Technical Nuances of Autologous Pericranium Harvesting for Dural Closure in Chiari Malformation Surgery

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Abstract

Duraplasty is a step commonly used for the treatment of Chiari I malformation after foramen magnum decompression. A variety of dural substitutes are currently available for dural closure to minimize the complications related to cerebrospinal fluid (CSF). We describe a technique of harvesting occipital pericranium for duraplasty associated with preservation of a wide cuff of muscle at the superior nuchal line that allows anatomical muscle closure at the end of the procedure. Five symptomatic patients with Chiari I malformation and one patient with syringomyelia-Chiari I complex were operated on with this technique. The indications to perform a duraplasty were accidental arachnoid breaching in three patients during an extra-arachnoidal approach and arachnoidal dissection due to intraoperative findings of arachnoid pathology in the remaining three patients. The overall morbidity of this technique was nil. In all patients the postoperative magnetic resonance imaging scan demonstrated significant expansion of the cisterna magna with no evidence of pseudomeningocele. Duraplasty with autologous pericranium and standardized closure of soft tissues seem promising in reducing the CSF-related complications during Chiari surgery.

Keywords
- Chiari I malformation
- dural closure
- duraplasty
- morbidity
- pericranial graft

Introduction

Despite recent advances in understanding the pathophysiology of Chiari I malformation, much controversy concerning a great number of technical nuances during the foramen magnum decompression is still present. Controversy exists regarding the extent of bony removal and the need for additional steps such as dural opening, arachnoid dissection, reduction of cerebellar tonsils, and duraplasty. In recent years, evidence is accumulating that an optimal clinical result after surgery for Chiari malformation can be achieved when the surgical strategy is tailored to address the patient-specific pathophysiologic variations of tonsillar prolapse and the intraoperative findings. It is argued that when arachnoid dissection is planned or the arachnoid is accidentally breached during an extra-arachnoidal approach, a watertight dural repair should be performed to avoid complications related to cerebrospinal fluid (CSF).[1–4] In an attempt to reduce the CSF-related morbidity after surgery for Chiari malformation, we developed a procedure in which a wide cuff of muscle is left attached at the superior nuchal line and the occipital pericranium is harvested through the same skin incision. Preservation of the nuchal attachments allows anatomical muscle closure, and when combined with autologous duraplasty it helps establish a watertight closure at the end of the procedure.

Materials and Methods

Patient Characteristics

Between February 2011 and November 2012, five patients with Chiari I malformation and one patient with

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syringomyelia-Chiari I complex underwent duraplasty with autologous pericranium. The five female patients and one male patient ranged in age from 21 to 51 years (mean age: 30 years). All patients were symptomatic. The indications to perform a duraplasty were accidental arachnoid breaching in three patients during an extra-arachnoidal approach and arachnoidal dissection due to intraoperative findings of arachnoid pathology in the remaining three patients. The analysis of morbidity focused on complications related to dural opening, such as pseudomeningocele, CSF leakage, postoperative hydrocephalus, and meningitis. Postoperative magnetic resonance imaging (MRI) scans were performed at 3-, 6- and 12-month follow-up examinations.

Surgical Technique

After induction of general anesthesia, the patient is placed prone with the head secured within a Mayfield head holder and the cervical spine flexed in the anteroposterior plane. Local subcutaneous anesthesia is used at the proposed site of the skin incision. A midline linear skin incision is made from just 2 cm above the inion to the second cervical spine (►**Fig. 1A**). A subgaleal dissection is performed under the superior edge of the wound to expose the occipital pericranium, using a combination of scissors and blunt dissection with a finger (►**Fig. 1B**). The occipital pericranium exposed can now be amputated using the scalpel or the monopolar cautery and released with a periosteal elevator (►**Fig. 1C**). This technique yields a graft ranging from 4 to 6 cm in length, with a width of ~3 cm and a thickness of 2 to 5 mm (►**Fig. 1D**). The thickness of the graft is related to the interindividual variability of the loose areolar layer that constitutes the subgaleal fascia. Once the graft is harvested, it is kept wet in a saline solution for the duration of the procedure.

