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Use of Titanium Mesh vs. Prolene Mesh with Polymethylmethacrylate Bone Cement in the Repair of Skull Vault Defects: A Comparative Study

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Abstract

Background: The medical procedure known as cranioplasty is utilized for the purpose of reconstructing the skull's anatomy and repairing any defects present in the skull. Achieving optimal skull reconstruction poses a challenge for neurosurgeons, and the most effective strategy to attain the best outcome is still a subject of discussion.

Aim of Study: To present the different indications, benefits, possible techniques, and methods of surgical repair of cranial vault defects. In addition, 20 cases will be presented comparing two methods of surgical repair of these defects.

Patients and Methods: The data collected from the 20 cases that were operated upon during the study were analyzed as 10 cases operated upon by prolene mesh with bone cement cranioplasty and 10 cases operated upon by titanium mesh cranioplasty, and the results were concluded and evaluated.

Results: We discussed the characteristics of many materials used in cranioplasty and set standards for the characteristics of an ideal cranioplasty material in general, then compared the outcomes of two of the most important materials used nowadays. In addition, we have included 20 cases with cranial defects that required surgical repair, caused by different etiologies, mostly post-traumatic and post-tumor resection, and demonstrated the results. These cases have been operated upon by placing titanium mesh in 10 cases and prolene mesh with a bone cement implant in another 10 cases. When comparing both materials, we found that there was no significant difference in cosmetic outcome. However, prolene mesh with bone cement implants was found to restore contouring more easily than titanium mesh, as prolene mesh is more flexible and bone cement is easier to mold. As regards cost, prolene mesh with bone cement is cheaper than titanium mesh. As regards complications, there was one case of prolene mesh with bone cement that had a wound infection, and we believe this was most probably due to the poor hygiene of the patient, so this obstacle can be avoided in future cases.

Conclusion: We discovered no significant difference in aesthetic result between the two types of reconstruction, however prolene mesh with bone cement implants restored contouring more easily than titanium mesh because it is more flexible and simpler to shape. Titanium mesh costs more than bone cement-coated prolene mesh.

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Key Words: *Titanium mesh – Prolene mesh – Polymethylmethacrylate bone cement.*

Introduction

CRANIAL defects usually occur after trauma, neurosurgical procedures like decompressive craniectomy, tumor resections, infection, and congenital defects. Cranioplasty is a reconstructive procedure that allows restoration of the skull anatomy and helps the patient avoid social sequelae. Many factors make optimal reconstruction a challenging issue, including the biocompatibility of the implant and the cosmetic results **[1]**.

Throughout the history of cranioplasty, many different types of materials have been used. An ideal cranioplasty material should fit the cranial defect, achieve complete closure, be radiolucent, resistant to infection, easy to shape, strong to biomechanical processes, not be dilated with heat, and not be expensive **[2]**. The options for reconstructive materials include autologous split calvarial and rib grafts and alloplastic materials such as titanium mesh, polymethyl methacrylate, calcium hydroxyapatite, and polyether ether ketone. The most important aspect of cranial reconstruction is to find the most aesthetic, safe, and reliable means of filling a defect **[2,3]**.

Titanium plates offer an excellent choice for cranioplasty based on their strength, low infection rate, biocompatibility, handling characteristics, and suitability for postoperative imaging techniques, but they are often avoided because of their high costs **[4,5]**. Polymethyl methacrylate bone

cement is another excellent choice for cranioplasty as it is easy to mold, less irritant to surrounding tissues, has a good cosmetic result, is affordable, and can be impregnated with antibiotics so the rate of infection can be lowered [5,6,7]. However, any synthetic material implanted may lead to infection or seroma that may lead to exposure of the construct and may need reoperation [3].

Aim of the work:

This work aims to present the different indications, benefits, possible techniques, and methods of surgical repair of cranial vault defects. In addition, 20 cases will be presented comparing two methods of surgical repair of these defects.

