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TECHNICAL NOTE

Spinal Cord Rotation by Denticulate Ligamental Stay-sutures for Anteriorly Placed Intradural Lesions—Technical Note

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ABSTRACT

Anteriorly placed intradural lesions pose specific surgical challenges in accomplishing tumor resection without manipulation of the spinal cord. The authors describe a technique of 'flipping of spinal cord' by up to 30-degrees using denticulate ligamental rotational stay-sutures. The technique of spinal cord rotation enables the surgeon to obtain corridor amongst dorsal nerve rootlets for tumor exposure through standard posterior or postero-lateral approaches to the spinal column. The authors believe that this technique minimizes handling of the spinal cord and negates the need for spinal cord retraction for tumor access. Relevant anatomy of dentate ligaments, salient steps in the procedure with representative pictures and video are described. Advantages, as well as limitations of this technique, are highlighted.

Keywords: Dentate ligament, Denticulate ligament, Spinal cord tumor, Spinal cord rotation, Spinal cord retraction.

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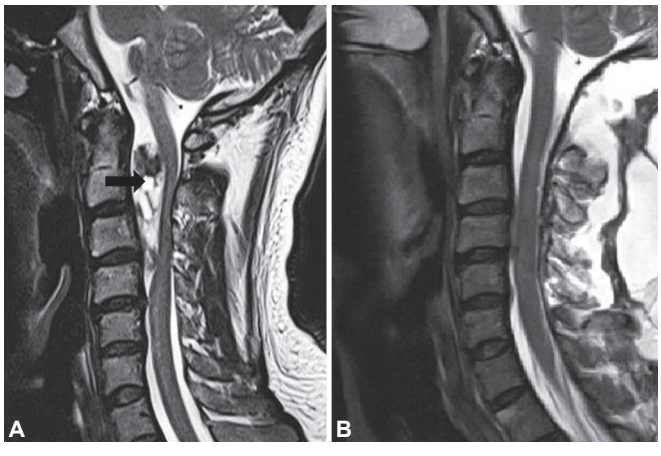
BACKGROUND

Surgical excision of anteriorly placed intradural spinal lesions (Fig. 1) is a technical challenge through standard posterior approaches. Anterior and lateral approaches offer direct exposure for these lesions but are often fraught with the limitation of access, difficulties in dural closure, CSF leak and need for stabilization.[1,2] In approaches through posterior route for tumors, the spinal cord often appears wrapped around anteriorly placed tumor. The tumor itself is often barely visible during initial exposure (Fig. 2A). Exposing the tumor surface often necessitates retracting the cord and/or significant manipulation of the cord structure. Several spinal cord/nerve retractors are commercially available (Cushing®, Love®, Caspar®, D'Errico®, etc.). Many surgeons prefer to use tips of their suction cannulae as their preferred instrument of intermittent retraction although some degree of spinal cord handling is inevitable. The surgeon, primarily concentrating on the tumor, can lose focus on the exact degree of traction placed on the cord tissue. The prolonged retraction has an additional risk of a vascular insult. The authors describe a method of spinal cord rotation using denticulate stay-sutures as a less traumatic alternative to obtaining access to lesions located anteriorly in the spinal canal.

Anatomy of Dentate Ligaments

The ligamentum denticulatum (dentate ligaments) are narrow, white, non-vascular fibrous bands arising laterally from pia mater on either side of the cord. Their medial borders are continuous with the pia mater. Their lateral borders present a series of triangular tooth-like processes, the points of which are fixed, at intervals, to the dura mater, superomedial to lower intervertebral foramina. Their function is to anchor and support the spinal cord against the dural sac. The same natural function can be



Figs 1A and B: Preoperative and post-operative sagittal MRI scan images showing anteriorly placed intradural spinal tumour before (A) and after (B) excision. Lesion is marked by black arrow in image A. Note preservation of posterior spinal elements by performing laminoplasty (B)

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exploited to rotate the spinal cord along its long axis without actually handling the cord tissue itself.

Technique

The spinal cord is normally anchored with the walls of the dural sac through short dentate ligaments and the exiting nerve rootlets. The nerve-roots have some degree of extra length which permit retraction on the spinal cord, but the dentate ligaments are short and firm and do not permit movement of the cord within the canal.

In the method we use, the dentate ligaments are sharply divided closer to their dural ends leaving their longer stubs closer to the cord through which sutures can be passed.[1,3] These ligaments being avascular their coagulation is unnecessary and may cause shrinkage of the ligament. This leaves long stumps of dentate ligaments on the side of the cord. Depending on the length and breadth of access required, consecutive 4–5 dentate ligaments are severed on the side where the tumor is most likely to be accessible. The stumps of ligaments are held together with thin (5-0/6-0) nylon sutures to anchor and rotate the spinal cord. It is vital to ensure that the nerve rootlets are not inadvertently mistaken as dentate ligaments and injured. The cord is gently lifted and rotated contralaterally as much permitted by the laxity of the nerve rootlets (Fig. 2B). Any stretch on the roots may result in neurapraxia or axonotmesis. Spinal cord rotation of up to 30 degrees can be accomplished by this technique allowing sufficient corridor for access to anteriorly placed lesion without traction or retraction of the cord whatsoever. The lesion can then be dealt with using standard microsurgical techniques[1,2] (Figs 1B and 2C Video).

