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Incidence of complications following non-watertight dural reconstruction with a non-suturable, absorbable collagen matrix onlay graft in elective cranial surgery

Asman Ali, Debadatta Saha*

Department of Neurosurgery, Gauhati Medical College and Hospital, Guwahati, Assam, India

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***Correspondence:**
Dr. Debadatta Saha,
E-mail: dbdttsaha1234@gmail.com

ABSTRACT

Background: Collagen matrices are effective duraplasty grafts with increasing acceptability. However, little evidences exits for dural reconstruction utilizing monolayer collagen matrix onlay graft in a non-watertight fashion. Purpose of our retrospective analysis was to advance our understanding of the use of semisynthetic collagen as dural substitute in elective cranial surgery.
Methods: A consecutive series of sixty patients who underwent elective cranial surgery, where non-watertight dural reconstructions were done with a non-suturable, absorbable collagen matrix onlay graft, has been analysed retrospectively.
Results: Overall, the most common indication for duraplasty was tumor resection (93.3%). CSF leak rate was 10.0%. Incidence of aseptic meningitis was 8.3% and all cases has been resolved with steroids alone. Similarly, postoperative surgical site infection rate was 8.3%. Incidence of pseudomeningocele in follow-up was 6.7%. Only in one case (1.7%), permanent CSF (cerebrospinal fluid) diversion was needed due to troublesome CSF leak with associated hydrocephalus.
Conclusions: Semisynthetic, monolayer collagen matrix used as an onlay dural graft is a simple, yet an attractive alternative in duraplasty due to their easy handling, lower surgical time, and high biocompatibility, where primary dural closure is undesirable or not feasible. Our study provides greater insight into non-water tight duraplasty procedure. However, further study is needed to determine the optimal strategy for dural reconstruction. Data from this study may be used to compare alternative methods of dural reconstruction in elective cranial surgery.

Keywords: CSF leak, Collagen matrix, Dural reconstruction

INTRODUCTION

At the conclusion of craniotomy procedures, it is a common practice to reapproximate the dura to mitigate the leakage of CSF. Dural closure also limits muscle and epidural scar tissue from coming into contact with the brain following the operation. Duraplasty occurs by interposing a graft material between the dural defects (secondary closure). Duraplasty materials vary from autologous substances, such as pericranium and fat, to synthetic, such as acellular human dermis or collagen matrix.[1,2] Closure of dural defects is a necessity after neurosurgical procedures to prevent cerebrospinal fluid (CSF) leakage and to reduce the risk of perioperative infections.[3] In several surgical settings primary closure is technically impossible, e.g. due to coagulation-induced shrinkage or retraction of dura, surgical excision of dura (resection of meningiomas), or dural injury after trauma and therefore reconstruction of the dural defect using a substitute is required.[2] Reconstruction with endogenous material is most common.[4] However, harvesting of periosteum or fascia lata may require extended surgical approach, additional incisions and time intensive suturing.[5] Numerous dura substitutes are currently

commercially available. Among these dura substitutes, onlay grafts of semisynthetic collagen matrices appear promising, since they are thought to provide a matrix for ingrowth and subsequent replacement by endogenous connective tissue, while continuously presenting a mechanical barrier.[6,7] DuraGen (Integra Lifesciences) is a sutureless dural substitute graft composed of purified type I collagen extracted from bovine Achilles tendon. The collagen matrix provides a scaffold for invasion of host fibroblasts, promotes fibrin clot, and is fully reabsorbed as the wound heals.[8] Previous studies using DuraGen™ showed that dura onlay grafts may be superior to other synthetic devices for duraplasty since they do not require labour-intensive suturing, allow dura reconstruction with sufficient tightness to avoid perioperative CSF fistulas effectively, and cause no major reaction of the surrounding tissue.[4,5,7]

The incidence of cerebrospinal fluid (CSF) leak after cranial surgery ranges between 1-14% in the literature.[9,10] CSF leak has also been associated with significant medical costs due to prolonged hospital stay and need for additional interventions. Pseudomeningoceles without CSF leak can present with cosmetic deformity and debilitating symptoms such as positional headache. The incidence of clinically relevant pseudomeningocele in the literature ranges from 4-23%.[11] Duraplasty material and/or technique is driven primarily by surgeon preference, as the literature is fraught with contradictory reports regarding their safety and efficacy. A commonly used safety endpoint is the occurrence of a postoperative infection. While some studies report an association between synthetic dural grafts and infection others report no such difference.[12] The efficacy of a dural closure technique relates to its ability to prevent a CSF leak. However, several studies have reported that a watertight closure is not necessary for supratentorial surgery.[8,10] These 2 outcomes, infection and CSF leak, can also be dependent variables, such that infection is sometimes believed to result in CSF leak and vice versa.[4] Thus, in deciding whether to use a synthetic dural substitute, the surgeon must weigh the potential benefit of improved dural closure compared with primary closure against the potential increase in infection.

The purpose of this study was to determine the incidence of various complications for non-watertight dural reconstruction, when primary dural closure is undesirable or not feasible, using non-suturable, absorbable collagen matrix.