Patients and Methods

Biocompatibility features:

Assessment of each method of repair of cranial vault defects will take into consideration tissue tolerance, simplicity of manufacture intraoperatively, ease of sterilization, biomechanical reliability, resistance to infections, cost, and readiness to use.

Cosmetic results:

The most important assessment criterion in comparison of both techniques would be the achievement of the best and most acceptable cosmetic results. Cosmetic results would be graded into "perfect, good, acceptable," and not satisfactory according to the perception of the patient and his relatives.

Operative procedure:

The ease of the procedure, the overall operative time, and the estimated blood loss are among the factors to be considered in comparing each method.

Complications:

The occurrence of post-operative complications, including infection, seroma, exposure of the construct, need for reoperation, post-operative hemorrhage, and seizures, would be noted for each procedure and compared together.

Study design:

Prospective study from October 2021 till April 2022.

Study Methods:

Population of study & disease condition:

20 patients with skull defects were operated upon by cranioplasty in the Neurosurgery Department, Cairo University Hospitals.

Inclusion criteria: Post traumatic skull defects (after 3 months of compound skull fracture craniectomy and normalization of CRP and ESR). Post-neurosurgical procedures, skull defects, supratentorial defects. Patients are fit for surgery. Healthy overlying skin.

Exclusion criteria: Post-infectious (less than 3 months of craniectomy) and congenital skull defects. Infratentorial defects. Patients unfit for surgery. Affected "macerated or fibrosed" overlying skin until we involve the plastic surgery department in co-management and infection resolution (guided by ESR and CRP).

Methodology in details:

Twenty patients with post traumatic and post neurosurgical procedures skull defects will be operated upon by cranioplasty in the period starting from October 2021 till April 2022. They will be divided randomly into two groups: Group (A): 10 patients for Titanium mesh cranioplasty. Group (B): 10 patients for Prolene mesh with Polymethyl Methacrylate (PMMA) bone cement cranioplasty.

Clinical assessment:

History-taking: Personal history (name, age, sex, occupation, address, habits, marital status and handedness). History of present illness (analysis of complaint, other neurological symptoms, other body systems, previous treatments, and previous investigations). Past history (surgical history, medical history, similar attacks, trauma, medications, and allergies). Family history (consanguinity, disease, congenital anomalies, and similar conditions).

Examination:

General examination: Vital signs, general look, head and neck, chest and CVS, abdomen, extremities.

Neurological examination: Glasgow Coma Score, higher brain functions (cognition, mental status, speech, and gait), cranial nerve examination, extremities (motor, sensory, reflexes, and coordination), chest and abdomen (sensory level and abdominal reflex), autonomic system (sphincter status), spine examination (range of mobility, deformity, point of tenderness, and tension roots signs).

Investigations: CT brain with 3D reconstruction after craniectomy showing skull defect. CT brain with 3D reconstruction after cranioplasty (24 hours post-operative). MRI of the brain with contrast if the cause is an invasive tumor.

Intervention:

In both groups there is some common steps: General anesthesia. Position according to site of previous craniectomy. Proper sterilization of the wound using povidone iodine is to be done. Intradermal and subgaleal injection of adrenaline 1:200000 with 10ml of 0.5% xylocaine is to be administered all over the planned skin incision to induce vasoconstriction and minimize bleeding from the skin. Generous subgaleal injection of saline is to be done, with caution to facilitate separating the adherent scalp from the defect and underlying dura mater. After injection the wound is to be re-sterilized. Scalp incisions would be designed to be outside of the defect, behind the hair line, never parallel to previous wounds or scars to avoid sloughing or incision over scar of previous craniectomy, and with a broad flap base to accommodate the vascular supply to the area of skin within the flap, dissection of dura from overlying skin. Cranioplasty: With titanium mesh or prolene mesh with PMMA. At the end of both procedures: Closure of the skin and underlying galea with insertion of sub-galeal drain.

Postoperative care: Day after day, wound dressing using povidone iodine would be done for two weeks. All patients will receive post-operative antibiotics in the form of the third-generation cephalosporin; ceftriaxone. The hospital stay would be 2 days post-operative in the best circumstances. Stitches would be removed for all patients 10 days after surgery.

