Dura-splitting decompression of the craniocervical junction: reduced operative time, hospital stay, and cost with equivalent early outcome

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Object. The choice of surgical technique for decompressive surgery in patients with Chiari I malformation is controversial. Good preliminary postoperative outcomes have been achieved in patients with Chiari I malformation (without syringomyelia) after using a dura-splitting technique. The authors evaluated safety, resource use, and early outcome after this surgery in patients without syringomyelia and compared the findings associated with duraplasty in patients with syringomyelia.

Methods. A prospective series of 24 patients with Chiari I malformation (12 with a syrinx) underwent decompression of the craniocervical junction (CCJ). An allograft-augmented duraplasty was performed in patients with syringomyelia. Intraoperative ultrasonography confirmed adequate tonsillar decompression after lysis of the peristomal bands at the foramen magnum and C-1 arch as well as partial resection of the outer leaf of the dura in patients without syringomyelia. Patients in each group were of similar mean age (syringomyelia 10.8 years and no syringomyelia 7.6 years old; p = 0.07) and functional status. The mean follow-up period was 15.3 months (range 3–30 months). Dura-splitting decompression required significantly less mean operative time (99 minutes compared with 169 minutes, respectively; p < 0.001), total operating room time (166 minutes compared with 249 minutes, respectively; p < 0.001), duration of hospitalization (3 days compared with 3.75 days, respectively; p < 0.05), perioperative charges ($3615 compared with $5538, respectively; p < 0.001), and overall hospital charges ($7705 compared with $9759, respectively; p < 0.001) than the duraplasty. Mean clinical outcome scores were similar (syringomyelia 1.53 of 2; no syringomyelia 1.67 of 2; not statistically significant).

Conclusions. Dura-splitting CCJ decompression in pediatric patients with Chiari I malformation and without syringomyelia is safe, provides good early clinical results, and significantly reduces resource use. A randomized controlled trial of dura-splitting decompression in a uniform population of patients with Chiari I malformation is indicated.

KEY WORDS • Chiari malformation • dura mater • craniocervical spine • decompression • duraplasty • pediatric neurosurgery

William’s hypothesis regarding the pathophysiology of Chiari I malformation focused attention on abnormal CSF flow at the foramen magnum. Since that time, one focus of surgical treatments for this condition has been the restoration of normal CSF dynamics at the CCJ.

Previously used procedures included more invasive techniques, such as stenting of the fourth ventricle or syrinx, resection or cauterization of the cerebellar tonsils, and other intradural manipulations. More recently many authors have advocated CCJ decompression by using a simple duraplasty and little or no manipulation of the intradural contents. This trend toward less invasive procedures has culminated most recently in recommendations for extradural CCJ decompression in patients with Chiari I malformation.

We hypothesized that extradural CCJ decompression may be better tolerated by patients than intradural procedures and may also require fewer medical resources. To evaluate our hypothesis, we prospectively studied 24 consecutive patients undergoing CCJ decompression performed by a single surgeon (N.R.S.) at an academic pediatric medical center. Two different clinical groups were studied. The first group comprised patients with symptomatic Chiari I malformation and syringomyelia, in whom CCJ decompression and duraplasty were conducted without manipulation of intradural contents. The second group

Abbreviations used in this paper: CCJ = craniocervical junction; CSF = cerebrospinal fluid; LOS = length of stay; MR = magnetic resonance.
Dura-splitting CCJ decompression comprised patients with symptomatic Chiari I malformation and no syringomyelia, in whom a dura-splitting (extradural) CCJ decompression was performed.

We compared early clinical outcome, procedural and operative time, hospital LOS, and complication data in these two groups.

Clinical Material and Methods

Between July 2000 and October 2002, the senior author (N.R.S.) performed CCJ decompression in a consecutive series of 24 patients with Chiari I malformation at a tertiary referral academic children's hospital. The patients were divided into two groups (Table 1): 12 patients without syringomyelia (age 2–14 years, mean 7.6 years) and 12 other patients with syringomyelia (age 3–19 years, mean 10.8 years); approximately half of each group was composed of female patients.

According to our preexisting practice protocol, in patients with syringomyelia we performed a standard CCJ decompression, including a small suboccipital and foramen magnum craniectomy, removal of the C-1 arch, and placement of an expansion allograft duraplasty, and watertight closure. No manipulation of intradural contents was undertaken. All procedures were performed after induction of general anesthesia, in the prone position with the neck flexed, using a Mayfield pinhead holder. A single dose of antibiotic agents was administered at induction. Midline tissue soft dissection followed the intermuscular raphe. Subperiosteal dissection was used to expose the suboccipital region and the C-1 arch, with care taken not to disturb the muscular attachments to C-2. Marcaine was infiltrated into the exposed suboccipital musculature prior to closure.