METHODS

Patient population

A retrospective study was established of patients who underwent elective cranial surgery in our institution between April, 2018 and September, 2019. Inclusion criteria consisted of age greater than 18 years and supra- or infratentorial lesion with intradural component, where collagen matrix was used as an onlay graft for reconstruction as the dura was not closed primarily. Exclusion criteria consisted of burrhole placement alone, craniectomy procedure, use of autograft for duraplasty, presence of temporary CSF diversion, coagulopathy, traumatic brain injury and infectious lesions (such as brain abscess). Sixty such operations were analysed.

Operative details

Primary dural closure were attempted in all cases. If a dural defect was present, an absorbable collagen matrix graft of appropriate size was selected as an onlay graft for non-watertight duraplasty (Figure 1). Pieces of absorbable compressed gelatin sponge pieces were placed at the margin of collagen matrix. Gelatin sponge reinforces the position of graft in place by providing fibrin. After the graft has been appropriately placed and secured, replacement of bone flap has been performed without placement of any drain.

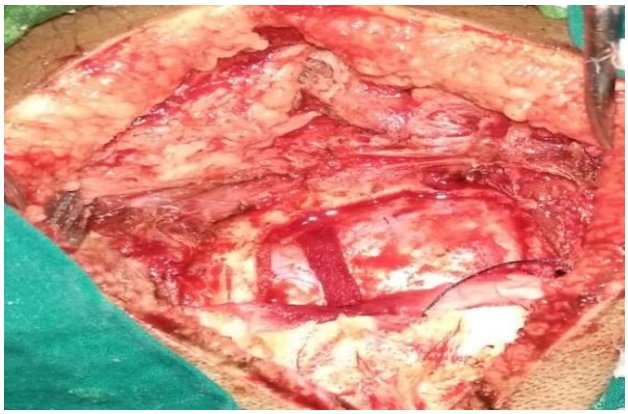

Figure 1: Semisynthetic, absorbable collagen matrix placed as an onlay graft to repair the dural defect in an elective cranial surgery.

Post-operative wound complications

Patients were followed up for up to 6 months after the surgery. Post-operative wound complications included CSF leak, pseudomeningocele, surgical site infection, aseptic meningitis, and requirement for permanent CSF diversion. CSF leak was defined as clear or blood tinged fluid egression outside the wound. Pseudomeningocele was defined as an extra-axial fluid collection evident on follow-up physical examination. All patients underwent contrast enhanced MR imaging of brain in the immediate post-operative period and at 6-months of follow-up as watertight primary dural closure was not done. Solely radiographic pseudomeningocele were excluded since these are small, asymptomatic for which no intervention was required. Whenever, wound infection was noted, antibiotics were used to treat it. Patients who had meningismus and headache that resolved with the administration of steroids, or have CSF leucocytosis without positive cultures, were diagnosed to be a case of aseptic meningitis. Although aseptic meningitis can

develop following a variety of cranial operations and not a specific complication of collagen matrix, we included this as a complication of collagen matrix since it could be a result of inflammatory reaction against the foreign body.

Statistical analysis

The data of relevant information was collected and tabulated and systematically analysed.

RESULTS

Collagen matrix was used in 60 patients, who underwent elective cranial surgery. Case demographics and risk factors are listed in Table 1. Ages ranged from 19-68 years (mean 42.3 years). Majority of the patients (55%) were male. Various risk factors for collagen graft associated complications were identified. These are current tobacco user (21.7%), current steroid user (18.3%), diabetes mellitus (11.7%), history of radiation to operative site (6.7%), and history of receiving chemotherapy (1.7%).

Table 1: Demographics and risk factors for 60 patients.

Characteristics of patients	N (%)
Range of age (years)	19-68
Mean age (years)	42.3
Male patient	33 (55.0)
Female patient	27 (45.0)
Current tobacco user	13 (21.7)
Current steroid user	11 (18.3)
Diabetes mellitus	7 (11.7)
History of radiation to operative site	4 (6.7)
History of receiving chemotherapy	1 (1.7)

Table 2: Histopathological analysis of 60 cases.

Pathology	N (%)
High grade glioma	17 (28.3)
Meningioma	12 (20.0)
Low grade glioma	5 (8.3)
Pituitary adenoma	4 (6.7)
Schwannoma	4 (6.7)
Epidermoid	3 (5.0)
Hemangioblastoma	3 (5.0)
Ependymoma	2 (3.3)
Pineoblastoma	2 (3.3)
Craniopharyngioma	2 (3.3)
Cerebral circulation aneurysm	1 (1.67)
Medulloblastoma	1 (1.67)
Colloid cyst of third ventricle	1 (1.67)
Clival chordoma	1 (1.67)
Arterio-venous malformation	1 (1.67)
Trigeminal nerve vascular compression	1 (1.67)

Overall, the most common indication for duraplasty was tumor resection (93.3%). On histopathological analysis, (Table 2) most common pathology was high grade glioma (28.3%). 2nd most common pathology being meningioma (20.0%). Low grade glioma found in 8.3% cases. 6.7% cases were pituitary adenoma and schwannoma, each. 5% cases were epidermoid and hemangioblastoma, each. Other less commonly encountered pathologies were ependymoma, pineoblastoma, craniopharyngioma (each comprises 3.3% of total cases) and cerebral circulation aneurysm, medulloblastoma, colloid cyst of third ventricle, clival chordoma, arterio-venous malformation and trigeminal nerve vascular compression (each comprises 1.67% of total cases).

