Spinal cord suspension using dentate ligament hitch stitches: A novel technique for the repair of ventral spinal cord herniation

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Abstract:

Background: Idiopathic spinal cord herniation is usually repaired by releasing the spinal cord and inserting a dural patch to close the herniated segment of dura. However, re-herniation is a potential limitation of this standard technique.

Objective: To describe early results of a novel technique that utilizes the dentate ligament to hitch the spinal cord and prevent re-herniation.

Methods: Two patients underwent dural hernia repair and the dentate hitch technique was performed.

Results: Restored lower limb power and mobility, and satisfactory reduction of spinal cord herniation on MRI in 2 patients at 6- and 24-month follow-ups respectively.

Conclusion: The dentate hitch technique can achieve repair of spinal cord herniation, with satisfactory postoperative results and minimizes the risk of re-herniation.

Key Words: Dentate Ligament; Dura; Herniation; Hitch stitch; Spinal cord

Running Title: Spinal cord suspension using dentate ligament hitch stitches

Idiopathic spinal cord herniation (ISCH) through a ventral dural defect is recognized in the literature as an uncommon occurrence. The commonest location of a ventral dural hernia is the mid-thoracic column, but cervical cases have also been reported.[1] Patients typically present with progressive myelopathy and Brown-Séquard syndrome can be the initial presentation. Preoperative diagnosis can be made with magnetic resonance imaging (MRI). The main aim of surgery is to release the incarcerated cord and to prevent re-herniation, for which numerous strategies have been described including: widening the dural defect, direct dural defect repair with stitches, and covering the dural defect with a dural patch. There is no clear consensus of opinion regarding the optimal surgical technique. However, with numerous reported cases of re-herniation after surgery, surgical technique remains a key concern. We describe a novel technique of spinal cord suspension to the inner leaf of the dura using dentate ligament hitch stitches to address this problem.

METHODS

Illustrative Case 1

A 62-year-old man presented with a 2-year history of dragging his left leg, which was becoming more pronounced. He also reported hypersensitivity of the left leg in the shower and had noticed some loss of muscle bulk in the left leg.

On examination, there was hypertonia in both legs with upgoing plantars. His lower limb reflexes were exaggerated and there was a sensory level at T4 on the right side. His gait was abnormal with MRC grade 4/5 power in the left lower limb.

His initial MRI was done elsewhere and was reported to be normal. However, on review it showed clear abnormal anterior displacement of the spinal cord at the T2/3 level. Repeat MRI spine with Cine-imaging in steady state (CISS) sequences showed a clear left ventral lateral deviation of the cord at the T2/3 disc level (Figure 1A and 1B). A CT myelogram was performed to rule out arachnoid cyst related cord displacement, and showed focal dural leakage at T2/3, further confirming the diagnosis of ventral spinal cord herniation.

He underwent a T2-T3 laminectomy with partial left sided facetectomy and repair of the dural herniation with dural patch and dentate ligament hitch stitches. Intraoperatively, we did not encounter any dorsal arachnoid pathology.

Illustrative Case 2

A 42-year-old female presented with progressive deterioration in mobility and pain radiating around the lower rib cage. Her walking was limited to 15 minutes due to leg spasticity. Ten years prior to this, she had an acute episode of left leg weakness that improved over time and had been attributed to a possible inflammatory spinal cord episode. No previous imaging was available for review.

On examination, she had a spastic gait with marked lower limb hypertonia, brisk reflexes and MRC grade 4/5 power in the hip flexion and knee extension.

MRI whole spine was arranged, which demonstrated ventral spinal cord herniation at the T5/6 disc level, just to the right of the midline, with ventral epidural cerebrospinal (CSF) collection (Figure 2A and 2B).

She underwent a T5/6 thoracic laminectomy and repair of the spinal cord herniation with a dural patch and spinal cord suspension with dentate ligament hitch stitches.

As per hospital trust policy valid consent was taken for all patients prior to surgery. No patient identifiable information has been used in this publication, according to guidelines.

Operative Technique

After performing a laminectomy or laminoplasty, we perform a midline durotomy preserving the arachnoid. The dura is hitched back with 4-0 prolene stitches. The arachnoid is then opened and hitched back to the dura with clips.

Using micro-dissectors, the spinal cord is circumferentially freed from the dural defect at the level of the herniation. An artificial dural patch is then placed ventral to the cord to cover the dural defect (Figures 3A and 3B, 4). The dural patch covers the entire ventral defect at the level of the herniation. The patch is secured with glue, which is sprayed first into the dural defect ventral to the dural patch allowing an adequate seal.

Six-0 prolene sutures are then used to hitch the dentate ligament at the level of the herniation to the inner leaf of the dura. This allows gentle dorsal migration of the spinal cord away from the dural defect. Similar hitch stitches are inserted proximally and distally to the first stitch allowing adequate support. This is repeated on the contralateral side (Figure 5A and B; see Video, Supplemental Digital Content, which illustrates this technique).

RESULTS

There were no perioperative complications. Both patients experienced improvement in symptoms within a few days of surgery.

At 6-month follow-up, our first patient reported improvement in gait and mobility with normal power in both lower limbs. However, the preoperative hyperesthesia in his left leg remained. Follow-up MRI at 6 months (Figure 6A and 6B) showed that the spinal cord was no longer deviated and appropriate CSF flow voids were noted ventral to the cord.

At 24-month follow-up, our second patient also reported significant and progressive improvement in symptoms with recovery of normal lower limb power and mobility. Follow-up MRI at 24 months (Figure 7A and 7B) confirmed satisfactory reduction of cord herniation and no anterior displacement.

