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A Modified Autogenous Duraplasty for Chiari I Malformation: An University Hospital Experience

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Abstract

Introduction: Posterior fossa decompression with duraplasty is the most commonly performed surgery to treat symptomatic Chiari I malformation (CMI). However, the types of dural substitutes are still controversial. We report our institutional experience using an innovative autogenous duraplasty technique in the treatment for CMI.

Materials and Methods: The author performed a retrospective review of 16 patients who underwent bony decompression and duraplasty with the deep fascia of semispinalis capitis, musculi rectus capitis posterior and rectus capitis muscle and and reverse suture watertight technique. A detailed review of clinical charts was performed, including anesthesia records and radiographic results.

Results: The majority of patients undergoing this method had symptomatic improvement (n=15), only one patient had fluid collection and one patient had aseptic meningitis who recovered rapidly. Compared with the traditional surgical approach, this method has simialr operation time and blood loss. Furthermore, this modified duraplasty technique has lower complications and attained a higher improvement rate as 93.7%.

Conclusions: The pedicled autologous deep fascia may be an ideal way to repair dura mater for Chiari I malformation.

Keywords: Chiari I malformation, duraplasty, surgical technique.

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Introduction

Chiari malformation type I (CMI) was first described in 1891 by Hans Chiari [1]. There has been a general consensus that surgical decompression is the treatment of choice in symptomatic CMI patients. [2-4]. Suboccipital craniectomy and C1 laminectomy is typically employed. However, other aspects of decompressive surgery is the subject of debate. Among the debated topics includes ideal amount of bone removal, need for duraplasty, type of material for duraplasty, subarachnoid dissection, and need for tonsillar shrinkage. This may or may not be accompanied by expansile duraplasty with autograft or allograft.

Currently, most neurosurgeons would perform posterior fossa decompression with duraplasty [5]. Posterior decompression along having the advantage of protection from postoperative complications related to dural and arachnoid space opening and reduced operative time. Decompression with traditional duraplasty carries additional risks such as meningitis, cerebral spinal fluid (CSF) leakage, pseudomeningocele, cerebellar ptosis, and hydrocephalus

[6]. However, many surgeons believe it is essential to restore normal CSF dynamics, associated with a lower reoperation rate, and can attain symptomatic improvement [5,7,8].

Numerous materials have been advocated for duraplasty, including autologous, such as pericranium, fascia lata, posterior atlantooccipital membrane, ligamentum nuchae, splenius capitis muscle flap, and non-autologous such as bovine pericardium, cadaveric dura, synthetic bovine collagen matrix (Duragen), acellular human dermis allograft (AlloDerm), expanded polytetrafluoroethylene (PTFE), and porcine small intestinal submucosa (Durasis) [9-13].

Despite several decades of experimentation and investigation of a wide range of materials, no consensus has been reached on the ideal dural substitute. An ideal graft would provide watertight closure without promoting excess arachnoid scar formation and minimize inflammatory response. In general, many surgeons prefers autologous materials over nonautologous substitutes for their lack of immunogenic complications. However, traditional autologous duraplasty still had a high incidence of complications from CSF leak [14]. This maybe due to the dissolution of dura substitute devoid of its blood supply during graft harvest.Therefore, an autogenous dura substitute with blood supply in combination with a water-tight suture technique could be an ideal choice for the treatment of CMI. We present our institutional experience with a modified autogenous duraplasty using pedicled autologous deep fascia.

Materials and Methods

Patients Population

Approval for the study was obtained from the Ethical Review Board of our hospital, and all patients provided written informed consent to participate in the study. This retrospective study was performed at the First Affiliated Hospital of Harbin Medical University. The radiological criterion for diagnosis of the Chiari I malformation requires a downward herniation of the cerebellar tonsils greater than 5mm below the foramen magnum. The primary inclusion criteria were

1. Radiological evidence of CMI;

2. Tussive suboccipital headache, cranial nerve dysfunction, and/or cerebellar symptoms;

3. Age between18 to 70 years; and

4. Failed conservative therapy [15]. Patients were excluded if they had history of cervical spinal surgery. Surgery was recommended for symptomatic patients only. This is a single-surgeon series.

