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Technical Note

Titanium mesh-assisted dural tenting for an expansile suboccipital cranioplasty in the treatment of Chiari 1 malformation

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ABSTRACT

Cerebellar ptosis and dural prolapse are known complications after posterior craniocervical decompression of Chiari 1 malformation (CM1), and are associated with larger craniectomies, epidural scarring and intradural adhesions. Although management of these complications has been well documented, little has been reported in regards to their prevention. We describe our variation of the posterior fossa decompression technique for CM1 using a titanium mesh-assisted dural tenting expansile cranioplasty to prevent both cerebellar ptosis and dural prolapse. A watertight dural augmentation patch is performed after posterior craniocervical decompression. A titanium mesh cranioplasty is performed to cover the superior aspect of the craniectomy. The duraplasty is then tented to the titanium mesh plate with several interrupted sutures. The titanium mesh plate was intended to prevent postoperative cerebellar ptosis or sag, while the dural tenting was performed to prevent delayed collapse and restenosis of the cistern magna. Four patients with CM1 underwent this technique without complication. Postoperative MRI did not demonstrate cerebellar ptosis, restenosis or collapse of the cisterna magna. The expansile suboccipital cranioplasty with titanium mesh-assisted dural tenting technique is a simple and efficient strategy that may be useful to prevent cerebellar ptosis and dural prolapse and maintain the patency of the surgically created neo-cisterna magna.

1. Introduction

Over a century ago, Hans Chiari described what is known today as Chiari 1 malformation (CM1) [1]. The clinical presentation of CM1 depends on the degree of foramen magnum crowding and spinal cord dysfunction from a syrinx and/or structural compression of the cervicomedullary junction. Occipital headache that is brought on by Valsalva maneuvers is the most common presenting symptom [2–5]. Although the pathophysiology of CM1 is still elusive, the first line surgical treatment for this condition has been, and remains, posterior craniocervical decompression (PCD), since it was first introduced by Van Houweninge Graftdijk in 1932 [6,7], then later by Penfield in 1938 [8]. Since then, many different surgical techniques have been described in the literature with the goal of enlarging the posterior fossa and reconstructing the cisterna magna to restore normal cerebrospinal fluid (CSF) dynamics at the craniocervical junction [9–16].

The most frequent complications of PCD are meningitis [17,18] and CSF leak [17,18] with or without pseudomeningocele formation [19,20]. Cerebellar ptosis, also known as cerebellar prolapse, slump, or sag, is another well-recognized complication [18,21–23]. This has been postulated to be associated with larger craniectomies [12,22,24,25]. Dural prolapse, or collapse of the cistern magna, is another complication that is due to scar formation and intradural adhesions that results in loss of cistern magna volume and obstruction of CSF flow across the cervicomedullary junction [13,26,27]. Almost one-third of patients will experience recurrent CM1 symptoms after PCD over their lifetime [28–30] with re-operations often revealing dural prolapse with scar formation and intradural adhesions as the source of these recurring symptoms [13,26]. The slumped cerebellum also causes scarring and dorsal adhesions resulting in distinct symptoms from those associated with CM1 [24]. Neurosurgeons continue to search for the optimal procedure to treat primary CM1 symptoms and to prevent recurrence and re-operation.

In this report, we describe our variation of the PCD technique using a titanium mesh-assisted dural tenting expansile cranioplasty to prevent both cerebellar ptosis and dural prolapse. In addition to enlarging the posterior fossa and re-creating the cisterna magna for improved CSF flow across the craniocervical junction, the expansile titanium mesh cranioplasty aims to prevent

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cerebellar ptosis and sag while the dural tenting aims to prevent dural prolapse and collapse of the cisterna magna. We describe our operative technique with some illustrative patients.

2. Operative technique

A standard midline suboccipital craniectomy and C1 laminectomy is performed in the prone position (Fig. 1). The decompression is extended to the posterior aspect of the occipital condyles at the level of the foramen magnum. A partial superior C2 laminectomy is performed if necessary for low-lying tonsils at this level. We prefer not to perform a complete C2 laminectomy in order to avoid delayed kyphotic deformity. The atlanto-occipital ligament and the dural bands constricting the craniocervical junction are excised. The dura is opened in a Y-shaped fashion and the inferior limb of the incision is opened in an upside down T-shaped fashion to enlarge the dural opening. Care is taken to keep the arachnoid intact. However, if the arachnoid layer is breached, the tonsils are separated, but never resected, and the arachnoid adhesions, if any, are lysed to expose and identify the fourth ventricle floor and the obex. Care is taken to keep blood out of the subarachnoid space.