DISCUSSION

Idiopathic Ventral spinal cord herniation (ISCH), first described by Wortzman in 1974,[2] is a rare but recognized cause of myelopathy. Until 2016, less than 200 cases have been identified in literature, indicating its exceptional occurrence. The introduction of MRI has led to increasing recognition and reporting in the medical literature with the majority of reported cases being since the 1990s.[3,4]

Delayed diagnosis and hence delay in treatment is not uncommon. Carter et al[5] analyzed 37 reported cases of ISCH and found that the median time from presentation to imaging diagnosis was 20 months in patients under the age of 60 and 5 months for patients over the age of 60.

Numerous hypotheses have been mooted to explain its pathoetiology. Initially, it was thought that the ventral dural defect had been caused as a result of an arachnoid cyst.[6] Subsequent cases have reported a remote history of trauma.[4,7,8] The prevailing view for a long time was that the dural defect was probably secondary to a thoracic disc herniation.[4,8,9] Congenital duplication of the ventral dura with a defect in the inner layer and cord herniation through the inner layer is a concept that finds favor with several Japanese authors.[10,11] Inflammatory etiology was proposed in 2004. It was suggested that an inflammatory process of the meninges or the cord leads to ventral cord adhesion and migration, with a dural defect gradually developing over years due to the inflammation.[12] Local deficiency of the dentate ligament may also be a contributory factor.

Various surgical strategies have been described to release the herniated cord from the dural defect and to repair or cover the defect to prevent re-herniation. Once the herniated cord has been released from the dural defect, direct dural repair with sutures may be possible.[2,7,8] Covering the dural defect with a patch (fascia lata or artificial patch) is another widely used strategy. [4,7,13,14] Others advocate simply widening the dural defect after cord release.[15,16] The purpose is to minimize cord manipulation while resolving the incarceration of the spinal cord.

Surgical repair usually leads to neurological improvement or stabilization, with improvement reported in 73% and motor deterioration in 7% of the patients.[4] Patients with Brown-Séquard syndrome as a presenting feature seem to have a better postoperative prognosis.[4,12] Regardless of the repair techniques, recurrence of spinal herniation after repair has been reported.[16,17,18,19,20] Traumatic and delayed recurrences have been reported between 10 months to 10 years after initial surgery.

Furthermore, the artificial dural patch can potentially migrate due to CSF pulsations, although this is obviated to an extent by the use of sealant glue. Even after cord herniation repair, the ventral cord deformity is noticeable and the cord may not be maintained in its natural position, resulting in re-prolapse. Persistent anterior displacement (PAD) of the cord was noted in post-op MRI scans of 7 out of the 66 patients who had follow-up imaging after a variety of repair techniques.[4] PAD can also lead to ventral arachnoid adhesions which may distort CSF flow.

Arts et al[21] suggested wrapping the entire cord with a sheet of dural patch to prevent re-herniation, although this carries the risk of cord strangulation. Dividing the dentate ligament and using it to gently rotate the spinal cord is a recognized and well-established surgical technique. However, to the best of our knowledge, this is the first reported use of dentate ligament hitch stitches to augment spinal hernia repair.

Our technique can be used to prevent recurrent spinal cord herniation. As noted in our follow-up scans, the restored spinal cord position is maintained postoperatively, and normal CSF flow is established ventrally. The technique adds up to 20 minutes to the standard operative technique.

CONCLUSION

We have developed a novel technique to prevent recurrent spinal cord herniation by hitching the denticulate ligament to the dura. Preliminary results show that it is safe and feasible. Patients have made full recovery at 6- and 24-month follow-ups respectively, without radiological evidence of recurrent prolapse.

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Figure Legends:

Figure 1: Preoperative MRI (A) sagittal image and (B) axial images of Patient 1, showing anterior displacement of the cord at the level of the disc with subtle signal change and ventral spinal cord herniation through the dura more apparent on the axial image.

Figure 2: Preoperative MRI (A) sagittal and (B) axial image of Patient 2, showing ventral cord displacement at the level of the disc suggestive of cord herniation.

Figure 3: Illustrative (A) sagittal and (B) axial images demonstrating cord herniation

Figure 4: Illustrative image showing insertion of dural patch ventral to the cord to cover the dural defect.

Figure 5: Illustrative (A) sagittal and (B) axial images demonstrating our novel technique of bilateral dentate ligament hitch stitches to suspend the cord, in addition to the ventral dural patch to prevent re-herniation.

Figure 6: Six-month postoperative MRI (A) sagittal and (B) axial images of Patient 1, showing resolution of cord herniation and adequate cord suspension through dentate ligament hitch stitches visible on axial image.

Figure 7: Twenty-four-month postoperative follow-up MRI (A) sagittal and (B) axial images of Patient 2, showing resolution and repair of the ventral cord herniation.

SUPPLEMENTAL DIGITAL CONTENT

Video that demonstrates the dentate ligament hitch stitch technique.

