ORIGINAL ARTICLE

Methyl Methacrylate Cranioplasty

A Azmi, A Z Latiff, A Johari

Department of Neurosurgery, Hospital Kuala Lumpur, Jalan Pahang, Kuala Lumpur

Summary

We conducted a prospective study in order to audit our experience of repairing cranial defects using Methyl methacrylate. This included a total of 49 patients undergoing cranioplasty using methyl methacrylate, of which 45 were males and 4 females. The age of patients at the time of surgery ranged from 16 to 40 years old, with an average of 24 years. Malays were the majority (67%), followed by Chinese (23%) and Indian (10%). Cranial defects were mainly caused by motor vehicle accident (94%), while gunshot wounds, industrial accidents and tumours, each contribute 2%. Bone flaps were commonly removed during previous surgery related to traumatic subdural haemorrhage (33%), contusion (21%) and intracerebral haemorrhage (14%). The size of cranial defects ranged from 28cm^2 to 440cm^2, with an average of 201cm^2. Most had right sided (55%) and lateral defects [temporoparietal (52%) followed by temporal (16%), frontal (16%), frontotemporal (14%) and occipital (2%)]. Duration of surgery ranged from 70 to 275 minutes, with an average of 135 minutes. Nine of 12 patients (75%) with neurological disability had some improvement while 85% of symptomatic patients had symptoms improvement after cranioplasty. The infection rate in this series was 4%.

Key Words: Cranioplasty, Methyl methacrylate, Cranial defects

Introduction

Most Cranial defects are acquired as a result of trauma, tumour operations and infected bone flaps. Cranioplasty is defined as the repair of a cranial defect or deformity. It replaces the natural protective structures of the brain and restores the shape and appearance of cranium.

Various techniques and materials have been used to repair cranial defects, such as autogenous bone grafts and alloplastic implants. We routinely use methyl methacrylate as a cranioplastic material because it is relatively cheap and easily available.

Materials and Methods

A prospective analysis of 49 patients undergoing cranioplasty over 24 months from January 2001 to December 2002 was done. Methyl methacrylate was used in all patients and cranioplasties were performed under general anaesthesia.

The patient's head is fully shaved and prophylactic antibiotic with intravenous cefuroxime is given in the induction room. The skin is incised at a distance of at least 1cm, from the defect. A scalp flap is carefully separated from the dura using sharp dissection, avoiding injury to the dura and the cranial defect is entirely exposed. Dura defects are repaired with watertight sutures or with pericranial fascia.

A periosteal incision is made near the defects margin and reflected about 1-2cm away. In order to obtain good approximation of the cranioplastic plate, 3 to 5mm of outer table of defect edge is often rimmed. The cranial defects are measured intraoperatively

This article was accepted: 11 December 2003
Corresponding Author: Azmi Alias, Department of Neurosurgery, Hospital Kuala Lumpur, Jalan Pahang, Kuala Lumpur

(centimetre) and area is calculated using ellipse formula (ab π cm^2).

Methyl methacrylate is prepared by mixing the liquid monomer (catalyst) with the powder polymer. This mixture is constantly stirred until its consistency is doughy (within 15 minutes). It is then place in between plastic layers and moulded according to the cranial defect with minimum 3 to 5mm thickness. The cranioplastic plate edge is trimmed with a Mayo scissors before it solidifies.

Multiple angled drills hole made through the outer cortical bone and acrylic plate. An absorbable suture material such as Vicryl 1/0 is inserted through the drill holes and used to hold the cranioplasty plate in position. A subgaleal active drain is placed and the flap closed in 2 layers. Patients are given oral analgesics and discharged after 2 days. The operative sites and neurological status are assessed during clinic follow-up at 6 weeks, 3 months and follow-up phone call at 1 year.

Results

A total of 51 cranial defects, involving 49 patients were included, of which 45 were male (92%) and 4 female (8%). The age at the time of surgery ranged from 16 to 40 years old, with an average of 24 years. Among ethnic groups, Malays were predominant (67%) followed by Chinese (23%) and Indian (10%).

Most of the cranial defects were caused by trauma (98%) i.e. motor vehicle accidents (94%), gunshot wounds (2%) and industrial accident (2%). Only one case (2%) was related to a tumour (astrocytoma).

Table I: Type of injury where bone flaps were removed

Type of injury	n (51 defects)	%
Acute Subdural Haemorrhage (ASDH)	17	33
Contussion	11	21
Intracerebral hemorrhage	7	14
Extra Dural Haemorrhage (EDH)	6	12
EDH/ ASDH	5	10
EDH /Compound depressed fracture	5	10

Total cranial defects was 51 as two patients had bilateral defects. The right side was commonly involved (55%) as compared to left (41%). Two patients had bilateral defects (4%). Most had lateral defects: temporoparietal region (52%), temporal (16%) followed by frontal defect (16%), frontotemporal (14%) and occipital (2%). The size of defects ranged from 28 cm^2 to 440cm^2, with an average area of 201cm^2.

Table II: Size and site of defects

Size (ab π) cm^2	Site					n (51)
	F	FT	T	TP	O	
0 - 50	1		1			2
51 - 100		2		4		6
101 - 150				4		4
151 - 200	1	2	5	11		19
201 - 250		1		2		3
251 - 300	3		5		1	9
301 - 350	2					2
351 - 400	1	1	1			3
401 - 450		1				1
n	8	7	12	21	1	51

a = maximum vertical length of skull defect (cm)

b = maximum anterior-posterior length of skull defect (cm)

F = Frontal FT = Frontotemporal

T= Temporal TP = Temporoparietal O= Occipital

The time interval between cranioplasty and initial trauma or surgery ranged from 6 months to 12 years. Reasons for the delay of cranioplasty included the patient defaulting from follow-up and slow neurological recovery.

