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TECHNICAL NOTE

In situ cranioplasty with methylmethacrylate and wire lattice

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Abstract
Most techniques of cranioplasty are expensive and require advance preparation if a custom-moulded prosthesis is to be used. Technical problems with cranioplasties using synthetic materials include sinking, elevation and rotation, while those with hydroxyapatite or bone graft cranioplasties include resorption and harvest site disfigurement. We report our technique of *in situ* cranioplasty using methylmethacrylate and a wire lattice that is fast, inexpensive and avoids these technical problems.

Key words: *Cranioplasty, hydroxyapatite, methylmethacrylate, wire lattice.*

Introduction

Cranioplasties have probably been performed almost as long as the technique of trephining or, at least, soon thereafter.[1] Common indications include decompressive craniotomies, open traumatic skull defects, infectious loss of a prior craniotomy bone flap and bony involvement by tumours.[2] Meticulous cranioplasty is important for good cosmetic results, as well as long-term protection of brain from external environment. Cerebral blood flow, brain metabolism, as well as neurological status are affected by the outside pressure in patients with skull defects and may improve after cranioplasty.[3–5] Materials commonly used for cranioplasties include methylmethacrylate,[6–11] hydroxyapatite,[2,12] titanium,[2,12–24] polyethylene,[25–28] and allogeneic or autologous bone.[29–32] Of these, titanium mesh cranioplasties, with or without bone, acrylic or hydroxyapatite reinforcement, are currently in wide use. Technical problems with cranioplasties using artificial materials include sinking, elevation and rotation. Technical problems with hydroxyapatite or bone graft cranioplasties include resorption and harvest site disfigurement. In addition, custom prostheses from three-dimensional computed tomography models of the defect are expensive and require significant preparation in advance. We describe a technique of cranioplasty using methylmethacrylate and wire lattice. This technique has the advantages of being less expensive than a preformed methylmethacrylate cranioplasty and does not have to be prefabricated. Utilization of structural joining concepts from carpentry site preparation techniques help to prevent the commonly encountered problems with other forms of cranioplasties. The main advantage of this technique, however, lies in providing a wire lattice framework internally supporting the cranioplasty construct that derives from the principle of internal rebar metal reinforcement in fabricating reinforced concrete. *In situ* moulded acrylic cranioplasties have been in use for several years with a low infection rate.[6,33,34] Although the rate of infection with prefabricated methylmethacrylate implants may be lower than intraoperatively moulded cranioplasties,[35] long-term comparisons with large number of patients are needed.

Steps of cranioplasty

Donor site preparation

Donor site preparation is the first step. We start with the carving of dove-tail joints at three or four radial positions around the margins of the skull defect depending on its shape. These prevent any rotational movement of the cranioplasty. In between the dove-tail joints, the edges of the cranial defect are bevelled. This is done in an alternating fashion with inner and outer table bevels (Fig. 1). This bevelling prevents elevation or sinking of the cranioplasty once the bevels have been filled with methylmethacrylate. Holes for placement of wire are also placed centred in between two adjacent dove-tail joints.

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Internal wire lattice formation

In the next step, a fine gauge wire is placed through two opposing holes along the margins of the skull defect traversing the full thickness of the bone. This is done in a vertical 'figure of 8' configuration (Fig. 2). Another wire is placed through other opposing holes at right angle to the first wire. This forms a