Figure1a

Click here to download Figure Figure 1a.tif

Figure1b

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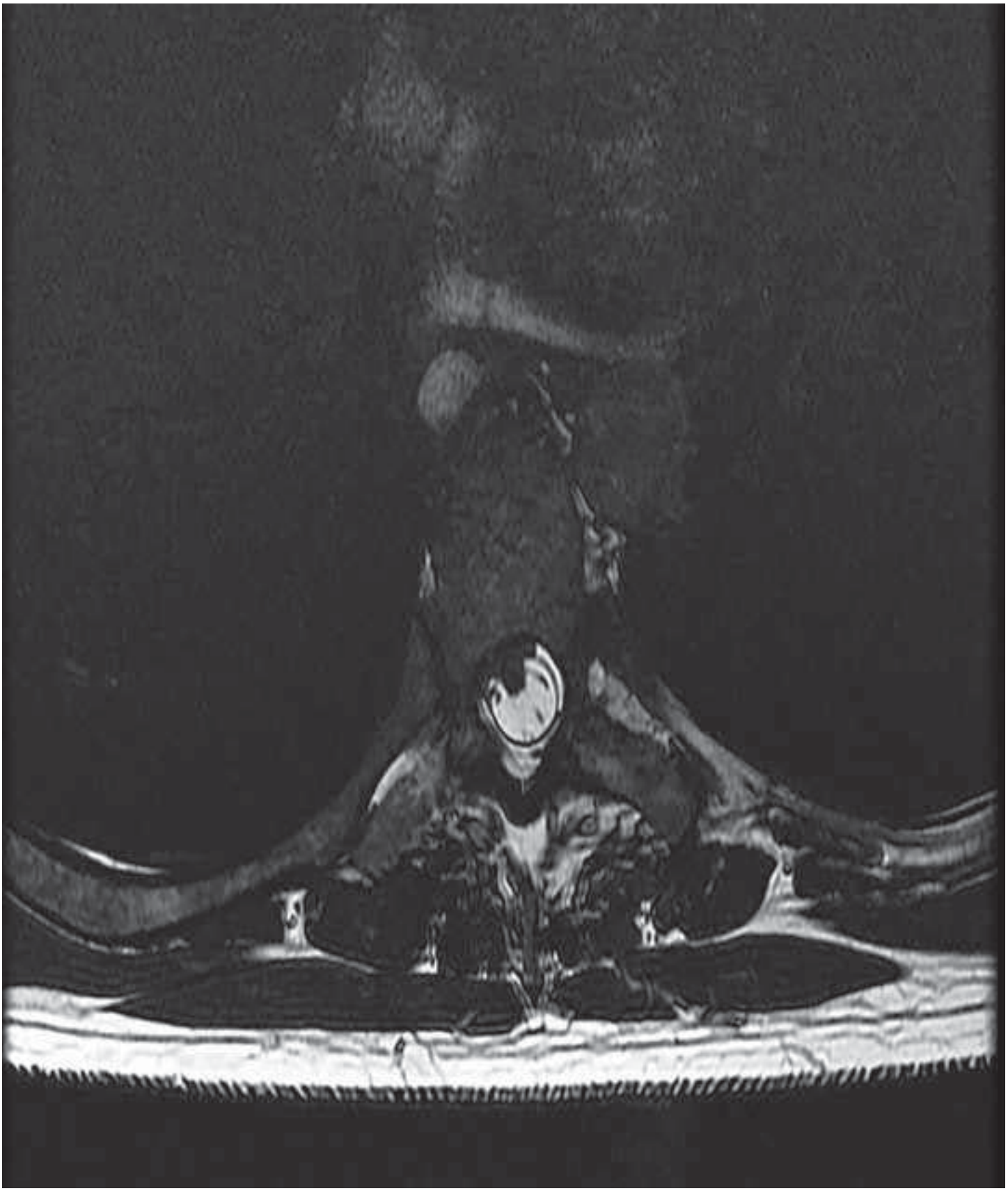

Figure 2a

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Figure 2b

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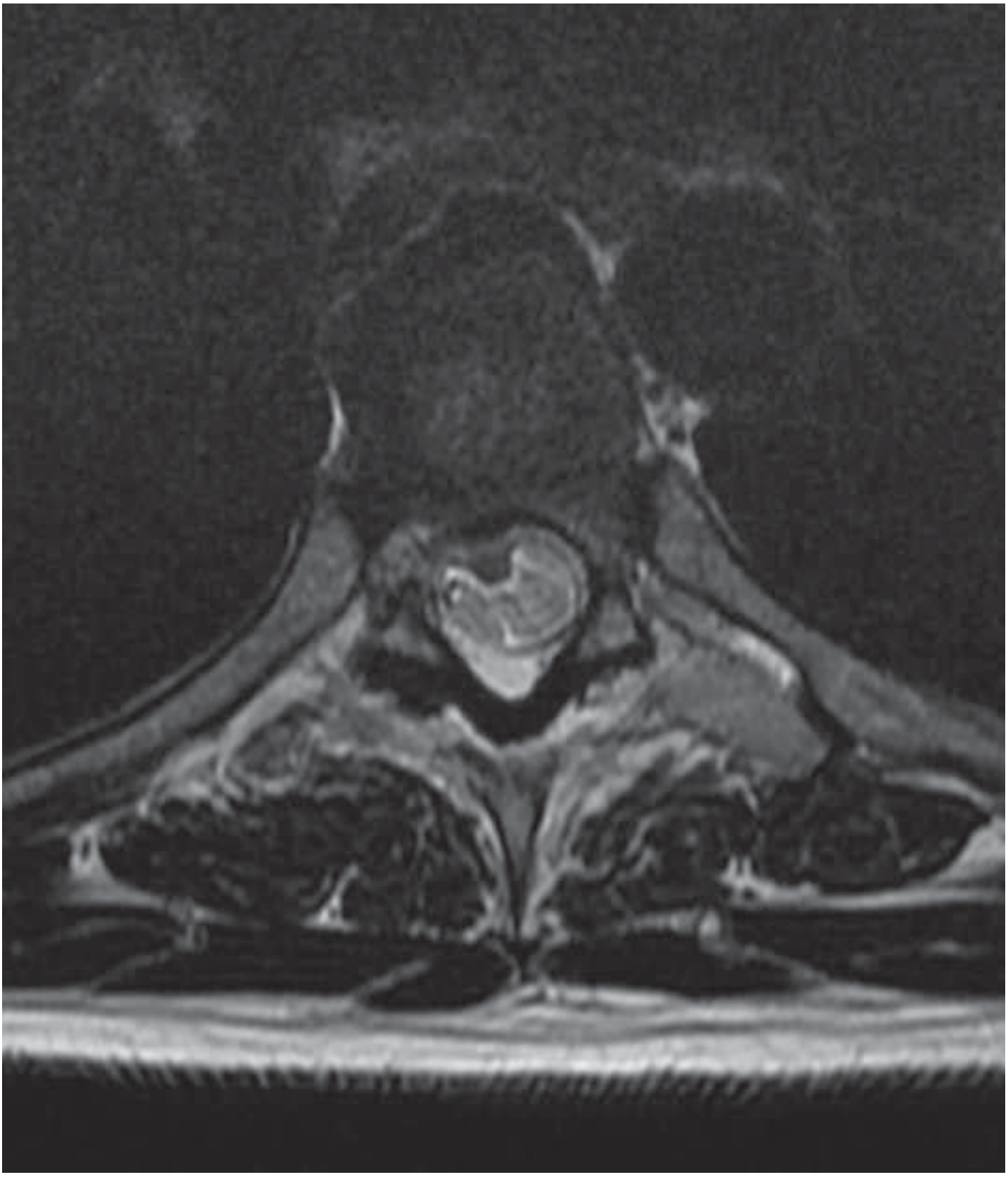

