We have compared the outcome of cranioplasty using bone grafting and titanium mesh in terms of complications like pain, seroma formation and abscess formation. Results of our study show that the patients will have more pain and increased chances of seroma and abscess formation if bone grafting is used to close the defect, making titanium mesh usage superior to it.

CONCLUSION

Cranioplasty using titanium mesh is superior to autologous bone grafting as it has less complication rate in terms of pain, seroma and abscess formation. So, its usage in future will decrease the burden on health budget by decreasing the complication rate.

Conflict of Interest: None.

Author's Contribution

Following authors have made substantial contributions to the manuscript as under:

BS & AAK: Conception, Study design, analysis, Interperitation of data, approval for the final version to be published.

MJM & ASA: Data acquisition, manuscript writing, approval for the final version to be published.

AA & MS: Critically review, concept, drafted manuscript, approval for the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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