There are several points to note when deploying this method:

- Preoperative planning of the trajectory based on MRI is important.[2]
- Sacrificing denticulate ligaments bilaterally at the same level may put the spinal cord in a precarious position due to lack of support.
- Laminectomy at least one level above and below the extent of the lesion is usually required. Without such an extension, it may not be possible to achieve the desired rotation of the cord.
- Facet joint(s) may have to be drilled for adequate lateral exposure.[1,2]
- It is necessary to take multiple dural stitches to expose the spinal cord widely. We prefer to tie the dural stitches to paraspinal muscles as low as possible rather than simply hanging them outside. This maximizes exposure in addition to preventing extradural blood from percolating through.
- It is important not to coagulate the arachnoid otherwise natural planes may be lost. We prefer to carry out tumor dissection in extra-arachnoidal planes and indeed rotate entire pia-arachnoidal complex along with the cord.

Advantages and Limitations of the technique

This technique of spinal cord rotation has several advantages. It is safe, simple and can be carried out by a relatively inexperienced surgeon, unlike extreme lateral or anterior approaches that require a considerable degree of experience and expertise. Secondly, it obviates the need for spinal cord retraction and minimizes its handling. Thirdly, the "flipping technique" even works for lesions at the spino-medullary junction. The medulla also has dentate ligaments that are reasonably strong to hold stay sutures. The spinal exposure can be easily extended cranially by removing posterior rim of the foramen magnum. Fourthly, it is quick, reproducible in re-exposures and does not need instrumentation or, unlike some anterior

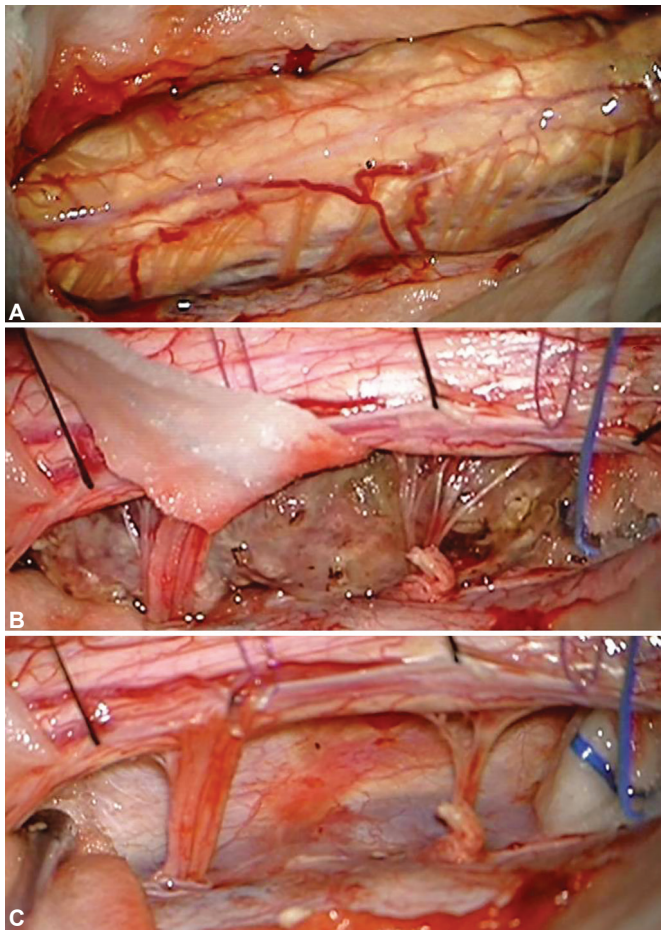

Fig 2A to C: Intraoperative photographs of an index case. (A) Appearances after initial exposure. Note the cord is wrapped around the tumour which is barely visible; (B) Spinal cord rotation using denticulate ligamental sutures to expose anteriorly placed tumour; (C) Operative appearances after complete resection of the tumour through the corridor created by spinal cord rotation

spinal approaches. Lastly, the spinal cord architecture is undisturbed, and the possibility of vascular injury is minimal.

In summary, the authors believe that majority of anteriorly located intradural lesions can be safely excised deploying this method of spinal cord rotation using denticulate stitches through standard posterior approaches, with minimal risk of causing neurological damage (Fig. 2C).

The technique is not without limitations. Longer laminectomy is needed to facilitate adequate cord rotation. Wider lateral exposure of the dural sac, necessitating drilling of the ipsilateral facet joint(s), is necessary. Minimal access to spinal approaches and key-hole methodologies are unsuitable to exercise this technique. In the pediatric population, denticulate ligaments are flimsy and may not hold stay-sutures. Without intraoperative physiological monitoring, there are no objective indicators to judge the degree of rotation that can be safely tolerated by the cord. Excessive rotation may place the cord and roots under undue traction. The authors do not have any comparative data to recommend its use over standard techniques.

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