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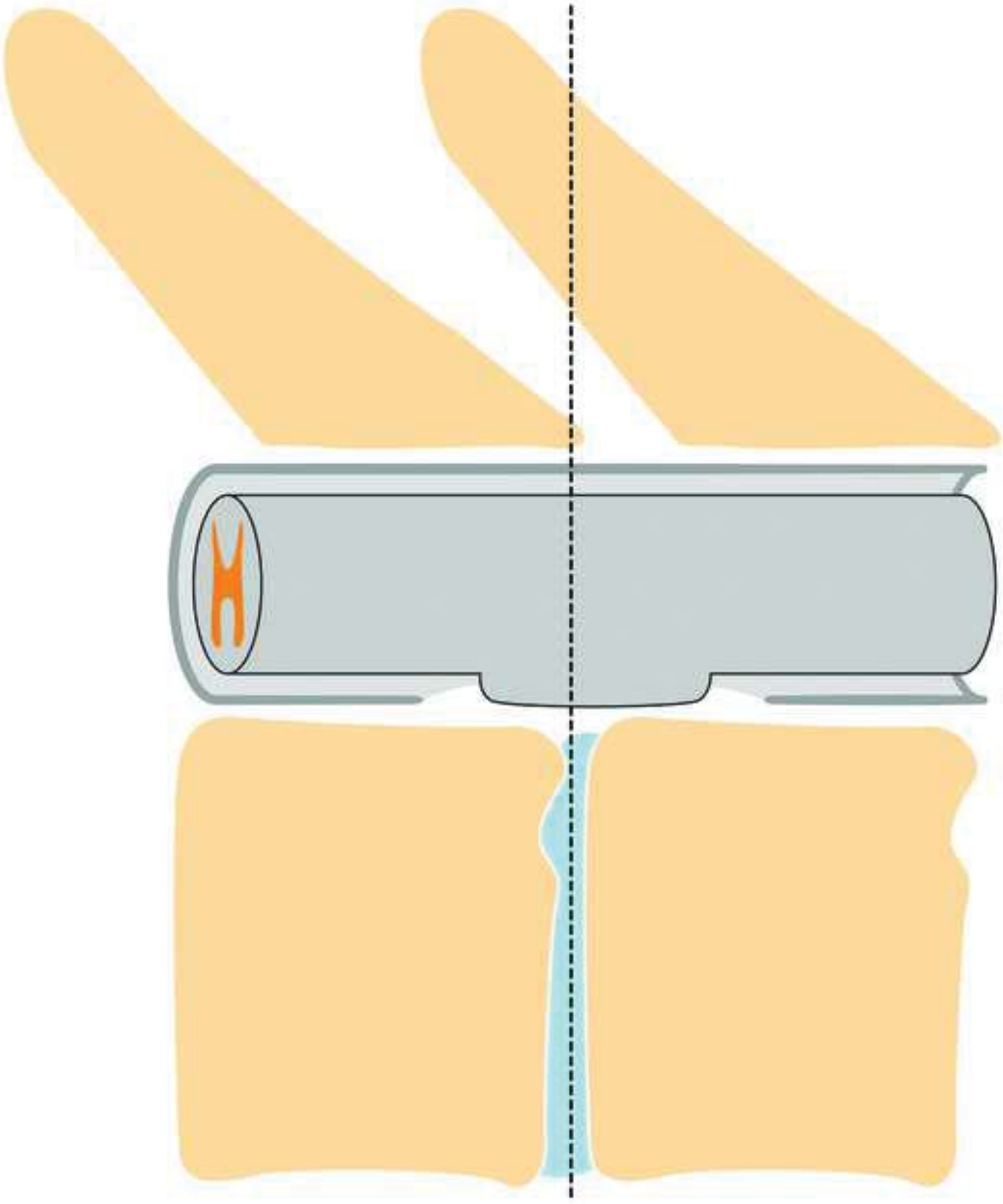