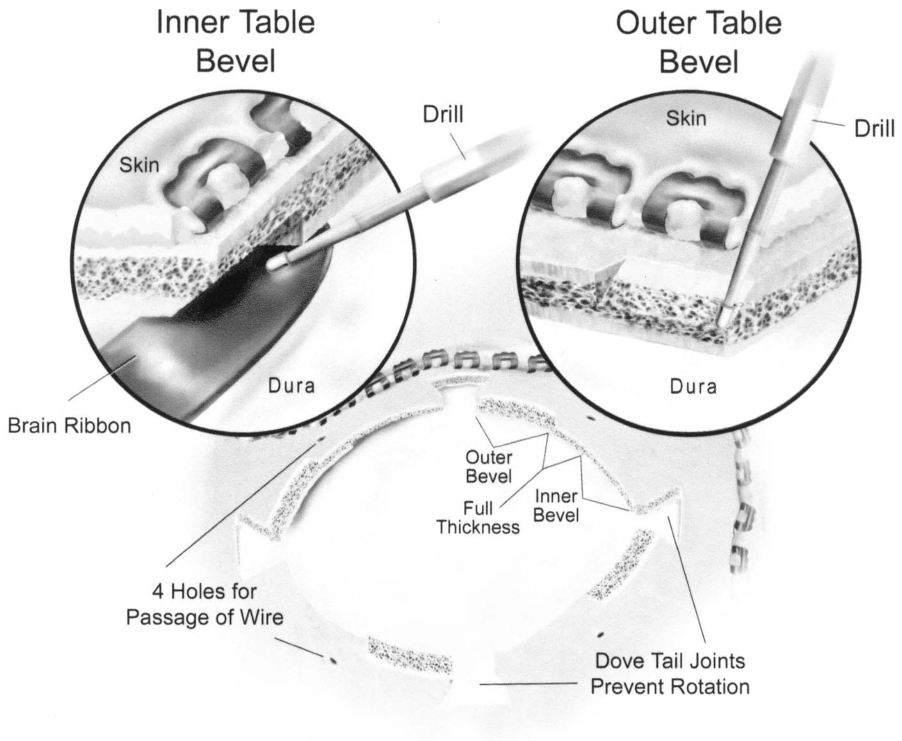

FIG. 1. Bevels in the edges of the cranial defect alternate between the inner and outer tables of the skull. The inner table bevel prevents elevation while outer table bevel prevents sinking in of the cranioplasty. The dove-tail joints resist rotational movement. A metallic malleable retractor is placed over the dura for protection during drilling.

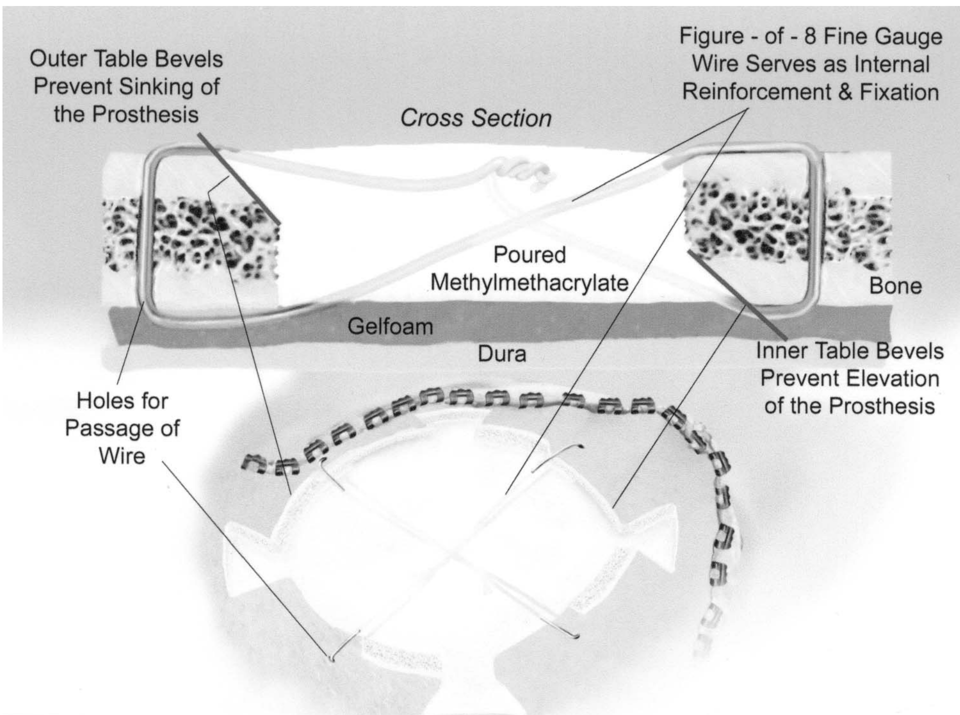

FIG. 2. Cross-sectional view of the cranioplasty area. The alternating bevelled inner and outer tables prevent sinking or elevation of the cranioplasty.

