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SURGICAL NEUROLOGY INTERNATIONAL

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Editor: **James I. Ausman,** MD, PhD University of California, Los Angeles, CA, USA

SNI: Skull Base

Original Article

Hydroxyapatite bone cement application for the reconstruction of retrosigmoid craniectomy in the treatment of cranial nerves disorders

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Received: 21 January 17 Accepted: 07 April 17 Published: 13 June 17

Abstract

Background: Retromastoid craniectomy (RSC) is a cardinal surgical approach used to access the posterior fossa. Hydroxyapetite bone cement (HBC) is frequently employed for cranioplasty in efforts to prevent cerebrospinal fluid (CSF) leak, whilst maintaining low complication rates and good cosmetic satisfaction. The authors aim to determine the safety and effectiveness of HBC for reconstruction RSC used for treatment of various cranial nerves disorders.

Methods: The authors conducted a retrospective one-center two surgeons review of 113 patients who underwent RSC filled with HBC for the treatment of cranial nerve disorders. The study period extended from January 2011 through April 2016. Charts were reviewed for documentation of descriptors pertinent to the endpoints described above. Revisions and reoperations were excluded from analysis.

Results: Ninety-three patients met the inclusion criteria; there was one case of postoperative pseudomeningocele, which was considered as CSF leak (1%), 3 (3,2%) superficial infections, and no deep infections. Cosmetic satisfaction was obtained in all but one case (98.9% satisfaction) and long-term incisional pain was problematic in 1 (1.1%) patient. Other complications (serous drainage, headache, ear pain) accounted for three cases (3.2%).

Conclusions: The application of HBC in the reconstruction of RSC for the treatment of cranial nerves disorders is an effective method, yielding good cosmetic results whilst eliminating CSF leak. Additionally, it is safe due to the lack of deep-seated wound infections with low incidence of chronic incisional pain.

Key Words: Calcium phosphate, cerebrospinal fluid leak, hydroxyapatite, microvascular decompression, retrosigmoid craniotomy

Access this article online

Website: www.surgicalneurologyint.com

DOI: 10.4103/sni.sni_29_17

Quick Response Code:

How to cite this article: Aldahak N, Dupre D, Ragaee M, Froelich S, Wilberger J, Aziz KM. Hydroxyapatite bone cement application for the reconstruction of retrosigmoid craniectomy in the treatment of cranial nerves disorders. Surg Neurol Int 2017;8:115.
http://surgicalneurologyint.com/Hydroxyapatite-bone-cement-application-for-the-reconstruction-of-retrosigmoid-craniectomy-in-the-treatment-of-cranial-nerves-disorders/

INTRODUCTION

Hydroxyapatite bone cement (HBC) is frequently employed in the treatment of cranial bony defects. It has been championed as a viable option for cranial defect reconstruction when cosmetics and fluid hydrostatics are considered. Infratentorial craniotomies or craniectomies have higher rates of cerebrospinal fluid (CSF) leakage than supratentorial defects due to their gravity-dependent nature, lending desire for safe reconstructive options capable of restoring the natural barrier provided by the skull.

HBC is known to have osteoconductive properties, providing for more physiologic restoration of cranial defects.[1,9-11,17,26] While some authors have demonstrated HBC as an acceptable method of preventing CSF leaks in craniotomies of the skull base,[1,7,11,12] others have used the cement as an adjunct to titanium mesh, plates, fat grafts, and/or dural substitutes.[2,18]

Retrosigmoid craniecotomy (RSC) is used to access a wide variety of neurosurgical posterior fossa pathologies and cranial nerves disorders.[3,4,6,8,14,15,21,25,29] Closure methods often include watertight dural and galeal closure in addition to bone, muscle, pericranial, and fat grafts. Titanium plates and mesh are often utilized for structural support over the craniectomy defect. Various skin-suturing techniques are employed to prevent CSF leaks at this more superficial location in addition to deeper locations such as the dura and galea.[23,28] Such techniques can infrequently provide adequate barriers to the hydrostatic forces of CSF. As such, the flow of CSF should ideally be contained to its native intracranial vault with the aim of mitigating unnecessary pressure on soft tissues. Furthermore, metal plates and screws may place tension on the overlying skin, leading to palpable deformities and incisional pain and/or tenderness.