Study outcomes:

Primary outcomes: Cosmetic results. Complications. Compatibility of Implants.

Secondary outcome parameters: Operation time. Blood loss.

Sample size: Epi-calc 2000 would be used to calculate the sample size of this comparative study. Assuming 80% power, 0.05 level of significance, 20% null hypothesis value and estimated proportion of 10%. Total sample size=20 cases (10 cases each group.

Results

The data collected from the 20 cases that were operated upon during the study were analyzed as 10 cases operated upon by prolene mesh with bone cement cranioplasty and 10 cases operated upon by Titanium mesh cranioplasty, and the results were concluded and evaluated.

Age:

The youngest patient operated upon by cranioplasty was 3 years while the oldest was 52 years; patients had a mean age of 30 years.

Table (1): Showing age of patients participating in the study.

	Mean	Median	Minimum	Maximum	Standard deviation	Percentile 25	Percentile 75
Age	30	33	3	52	16	18	42

Sex:

The study included 15 males (75%) and 5 females (25%). Cases operated upon by the cranioplasty divided into; Prolene mesh with bone cement (6 males, 4 females), Titanium mesh (9 males, 1 female).

Etiology of defect:

The study included 14 cases with depressed skull fracture (70%), 3 cases of bony lesions (15%), one case of growing skull fracture (5%), one case of infected bone flap removal (5%) & one case of acute subdural hematoma (5%).

Site of the defect:

The study included 5 cases of right frontal defects (25%), 4 cases of left parietal defects (20%), 4 cases of right parietal defect (20%), 2 cases of left frontal defects (10%), 2 cases of left frontoparietal defects(10%), 2 cases of right frontoparietal defects(10%), one case of right frontoparieto-temporal defect (5%).

Time of craniectomy:

The study included 6 cases had craniectomy 6 months before presentation (30%), 5 cases had craniectomy same session of cranioplasty (25%), 2 cases had craniectomy 3 months before presentation (10%), 2 cases had craniectomy 3 years before presentation (10%), 2 cases had craniectomy 4 months before presentation (10%), one case had craniectomy one year before presentation (5%), One case had craniectomy 2 years before presentation (5%), one case had craniectomy 8 months before presentation (5%).

Table (2): Showing relation output between the study inputs.

	Method of repair						p-value
	Prolene mesh with bone cement		Titanium mesh		Total		
	N	%	N	%	N	%	
Sex:							
Male	6	40.0	9	60.0	15	100.0	0.303
Female	4	80.0	1	20.0	5	100.0	
Cosmetic results:							
Perfect	10	52.6	9	47.4	19	100.0	1.000
Good	0	0.0	1	100	1	100.0	
Complications:							
None	9	47.4	10	52.6	19	100.0	1.000
Infection	1	100.0	0	0.0	1	100.0	
Bleeding Intraoperative:							
100 ml	9	47.4	10	52.6	19	100	1.000
150 ml	1	100%	0	0.0	1	100	
Etiology of defect:							
Acute subdural hematoma	1	100.0	0	0.0	1	100.0	0.129
Bony lesion	3	100.0	0	0.0	3	100.0	
Depressed skull fracture	5	35.7	9	64.3	14	100.0	
Growing skull fracture	0	0.0	1	100.0	1	100.0	
Infected bone flap removal	1	100.0	0	0.0	1	100.0	
Time of craniectomy:							
1 year before presentation	1	100.0	0	0.0	1	100.0	0.636
2 years before presentation	1	100.0	0	0.0	1	100.0	
3 months before presentation	1	50.0	1	50.0	2	100.0	
3 years before presentation	1	50.0	1	50.0	2	100.0	
4 months before presentation	0	0.0	2	100.0	2	100.0	
6 months before presentation	3	50.0	3	50.0	6	100.0	
8 months before presentation	0	0.0	1	100.0	1	100.0	
Same session	3	60.0	2	40.0	5	100.0	
Site of defect:							
Left frontal	1	50.0	1	50.0	2	100.0	0.340
Left fronto-parietal	2	100.0	0	0.0	2	100.0	
Left parietal	1	25.0	3	75.0	4	100.0	
Right frontal	4	80.0	1	20.0	5	100.0	
Right fronto-parietal	1	50.0	1	50.0	2	100.0	
Right fronto-parieto-temporal	0	0.0	1	100.0	1	100.0	
Right parietal	1	25.0	3	75.0	4	100.0	