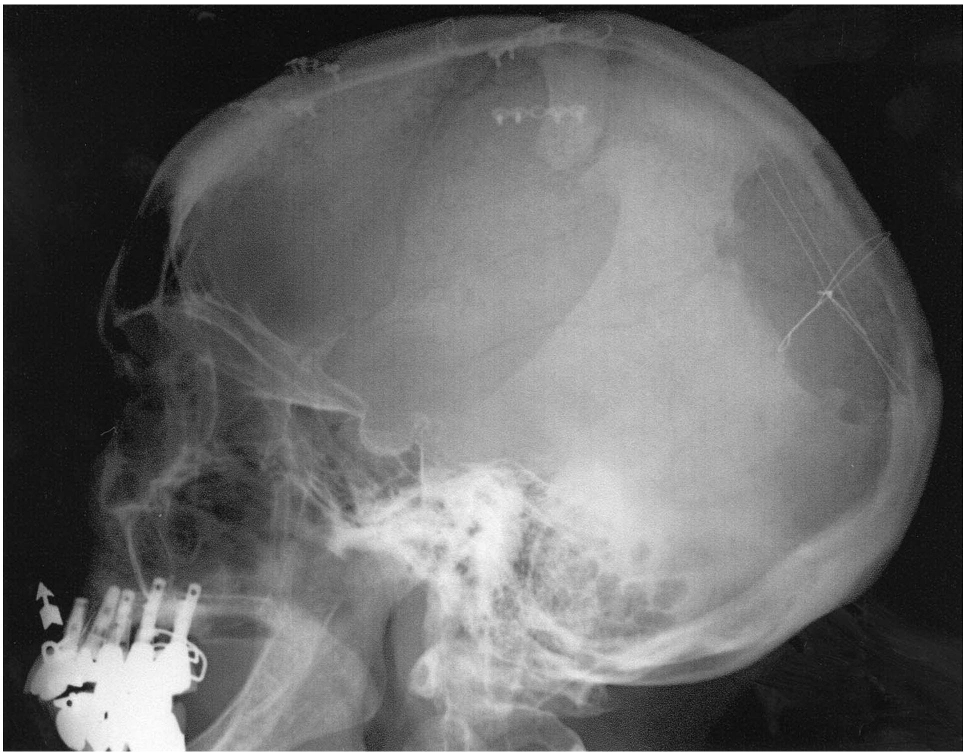

FIG. 3. Postoperative plain skull radiograph (lateral view) after wire lattice methylmethacrylate cranioplasty.

radially-crossed lattice. The twisted ends of the wire are positioned to have a final position within the acrylic construct. The purpose of this lattice is to provide internal reinforcement for the methylmethacrylate.

Methylmethacrylate implant formation

A single layer of saline-soaked gelfoam is placed over the exposed layer of the dura. This helps insulate the dura from the exothermic reaction that takes place as methylmethacrylate hardens. Methylmethacrylate is then trowelled over the wire lattice once it has reached a mouldable viscosity. It is then contoured by the surgeon into a smooth surface imitating the normal contours of the skull in that region. The acrylic flows to fill the radial dove-tail joints, as well as the spaces created by the inner and outer table bevels. Continuous irrigation with cool antibiotic saline solution is done until the exothermic hardening reaction is complete. After the cranioplasty is complete, the wound is closed in a standard fashion.

Results

Six patients underwent cranioplasties using this technique. We had good clinical outcomes in all our patients. There was no immediate or delayed incidence of cranioplasty elevation, sinking or rotation with good cosmetic results in all cases (Fig. 3). Although magnetic resonance artefact from steel wire was minimal and did not interfere with postoperative imaging for tumour recurrence, using titanium wire or braided cable can reduce this still further.

Conclusions

The technique of cranioplasty described above is innovative, structurally sound and inexpensive. It provides excellent cosmetic results and does not require long preparation times in advance. Although a strong stand-alone construct by itself, it may also be supplemented by other means like titanium mesh implants in certain situations.

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References

1 Sanan A, Haines SJ. Repairing holes in the head: a history of cranioplasty. *Neurosurgery* 1997;40:588–603.
2 Miyake H, Ohta T, Tanaka H. A new technique for cranioplasty with L-shaped titanium plates and combination ceramic implants composed of hydroxyapatite and tricalcium phosphate (Ceratite). *Neurosurgery* 2000;46:414–8.
3 Agner C, Dujovny M, Gaviria M. Neurocognitive assessment before and after cranioplasty. *Acta Neurochir (Wien)* 2002; 144:1033–40; discussion 1040.
4 Segal DH, Oppenheim JS, Murovic JA. Neurological recovery after cranioplasty. *Neurosurgery* 1994;34:729–31; discussion 731.
5 Yoshida K, Furuse M, Izawa A, Iizima N, Kuchiwaki H, Inao S. Dynamics of cerebral blood flow and metabolism in patients with cranioplasty as evaluated by 133Xe CT and 31P magnetic resonance spectroscopy. *J Neurol Neurosurg Psychiat* 1996; 61:166–71.
6 Blum KS, Schneider SJ, Rosenthal AD. Methyl methacrylate cranioplasty in children: long-term results. *Pediat Neurosurg* 1997;26:33–5.