The safety of HBC in cranial surgery has been challenged in recent years, lending reservation to many surgeons. Delayed inflammatory reactions have been suspect in cases where thinning of the skin and breakdown resulted after HBC cranioplasty.[20,22] Infections, meningitis, seromas, and cement fracture have been previously associated with HBC.[5,17,19,24,30] Current data suggest that the rate of wound infection associated with HBC cranioplasty ranges from 0 to 1.3%.[11,12,24] The incidences of CSF leak and infection after non-HBC RSC have been previously reported to be 0 to 23.4%[12,14,21,28,31] and 0 to 10.9%,[8,12,16,27,28,31] respectively.

Previous publications have reported on complication rates associated with HBC for a wide variety of craniotomy types; however, there is currently a paucity of studies demonstrating the results specific to RSC for the treatment of cranial nerve pathologies. The authors aim to determine the effects and complication profile of HBC in this specific setting.

MATERIALS AND METHODS

An institutional review board (IRB) review and approval was obtained to initiate this study. The authors conducted a retrospective analysis of one hundred thirteen cases of retrosigmoid craniotomies performed for microvascular decompression (MVD) in the treatment of various cranial nerves disorders and vestibular nerve sections. The cases were pooled from a prospectively maintained database. Any patient who had a prior surgery at the site of interest was excluded from analysis. Only patients who were operated on by one of the two surgeons (KA and JW) at a single institution (Allegheny General Hospital, Pittsburgh, PA 15212) were included in analysis.

Cosmetic satisfaction was graded as all or none upon follow-up by posing a simple question to the patient at the follow up visit: "Are you satisfied with the cosmetic results of your procedure?" Long-term incisional pain was defined as pain and/or tenderness at the incision requiring pain medication and/or clinical evaluation 3 months (or longer) postoperatively. All other postoperative events were recorded including: superficial or deep infection, CSF leak, headache, ear pain, and serous drainage. RSC (one-inch diameter) was carried out in a standard manner, as previously described.[15] Watertight dural closure utilizing 4-0 nylon suture was carried out in all cases with or without autologous fascia or muscle graft. All soft tissue and adjacent periostium adherent to the craniectomy edges were stripped prior to the cranioplasty. In the authors' experience, this technique allows for better adherence of the cement to the bony edges. The commercially available HydroSet™ bone cement (Stryker Inc., Kalamazoo, MI) was mixed according the manufacturer recommendations and applied to fill the craniectomy defect after a uniform consistency was attained. Five minutes of setting time was allowed in all cases, followed by irrigation of one liter of bacitracin-infused saline. Layered closure consisted of 2-0 and 3-0 Polysorb™ suture followed by 4-0 Monocryl™ running subcuticular stitches and a thin layer of Dermabond™ skin glue.

RESULTS

Over the 63 months' study period, 113 patients underwent RSC for MVD or section of cranial nerves. Ninety-three patients met inclusion criteria and were therefore included in analysis. Of those excluded from the series, 8 were revisions, while the rest did not carry adequate documentation and/or follow-up to be included in analysis. Mean age was 51 years (range 31 to 83 years), and there were 52 females and 41 males

who underwent RSC for various disorders, including trigeminal neuralgia (TGN, N = 78), glossopharyngeal neuralgia (GPN, N = 1), Ménière's Disease (N = 7), and hemifacial spasm (HFS, N = 7) as a primary diagnosis. Of the 93 patients in the cohort, three carried a diagnosis including more than one of those listed above. Mean follow-up was 9.7 months (range 3 to 39 months). HBC cranioplasty without additional materials was accomplished in all cases.

While there were no deep-seated postoperative infections, three patients developed superficial wound complications requiring revision [Table 1]. In all three cases, the HBC graft was verified to be structurally intact upon intraoperative exposure, and none of the patients required a third operation.

CSF external leak from the wound did not occur in any cases, however, one patient presented a pseudomeningocele 15 days post operatively and underwent a surgical revision after an external lumbar drainage failure; the HBC was changed to a titanium mesh cranioplasty.