Surgical Technique

A standard posterior fossa decompression (PFD) through a midline suboccipital craniectomy and C1 laminectomy was used in each patient. The patients were placed in concorde position. Suboccipital incision was planned in the midline from roughly the inion to the C3-C4 level. Care was taken to remain within the midline avascular raphe, and expose subocciput and posterior arch of C1. During the process, trapezius, semispinalis capitis, musculi rectus capitis posterior and rectus capitis posterior minor were separated from the midline, and detached from occipital bone and C1 posterior arch. Dura was exposed after suboccipital craniectomy and removal of C1 lamina. A Y-shaped dural incision was made, keeping the arachnoid intact

The deep fascia of right or left semispinalis capitis, musculi rectus capitis posterior and rectus capitis muscle was sharply separated with scissors, making sure to keep the facia intact. A 4cmx3cm trapezoid facia was dissected, with the facia of the rectus capitis posterior minor as the pedicle in the size about 1.5cm. This pedicle was dissected as deep as we can till it reached the midline. Then the separated deep facia was reversed with the facia of the rectus capitis posterior minor as the pedicle. A vascular suture technique was applied to get a water tight seal with 6-0 Prolene as shown in (Figure1). Subsequently, gel foam was used to cover the operative field. The incision was closed in anatomical layers.

Clinical Outcome

Surgeon and anesthesia operative records were reviewed to document intraoperative findings, blood loss, and operative time. Computed tomography scans (CT) were evaluated for the presence of subarachnoid hemorrhage, epidural hematoma or fluid collections after the decompression operation. Lumbar puncture, blood test and CSF bacterial culture were taken for the patients with persistent postoperative fever and suspected meningitis. Follow-up MRI scans were reviewed for the evidence of hydrocephalus, pseudomeningocele or delayed extra axial fluid collections, and the changes of tonsil herniation and syringomyelia.

Results

Patient Series

A total of 16 CMI patients with the modified autogenous duraplasty were included from March 2013 to June 2015, the average follow-up period was 1.3years, ranging from

