Collagen matrix duraplasty for posterior fossa surgery:
evaluation of surgical technique in 52 adult patients

Clinical article

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Object. Complete dural closure is not always possible following posterior fossa surgery, often requiring a graft
to secure complete closure. The authors report their experience of using a collagen matrix as an onlay dural graft for
repair of a posterior fossa dural defect.

Methods. A retrospective analysis was performed in 52 adult patients who had undergone collagen matrix dura-
plasty for the posterior fossa. Complications directly related to the dural graft, the presence or absence of hydrocepha-
lus, and the role of closed suction wound drainage in relation to postsurgical pseudomeningoceles were analyzed.

Results. The indication for posterior fossa surgery was tumors in 32 patients, vascular abnormalities in 9 pa-
tients, and spontaneous cerebellar hemorrhage in 11 patients. Closed suction wound drainage was used in 23 patients
(44.2%). Forty-eight (92.3%) of 52 patients had a dural defect > 2 cm. Nine (81.8%) of 11 patients with hydroceph-
alus required ventriculoperitoneal shunts. Complications of the surgery included pseudomeningoceles in 2 patients
(3.8%; no closed suction wound drainage); superficial wound infections in 1 patient (1.9%; with closed suction
wound drainage); and unexplained eosinophilia in 1 patient.

Conclusions. Duraplasty using a collagen matrix is safe and effective in the posterior fossa, and is easy to use
and time efficient. Meticulous layered wound closure, the detection and effective control of hydrocephalus, and the
use of closed suction wound drainage reduces complications related to collagen matrix duraplasty for the posterior
fossa. (DOI: 10.3171/2008.10.JNS08993)

Key Words • cerebrospinal fluid leak • collagen matrix • duraplasty •
hydrocephalus • posterior fossa

Failure of complete dural closure following posterior
fossa surgery may not always be possible and is
usually due to contraction of dural edges following
prolonged surgery or cerebellar swelling from retraction
and/or manipulation. In these situations the use of a dural
graft is often necessary to obtain dural closure. In addi-
tion, cerebellar swelling in the postoperative period may
impede a watertight dural closure.13

Current practice for posterior fossa duraplasty in-
volves reapproximation of the previously exposed dura
that has usually been opened in a Y-shaped fashion. The
graft is cut to size, shaped, and usually sutured in place,
requiring time-consuming effort to effect a watertight re-
pair, but despite this effort, an average CSF leakage rate
of 7.7% has been reported following posterior fossa dura-
plasty.10,18,24,28 The ideal dural substitute should be readily
available, strong, malleable, immunologically inert, non-
toxic, of uniform thickness, able to form a barrier, unlike-
ly to adhere to the brain or cranium, and unable to spread
infectious diseases.16,21 A wide variety of both biological
and synthetic materials have been used for grafts, yet few
meet all these requirements. In this technique appraisal,
we describe our experience with the use of collagen ma-
trix as an onlay graft to promote dural repair following
posterior fossa surgery.

Abbreviation used in this paper: VPS = ventriculoperitoneal
shunt.
Methods

Patient Information

A retrospective review was undertaken of all patients requiring collagen matrix as a dural onlay graft following posterior fossa surgery. Demographic, clinical, neuroimaging, surgical, and outcome data were collected. Hydrocephalus as a comorbidity was also recorded. Clinical outcome was recorded using the Glasgow Outcome Scale.

During surgery, the size of the dural defect and the use of closed suction wound drainage was recorded. Patients were classified according to levels of contamination at the time of surgery into 5 case types as previously described. All patients were monitored for wound infection, CSF leakage, and any boggy swelling in the postoperative period. The primary end points of the study were confined to postoperative complications: CSF leakage, neurosurgical wound infection, pseudomeningoceles (clinically or radiologically apparent), extraaxial fluid collection, and delayed hemorrhage.