	Method of repair	N	Mean	Std. Deviation	p-value
Cost of the implant	Prolene mesh with bone cement	10	2370.00	629.020	0.787
	Titanium mesh	10	2290.00	672.392	
Operation time	Prolene mesh with bone cement	10	1.250	.2635	1.000
	Titanium mesh	10	1.250	.2635	

Method of repair:

The study included 20 cases of skull vault defects operated upon by cranioplasty, divided into: (1) Group A: 10 cases operated upon by cranioplasty using Titanium mesh (50%). (2) Group B: 10 cases operated upon by cranioplasty using prolene mesh with bone cement (50%).

Cost of the implant:

Minimum cost 1700 LE in favor of bone cement implants, maximum cost 3300 LE not in favor of titanium mesh implants, mean cost 2300±635 LE. Titanium mesh implants are more expensive than prolene mesh with bone cement, yet statistically insignificant (p-value 0.787).

Operation time:

Minimum time one-hour, maximum time 1.5 hours, mean 1.3 hours, standard deviation 0.3.

Bleeding intraoperative:

Blood loss in almost all cases was 100ml (as they have smaller defects) except for one case operated upon by cranioplasty using prolene mesh with bone cement; blood loss was 150ml due to larger defect.

Cosmetic results:

The study included 19 patients with perfect cosmetic result (95%) & one patient with good cosmetic result (5%) found in Group A: Titanium mesh cranioplasty in the form of minute cosmetic failure in close inspection.

Complications:

The study included one patient complicated with infection (5%) found in Group B (cranioplasty using prolene mesh with bone cement) and we believe that it was due to poor hygiene of the patient & 19 patients had no complications (95%).

The complicated case was operated upon by flap removal & cranioplasty with titanium mesh 3 months later.

Relation output:

- Significant *p*-values (*p*-value <0.05).
- Insignificant *p*-values (*p*-value >0.05).

Age:

After reviewing the results, we found that there is no significant difference between the 2 methods of repair of skull vault defects regarding cosmetic results, complication rate, operation time, or cost of the implants, with a *p*-value >0.05. However, titanium mesh implants are more expensive than prolene mesh with bone cement.

Table (3): Showing relation output regarding age of the patients.

				p-value
Prolene mesh with bone cement	N	Valid	10	0.733
		Missing	0	
	Median		31.00	
	Minimum		3	
	Maximum		50	
	Percentiles	25	14.50	
Titanium mesh		75	41.00	
	N	Valid	10	
		Missing	0	
	Median		32.50	
	Minimum		3	
	Maximum		52	
	Percentiles	25	17.00	
		75	45.25	

Case presentation:

An 18-year-old male patient presented complaining of a skull bone defect after 6 months of RTA, causing a depressed skull fracture that was operated upon by removal of the depressed skull bone.

On examination, the patient was fully conscious with no neurological deficit.

A CT brain with soft and bone windows as well as 3D reconstruction was done, showing a right parietal skull bone defect.

The patient underwent a cranioplasty using prolene mesh and bone cement, and the post-operative patient's cosmetic results were perfect.

Three weeks later, the patient developed a wound infection, most probably due to poor hygiene. patient operated upon by implant removal and operated upon by cranioplasty again using titanium mesh 3 months later in Yemen.