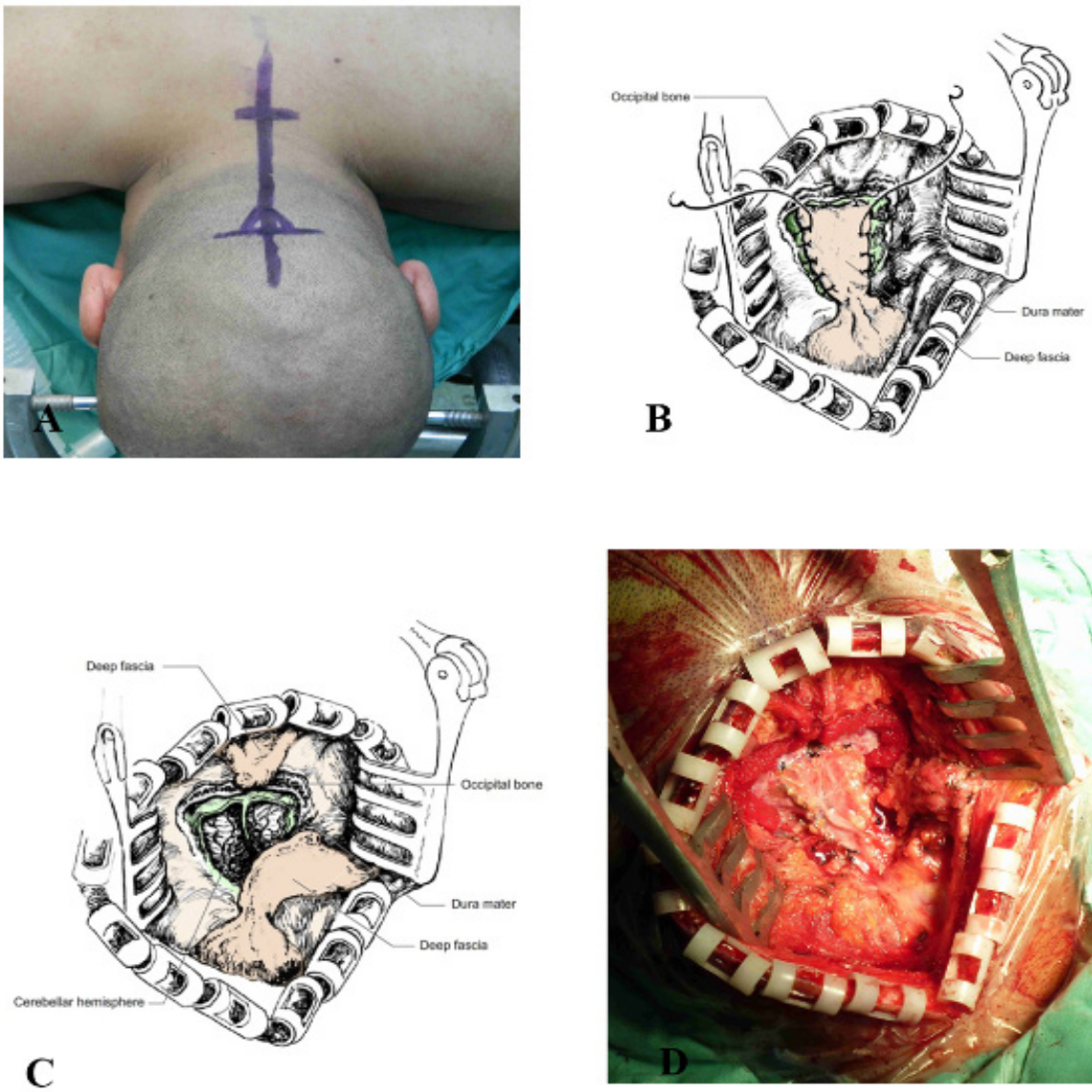

Figure 1: Intraoperative photographs and graphics. A: Patient's position and planned skin incision. B: The deep fascia was sharply separated and collected as a trapezoid shape, and it was reversed to be dura substitute. C: The reversed deep facia was sutured with the residual dura mater via a vascular suture technique. D: The separated deep facia was reversed and sutured with the dura.

6 months to 2.8 years. Follow-up was based on telephone calls to patients, families, and regular follow-ups. Patient's hospital and office records were evaluated retrospectively. The average age was 36.1±10.7 years, and the average period of symptoms prior to registration was 1.9±0.5years. The other patient characteristics were shown in (Table 1).

Duraplasty

Tonsil herniation was confirmed in all cases after opening the dura. Unintentional arachnoid leak occurred in 4 cases after opening dura, 2 of which were sutured with 9-0 because leak was more than 5mm in length. In all cases, dura was sutured water-tight with the deep muscle facia via a modified autogenous duraplasty. The mean operative time was 163.4±32.7 minutes (from incision to closure). The mean estimated blood loss was 17.3±5.2ml. There were no documented intraoperative complications in the series.

Clinical Outcomes

Postoperative CT scans obtained within 72hours did not reveal subarachnoid hemorrhage or epidural hematoma. One patient developed fluid collection, which was managed conservatively and demonstrated eventual resolution on follow up MRI. 6 patients developed moderate postoperative

Table 1: Patient characteristics.

Variables	Total (n=16)
Age	
Mean	36.1±10.7 years
Range	28-65 years
Sex	
Male	9
Female	7
onset symptoms	
headache	14
neck rigidity	16
hypoesthesia	13
muscle weakness	6
dysphagia	3
cranial nerve deficits	4
syringomyelia	8

fever, 5 of whom defervered spontaneously after 72 hours. One had persistent fever, and lumbar puncture showed elevated opening pressure, and CSF profile consistent with aseptic meningitis. Patient responded to mannitol and dexamethasone and defervesced three days later. None of the patients had wound infection.

Almost all the patients experienced improvement or resolution in their presenting symptoms except for one whose headache worsened. The improvement rate was 93.7%. The follow-up MRI at 6 months showed that all patients had full resolution of tonsillar herniation, absence of brainstem compression, and a capacious posterior fossa with no evidence of pseudomeningocele formation and hydrocephalus (Figure 2).

Discussion

Despite the best approach for surgical decompression is still under much debate, most neurosurgeons select posterior fossa decompression with duraplasty for CMI. Among the myriad of possible candidates for dural graft, most neurosurgeons prefer autologous material for their better rates of aseptic meningitis, wound infections, and pseudomeningocele formation compared to allografts. However, all of the autologous graft material are devoid of blood supply.The graft needs neovascularization and neoepithelialization [16-19]. Studies shows fibroblast proliferation within the graft was evident in 2 weeks, and the graft was filled with endogenous collagen after two