Long-term incisional pain occurred in one case where prescription pain medication was continually requested by the patient. The pain subsided to a low-intensity tenderness at the operative site at 6 months but remained present at one year. At no point was there concern for infection due to the lack of clinical evidence of such, including erythema, dehiscence, drainage or systemic signs of infection. A different patient had persistent pain associated with a headache and earache of gradual onset at two months. Further work-up and neuro-otological evaluation revealed otitis externa, which was treated with antibiotics, resulting in resolution of the headaches, earaches, and incisional tenderness. One patient was hospitalized for 6 days postoperatively due to uncontrollable headaches, which gradually tapered off by the time of clinical follow up. In one case, small amounts of straw-colored fluid drained from the incision was observed; no clinical or biological sign of infection was found, the "leakage" had resolved gradually under a conservative management and observation. Table 2 summarizes these results.

Table 1: Summary of postoperative infections

	Procedure	Complication	Organism	Time Until Revision	Nature of infection
31F	R MVD CN V	Stitch abscess	None	35 days	Superficial
65M	R MVD CN V	Purulent drainage	MRSA	41 days	Superficial
61F	R MVD CN IX, V SNI	Stitch abscess	None	92 days	Superficial

MVD: Microvascular decompression, SNI: Section of nervus intermedius, CN: Cranial nerve, MRSA: Methicillin-resistant Staphylococcus aureus

One patient was dissatisfied with the cosmetic results due to the scar, which formed after revision for stitch abscess. There were no complaints of palpable or visible deformities beneath the skin. All other patients stated complete satisfaction with the cosmetic results including the three other patients who underwent revision for superficial wound infection.

DISCUSSION

The HBC cranioplasty used in reconstruction of RSC seems to be a safe method to eliminate the CSF leak and deep wound infections' it yields a good cosmetic dissatisfaction as well. Our results reaffirm the safety of HBC and its efficacy in providing a water-tight barrier. Table 3 summarizes infection rates after RSC of several previously published series as compared to the current study.

Technical nuances employed in the application of HBC likely contribute to the low rate of patient dissatisfaction. Smoothing of the HBC to the contours of the skull with the lowest possible profile without allowing for the uncured cement to sink into the craniectomy is paramount, as HBC cranioplasty may lead to palpable depressions.[12]

In our series, scar formation was the source of the one instance where cosmetic satisfaction was not attained; therefore, the authors consider this unrelated to the cement cranioplasty but rather attributable to soft tissue wound healing.

Other complications included persistent postoperative incisional pain (N = 1), diffuse headache (N = 1), scant serous wound drainage (N = 1), otitis externa (N = 1), and pseudomeningocel (N = 1).

Persistent postoperative incisional pain has been attributed to damage or irritation of the lesser occipital and/or greater auricular nerves through contact with the underlying cranioplasty.[12,13] Because HBC allows for smooth contouring of the graft to the native curvature of the calvarium, it follows that postoperative pain accounted for through this mechanism would be minimized. The bone cement cannot, however, reduce postoperative pain associated with damage or irritation of the nerves, which occurs upon exposure and/or closure. Postoperative headache is a known complication of RSC, and technical modifications aimed at reducing frequency and severity of them have been previously reported.[27]

Headaches frequently occur after craniotomy due to loss of CSF, therefore, measures aimed at the reduction of CSF loss should be employed. The authors propose that the low incidence of uncontrollable postoperative headaches is partly attributable to the very low incidence of postoperative CSF leakage in the series at hand, as well as to the copious saline irrigation used intraoperatively.

Table 2: Summary of non-infectious postoperative complications

	Procedure	Complication	Outcome
39F	R MVD CN V	Immediate post-op persistent HA requiring prolonged hospitalization	Resolution of HA by second clinical follow-up at one month
33F	L MVD CN V and section of NI	Ear pain, incisional tenderness and HA at 2 months post-op	Resolution of Symptoms after treatment of otitis
54F	L MVD CN V	Long-term incisional pain	Diminution of pain by six months. Persistent tenderness at 1 year
45F	R MVD CN V	Pseudomeningocele at Day 15 post-op	5 days of lumbar drainage then surgical revision. The HCB changed to titanium mesh
45F	L MVD CN V	Scant intermittent serous drainage	Spontaneous resolution