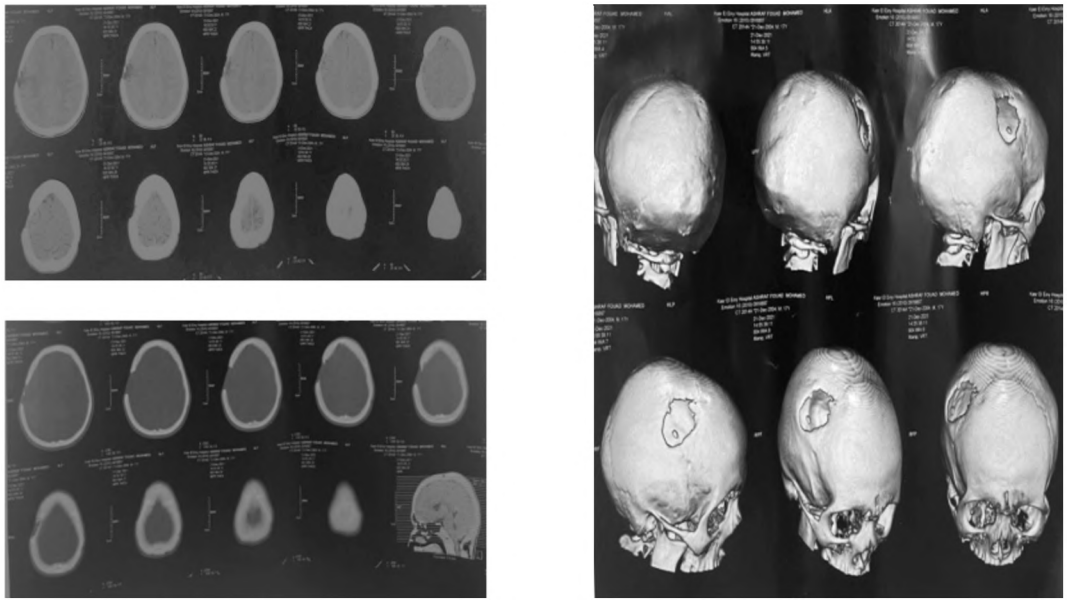


Fig. (1): Showing CT brain with soft & bone windows as well as 3d reconstruction showing skull bone defect (case 1).

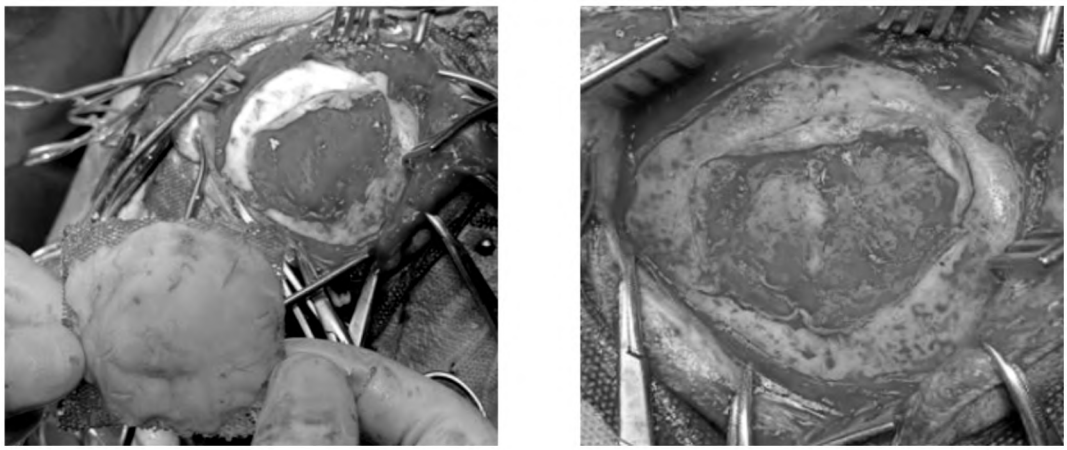
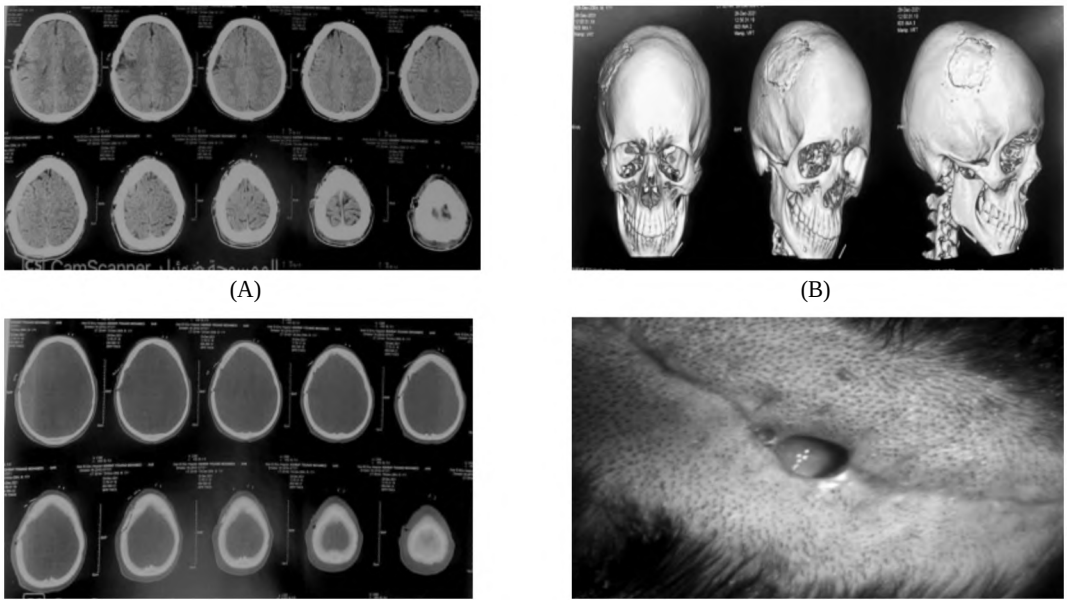