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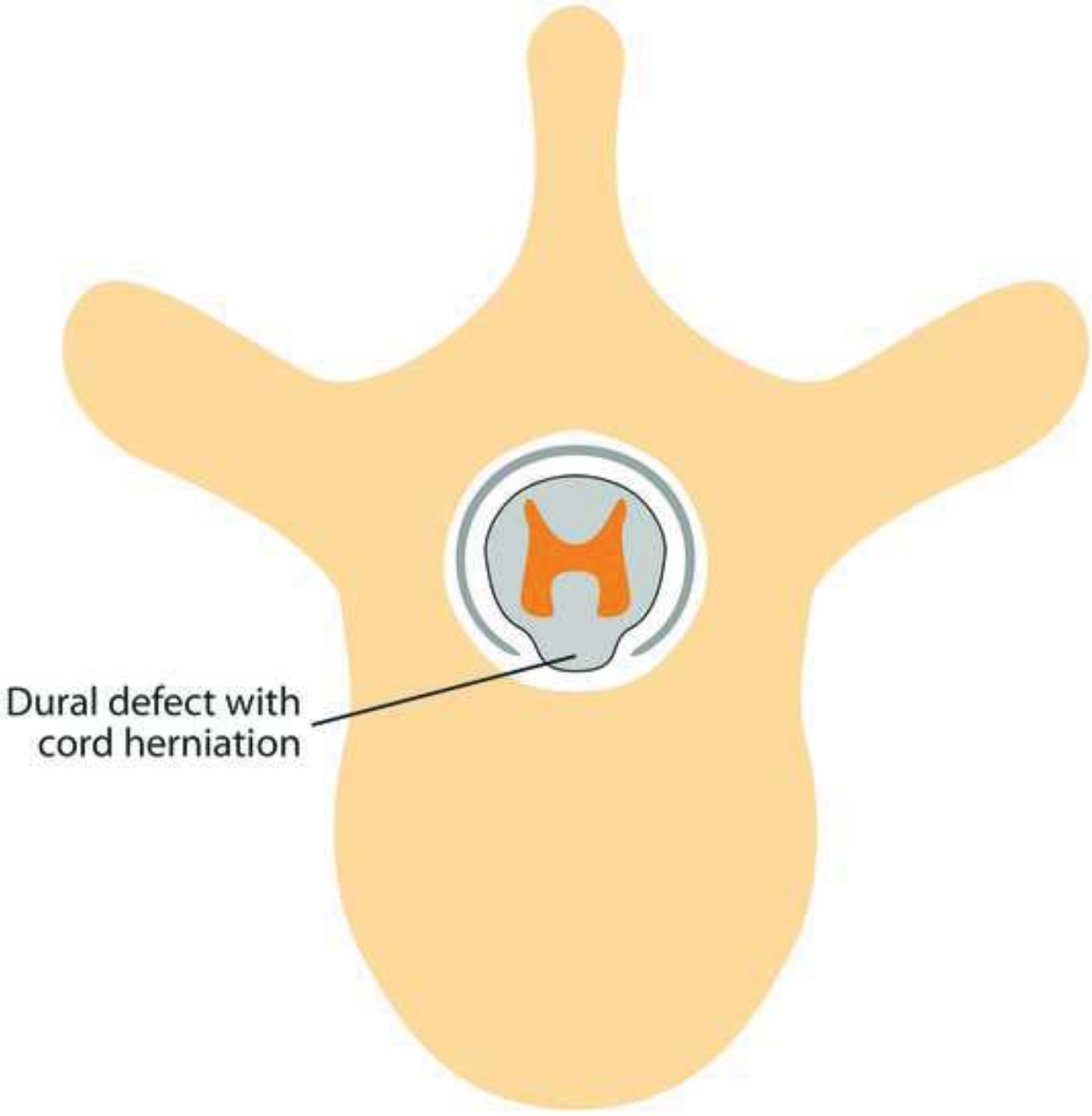