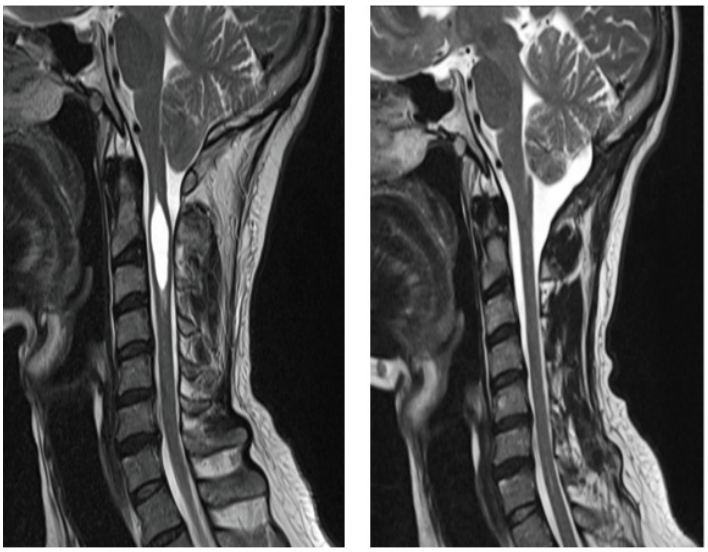

Figure 2: Head MRI scan obtained prior to operative intervention showed the cerebellar tonsil herniated into the superioredge of the posterior arch of the atlas, with associated syringomyelia. Postoperative MRI suggested that cerebellar tonsil was back to normal anatomical position, and resolution of the syringomyelia.

months post implantation [20]. Because incorporation of both acelluar cadaveric and collagen matrix grafts seemed to take at least 2 to 3 weeks as indicated by laboratory studies to achieve true watertight seal, the grafts cannot be relied on to prevent CSF leak during the perioperative period [21]. Our innovative pedicled autologous deep fascia carries with its own blood supply and therefore will speed up the healing process significantly while the water tight reverse suture technique holds the tissue in place. This technique can be safely used in CMI patients to achieve good clinical results. This technique did not significantly affect operative time and blood loss when compared with data from other studies.

CSF leak and pseudomenigingocele were among the most common complications with suboccipital decompression for CMI regardless of the surgical approach employed [14,16,17]. Pseudomeningocele has a reported rate of 5.9% [14]. Achieving watertight dural closure is crucial and can be challenging as evident by the high pseudomeningocele rate, as high as 9-46% in some series. Inspired by the carotid endarterectomy and other vascular surgical operations, we invented a reverse suture method to approximate dura with the fascial flap. We successfully obtained the watertight closure in the majority of the patients. Only one patient in our study had CT evidence of fluid collectionwhichresolved with conservative management.

CSF fistula occurs after dura opening and arachnoid rupture. In our experience, we kept the arachnoid intact

as best as we can. However, injury to the arachnoid can be very easily done when opening dura because the compact posterior fossa has a relatively high local CSF pressure and the arachnoid is attached closely to the dura. 4 cases had arachnoid tear during dura opening and primary repair was done whenever possible.

One patient suffered aseptic meningitis. Intraoperatively, the arachnoid was unintentionally torn 1 cm in length, with influx of blood into subarachnoid space. Effort was made to aspirate blood in subarachnoid space and arachnoid was sutured. Postoperative CT showed CSF collection for this patient. Some authors claimed that aseptic meningitis appeared to be related to the type of material used for duraplasty. It was reported that lyophilized dura, fascia lata, or galea were more likely to obtain aseptic meningitis [22,23]. We hypothesized that residual blood in the subarachnoid space together with post-operative CSF infiltrated by markers of inflammatory response contributed to this patient's aseptic meningitis.

Hydrocephalus is an important postoperative complication, which has a reported rate of 3.0% in the 30 day post operation period [24]. It was highly associated with dura opening, which caused CSF related complications. In our study, none of the patients had hydrocephalus with a maximum 18months follow up. The small sample size and retrospective nature of this study did not allow for significant comparison with other surgical techniques. A larger samples size and a randomized controlled trial will be needed to further investigate this innovative surgical technique. Furthermore, it is not a routine practice to perform intracranial pressure (ICP) monitoring, brainstem auditory evoked potential

(BAEP) and electromyogram (EMG) at our institution, which can display changes visually and objectively, hence can explain the detailed mechanism related with cerebrospinal fluid dynamics and electrical activity. Nontheless, we proposed an innovative duraplasty with lower complication rate, cheaper operation cost, better wound closure, less CSF leak, which could be a potential ideal way to repair dura mater for CMI.

Conclusions

We reported a modified duraplasty technique, using the autogenous pedicled deep facia via reverse suture had lower complication rate such as CSF fistula, pseudomeningocele, cheaper operation cost, and attained a high improvement rate as 93.7%. This blood supplied graft is a potential ideal substitute for dura mater. A longer follow-up and a large number of patients are important to validate these findings further.

Disclosure

The author reports no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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