Fig. (2): Showing intraoperative placement of prolene mesh with bone cement (case 1).



(A) (B)

(C) (D)

Fig. (3): Post operative imaging after insertion of prolene mesh with bone cement (case 1). (A) Soft window, (B) 3D reconstruction, (C) Bone window, (D) Skin infection (Sinus).

Discussion

The medical procedure known as cranioplasty is utilized for the purpose of reconstructing the skull's anatomy and repairing any defects present in the skull. The task of achieving optimal skull reconstruction poses a challenge for neurological surgeons, and the most effective approach to attain the desired outcome is still a subject of discussion. The primary objectives of this study were to restore the cosmetic appearance of the cranium and to provide adequate cerebral protection and functionality through cranioplasty. The objective of this study is to compare two distinct manufacturing processes utilized in the reconstruction of calvarial skull defects. Specifically, we are going to compare the use of hand-molded titanium mesh versus prolene mesh with bone cement.

As regards the age of patients, in our study, the mean age of patients was 30 years old (middle age). This may be explained by a higher traumatic etiology, such as in fights, and road traffic accidents. This is in accordance with the Staffa et al., study **[8]** which showed a mean age of 35 (middle age).

In reference to the gender distribution of patients in our study, 15 patients (75%) were identified as male, while the remaining 5 patients (25%) were identified as female. The study conducted by Staffa et al. **[8]** also observed a higher prevalence of males, with 64.4% of the participants being men. Additionally, a study conducted by Honeybul et al. **[9]** consisted of a total of 70 patients, of which 45 (64.2%) were male and the remaining 25 (35.8%) were female.

Regarding the etiology of defects, the study revealed that the majority of cranial defects, specifically 85%, were attributed to traumatic etiology, while the remaining 15% were caused by neoplastic etiology. This is in reference to the study conducted by Staffa et al. **[8]** mentioned above. The etiology of trauma was attributed to either physical fights or roads accidents, with a higher incidence observed among males compared to females.

This finding was not observed in the study conducted by Jonkergouw et al. **[10]**, wherein stroke (39%), trauma (34%), tumor resection (21 %), and infection (5%) were identified as the most frequent indications for primary craniectomy.

