A Modified Footplate for the Kerrison Rongeur

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1 Background

Lumbar laminectomies and discectomies are among the most common procedures performed in hospitals [1]. Risks of these surgeries include unintentional tears of the dural sac leading to cerebrospinal fluid (CSF) leaks, which occur in up to 16% of lumbar spine operations [2–4]. In one recent retrospective study, for instance, dural tears were encountered in ten of 110 patients (9%) undergoing laminectomies [2]. Sequelae of this particular complication include headache, tinnitus, vertigo, nerve palsies, pseudomeningocele, durecutable fistulas, intracranial hemorrhage, meningitis, arachnoiditis, and epidural abscess [5]. In addition, incidental durotomy frequently results in extended periods of bed rest or CSF diversion [6,7], and may require re-operation for repair [8,9]. Some studies have also suggested that dural tears at the time of surgery are associated with adverse affect outcome as late as 10 yrs postoperatively [10,11]. In addition to the clinical implications, incidental durotomy is the second most common cause of litigation in spine surgery [12], which itself is the dominant source of malpractice claims in neurosurgery [13].

In lumbar surgery, the majority of dural tears occur during use of the Kerrison rongeur [3]. This can happen while tearing ligaments or scar that is tightly adherent to the dura, or if a fold of the dura inadvertently is caught in the instrument’s cutting surface. Although many different proprietary versions of the Kerrison rongeur exist, few modifications have been previously reported, and none of them specifically address its safety [14–16]. Here, we report a useful modification of the rongeur footplate intended to prevent dural tears.

2 Method of Approach

2.1 Technical Description. It is believed that the current design of the Kerrison rongeur does little to prevent the occurrence of dural tears during use. A number of modification strategies were studied including an active retractable metal barrier, a jet of pressurized air, a camera located at the tip of the footplate to visualize the cutting surface during device operation, and altering the closure force and the size and shape of the footplate and shaft. The simplest and least cumbersome modification involved is altering the footplate so that it deliberately keeps soft tissues away from entering the region between opposing cutting surfaces during instrument occlusion (Fig. 1). The tapered end of the rongeur reduces the amount of material at the tip of the footplate, resulting in less underlying soft tissue compression. Meanwhile, the strength of the cantilever design should be maintained since the force on the footplate is concentrated at its root, and perhaps, improved due to the introduction of a flange.

Finite element analysis was done to predict the stresses on the proposed modification (COSMOSXPRESS, SolidWorks Corporation, Concord, MA). Plastic stereolithography (SLA) models of the footplate were then designed using computer-aided design software (SolidWorks Corporation, Concord, MA) and produced as snap-on additions to an existing 3 mm Kerrison rongeur. Two of these models with different sizes of overhang were tested in a single lamb cadaveric spine with characteristics of bone and anatomy similar to that of the human spine (Fig. 2). Subsequently, a prototype with 1 mm of additional length and width of the footplate was produced by machining and microwelding an addition of surgical grade stainless steel onto an existing 3 mm Kerrison rongeur (Fig. 3). This prototype was then em-

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3 Results

3.1 Laboratory Testing. Stress determination of our proposed modification, in comparison to the existing footplate, demonstrated a 30% reduction in peak stress on the footplate due to the flange (Fig. 4). During cadaver tests, the 0.5 mm addition showed some improvement over the current design; however, dural tears were still possible. The 1 mm addition, on the other hand, effectively prevented the soft tissue from entering the cutting surface, and resulted in little additional interference while manipulating the footplate of the rongeur underneath the bone. A prototype instrument with 1 mm of additional length and width was therefore produced and used in subsequent clinical testing.

3.2 Clinical Testing. We documented the effectiveness of this modified footplate in clinical applications by reviewing our experience with 20 patients undergoing surgical treatment of lumbar spinal stenosis. Despite its tapered end, the footplate retained its strength. We found that the modified footplate prevents the soft tissues from entering the cutting surface of the Kerrison rongeur in the manner intended by its design, and no dural tears, CSF leaks, or signs of additional nerve root compression have been encountered to date. Based on the known incidence of dural tears during similar procedures using a conventional Kerrison rongeur, one to three dural tears would have been expected to occur in our patient population [2–4]; however, clinical testing in a much larger number of patients and with different surgeons would be necessary to establish the true incidence of dural tears and the potential risks of using the modified instrument. Based on our limited testing, however, the modified Kerrison appears effective at preventing incidental durotomy and with few disadvantages.

4 Discussion

Use of the Kerrison rongeur may be associated with tearing of the dura by nature of its design. The lack of direct visualization, along with the absence of inherent active or passive mechanism to exclude soft tissues from the instrument’s cutting surface, places adjacent structures at risk. In this paper, we describe a modification intended to improve the safety of the Kerrison rongeur and to prevent potential morbidities associated with dural tears. Since incidental durotomies are frequent [3,4] and are associated with added morbidity [11], trying to reduce the occurrence of this common complication is important.

Specifically, our design involved two passive modules: (1) tapering the undersurface in order to deflect tissue downward during the positioning of the footplate underneath the bone, and (2) increasing the dimensions of the footplate at its forward and lateral aspects to keep the soft tissues away from the opposing surfaces of the instrument. The modification was first designed as a snap-on addition to an existing rongeur and various sizes of the footplate were tested on cadaveric models. A fully functional prototype of the footplate was then produced by a machining process, followed by microwelding of the addition onto an existing Kerrison rongeur. This prototype proved to be effective in 20 laminectomy cases and did not cause any adverse effects. We anticipate that a production unit of our modified footplate would be forged or investment cast, laser welded, or machined from solid, then heat-treated and ground finished.

There are several disadvantages to this modification. Since the footplate size has been increased, one effectively loses cutting width with each bite. The prototype tested was built into an existing 3 mm rongeur, and the size of the modified footplate added 1 mm in length at the forward aspect and 1 mm in width on each
can abut the leading edge of the instrument. Especially when the dura is patulous or when working in a lordotic instrument, however, is ideal for central canal decompression, especially when working in a lordotic instrument, however, is ideal for central canal decompression, and has not been associated with unintended durotomies in 20 patients.

5 Conclusions

We modified the footplate of a Kerrison rongeur in an effort to reduce the incidence of CSF leaks in spinal surgery. The instrument bears a wider, more tapered footplate that effectively counteracts the tendency of the soft tissues to enter the cutting surfaces. The modified Kerrison rongeur has been used effectively, and has not been associated with unintended durotomies in 20 patients.

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Fig. 4 Results of a finite element analysis comparing stresses in the existing footplate (a) with the modified footplate, and (b) as the modified footplate is approximately 30% wider at the area of peak stress (the corner between the footplate and the shaft), the peak stress decreases by approximately 30%. This analysis assumed a force on the footplate from the slider of 100 N.

References


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