A watertight dural augmentation patch is performed with a dural substitute. We prefer to use an acellular dermal allograft (AlloDerm; BioHorizons, Birmingham, AL, USA) for Chiari operations because of its handling, durability, and ability to hold sutures for a watertight closure and for dural tenting (Fig. 2, 3). A titanium mesh cranioplasty is performed in an attempt to prevent future cerebellar sag or ptosis. Care is taken to ensure that the cranioplasty covers only the superior aspect of the craniectomy to avoid re-stenosis of the newly decompressed cervicomedullary junction. Next, the duraplasty is tented to the titanium mesh plate with approximately two to three interrupted 4-0 Nurolon sutures (Johnson & Johnson Medical, Piscataway, NJ, USA) to prevent collapse and adhesions of the newly created cisterna magna (Fig. 2, 3). The closure is then augmented with Tisseel Fibrin Glue (Baxter, Deerfield, IL, USA) followed by a single layer of Surgicel (Johnson & Johnson Medical). Meticulous closure is then performed in a multi-layered fashion.

3. Results

Four patients (two men and two women, mean age 30.25 years) underwent suboccipital PCD for CM1 using the mesh-assisted dural tenting technique described above (Table 1). All patients initially presented with suboccipital headaches that were induced by Valsalva maneuvers. Three of the four patients had a syrinx associated with the CM1. All four patients had an uncomplicated postoperative course, with mean hospital course being 2.5 days. Postoperative MRI were obtained on postoperative day 1, and at 3 month and 1 year postoperative follow-up visits (Fig. 4, 5). No patient developed cerebellar ptosis, collapse or restenosis of the cisterna magna, or obstruction of CSF flow due to dural adhesions, requiring re-operation. There were also no complications of infection, CSF leak, pseudomeningocele, or recurrent Chiari 1 symptoms. All patients had postoperative improvement or resolution of Chiari symptoms and their radiographic syrinx. The mean follow-up was 19 months (range: 8–35 months).

4. Discussion

In this report, we describe a simple and efficient technique to prevent cerebellar ptosis and dural prolapse using a titanium mesh-assisted dural tenting expansile cranioplasty. The titanium plate assists in preventing cerebellar ptosis and also serves as a scaffold to suture the duroplasty to the plate. The tenting of the duraplasty aims to maintain patency of the cistern magna and the titanium plate also serves as barrier between the dura and the cervical musculature that can potentially re-stenose the cervicomedullary junction.

The standard surgical management of symptomatic CM1 without hydrocephalus is PCD via suboccipital craniectomy, C1 and/or

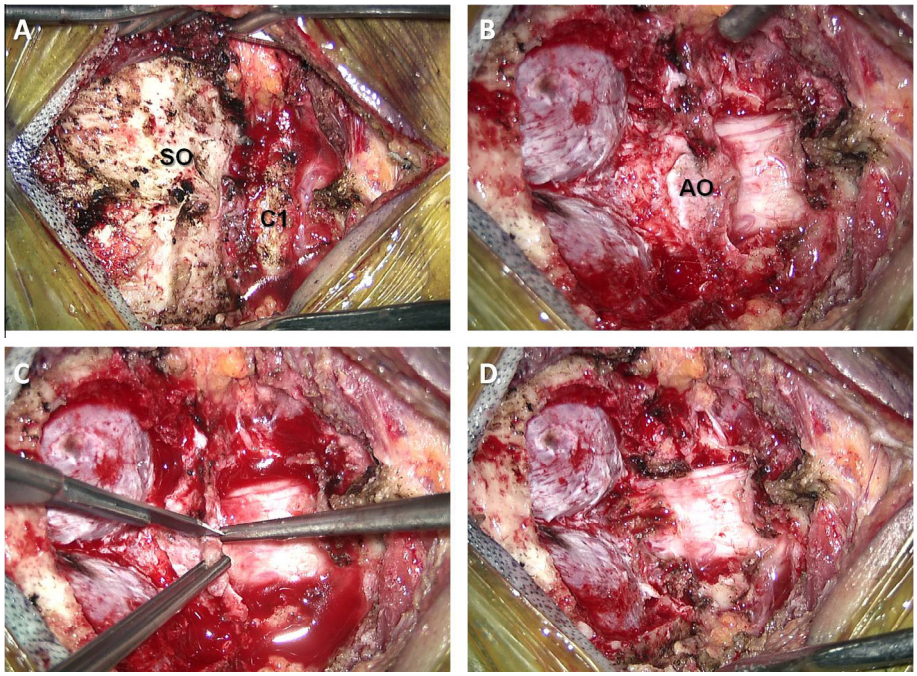

Fig. 1. Intraoperative photographs. (A) Midline posterior approach to the craniocervical junction exposing suboccipital bone (SO), the foramen magnum, and the arch of C1. (B) Suboccipital craniectomy is performed along with C1 laminectomy exposing the cerebellar hemispheres and craniocervical junction. (C) The atlanto-occipital ligament (AO) is divided sharply and resected to relieve pressure from the craniocervical junction. (D) View of completed extradural posterior suboccipital decompression. (This figure is available in colour at www.sciencedirect.com)