Also according to our protocol, patients without syringomyelia underwent a similar approach and osseous decompression. In these patients, however, the midline dura was split from above the foramen magnum to below the C-1 arch and dissected into two, discrete anatomical “leaves.” The midline portion of the outer dural leaf was resected, and the lateral edges of this outer leaf were tented to the periosteum to encourage the dorsal expansion of the more supple inner leaf (Fig. 1). In each case intraoperative ultrasonography confirmed adequate tonsillar decompression (enlarged retrotonsillar subarachnoid space and reduced pulsatile caudal motion of the cerebellar tonsils in systole [see the study by Oldfield, et al.]).

Patients were observed overnight in the pediatric intensive care unit and were then transferred to the regular inpatient ward and mobilized. In patients not presenting with dysphagia, diet was advanced as tolerated immediately after surgery.

Hospital databases were searched for LOS, duration in the operating room, minutes of operative procedure, estimated blood loss, operating room cost, total hospital cost, and readmission if any. Any peri- or late postoperative complications were recorded. The status of each preoperative presenting complaint and/or neurological finding was queried at follow-up visits, and clinical results for the three principal presenting clinical problems were assigned a value according to the following scale: resolved, 2; improved, 1; unchanged, 0; and worsened, −1. A mean of these scores was then determined to produce a single outcome score for each patient, ranging from −1 (poor outcome, all symptoms worsened) to 2 (good outcome, all symptoms resolved).

All quantitative data for each group were compared using t-tests with alpha set at a probability value less than 0.05.

Results

Age and sex distribution in both groups were similar (Table 1). Presenting clinical symptoms were also similar, although there was a higher incidence of headache in those without syringomyelia and a higher incidence of scoliosis alone and urinary incontinence in those with syringomyelia (Table 2). Although secondary urinary incontinence is an uncommon presenting symptom in ambulatory patients with Chiari I malformation, it was present in two patients in our series in association with massive holocord syrinx. Incontinence improved in one patient (age 11 years) and

**TABLE 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Duraplasty</th>
<th>Dura Splitting</th>
<th>p Value</th>
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<tr>
<td>no. of cases</td>
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<td>0.07</td>
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<tr>
<td>age (yrs)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
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<td>7.6</td>
<td></td>
</tr>
<tr>
<td>range</td>
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</tr>
<tr>
<td>female sex (%)</td>
<td>50</td>
<td>58</td>
<td>NS</td>
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<tr>
<td>FU period (mos)</td>
<td></td>
<td></td>
<td>NS</td>
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<tr>
<td>mean</td>
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<td>3–30</td>
<td>4–27</td>
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* FU = follow-up; NS = not significant.

Fig. 1. Intraoperative photograph obtained during the extradural CCJ decompression procedure. Note that the outer leaf of dura is partially resected at the foramen magnum and C-1 level. The residual dural edges are tented back with suture.
resolved in the other (age 5 years) after CCJ decompression and duraplasty. All patients in both groups were ambulatory and participated in age-appropriate activities of daily living at the time of initial evaluation and follow-up examination. The mean clinical follow-up period was approximately 15 months in both groups (Table 1). In no patient were there radiographic signs of tethered spinal cord on MR imaging.

Examination of clinical outcome scores demonstrated that most major presenting symptoms improved or resolved in both groups (duraplasty mean outcome score 1.53, dura-splitting score 1.67; difference was not statistically significant; Table 3). In the 10 duraplasty-treated patients in whom postoperative imaging studies were available, syringomyelia had improved (seven cases) or resolved (three cases). In the 10 patients treated using the dura-splitting procedure in whom postoperative imaging studies were available, enlargement of the subarachnoid space behind the cerebellar tonsils was noted in all cases, and syringomyelia was absent. Although certain patients in each group presented with some degree of anterior CCJ compression evident on MR imaging, this anterior compression was stable to improved after posterior CCJ decompression alone. No patient has subsequently required craniocervical fusion or anterior decompression. Illustrative examples are represented in Figs. 2 through 4.

One patient in the duraplasty group was readmitted to the hospital for 2 days to undergo treatment of aseptic meningitis, without any permanent sequelae. The hospital days and cost of this readmission were not included in our analysis of resource use, which was restricted to the primary hospital admission only. There were no CSF-related or other complications among those who underwent dura-splitting CCJ decompression. Although manipulation (splitting or opening) of the posterior fossa dura in children may result in significant venous bleeding, there were no instances of uncontrollable bleeding in either group, and no patient received blood product transfusions. The anesthesiologists’ estimates of blood loss were no different between the groups (duraplasty group mean 80 ml, range 25–250 ml; dura-splitting group mean 73 ml, range 25–300 ml; difference was not statistically significant).