Duration of surgery ranged from 70 to 275 minutes, with an average of 135 minutes. The clinic follow-up ranged from 3 to 22 months with an average of 9 months and follow up phone call at 1 year.

Most of the of patients are well (76%) (full work), followed by those with minimal disability (20%) (self-sufficient) and partial disability (4%) (semi self-sufficient) prior to cranioplasty. Nine of 12 patients (75%) with neurological disability showed some improvement in neurological status.

Headache was the most predominant preoperative symptom suffered by 18 patients. Twenty-two of 28 symptomatic patients (78%) improved after cranioplasty. Thirteen patients had headache after surgery, but 11 of these patients improved within 2 months. Only two patients had persistent headache requiring regular medications. One patient had worsening headache with vomiting during immediate postoperative period but recovered after 1 month.

The infection rate in our series was 4%. One patient had a deep wound infection requiring debridement and removal of cranioplasty plate twice. He sustained acute subdural haemorrhage and underwent decompressive craniectomy following motor vehicle accident in 1993. A cranioplasty was done two years later. In 2000, he fell from a motorcycle and sustained scalp lacerations exposing the underlying cranioplasty plate. This was further complicated by wound infection and a *Staphylococcus aureus* epidural abscess. Wound debridement and removal of cranioplasty plate was done. Another cranioplasty performed 12 months later in 2001 also became infected by the same organism and was subsequently removed. One patient had superficial wound infection but it resolved after local dressing and antibiotics.

Six patients (12%) had subgaleal collections after removal of the Radivac® drain but these subsided after 2 weeks. There were no other acute postoperative complications noted. Apart from one patient who had a frontal prominence, all of others patients achieved satisfactory cosmesis.

Table III: Neurological changes at 1 year after cranioplasty

Status	Preoperative n (49)	Postoperative n (49)
Well (full work)	37	45
Minimal disability (work self sufficient)	10	4
Partial disability (semi-self sufficient)	2	0
Total disability (bed- ridden)	0	0

Table IV : Symptoms at 1 year after cranioplasty

Status	Preoperative n (49)	Postoperative n (49)
Asymptomatic	21	43
Headache	11	1
Headache with hemiparesis	5	1
Hemiparesis	4	2
Headache with seizures	3	0
Seizures	3	1
Cranial nerve palsy	2	1

Discussion

Methyl methacrylate was first used as a cranioplastic material by Zander in 1940 [1]. The major advantages of methyl methacrylate over most of the other materials are that it is completely malleable in the initial stages of hardening, and thus can be moulded easily during surgery to fit the contour defects. It is relatively cheaper, biologically inert and does not interfere with computed tomography or magnetic resonance imaging studies[2].

The autopolymerization of methyl methacrylate during its preparation can cause thermal damage to the underlying brain due to its exothermic reaction. However, irrigating with saline[3] or placing layers of wet gauze or cotton in between acrylic and dura can prevent this. Obtaining a good cosmetic result is often difficult when the defect is large or complex, especially when it involves the orbital rim. The use of struts with titanium mesh, stainless steel mesh or miniplates have been advocated, as a scaffold to improve the mechanical strength and cosmetic results, but this technique is more costly.

Without the cranium,the direct effect of atmospheric pressure on scalp and dura causes closure of subarachnoid space and reducing the brain perfusion pressure. As a result, some of patients may experience "syndrome of the trephined" such as as headache, dizziness, irritability, and loss of concentration, depression, and discomfort at defect edge, anxiety, and contra lateral hemi paresis, intolerance to noise, vibration and heat. Suzuki et al[4] have reported postoperative neurological recovery in association with improvement of cerebral blood flow. Similar findings were observed in our series, in which 75% of patients with neurological disability had some improvement in neurological status while 78% of symptomatic patients had symptoms improvement after cranioplasty .

The reported infection rate for methyl methacrylate is 3.8 to 12% (seixes, 1981: Benzel, 1990). Risk factors include timing of cranioplasty, communication with air sinuses, air within the methyl methacrylate plate and previous infection especially osteomyelitis of skull.

Immediate cranioplasty is occasionally done especially if bone was removed due to tumour involvement. In most of severe head injury cases, diffuse cerebral swelling sometimes require external decompressive craniectomy resulted in cranial defects. Cranioplasty is only performed when cerebral oedema subsides and the neurological condition improves. If there has been delayed primary wound healing or when fracture has involved air sinuses, the operation is delayed for 6 to 12 months.

Both patients and surgeons subjectively assessed the cosmetic outcome in this series. Majority of the cases involved lateral defects and have been successfully repaired with satisfactory appearance.

Conclusion

Most cranial defects are acquired as a result of motor vehicle accident involving adults and male populations. Methyl methacrylate cranioplasty is relatively safe, provides an acceptable aesthetic reconstructive option and contributes to neurological improvement in the treatment of cranial defects.

References

1. Abhay Sanan, Stephen J. Haines. Repairing Holes in the Head: A History of Cranioplasty. Neurosurgery 1997; 40: 588.
2. Alexander V.van Gool.Preformed Polymethylmethacrylate Cranioplasties. J Max-Fac Surg 1985; 13: 2-8.
3. Ganes AS. Cranioplasty made easier. Surg Neurol 1978; 10(4): 285-87.
4. Suzuki N, Suzuki SH, and Iwabuchi T: Neurological improvement after cranioplasty. Acta Neurochir (Wien) 1993; 122: 49-53.
5. Murad Bavbek. Cranioplasty. In Head trauma. Contemporary Neurosurgery 1996.Chapter 108: 526-31.