In our study, it was observed that the parietal region was the most frequent site of cranial defects (40%), followed by the frontal region (35%) and fronto-parietal region (20%). This wasn't found in the study done by Jaakko et al. **[11]** that showed most of the defects were temporal (65%), then parietal (17%), then frontal (13%) then occipital (5%).

Regarding the preoperative investigation done, in our study, all cases had CT brain with 3D reconstruction, with only 3 cases (15%) with bony lesions required MRI brain with contrast. This is approximately found in the study done by Jonkergouw et al. **[10]** in 2016 that showed that all patients had CT brain with 3D reconstruction, and 21 % of patients required MRI brain with contrast.

In our study, we found that the minimum duration between craniectomy and cranioplasty operations was three months, with a p-value greater than 0.05. This finding contradicts the study conducted by Jonkergouw et al. **[10]**, which showed that delayed cranioplasty is associated with a higher incidence of complications compared to immediate cranioplasty. Based on his explanation, it appears that the tissue dissection may be more challenging due to the development of adhesions between the dura and subcutaneous tissues. The purported benefit of implementing a waiting period is the prevention of performing surgery on a wound that may be contaminated. In our study, clinical assessment was employed to evaluate the condition of the overlying scalp skin, while CRP and ESR were utilized to confirm the resolution of any infection prior to the surgical procedure.

Regarding the duration of the operation, in our study, we found that there was no significant difference between 2 methods regarding operation time. This goes with a study done by Eissa S. et al. **[12]** in 2021 showing that there is no significant difference between the two methods of repair regarding operation time.

Regarding blood loss intraoperatively, in our study, bleeding loss was 100ml in almost all cases (as they had small defects) except for one case operated upon by prolene mesh with bone cement cranioplasty; bleeding loss was 150ml due to a larger defect. This goes with the study done by Melssa C. et al. **[13]**, which showed bleeding loss between 200:260ml due to the large defects included in her study.

Regarding patients' complications, in our study, we operated on 20 cases by cranioplasty, divided into:

- Group A: Titanium mesh (10 cases).
- Group B: Prolene mesh with bone cement (10 cases).

Complications were encountered in 1 case (5%) out of the 20 cases we operated on, in the form of a skin infection, found in group B (cranioplasty using prolene mesh with bone cement). This does not agree with the study done by Chang V. et al. **[14]** involving 213 cases, in which the infection rate was reported at 16.4% in 35 cases found in age groups older than 50 years old and in a group of patients using synthetic cranioplasty material.

As previously stated, the primary objective of cranioplasty is to restore cosmetic appearance and provide cerebral protection and functionality. For optimal cosmetic success, the cranioplasty material must be undetectable even upon close examination. A slight degree of temporal hollowing was considered acceptable, as it is primarily a result of the initial decompression rather than the cranioplasty material. Furthermore, there exist cosmetic factors that are not associated with the cranioplasty material, including skin thickness, hair length, and density.

Regarding cosmetic assessment by doctor and patient assessment; in our study, in group A (cranioplasty using Titanium mesh), 9 patients (45 %) of the total cases we studied showed a perfect (4) outcome regarding cosmetic appearance even in close inspection, and 1 patient with a large defect (5%) showed a good (3) outcome (minor cosmetic failure only noted in closer inspection). While in group B (cranioplasty using prolene mesh with bone cement), all cases (50%) of all cases we studied showed perfect (4) cosmetic outcomes postoperatively.

All cases in this study showed either perfect or good results, with absence of complete cosmetic failures that required mandatory revision surgery. And there is no significant difference in the cosmetic outcome. This agrees with Darwish M. et al. **[15]** study done in 2021 that showed no significant difference in cosmetic appearance postoperatively.

Regarding the cost of implants, in our study, we found that prolene mesh with bone cement is much cheaper than titanium mesh. This supports the 2017 study by Yam B. Roka **[16]** that demonstrated that bone cement is less expensive than titanium mesh.