Figure 4

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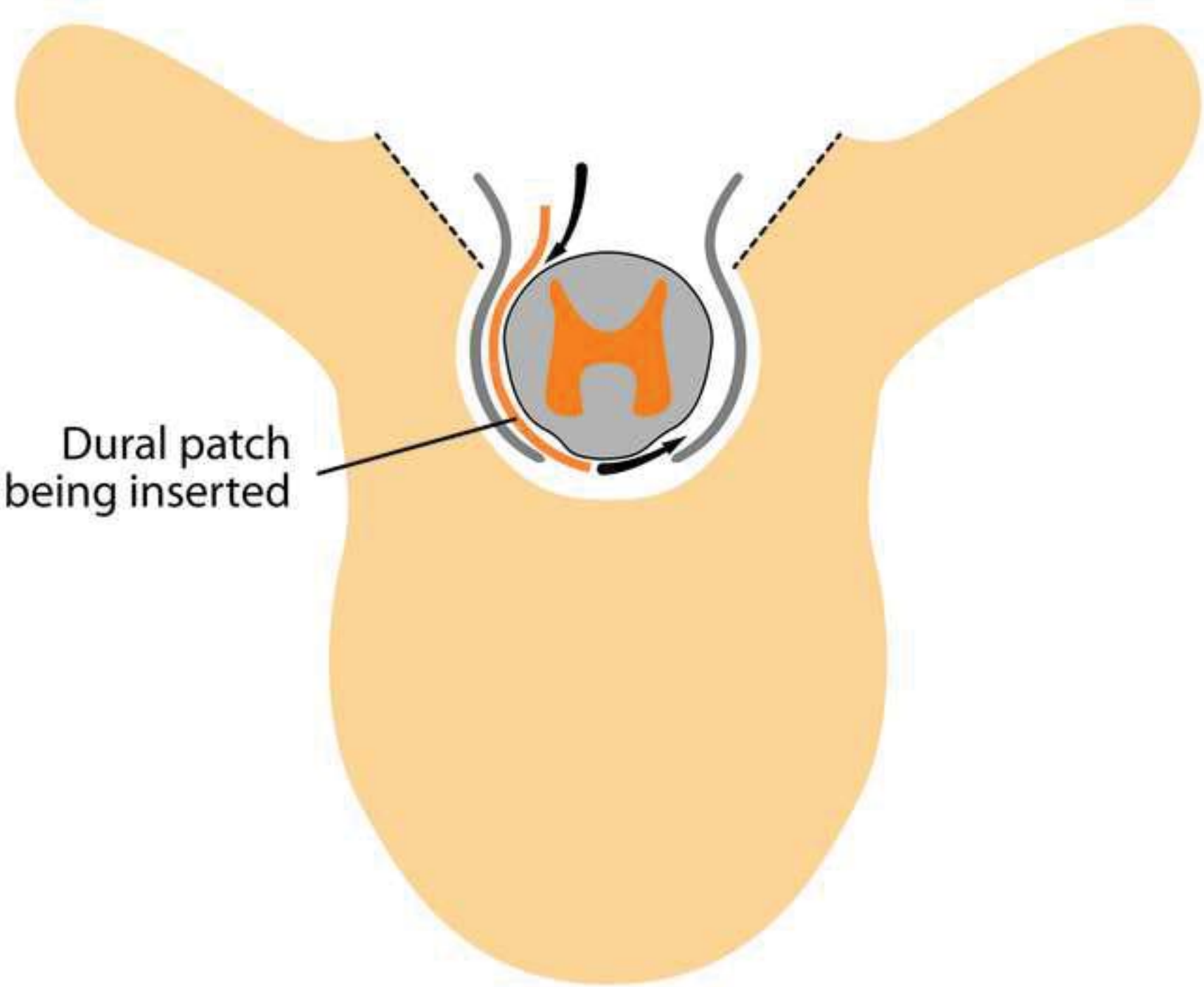

Figure 5a

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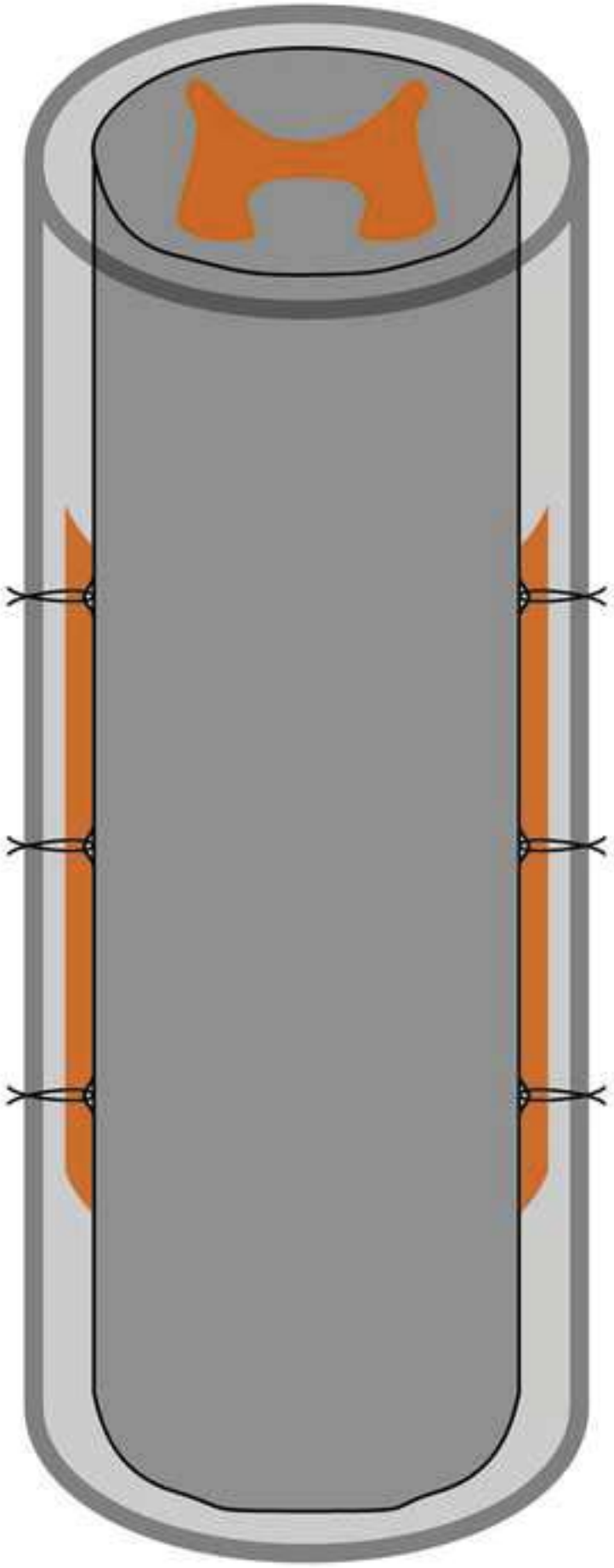