Surgical Technique

Collagen matrix (DuraGen, Integra Life Sciences Corporation) was used to effect dural repair via 2 methods. Following suboccipital craniotomy or craniectomy for posterior fossa intradural procedures, the dura was left wide open, tacked against the bone, and the edges were coagulated to secure hemostasis. The majority of the patients had the collagen matrix cut to size, shaped, and applied as an onlay graft between the exposed cerebellum and overlying muscle (Fig. 1A). Four patients had primary closure of dura resulting in a residual small dural defect, which was then covered with collagen matrix. In both forms of duraplasty, the collagen matrix edges were placed to ensure overlap with surrounding dural edges. Craniotomy bone flaps were replaced to reconstruct the occipital squame and fixed in position with titanium plates. Surgeon preference dictated the method of dural closure and use of closed suction wound drainage of the wound to obliterate the dead space. The drain was tunneled in a subfascial fashion to exit in a superior lateral location and generated a negative pressure of 5–10 mm Hg for 48 hours (Fig. 1B and C). Multilayered muscle closure was then performed using 2-0 Nurolon (Ethicon) sutures. The subcutaneous tissue was closed with Vicryl (Ethicon) 3-0 sutures, whereas the skin was closed with skin staples.

Results

Demographic, Clinical, and Outcome Data

There were 28 male (53.8%) and 24 female (46.2%) patients retrospectively identified with a mean age (± SD) of 55.8 ± 16.3 years. The median follow-up was 5 months. The indications for surgery are listed in Table 1. The majority of patients underwent clean contaminated surgery (80.8%). Craniotomies were performed in 32 patients (61.5%). Large-size dural defects (> 2 cm in length or width) that required a collagen matrix were found in

![Fig. 1. Illustrations showing the relationship of collagen matrix duraplasty, bone flap, and closed suction wound drainage. A: Shaped collagen matrix used as an onlay dural graft. B: Closed suction wound drainage over bone flap. C: Sagittal view showing the relationship of collagen matrix duraplasty and closed suction wound drainage. Illustrations by Spencer Rippen, Creighton University.]
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Collagen Matrix Duraplasty With Closed Suction Wound Drainage

In the 23 patients (44.2%) with closed suction wound drainage, CSF containment at the surgical site was recorded on follow-up and/or MR imaging examination. In 1 patient, a superficial wound infection was treated successfully (nonoperatively). Three patients in this group with preoperative hydrocephalus required VPS insertion.

Collagen Matrix Duraplasty Without Closed Suction Wound Drainage

In the 29 patients without wound drainage, 2 patients developed pseudomeningoceles. The first patient underwent a suboccipital craniotomy for resection of an epidermoid tumor. A large dural defect was noted at dural closure. A pseudomeningocele with postoperative hydrocephalus was found at the 2-week postoperative visit. A VPS was inserted for treatment of hydrocephalus. Magnetic resonance imaging at 1 year showed resolution of the pseudomeningocele. The second patient underwent a suboccipital craniotomy for resection of a cerebellar hemangioblastoma. A medium-sized dural defect was noted at dural closure. At the 3-month postoperative interval, a symptomatic pseudomeningocele was diagnosed. This patient was treated successfully using repeated lumbar punctures and a compressive head bandage over the operative site. In both cases no cerebellar swelling was recorded.

In this group, 6 of 7 patients required VPS insertion for treatment of hydrocephalus. Two patients experienced recurrent hypertensive cerebellar bleeds; the one who required repeat surgery died. The first patient with uncontrolled postoperative hypertension presented with a spontaneous cerebellar hemorrhage (angiogram negative), deteriorated in the postoperative recovery room, and required repeat surgery for evacuation of the hematoma (Table 1). The second patient, an 81-year-old female, was found to have a postoperative bleed that was managed in a nonoperative fashion. This patient died of hypostatic pneumonia in the postoperative period.

There was 1 patient who developed an unexplained eosinophilia following posterior fossa craniotomy and VPS insertion for spontaneous hypertensive cerebellar hemorrhage. This patient was found to have constant blood and CSF eosinophilia despite negative test results for parasites and allergy testing of shunt materials.

