Titanium dural clip testing

Technical note

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Spinal dural lacerations can be a difficult part of spinal surgery. A dural tear can result in complications that include meningitis and pseudocyst formation. Appropriate treatment for these tears is generally suturing, using 4.0, 5.0, or 6.0 suture. For successful closure of dural lacerations, the authors have collaborated in the design of a titanium clip, which resembles an aneurysm clip in appearance and is applied with standard aneurysm clip appliers. The titanium clip was tested against suture and Weck hemostatic vascular clips and found to have excellent tissue-approximating capacity and a rapid application time. It is believed that this is an appropriate device for the repair of spinal dural lacerations.

KEY WORDS • dural closure • spine • tears • clips • titanium

Materials and Methods

A dural ball was created by suturing a 0.238-mm-thick canine cranial (4 × 3 × 3 mm) or 0.382-mm-thick human cranial (8 × 5 × 4 cm) dura with 6.0 polypropylene suture.† Cyanoacrylate glue‡ was applied to cover the suture line completely to form a watertight closure. A watertight seal around pressure transducer tubing was created using a 2.0 silk suture and a syringe of normal saline solution connected in series in such a way that constant pressure could be recorded while saline filled the dural incision.

An iris scissors, scalpel, or a 15-gauge needle was used to create dural rents, which varied in size from 2 to 7 mm. Hemoclips, suture, and the new titanium clips were used to close the openings. A syringe was produced with an internal spring, similar to an aneurysm clip in design, that can be applied with a standard aneurysm clip applier. To resist slippage, the clips have corrugated jaws. Both the hemostatic clip and the new titanium clip tested successfully against suture in their ability to prevent leaking from a dural incision.

S PINAL dural tears are common (frequency 4% to 8%).¹ and reoperation on the lumbar spine increases the chance of dural rent and cerebrospinal fluid (CSF) leak.² Complications of dural tears include meningitis and pseudocyst formation, with or without nerve root herniation.¹²⁺⁻⁶ Generally, treatment for a lumbar dural tear is to suture the tear, with or without a fat, fascia, or muscle graft, after exposing the bone to allow for passing the needle and tying the suture.¹⁻³ The suture most commonly recommended is 4.0 to 6.0 monofilament polypropylene or nylon.¹² Some surgeons recommend using a 3 × 2-mm hemostatic vascular clip* for dural tears because of its ease and speed of application and because it is made of titanium, a material that is compatible with magnetic resonance imaging. However, because the clip is put in place using compression, as the tips close, it can tear the dura. It also tends to slip off easily, even while irrigating, and can become lost in the wound.

The authors wanted a clip suitable for approximating the dura, and because an aneurysm clip design was already available, we worked with a manufacturer of operative instrumentation to develop a titanium clip for use within the lumbar spine. A new titanium clip was produced with an internal spring, similar to an aneurysm clip in design, that can be applied with a standard aneurysm clip applier. To resist slippage, the clips have corrugated jaws. Both the hemostatic clip and the new titanium clip tested successfully against suture in their ability to prevent leaking from a dural incision.

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† Prolene suture supplied by Ethicon, Sommerville, New Jersey.
‡ Duro Super Glue supplied by Loctite Corp., Cleveland, Ohio.
used to fill the dural ball slowly, and a pressure reading was recorded at the time at which a leak occurred. Multiple readings were recorded for each closing device. The average readings are presented for a 7-mm dural opening in a human (Fig. 2). If the pressure reached 25 mm Hg with no leak, the test was discontinued to allow the rest of the testing to continue and to preserve the dural pouch. Both clips took less time to apply than sutures, with the titanium clip being faster to apply than the Hemoclip, which required more than one clip for all but the smallest opening.

**Discussion**

With healthy, thick dura and a clean incision, a 6.0 polypropylene suture will withstand significant pressure, but because most dural violations are tears with instruments such as a Kerrison punch, suturing of these openings is both time consuming and frustrating to the surgeon, often resulting in larger tears from tightening the suture.

Hemoclips have been used to allow quick approximation of the dura and can be positioned to allow intradural pressure to rise beyond the physiological range without leaking. However, their performance has often been variable, and dural laceration on application and easy dislodgement have been problems in our experience. These clips are also not easy to manipulate and once out of the applier, cannot be repositioned or reused. The force needed to apply them varies, and the dura can be lacerated by using too much force. We have also seen the clips wash off with irrigation.

The difference between the human and canine dura is of interest. Our observation is that the canine cranial dura is thinner (average 0.238 mm) than human cranial dura and more closely resembles human lumbar theca. The human cranial dura is thicker (average 0.382 mm) than canine dura and is not difficult to approximate by any selected method. The human cranial dura was sufficiently thick that the 6.0 suture holes did not leak as they did in the thinner canine dura. All clips held better in the thick than in the thin dura. However, nylon 4.0 suture leaked through the suture holes in both human and canine dura.

Titanium clips applied with an aneurysm clip applier were more precise, easier to control, and did not tear or lacerate the tissue. When the clips were removed, corrugated jaw imprints could be seen in the dural edges. These clips were more reliable and yielded more consistent numbers, usually 15 mm Hg or above.

When we tested titanium clips, we found that they could be applied and repositioned quickly and precisely without damaging the tissue. The curved clips can be applied in a “curve up” or a lower profile “curve down” position. The angled clips, with their longer jaw length, held slightly better. Unlike Hemoclips, they hold well in thin dura and cannot be washed away or removed easily. Because meningitis...
or pseudomeningocele with nerve root herniation may result if a dural tear is not properly closed, choosing the best closure is critical.

Conclusions

The unfortunate circumstance of including a nerve root in the closure is much easier with either suture or a Hemoclip than with the titanium clip. High operating room costs ($1000 to $2000 per hour) and anesthesia time also mandate that the shortest amount of time be spent in surgery. Dural tears occur most often toward the end of a lumbar laminectomy case when the surgeon is removing the last offending pieces of stenotic bone. At that time, a fast, effective method of dural repair is needed. To that purpose and given the success supported by the preliminary data, we recommend clinical application of the titanium clip.

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Disclosure

The authors have no financial interest in the instrumentation or technique being advanced in this study.

References


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