Table 3: Post-operative complications in 60 cases.

Postoperative complications	N (%)
CSF leak	6 (10.0)
Surgical site infection	5 (8.3)
Aseptic meningitis	5 (8.3)
Pseudomeningocele	4 (6.7)
Permanent CSF diversion	1 (1.7)

Various post-operative complications are listed in Table 3. CSF leak noted in 6 (10.0%) cases. Surgical site infection occurred in 8.3% cases. Similarly, aseptic meningitis diagnosed in 8.3% cases. 6.7% patients had Pseudomeningocele. The mean time until a complication was noted was 28 days (range 4-109 days) with 80% of complications occurred within 41 days after surgery.

Only in one case, permanent CSF diversion was required for troublesome CSK leak with hydrocephalus (confirmed by imaging study). In other cases, CSF leaks were treated by expectant approach. Antibiotics were administered in all cases of surgical site infection (duration ranged from 3 weeks to 6 weeks). In two cases, secondary suturing was done for wound dehiscence with the appropriate antibiotic coverage and other cases of surgical site infection were completely cured by the antibiotic administration alone.

All cases of aseptic meningitis were treated by a course of steroids (ranging from 2 weeks to 6 weeks). No patient of aseptic meningitis was treated with antibiotics. Among the 4 cases of clinically-evident pseudomeningoceles, only one of these patients (1.67% of total study population) were symptomatic with headaches. All these 4 cases had complete resolution of pseudomeningocele without any intervention.

DISCUSSION

The present study investigates various complications of duraplasty with a novel semisynthetic collagen matrix. The drawbacks of autologous grafts include donor site morbidity, and in cases of repeat surgery, paucity of appropriate local tissue. For this reason, various dural

substitutes have been investigated. Collagen sponges have thus far provided a promising option for a dural substitute and have been extensively studied.[13] These sponges have a large surface area for CSF absorption, which helps the graft adhere to dura via surface tension.[5] Blood on the sponge allows deposition of fibrin, which holds the graft in place in the immediate time period.[7,13] Fibroblasts begin to proliferate around 3-4 days and are established by 10-14 days. Over the next few weeks, fibroblasts deposit collagen onto the matrix pores and neovascularization of the graft continues.[7] By 6-8 weeks, the collagen matrix is reabsorbed.[7] A dura substitute should be easy to handle, not require to extend the surgical intervention, allow reconstruction with high water tightness, be biologically inert, resistant to disintegration while fully integrating into host dura, induce no adhesion between cortex and the dura or dura substitute, induce no adverse local or systemic reaction (immunological, toxic, prion infection) with high biocompatibility. Semisynthetic collagen matrices meet these conditions.[14]

Various studies concluded that the dura substitute DuraGen (semisynthetic collagen matrices of bovine origin) is a promising alternative to duraplasty with endogenous periosteum, which is consistent with other studies.[1,2,5,15] Similarly, in our studies, we found that semisynthetic collagen is an attractive option for duraplasty and various complications such as CSF leak, pseudomeningocele, aseptic meningitis, and wound infection were found to be within the acceptable range, which are not much different from other study results.

Limitations

Limitations of this study are largely due to its retrospective nature. Use of a comprehensive operative log and a detailed electronic medical record help to limit some of the shortcomings of a retrospective study design. Documentation of a dural graft was verified according to the surgeon's operative note and billing codes to mitigate recall bias. Patient management protocol for elective cranial surgery is variable from one institution to another institution. Hence, the study results which have been obtained in our analysis, may not be generalizable at other institutions. Due to the fact that the sample size in our series is not being too large, the actual result of our series may not be the similar to the result when it is conducted in a much larger study population. Furthermore, there are various unknown confounding factors that could not be assessed which may have an impact on the result of these analysis.

CONCLUSION

Semisynthetic collagen matrix used as an onlay dural graft is a simple, yet an attractive alternative in duraplasty due to their easy handling, lower surgical time, and high biocompatibility, where primary dural closure is undesirable or not feasible. Various complications such as CSF leak, pseudomeningocele, aseptic meningitis and wound infection, were within the acceptable range, which are consistent with the other study findings. Our study provides greater insight into non-water tight duraplasty procedure. However, further study is needed in order to determine the optimal strategy for dural reconstruction.

Recommendations

In spite of these drawbacks and concerns, we still believe that this review forms a basis for further research work and assessment in an order to make a precise guideline for the non-watertight dural reconstruction with a non-suturable, absorbable collagen matrix onlay graft in elective cranial surgery. In addition to clinical effectiveness, future study should focus on the cost-effectiveness of synthetic dural grafts.

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