Conclusion:

Based on our findings, it can be inferred that there was no statistically significant variation in the cosmetic outcome of the two repair methods. However, the utilization of prolene mesh with bone cement implants was observed to facilitate the restoration of contouring more efficiently than titanium mesh. This can be attributed to the greater flexibility of prolene mesh and the ease of shaping bone cement. In terms of cost, the utilization of prolene mesh with bone cement is more economical compared to the use of titanium mesh.

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استخدام شبكة من التيتانيوم مقابل استخدام شبكة من البرولين وعظم صناعى لإصلاح عيوب وكسور عظام الجمجمة : دراسة مقارنة

الخلفية : يتم استخدام الرجراء الطبى المعروف بأسم الإصلاح الجراحى لعيوب عظام الجمجمة لغرض إعادة بناء عظام الجمجمة وإصلاح أى عيوب موجودة فى الجمجمة. يمثل تحقيق إعادة بناء الجمجمة المثلى تحدياً لجراحى الأعصاب، ولا تزال الإستراتيجية الأكثر فاعلية لتحقيق أفضل النتائج موضوعاً للنقاش.

الهدف من الدراسة : لعرض المؤشرات المختلفة والفوائد والتقنيات الممكنة وطرق الإصلاح الجراحى لعيوب عظام الجمجمة. بالإضافة إلى ذلك، سيتم عرض ٢٠ حالة للمقارنة بين طريقتين للإصلاح الجراحى لهذه العيوب.

المرضى والطرق : تم تحليل البيانات التى تم جمعها من ٢٠ حالة تم إجراؤها أثناء الدراسة على أنها ١٠ حالات تم بواسطة شبكة برولين مع الأسمنت العظمى و ١٠ حالات تم إصلاحها بواسطة شبكة التيتانيوم، وتم الانتهاء من النتائج وتقييمها.

النتائج : ناقشنا خصائص العديد من المواد المستخدمة فى جراحة رأب القحف ووضعنا معايير لخصائص مادة مثالية لرأب القحف بشكل عام، ثم قارننا نتائج اثنتين من أهم المواد المستخدمة فى الو قت الحاضر. بالإضافة إلى، قمنا بتضمين ٢٠ حالة مع عيوب فى الجمجمة تتطلب إصلاحاً جراحياً، ناجمة عن مسببات مختلفة، معظمها استئصال ما بعد الصدمة وما بعد الورم، وأظهرنا النتائج. تم إجراء العمليات الجراحية على هذه الحالات عن طريق وضع شبكة التيتانيوم فى ١٠ حالات وشبكة البرولين مع أسمنت عظمى فى ١٠ حالات أخرى. عند مقارنة كلتا المادتين، وجدنا أنه لا يوجد فرق كبير فى نتائج الشكل التجميلى. ومع ذلك، تم استنتاج أن الإصلاح بشبكة البرولين مع الأسمنت العظمى لاستعادة الكنتور يتم بسهولة أكبر من شبكة التيتانيوم، حيث أن شبكة البرولين أكثر مرونة ويسهل تشكيل الأسمنت العظمى. فيما يتعلق بالتكلفة، فإن شبكة البرولين مع الأسمنت العظمى أرخص من شبكة التيتانيوم. فيما يتعلق بالمضاعفات، كانت هناك حالة واحدة من الإصلاح بشبكة البرولين مع الأسمنت العظمى التى أصيبت بعدوى فى الجرح، ونعتقد أن هذا على الأرجح بسبب سوء النظافة للمريض، لذلك يمكن تجنب هذه العقبة فى الحالات المستقبلية.

الخلاصة : نستنتج أنه لا ويوجد فرق كبير فى النتيجة التجميلية بين طريقتين للإصلاح، ولكن تم استنتاج أن الإصلاح بشبكة البرولين مع الأسمنت العظمى لاستعادة الكنتور يتم بسهولة أكبر من شبكة التيتانيوم، حيث أن شبكة البرولين أكثر مرونة ويسهل تشكيل الأسمنت العظمى. فيما يتعلق بالتكلفة، فإن شبكة البرولين مع الأسمنت العظمى أرخص من شبكة التيتانيوم.