Efficacy of Placing a Thin Layer of Gelatin Sponge Over the Subdural Space During Dural Closure in Preventing Meningo-Cerebral Adhesion

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Key words
- Craniotomy
- Dural closure
- Gelatin sponge
- Meningocerebral adhesions

Abbreviations and Acronyms
Group C: Control group
Group G: Gelatin group
MRI: Magnetic resonance imaging

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OBJECTIVE: **One significant drawback during a cranial reoperation is the presence of meningocerebral adhesions. The appearance of connective tissue bridges between the inner surface of the dura and the pia-arachnoid is mostly related to dural closure and the condition in which the surgical field was left in the previous surgery. This study was done to determine the benefit of placing a thin-layer gelatin sponge of polypeptides subdurally to prevent meningocerebral adhesions.**

METHODS: **From September 2005 through May 2012, 902 craniotomies were performed for various lesions by the senior author (U.T.). Beginning in February 2009, we began placing a gelatin sponge under the dural flap to isolate the dural healing process from the cortical surface. To compare the degree of meningocerebral adhesions statistically, reoperation cases between February 2009 and May 2012 were divided into 2 groups as group G (gelatin) and group C (Control) in which the dural closure was made with and without subdural application of the gelatin sponge, respectively.**

RESULTS: **In all patients of group G (n = 15), a neomembrane was found when the dura was opened. This layer was easily dissected and showed no or minimal attachment to the underlying cerebral cortex. However, in group C (n = 14), meningocerebral adhesions in various degrees were detected. Adhesion scores were significantly greater in group C than in group G ($P < 0.001$).**

CONCLUSION: **This study proves that, during the dural closure, placing a thin layer of gelatin sponge in the subdural space is a safe and effective method for preventing meningocerebral adhesions.**

INTRODUCTION

Atraumatic surgery of the central nervous system is the keystone of all neurosurgical procedures, and the first aim of any surgical approach is to create a clean and wide-enough anatomic exposure (36). However, this ideal may become utopian during reoperation, when the surgeon approaches a previously exposed area that houses obscurity and dangerous traps. Therefore, reoperations, which seem to be increasing in number in direct proportion to the increase of survival times of patients with tumors, may be considered one of the most challenging problems in neurosurgical practice.

One significant drawback during reoperation is the presence of meningocerebral adhesions, where the dura mater attaches itself to the underlying neural and vascular structures. Dissecting this attachment can be tedious, time-consuming, and even dangerous, adding to the risk of injuring important structures (12). The appearance of these connective tissue bridges between the inner surface of the dura and the pia-arachnoid membrane is directly related to dural closure and the condition in which the surgical field was left in the previous surgery. Therefore, the surgeon must try to prevent such adhesion during the first procedure.

Historically, many investigators have made a number of efforts to develop an ideal method of closing the dura (3, 5, 8, 9, 13, 16, 19, 21-23, 27, 28, 30-34). Many materials and techniques have been tested in animals and humans, but none has been shown to be adequately effective in preventing meningocerebral adhesions (8, 14). In addition, not enough data exist on the effects of gelatin sponges with a polypeptide layer in the prevention of meningocerebral adhesion when they are placed as a barrier between the pia-arachnoid and the dura mater. Therefore, in this study we investigated the effect of placing a gelatin sponge underneath the dural flap during closure for the prevention of meningocerebral adhesion.

MATERIALS AND METHODS

In February 2009, after the written informed consent was obtained from each patient, we began to place a thin layer of gelatin sponge coated with polypeptides (Spongostan; Ethicon, Inc., Somerville, New Jersey, USA) as a barrier between the pia-arachnoid and the dura layer during the primary dural closure in all craniotomy cases, as described in detail in the section "Dural Closure Technique." After February 2009, we paid particular attention to the reopening cases to see whether there was any benefit from the insertion of this gelatin sponge in preventing

meningocerebral adhesions. The degree of meningocerebral adhesion in reoperations was compared prospectively between the cases in which a gelatin sponge was placed subdurally in the previous surgery (Group G; gelatin sponge group) and the cases previously operated in our institution before February 2009 in which, therefore, no gelatin sponge was placed subdurally (Group C; control group).

All the cases were operated by the senior author (U.T.). To have homogenous groups, only reoperations of patients who were previously operated in our department were included in this study. Any case that a homograft (pericranium) or allograft was used during dural closure in the previous surgery was excluded. Moreover, reoperations in the early postoperative period (<2 months) were excluded, as the time between 2 surgeries was not enough for the formation of meningocerebral adhesion.