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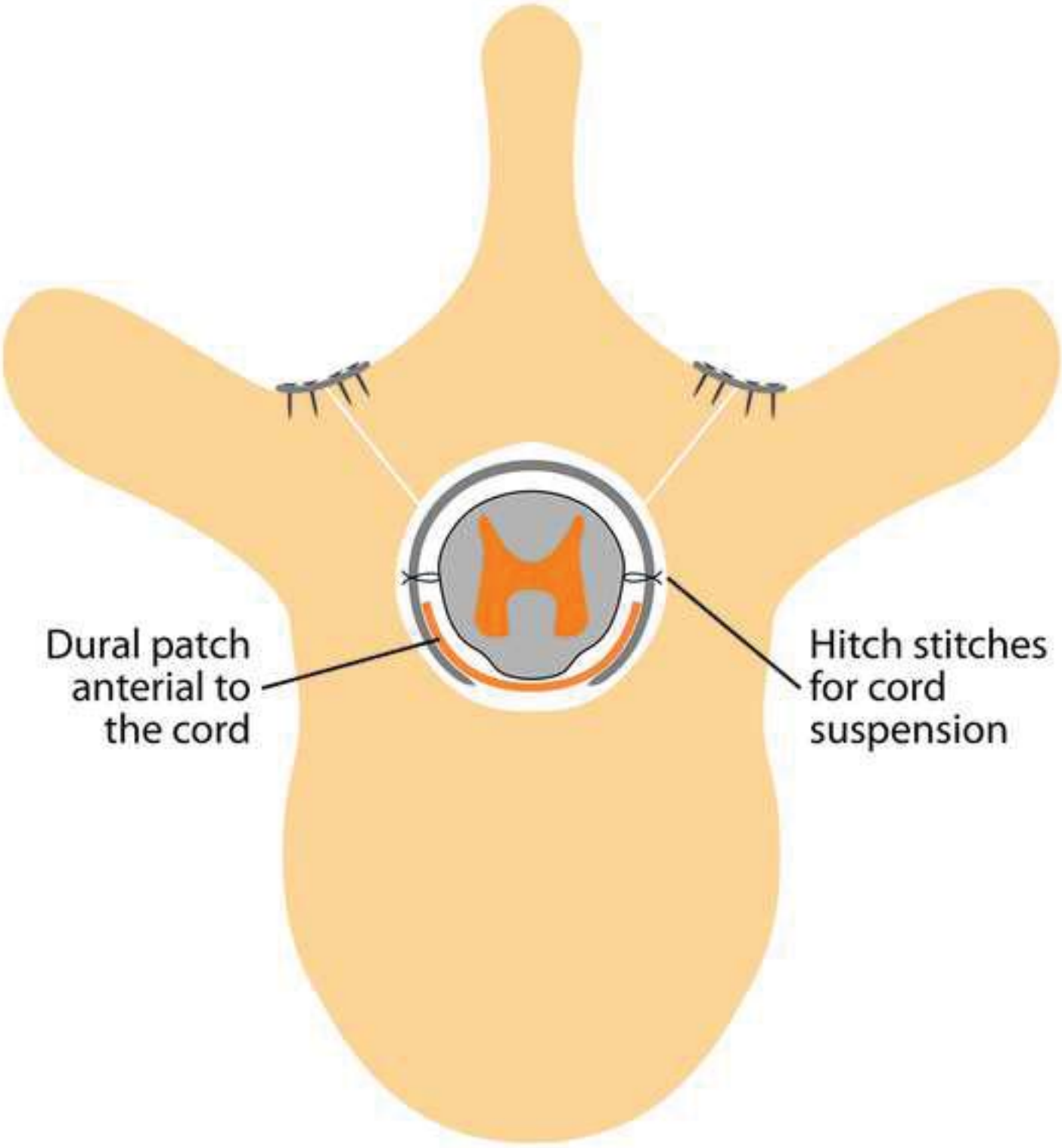

Figure 6a

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Figure 6b

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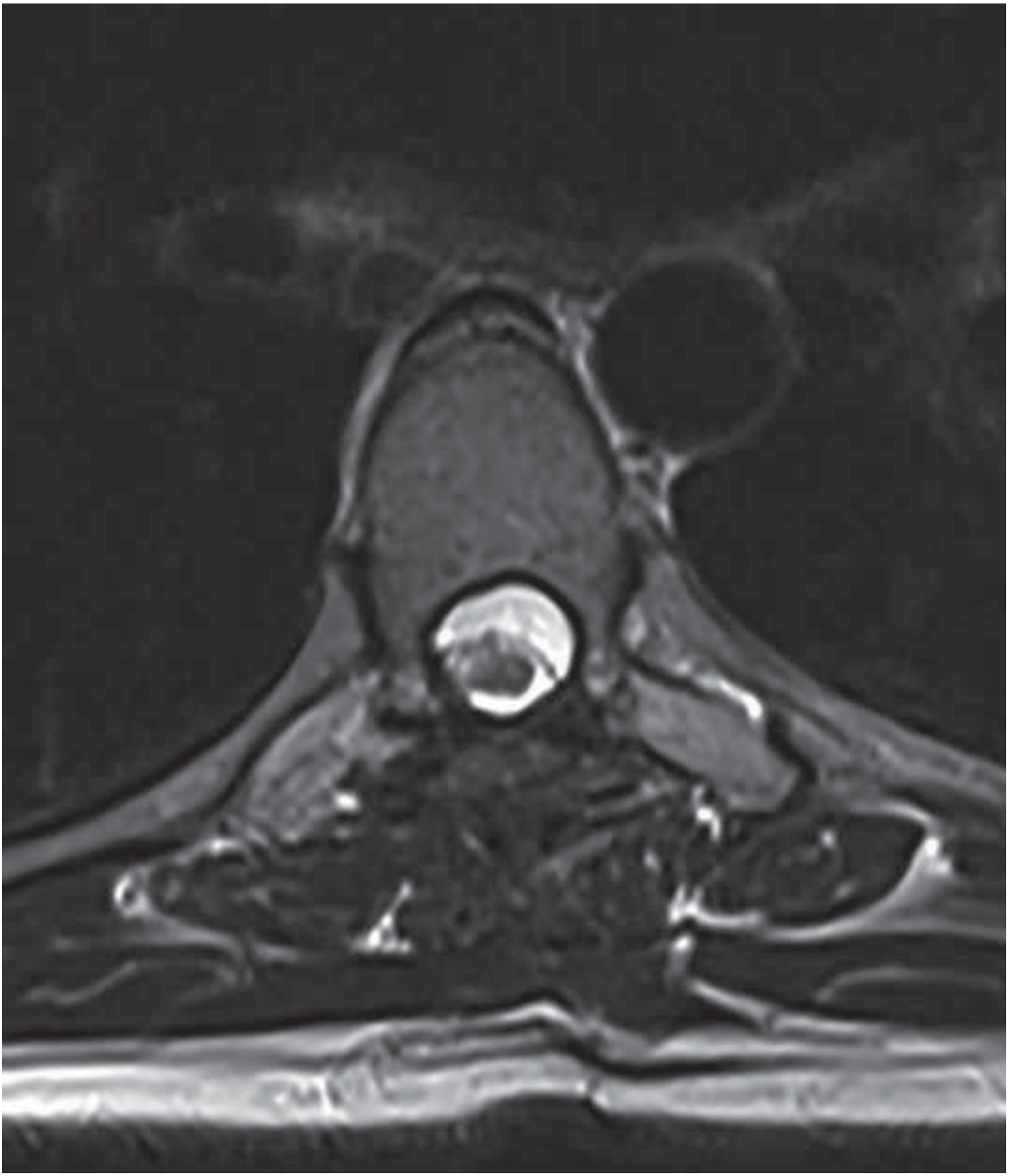