CN: Cranial nerve, HA: Headache, MVD: Microvascular decompression, SNI: Section of nervus intermedius

Table 3: Previously reported incidences of CSF leak and infections following RSC

Series	Cases	CSF leak (including pseudomeningocele)	Infections		HBC Cranioplasty Performed?
			Wound infection	Deep infection including Meningitis	
Barker *et al* (1995)	782	2.9%	0.5%	1.2%	No
Barker *et al* (1996)	1336	1.5%	NR	0.4%	No
Broggi *et al* (2000)	250	4.8%	NR	NR	No
Silverman *et al* (2004)	53	5.7%	1,9%	One case of aseptic meningitis	No
Li *et al* (2005)	217	0% - 2.8%*	NR	1.9%-2.6%*	No
Martinez-Anda *et al* (2012)	301	1.0%	NR	NR	No
Frederickson *et al* (2013)	79	0%	2.5%	0%	Yes
Foster *et al* (2016)	336	6%	5.4%	NR	No
	336	0%	0.6%	NR	Yes
Current Series (2016)	93	1%	3,2%	0%	Yes

CSF: Cerebrospinal fluid, HBC: Hydroxyapatite bone cement, NR: Not reported, RSC: Retrosigmoid craniectomy. *Results comparing the rate of complications with and without using an artificial dura mater respectively

Continuous intraoperative irrigation functions not only to replace the lost volume of CSF, but also to wash out any irritants, which may contribute to chemical meningitis, such as bone dust, blood products, or other foreign materials introduced into the arachnoid space.[12]

In the one case, where small amounts of straw-colored fluid drained from the incision, there were no signs of infection. The patient's temperature and white blood cell count were within normal limits, and there was no surrounding erythema or wound dehiscence. In fact, the drainage was not reproducible at the clinic visit. The authors instructed the patient to place a sterile gauze strip on the wound when and if the drainage reoccurred. The following night the patient presented to the emergency department with a small (1.5 cm) moist spot on the dressing, although the "leakage" had spontaneously resolved. There have been reports of HBC resorption leading to seroma formation after RSC,[5] and the authors suspect this mechanism may be partly responsible in this scenario, however, there was no evidence of fluid build-up or HBC resorption beneath the skin on Computed Tomography (CT) scan nor was there evidence of subcutaneous fluctuance. There was no evidence of fragmentation on CT scan in the aforementioned patient; lending suspect to the idea that HBC produced in different manners may contain chemicals which lead to allergic and/or inflammatory reactions.

The episode of otitis externa, which occurred in one patient postoperatively, is believed to be unrelated to the HBC, as there were no physical signs of wound healing problems at the incision. Additionally, the patient previously suffered from similar bouts of otitis externa, yet presented to the emergency department out of concern due to the recent surgery.

One patient presented at day 15 postoperatively due to a collection at the operation site without external leakage. The clinical, radiological, and biological investigations revealed a pseudomeningocele without infection signs. An external lumbar drainage was applied for 5 days. Unfortunately; the drain weaning failed, so the patient underwent a surgical local revision and the HBC was changed to a titanium mesh cranioplasty.

Limitations of the current study derive primarily from the retrospective nature of the investigation. Additionally, many patients included in the study reside a considerable distance from the authors' quaternary referral center, making travel cumbersome. Therefore, telephone interviews accounted for a sizeable proportion

of follow-up, making visual inspection impossible. Lastly, the binary nature of the question posed to all patients at follow up ("Are you satisfied with the cosmetic results of your procedure?") does not allow for in-depth analysis of those responses. While the number of patients included in the current study is sizeable, it is not as robust of a comparison amongst populations undergoing RSC as would be a study comparing RSC utilizing other traditional methods to the method at hand.

CONCLUSIONS

Hydoxyapatite bone cement for retrosigmoid cranioplasty used for the treatment of cranial nerves disorders is an effective method for the prevention of postoperative CSF leaks. Additionally, it is safe due to the lack of deep-seated wound infections and yields good cosmetic results with low incidence of chronic incisional pain. However, this observation reaffirms the necessity for in-depth investigation of the chemical and bio-reactivity properties and differences among available HBC products.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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