Compared with duraplasty, dura-splitting decompression required significantly less operating room time (duraplasty group mean 249 minutes, dura-splitting group mean 166 minutes; p < 0.001; Table 3) and operative time (169 and 99 minutes, respectively; p < 0.001; Table 3). Most of this difference in total operating room time (mean 83 minutes) was accounted for by the reduced operative time (mean 70 minutes) itself. In patients in the dura-splitting group initial LOS was also shorter (duraplasty group mean 3.75 days, dura-splitting group 3 days, p < 0.05; Table 3). These improvements in resource use resulted in both lower operating (duraplasty group mean $5538, dura-splitting group $3615, p < 0.001; Table 3) and total hospital (duraplasty group mean $9759, dura-splitting group $7705, p < 0.001; Table 3) costs in the dura-splitting group.

### Discussion

Dura-splitting decompression for pediatric Chiari I malformation is better tolerated by patients and avoids exposure to CSF-related complications compared with CCJ decompression and duraplasty. In our study, patients who underwent dura-splitting CCJ decompression returned home significantly sooner than patients treated using duraplasty and suffered no complications of surgery. One of 12 duraplasty-treated patients suffered a CSF-related complication (aseptic meningitis), requiring readmission to the hospital.

These clinical differences resulted in improved resource...
Dura-splitting CCJ decompression

Fig. 3. Same patient as in Fig. 2. Sagittal MR images revealing tonsillar decompression after duraplasty and CCJ decompression (A) and nearly complete resolution of syringomyelia (B [same spinal levels shown]). At 25 months postoperatively, the clinical outcome score in this patient was 1.7.

Fig. 4. Sagittal T2-weighted MR images of the midline obtained in a 12-year-old girl who presented with occipital headaches, gait instability, and dysphagia. A: A prominent Chiari malformation is present at the CCJ, but syringomyelia is absent. B: The cerebellar tonsils were decompressed after the extradural procedure. At 27 months postoperatively, the clinical outcome score in this patient was 1.7.

use in patients who underwent the dura-splitting procedure compared with the duraplasty. Significant decreases were noted in operative and operating room times, LOS, operating room charges, and total hospital charges. The costs resulting from the subsequent readmission of one duraplasty-treated patient for aseptic meningitis were not included in this analysis. Consideration of such costs would increase the advantages seen in the dura-splitting group.

Early clinical outcome was similar in both groups. Most presenting symptoms improved or resolved in each group. Two issues limit the interpretation of this clinical outcome data. First, symptoms of Chiari I malformation are known to recur, despite early resolution after apparently successful surgical intervention. Longer-term follow-up study will be necessary to address this issue. Second, our comparison group consisted of dissimilar patients: those with Chiari I malformation and syringomyelia. Although these considerations prevent us from evaluating the relative long-term clinical efficacy of the dura-splitting technique, our main conclusions regarding safety and resource use appear to be robust.

The choice of optimal surgical procedure for treatment of symptomatic Chiari I malformation without syringomyelia is controversial. Based on the personal experience of the senior author (N.R.S.), we advocate extensive splitting of the craniocervical dura into two clearly distinguishable anatomical leaves, with wide resection of the medial portion of the outer leaf. Inadequate splitting may fail to allow the much more supple inner leaf of the dura to relax fully and, thus, restore normal CSF dynamics at the foramen magnum. Furthermore, resection of a substantial portion of the outer dural leaf in the midline may prevent the osteogenic potential of this tissue from causing recurrent osseous stenosis. Our anecdotal experience preceding this study indicates that inadequate dural dissection leads to clinical failure after this procedure.

In our study we have documented the well-defined and significant advantages of the dura-splitting CCJ decompression, as well as encouraging preliminary clinical outcomes. We recommend the organization of a multicenter prospective randomized controlled trial of dura-splitting CCJ decompression compared with CCJ decompression combined with duraplasty in patients without a syrinx. Based on our data, we cannot comment on the separate issues of whether the dura-splitting technique may also be successfully applied in adult patients or in patients with syringomyelia.

Conclusions

Dura-splitting CCJ decompression in pediatric patients with symptomatic Chiari I malformation but without syringomyelia is safe, well tolerated and results in excellent early clinical outcomes, without exposure to the risk of CSF-related operative complications. The dura-splitting technique requires less operative and total operating room time than the CCJ decompression and duraplasty. Patients undergoing the dura-splitting procedure return home faster and have significantly lower operative and total hospital costs. A prospective randomized study should be conducted to compare these techniques in a uniform patient population.

References


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