Discussion

Grafts frequently need to be used when complete primary dural closure cannot be achieved due to tumor invasion, damage, expansion duraplasty for craniocervical decompression, or dural retraction and shrinkage during prolonged surgery.1–3,5,21,27,29 Autologous tissue such

<table>
<thead>
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<th>Variable</th>
<th>Value (%)</th>
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<tbody>
<tr>
<td>sex</td>
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</tr>
<tr>
<td>male</td>
<td>28 (53.8)</td>
</tr>
<tr>
<td>female</td>
<td>24 (46.2)</td>
</tr>
<tr>
<td>age (yrs)</td>
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<td>6 (11.5)</td>
</tr>
<tr>
<td>5</td>
<td>40 (76.9)</td>
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<tr>
<td>cause</td>
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<tr>
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<td>32 (61.5)</td>
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<td>9 (17.3)</td>
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<tr>
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<td>1 (1.9)</td>
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<td>medium (1–2 cm)</td>
<td>3 (5.8)</td>
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<td>large (&gt;2 cm)</td>
<td>48 (92.3)</td>
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<td>11 (21.2)</td>
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<tr>
<td>ventriculostomy insertion</td>
<td>16 (30.8)</td>
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<tr>
<td>VPS</td>
<td>9 (17.3)</td>
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<tr>
<td>complications</td>
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<tr>
<td>pseudomeningocele</td>
<td>2 (3.8)</td>
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<tr>
<td>infection (superficial)</td>
<td>1 (1.9)</td>
</tr>
<tr>
<td>recurrent hemorrhage</td>
<td>2 (3.8)</td>
</tr>
<tr>
<td>eosinophilia</td>
<td>1 (1.9)</td>
</tr>
</tbody>
</table>

* GOS = Glasgow Outcome Scale; ICH = intracerebral hemorrhage.

48 cases (92.3%). In 4 patients the surgeon attempted primary dural closure resulting in small (in 1 patient) and medium-sized (in 3 patients) dural defects. The majority of the patients (29 [55.8%]) had no closed wound suction drainage. Ventriculostomy catheters were inserted in 16 patients, 6 for preoperative hydrocephalus. Death occurred in 6 patients (11.5%). Four patients died of their primary pathology, whereas 1 patient died of respiratory complications and another patient died 1 year later from unrelated surgical complications related to vascular surgery.
Posterior fossa duraplasty and collagen matrix

as fascia lata, pericranium, or temporalis fascia (among the most popularly used dural grafts)\(^3\)\(^,\)\(^2\)\(^4\) has the obvious advantage in that it lacks immunogenicity with no risk of transmission of infectious diseases, but it may require an additional incision with the potential of future morbidity. Lyophilized cadaveric human dura mater, which has been widely used for 3 decades as an alternative to autologous tissue, had been implicated in the transmission of prion diseases such as Creutzfeldt-Jakob disease.\(^7\) Most of the synthetic materials, despite their theoretical advantages of uniform production and absence of risk of infection, have been rejected because of excessive local tissue reaction, which can result in irritation of the underlying brain, excessive scar formation or encapsulation of the graft, meningitis, or hemorrhage.\(^4,\)\(^3\)\(^5\)\(^,\)\(^2\)\(^4\) More recently, the collagen sponge has been reported to be a favorable dural substitute both in an experimental and clinical setting.\(^2\)\(^1\)\(^,\)\(^2\)\(^2\) Similarly, its successful use in spinal surgery has been reported in which it acted as an ideal graft in spinal dural repair with a success rate of > 95% CSF containment.\(^1\)\(^9\)

An important property of any dural graft is its ability to prevent the formation of CSF fistulas or leaks. Although there are still proponents who advocate for watertight dural closures, often using nonporous grafts,\(^1\)\(^6\)\(^,\)\(^2\)\(^2\)\(^,\)\(^2\)\(^4\) it has long been recognized that it is not mandatory to perform this watertight procedure.\(^3\)\(^1\) This issue becomes even more contentious when using a porous graft, that is, a collagen graft to resist CSF leakage. In the past, researchers pursued perhaps an obsessive quest to enable collagen grafts to hold sutures. However, this pursuit resulted in degradation of the collagen and induced severe inflammatory responses, which made the use of collagen grafts fall into disrepute.\(^1\)\(^5\) Moreover, the use of sutures is further minimized by using the collagen matrix as an onlay graft, which reduces not only operative time but, more importantly, the risk of an additional foreign body giant-cell reaction, which is commonly observed in response to sutures used to hitch the dura.\(^1\)\(^6\)\(^,\)\(^3\)\(^0\) In our previous extensive clinical experience with the collagen sponge, the incidence of CSF leakage was not increased despite any suture procedure to achieve a watertight seal of the collagen graft.\(^3\)\(^1\)