At this point, the muscle attachment just below the superior nuchal line is incised in a "T" fashion, leaving a 1-cm-wide cuff of muscle attached to the occipital bone, facilitating a watertight closure (►**Fig. 1E**). At the end of the procedure, the graft is cut at the shape of the dural defect. In addition, when the graft is considered too thick for the specific patient, a variable amount of subgaleal fascia is cut off.

Results

The follow-up ranged from 6 to 26 months (mean: 15 months). Symptomatic improvement was demonstrated in all patients, and complete resolution of symptoms was reported in four patients. The overall morbidity related to the arachnoid opening was nil. In all patients the postoperative MRI scans demonstrated a wider cisterna magna and the ascent of the

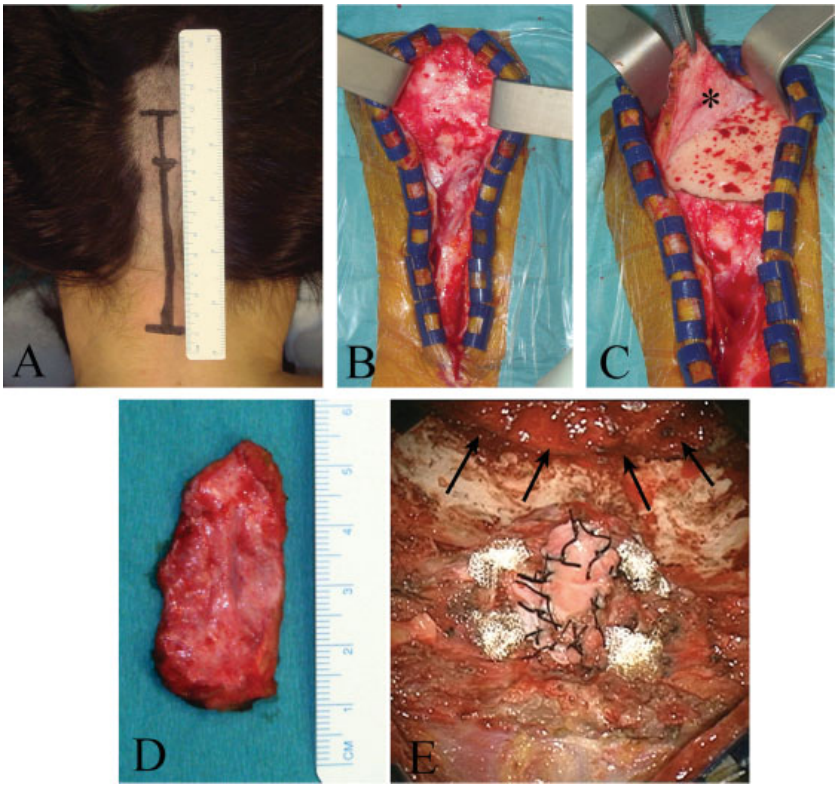

Fig. 1 Intraoperative photographs illustrating the steps of autologous pericranium harvesting and duraplasty. (A) The cutaneous skin incision is planned from just 2 cm above the inion to the second cervical spine. (B) The subgaleal space is expanded just above the superior nuchal line to expose the occipital pericranium. (C, D) A generous amount of pericranium (asterisk) is harvested performing a subperiosteal dissection. (E) A 1-cm cuff of muscle is left attached to the superior nuchal line (arrows) during the subperiosteal dissection of the suboccipital region. At the end of the procedure, preservation of the nuchal attachments allows anatomical muscle reapproximation facilitating a watertight closure.