During the reoperation, the meningocerebral adhesions were scored on a 3-point scale in all patients. Degree of adhesion was evaluated by noting how the dissection of the dural flap was made from the cerebral cortex. In cases in which the dural flap was easily opened without any dissection or dissection with only blunt tools was enough, we noted the meningocerebral adhesion as "grade I: no or minimal adhesion." The necessity of sharp dissection tools such as microscissors or knife was interpreted as increased meningocerebral adhesion and noted as "grade II: moderate adhesion." The cases in which bipolar coagulation was needed because pial disruption occurred during dissection were classified as "grade III: severe adhesion."

Although present in all, only in 3 random cases in group G, a small portion of the neomembrane between the dura and the pia-arachnoid layer was removed and sent for histological analysis to assess for foreign body reactions, inflammatory processes, and histological features.

Dural Closure Technique

Once the main purpose of the surgical procedure was accomplished and after adequate hemostasis of the surgical bed was achieved, we proceeded to the dural closure step (Figure 1A). First the dura is tented by the use of 4-0 sutures in small drill holes placed along the bone edge except in posterior fossa cases. No tenting sutures were used over the dural sinuses. After we removed the bone dust over the cortical surface with irrigation, the dura was approximated with 4-0 absorbable sutures.

After February 2009, before the approximation, we started to cover the exposed cortical surface as much as possible by using a thin layer of gelatin sponge with an aim of separating the pia-arachnoid membrane from the dura during the meningeal healing process. Often the gelatin sponge used was larger than the dural flap to extend the coverage over the dural incision line (Figure 1B). This technique was also useful in preventing cortical damage during dural closure. A gelatin sponge also was placed in the surgical corridors (e.g., the Sylvian fissure, interhemispheric fissure, or supracerebellar surface) to act as a barrier during meningeal regeneration of both sides.

The commercial product is produced in 1-cm thick layers that are easily divided with a scalpel into thinner layers of approximately 2- to 3-mm thick. In recent years, a different form of this gelatin sponge (Spongostan Special; Ethicon, Inc., Somerville, New Jersey, USA) has become available that is the same in content but denser and 10 times thinner (1 mm) and therefore much easier to apply. Application of the gelatin sponge was the only difference between group C and group G. The rest of the closure steps were the same in both groups.

After approximating the dura, 2–3 tack-up sutures were placed in the middle of the dural opening. A 4-0 absorbable continuous running suture was used to close the dura watertight. Finally, another sponge layer was placed in the epidural space between the dura and the bone flap to prevent adhesion of the dura to the bone. Central tack-up sutures were threaded through the bone flap and after securing the bone flap sutures were tied to close epidural space.

Clinical Outcome Data

When a gelatin sponge placed subdurally, after the surgery patients were carefully evaluated to see whether there were any side effects caused by the gelatin sponge. In all cases, contrast-enhanced magnetic resonance imaging (MRI) was performed 24 hours and 2 months after surgery. All

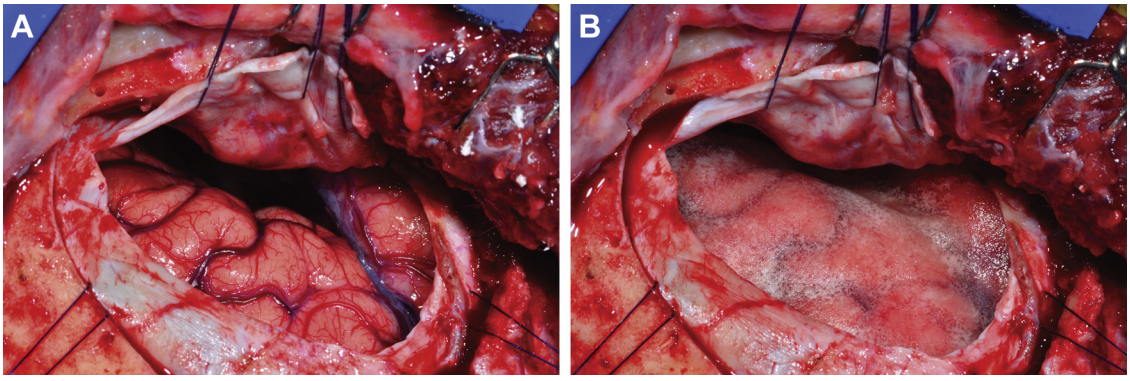

Figure 1. (**A**) Intraoperative photograph demonstrates the exposed cortical area after completing the main purpose of the surgery and hemostasis via right pterional craniotomy followed by the dural opening in semioval fashion around the Sylvian fissure. (**B**) Subdural cortical area is covered with a thin layer of gelatin sponge. The coverage extends over the unexposed cortical surface to separate the dural healing process from the pia-arachnoid membranes as much as possible. The gelatin sponge will also serve as an extra protection for the cortex during the suturing process of the dural flap.