Following surgery to the posterior fossa, watertight closure of the dura with multilayered wound closure is recommended to prevent CSF fistulas and their sequelae. However, previous reports concerning posterior fossa dural repair using watertight seals with other graft materials have recorded an average CSF leakage rate of 7.7%\(^1\)\(^1\)\(^,\)\(^1\)\(^8\)\(^,\)\(^2\)\(^4\)\(^,\)\(^2\)\(^8\) and average infection rate of 7.5%.\(^1\)\(^0\)\(^,\)\(^2\)\(^5\) The current study had no patients presenting with CSF leaks/fistulas attributable to the graft. Contrary to current neurosurgical belief, watertight dural closure does not appear to be essential in posterior fossa surgery.

Postoperative wound infection is an important complication because the collagen matrix is porous. In the current study, a single patient (1.9%; clean contaminated) with a tumor who was receiving high doses of steroids was reported to have superficial wound infection and was treated successfully (nonoperatively; Table 1). A more recent report by Gnanalingham et al.\(^1\)\(^0\) recorded an overall infection rate of 4.5% in patients undergoing posterior fossa duraplasty. These data support the view that dural grafts do not unduly influence neurosurgical wound infections.\(^1\)\(^9\)\(^,\)\(^2\)\(^1\)\(^,\)\(^2\)\(^4\)

Following implantation of a collagen matrix, incidental pseudomeningoceles may be observed in asymptomatic patients on follow-up MR imaging or CT scans.\(^2\)\(^0\) In this study, 2 patients (3.8%) were reported as having pseudomeningoceles as observed on postoperative MR images, with a single patient required permanent CSF diversion for hydrocephalus. In previous reports, an average rate of 11.8% for pseudomeningocele formation was reported following posterior fossa duraplasty, even with a watertight dural closure.\(^1\)\(^0\)\(^,\)\(^2\)\(^5\)

Two patients with spontaneous hypertensive bleeds had recurrent hematomas, with 1 patient requiring repeat surgery. We were unable to determine conclusively the reason for the hemorrages, but we believe that they may have been due to intraoperative CSF loss with a reduction in intracranial volume or severe postoperative hypertension. We do not believe the hemorrages were due to the collagen matrix because neurological deterioration was detected immediately in the postanesthesia recovery unit in the patient who had repeat surgery, whereas the second patient’s recurrent nonsurgical bleed was found on a routine postoperative CT scan. It was reported by Friedman et al.\(^9\) that CSF loss was the major factor leading to cerebellar hemorrhage following spinal and/or cranial durotomy.

Collagen matrix is suitable for use in the posterior fossa where it can be applied as an onlay graft without the inconvenience and time-consuming process of suturing.\(^8\)\(^,\)\(^1\)\(^3\)\(^,\)\(^1\)\(^4\) It also forms an effective separation layer between the brain and the overlying tissues to minimize adhesion formation.\(^1\)\(^1\)\(^,\)\(^2\)\(^0\)\(^,\)\(^2\)\(^1\) In the patients who had closed suction wound drains, no pseudomeningoceles developed. The pliable collagen matrix can easily accommodate transient postoperative cerebellar swelling, which often occurs after prolonged surgery. An onlay graft is beneficial if brain swelling is anticipated, particularly so in the posterior fossa and at times in supratentorial craniotomies. In the acute stages, collagen matrix forms a pliable and compressible separating layer, because it is not fixed to the dural edges. This layer can accommodate the swollen brain and cushion it against the bone flap and at the same time keep the brain surface moistened with CSF. Once the swelling settles, dural repair can proceed. Collagen matrix provides a low-pressure absorptive surface to diffuse any CSF and attaches to the dura via surface tension. The subfascial drain removes any residual fluid and transient CSF effusion when the patient is mobilized, accommodating the changes in hydrostatic pressure.