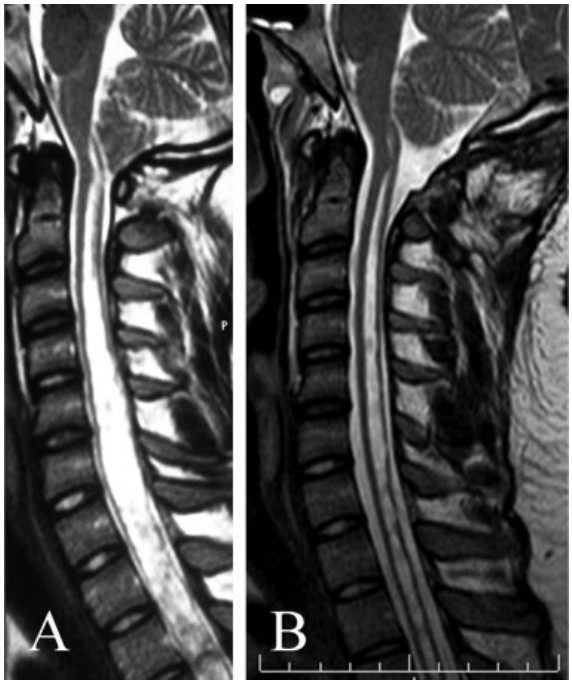

Fig. 2 (A) Preoperative and (B) postoperative sagittal T2-weighted magnetic resonance imaging (MRI) scans of a 22-year-old man with a 1-year history of motor and sensory symptoms in the right upper limb. The preoperative MRI scan demonstrated holocord syringomyelia associated with a Chiari I malformation. The first postoperative MRI study obtained 3 months after craniocervical decompression with arachnoid dissection and autologous duraplasty disclosed initial shrinkage of the syrinx and expansion of the cisterna magna with no evidence of pseudomeningocele.

cerebellar tonsils into the posterior fossa (►**Fig. 2**). In any case the follow-up MRI scan disclosed a pseudomeningocele or adhesions underneath the autologous duraplasty compromising CSF flow at the craniospinal level.

Discussion

The most frequently reported complications of foramen magnum decompression are CSF leak, aseptic meningitis, and pseudomeningocele, which are the results of arachnoid breaching without an efficient watertight dural closure.[1–7] Even though there is no general agreement on the great number of technical nuances of this operation, most authors support a watertight dural closure in the case of arachnoidal dissection or accidental arachnoidal rent in the course of an extra-arachnoidal approach.[1,2,4,5] In fact, when the arachnoid is intentionally or accidentally breached, leaving the dura open substantially increases the risk of CSF-related complications.[4,8] Recent series evaluating the morbidity associated with duraplasty report a rate of CSF-related complications ranging from 2.5% to 32.1%. Most of these complications are aseptic meningitis and CSF leak.[1–3,6,9,10] Although CSF leak has been described after duraplasty performed with both autologous and synthetic or allogenic patches, the autologous patch offers several advantages. Autologous tissues do not cause inflammatory or immune-allergic reactions, are inexpensive, and allow a very effective watertight dural closure.[5–7] Autologous dural substitutes include fascia lata, ligamentum nuchae, posterior atlantooccipital membrane, and pericranium.[5,7,11–13] Harvesting fascia lata requires an additional operative site and can induce local pain syndromes. The use of ligamentum nuchae, described by Kosnik,[11] weakens the posterior ligamentous structures and compromises the fascial closure. Harvesting posterior atlantooccipital membrane, described by Tubbs and colleagues,[13] provides a graft that can be used only for small dural openings. As an autologous dural graft, pericranium does not require a second incision, is available in abundance, and does not affect fascial closure and occipital C2 tension.[5,6,12] Interestingly, in a recent series of 100 posterior fossa surgeries where all patients received locally harvested pericranium, the complication rate was only 1% with one patient developing an aseptic meningitis and CSF leak.[7] The technique we described is a modification of a technique proposed by Stevens and colleagues[12] in which preservation of the cervicalis fascia and splenium capitis at the superior nuchal line allows anatomical muscle reapproximation, helps to reestablish a watertight closure, and prevents loss of the tension band. There is mounting evidence that a relevant role in reducing CSF-related complications is played by the correct anatomical muscle approximation.[2] Accordingly, it has been suggested that excessive use of electrocautery for soft tissue dissection and an inefficient closure of the muscular layer play a relevant role in the occurrence of postoperative CSF leak.[2]

Conclusion

We describe a technique for autologous duraplasty with pericranium combined with anatomical muscle closure that seems promising in reducing the CSF-related complications during Chiari surgery. A greater number of patients and longer follow-up will be necessary to evaluate the effectiveness of this technique.

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