7 Replogle RE, Lanzino G, Francel P, Henson S, Lin K, Jane JA. Acrylic cranioplasty using miniplate struts. *Neurosurgery* 1996;39:747 – 9.
8 Yanai A. Resin sealant: a new method of methyl methacrylate cranioplasty. Technical note. *J Neurosurg* 1991;75:328 – 30.
9 Yamamoto Y, Mendel E, Raffel C. Acrylic cranioplasty with alginate molding: technical note. *Neurosurgery* 1997;41:305 – 6; discussion 306 – 9.
10 Sherburn EW, Silbergeld DL. A new method of acrylic cranioplasty. *Surg Neurol* 1996;46:292 – 3; discussion 293 – 4.
11 Wong L, Manson PN. Rigid mesh fixation for alloplastic cranioplasty. *J Craniofac Surg* 1994;5(4):265 – 9.
12 Ducic Y. Titanium mesh and hydroxyapatite cement cranioplasty: a report of 20 cases. *J Oral Maxillofac Surg* 2002;60: 272 – 6.
13 Joffe JM, Nicoll SR, Richards R, Linney AD, Harris M. Validation of computer-assisted manufacture of titanium plates for cranioplasty. *Int J Oral Maxillofac Surg* 1999;28: 309 – 13.
14 Blair GA, Fannin TF, Gordon DS. Titanium-strip cranioplasty. *Br Med J* 1976;2(6041):907 – 8.
15 O'Broin ES, Morrin M, Breathnach E, Allcutt D, Earley MJ. Titanium mesh and bone dust calvarial patch during cranioplasty. *Cleft Palate Craniofac J* 1997;34:354 – 6.
16 Malis LI. Titanium mesh and acrylic cranioplasty. *Neurosurgery* 1989;25:351 – 5.
17 Simpson D. Titanium in cranioplasty. *J Neurosurg* 1965;22:292 – 3.
18 Murdoch A. Titanium cranioplasty in the repair of skull defects. *Nurs Times* 1976;72(37):1426 – 9.
19 Gordon DS, Blair GA. Titanium cranioplasty. *BMJ* 1974;2(917):478 – 81.
20 Joffe JM, Aghabeigi B, Davies EH, Harris M. A retrospective study of 66 titanium cranioplasties. *Br J Oral Maxillofac Surg* 1993;31(3):144 – 8.
21 Joffe J, Harris M, Kahugu F, Nicoll S, Linney A, Richards R. A prospective study of computer-aided design and manufacture of titanium plate for cranioplasty and its clinical outcome. *Br J Neurosurg* 1999;13:576 – 80.
22 Fushiki N. [Cranioplasty with titanium-screen]. *Nippon Geka Hokan* 1968;37:413 – 9.
23 Ban S, Ogata M, Yamamoto T, *et al*. [Cranioplasty with titanium plate. Report of 114 cases]. *Neurol Med Chir (Tokyo)* 1987;27:984 – 9.
24 Joffe JM, McDermott PJ, Linney AD, Mosse CA, Harris M. Computer-generated titanium cranioplasty: report of a new technique for repairing skull defects. *Br J Neurosurg* 1992;6:343 – 50.
25 Couldwell WT, Chen TC, Weiss MH, Fukushima T, Dougherty W. Cranioplasty with the Medpor porous polyethylene flexblock implant. Technical note. *J Neurosurg* 1994;81:483 – 6.
26 Karvounis PC, Chiu J, Sabin H. The use of prefabricated polyethylene plate for cranioplasty. *J Trauma* 1970;10:249 – 54.
27 Piccinini P. [Cranioplasty for craniostenosis or craniosynostosis by means of artificial suture with polyethylene interposition.] *Minerva Neurochir* 1961;5:14 – 8.
28 Andorno EE, Rojas RO. [20 cases of cranioplasty with polyethylene]. *Diagn Med* 1962;34:2360 – 2.
29 Kubler N, Michel C, Zoller J, Bill J, Muhling J, Reuther J. Repair of human skull defects using osteoinductive bone alloimplants. *J Craniomaxillofac Surg* 1995;23(6):337 – 46.
30 Lee C, Antonyshyn OM, Forrest CR. Cranioplasty: indications, technique, and early results of autogenous split skull cranial vault reconstruction. *J Craniomaxillofac Surg* 1995; 23(3):133 – 42.
31 Moss SD, Joganic E, Manwaring KH, Beals SP. Transplanted demineralized bone graft in cranial reconstructive surgery. *Pediat Neurosurg* 1995;23(4):199 – 204; discussion 204 – 5.
32 Vanaclocha V, Bazan A, Saiz-Sapena N, Paloma V, Idoate M. Use of frozen cranial vault bone allografts in the repair of extensive cranial bone defects. *Acta Neurochir (Wien)* 1997;139:653 – 60.
33 Aziz TZ, Mathew BG, Kirkpatrick PJ. Bone flap replacement vs acrylic cranioplasty: a clinical audit. *Br J Neurosurg* 1990;4: 417 – 9.
34 Josan VA, Sgouros S, Walsh AR, Dover MS, Nishikawa H, Hockley AD. Cranioplasty in children. *Childs Nerv Syst* 2005; 21:200 – 4.
35 van Gool AV. Preformed polymethylmethacrylate cranioplasties: report of 45 cases. *J Maxillofac Surg* 1985;13:2 – 8.