Comparison of Porcine and Bovine Collagen Dural Substitutes in Posterior Fossa Decompression for Chiari I Malformation in Adults

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■ BACKGROUND: **Posterior fossa decompression surgeries for Chiari malformations are susceptible to postoperative complications such as pseudomeningocele, external cerebrospinal fluid (CSF) leak, and meningitis. Various dural substitutes have been used to improve surgical outcomes.**

■ OBJECTIVE: **This study examined whether the collagen matrix dural substitute type correlated with the incidence of postoperative complications after posterior fossa decompression in adult patients with Chiari I malformations.**

■ METHODS: **A retrospective cohort study was conducted of 81 adult patients who underwent an elective decompressive surgery for treatment of symptomatic Chiari I malformations, with duraplasty involving a dural substitute derived from either bovine or porcine collagen matrix. Demographics and treatment characteristics were correlated with surgical outcomes.**

■ RESULTS: **A total of 81 patients were included in the study. Compared with bovine dural substitute, porcine dural substitute was associated with a significantly higher risk of pseudomeningocele occurrence (odds ratio, 5.78; 95% confidence interval, 1.65–27.15; $P = 0.01$) and a higher overall complication rate (odds ratio, 3.70; 95% confidence interval, 1.23–12.71; $P = 0.03$) by univariate analysis. There was no significant difference in the rate of meningitis, repeat operations, or overall complication rate between the 2 dural substitutes. In addition, estimated blood loss was a significant risk factor for meningitis ($P = 0.03$). Multivariate analyses again showed that porcine dural substitute was associated with pseudomeningocele occurrence, although the association with higher overall complication rate did not reach significance.**

■ CONCLUSIONS: **Dural substitutes generated from porcine collagen, compared with those from bovine collagen, were associated with a higher likelihood of pseudomeningocele development in adult patients undergoing Chiari I malformation decompression and duraplasty.**

INTRODUCTION

Chiari I malformations are frequently treated with posterior fossa decompression surgery in symptomatic patients. Controversy surrounds several aspects of the surgical approach, including posterior fossa bony decompression alone versus additional expansile duraplasty,[1-3] necessity of arachnoid opening,[4] duraplasty with sutured dural patch versus onlay graft,[5] and choice of duraplasty material.[6] The ideal duraplasty material must have multiple temporally evolving characteristics: good handling capacity for surgical ease, ability to form a watertight mechanical barrier between the subdural and epidural compartments to prevent cerebrospinal fluid (CSF) breach, adequate porosity to serve as a scaffold for the infiltration of fibroblasts and newly generated collagen fibrils, and nonimmunogenicity to prevent rejection or the development of adhesions. Autologous materials such as pericranium are nonimmunogenic and associated with fewer complications[7-10] but require an additional or extension of the incision and can be difficult to harvest reliably. Dural substitutes in use for duraplasty include collagen

Key words
- Chiari malformation
- Dural substitute
- Duraplasty
- Posterior fossa surgery

Abbreviations and Acronyms
BMI: Body mass index
CI: Confidence interval
CSF: Cerebrospinal fluid
EBL: Estimated blood loss
OR: Odds ratio

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Table 1. Characteristics of Adult Patients Presenting with Chiari I Malformations

Characteristic	All Patients	Bovine	Porcine	*P*
Number of patients	81	42	39	
Patient characteristics				
Age, in years (mean ± SD)	38.5 ± 12.2	37.0 ± 10.8	40.1 ± 13.6	0.38
Female sex	71 (87.7)	36 (85.7)	35 (89.7)	0.74
Body mass index (mean ± SD)	27.9 ± 6.6	28.8 ± 6.8	26.9 ± 6.2	0.18
Diabetes mellitus	6 (7.5)	4 (9.5)	2 (5.1)	0.68
Current smoker	12 (14.8)	8 (19.0)	4 (10.3)	0.35
Treatment characteristics				
Estimated blood loss, mL (mean ± SD)	112.5 ± 109.8	119.5 ± 134.2	104.9 ± 76.4	0.75
Operative time, hours (mean ± SD)	3.2 ± 0.9	3.1 ± 0.6	3.5 ± 1.0	0.11
Use of Tisseel dural sealant (vs. Duraseal)	20 (24.7)	15 (35.7)	5 (12.8)	**0.02**
Use of nylon suture (vs. Gore-Tex)	34 (41.0)	24 (57.1)	10 (25.6)	**0.01**
Received postoperative steroids	60 (74.1)	30 (71.4)	30 (76.9)	0.62
Duration of hospital stay, days (mean ± SD)	3.1 ± 1.0	3.3 ± 1.0	2.8 ± 0.9	**0.03**
Duration of follow-up, days (mean ± SD)	321.8 ± 276.6	390.1 ± 333.6	248.2 ± 174.0	0.09

Values are number (%) except where indicated otherwise.
Bold values indicate significance at $P < 0.05$.
SD, standard deviation.

matrix grafts derived from decellularized mammalian tissues,[4,5,11-22] allogenic dural substitute derived from human cadaveric tissues,[7,16,23] and synthetic dural substitutes.[8,24,25]

One popular dural substitute that has been widely studied in animal and clinical studies is the acellular collagen matrix dural graft, which is derived from bovine,[11,12] porcine,[13,14] or equine[15,19,22] tissues. Histologic evaluation of this graft type showed that the matrix of collagen fibers acts as a scaffold to support fibroblast migration, collagen deposition, and neovascularization, before being resorbed and replaced by native tissue.[11-15,18] There is a paucity of large-scale, randomized studies for testing the efficacy of dural substitutes in posterior fossa decompression surgeries. Some large cohort studies examining various materials are well powered,[20,25,26] but interpretation of these results is limited by the pooling of data from widely varying surgical approaches, indications for surgeries, and patient populations.

In this study, we investigated whether the type of dural substitute used in posterior fossa decompression for adult patients with Chiari I malformations was associated with surgical outcomes. We retrospectively evaluated 2 types of collagen matrix dural substitutes (bovine collagen and porcine collagen) and compared the incidence of postoperative complications after the implantation of these dural substitutes.

METHODS

Study Criteria

This study was approved by the institutional review board of Stanford Hospital and Clinics, and was conducted in compliance with Health Insurance Portability and Accountability Act regulations. A retrospective cohort study was conducted from a series of 81 adult patients undergoing surgical treatment for type I Chiari malformation between June 2008 and January 2015 at a single center (Stanford Hospital and Clinics). Multiple surgeons performed the surgeries and the data were pooled. Patient population characteristics, surgical outcomes, and postoperative complications were verified by chart review. The defining criteria of the cohort and the outcomes to be studied were decided a priori and not modified during the data analysis. Inclusion criteria consisted of diagnosis of type I Chiari malformation (with or without syringomyelia) via magnetic resonance imaging, patient age $\geq$18 years, and decompressive surgery including duraplasty with either bovine or porcine collagen matrix dural substitutes. Exclusion criteria comprised previous surgical treatment at the planned surgical site ($n = 2$), history of chronic corticosteroid treatment ($n = 0$), use of both bovine and porcine dural substitute in the same surgery ($n = 1$), and loss to follow-up or follow-up period shorter than 30 days after surgery ($n = 7$). Surgeries using other materials for dural closure, such as autologous pericranium or cadaveric human dermal matrix, were excluded from this study.

Clinical Variables

Clinical characteristics of patients reported here include age, sex, body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters), history of diabetes mellitus, and current cigarette smoking (Table 1). Patients were considered to be current smokers if they had smoked for at least 1 pack-year and if they were either actively smoking or had quit less than 1 year