Collagen is immediately hemostatic, initiating clot formation that results in a chemical seal similar to that observed previously with the collagen sponge.\(^2\)\(^1\)\(^,\)\(^2\)\(^2\) Similarly, fibrin glue when used with collagen matrix also results in a chemical sealing effect. The collagen matrix then provides a chemical signal for fibroblast infiltration, which commences after 3–4 days and becomes established over the next 10–14 days. The fibroblasts use the pores in the collagen matrix as a scaffold to lay down new collagen (Fig. 2). Over 6–8 weeks, the collagen matrix is
All CSF leaks eventually heal in this way.

Drains are not commonly used in posterior fossa surgery for fear of developing dural-cutaneous fistulas. Eismont et al. advocated strongly against the use of drains, whereas Wang and colleagues found that there was no increase in the rate of dural-cutaneous fistulas following incidental durotomy in spinal surgery. Even though it may add to postoperative discomfort, we believe subfascial drains evacuate any serous fluid, blood, or CSF, and obliterate the dead space following changes in the patient’s posture. We found that patients who had a drain

**TABLE 2: Incidence of complications following posterior fossa duraplasty using various dural substitutes compared with collagen-based grafts**

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Patients</th>
<th>Implants</th>
<th>CSF Leakage Rate (%)</th>
<th>Pseudomeningocele Rate (%)</th>
<th>Wound Infection Rate (%)</th>
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</thead>
<tbody>
<tr>
<td>Gnanalingham et al., 2002</td>
<td>54</td>
<td>various materials</td>
<td>4.0</td>
<td>9.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Munshi et al., 2000</td>
<td>23</td>
<td>various materials</td>
<td>8.7</td>
<td>0.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Narotam et al., 2007</td>
<td>79</td>
<td>collagen matrix</td>
<td>0.0</td>
<td>3.2†</td>
<td>3.8</td>
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<td>Narotam et al., 1995</td>
<td>102</td>
<td>collagen sponge</td>
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<td>6.1</td>
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<tr>
<td>Parizek et al., 1998</td>
<td>41</td>
<td>lyophilized dura, bovine pericardium</td>
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<td>12.3</td>
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<tr>
<td>present study</td>
<td>52</td>
<td>collagen matrix</td>
<td>0.0</td>
<td>3.8</td>
<td>1.9</td>
</tr>
</tbody>
</table>

* NA = not available.
† Clinically asymptomatic, detected on follow-up MR imaging only.
Posterior fossa duraplasty and collagen matrix

inserted experienced no instances of pseudomeningocele, whereas 6.9% of patients without drains developed this complication. Negative pressure created by the drain can prevent pseudomeningocele formation.

In Table 2, the main complications of posterior fossa duraplasty using different dural grafts requiring suture\(^6,8,13\) are compared with the collagen-based onlay grafts\(^3\) and the present study. This meta-analysis demonstrates that collagen-based dural onlay grafts compare favorably with their sutureable counterparts, and that the newer collagen matrix exhibits similar properties to the collagen sponge in its safety and efficacy profile. The present study reports our experience with collagen matrix duraplasty in posterior fossa surgery, but we acknowledge that the study has limitations due to its retrospective nature.

Conclusions

Duraplasty using collagen matrix, a more developed collagen-based dural graft compared with a collagen sponge, is safe, effective, easy to use, and time efficient in posterior fossa surgery. Meticulous layered wound closure, the detection and effective control of hydrocephalus, and the use of closed suction wound drainage minimize potential complications related to the use of collagen matrix duraplasty in the posterior fossa.

Disclosure

Pradeep Narotam, M.D., serves as a consultant for Integra Life Sciences. He has no direct financial gain from the sale of DuraGen.

References


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