Figure 7a

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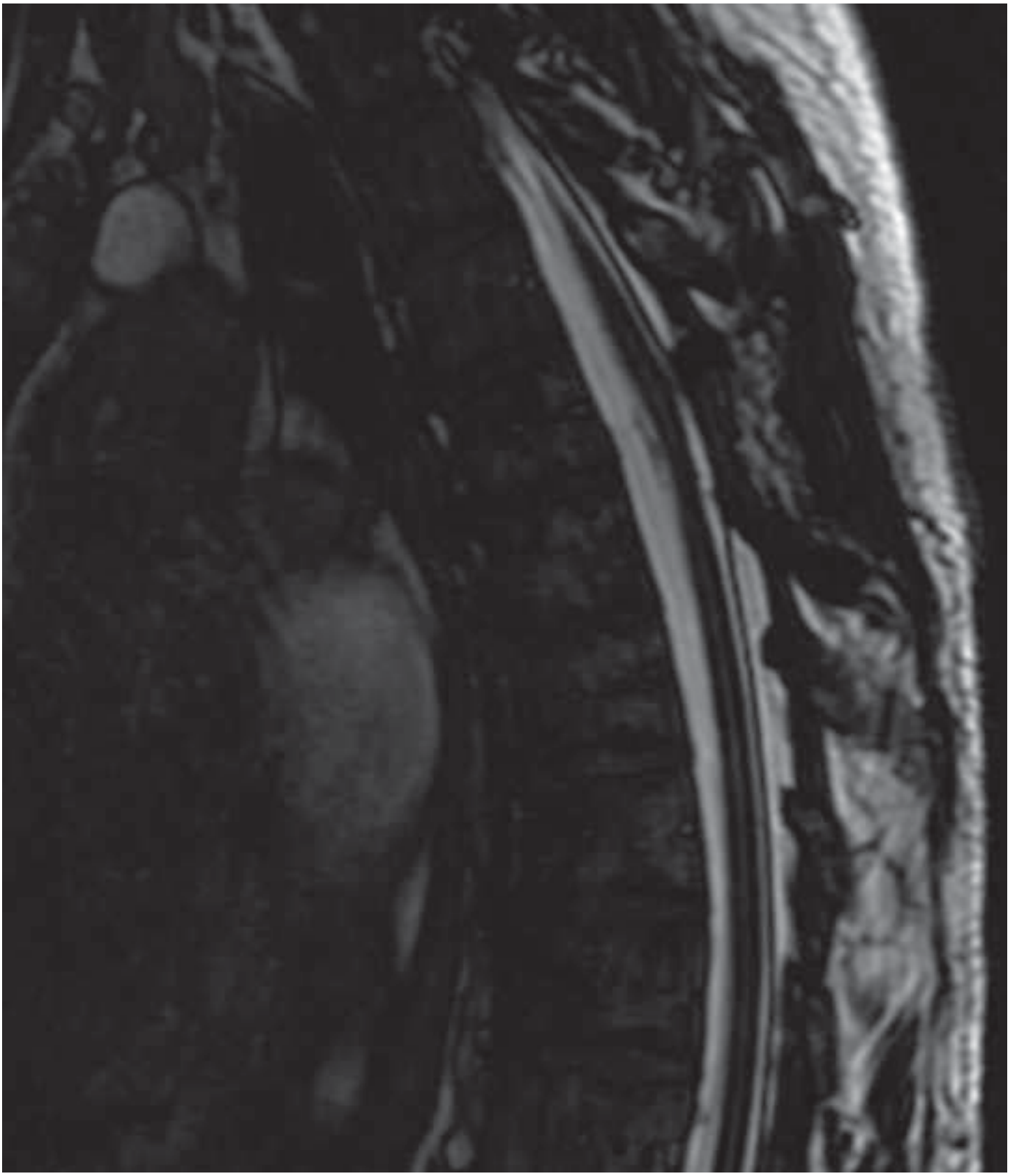

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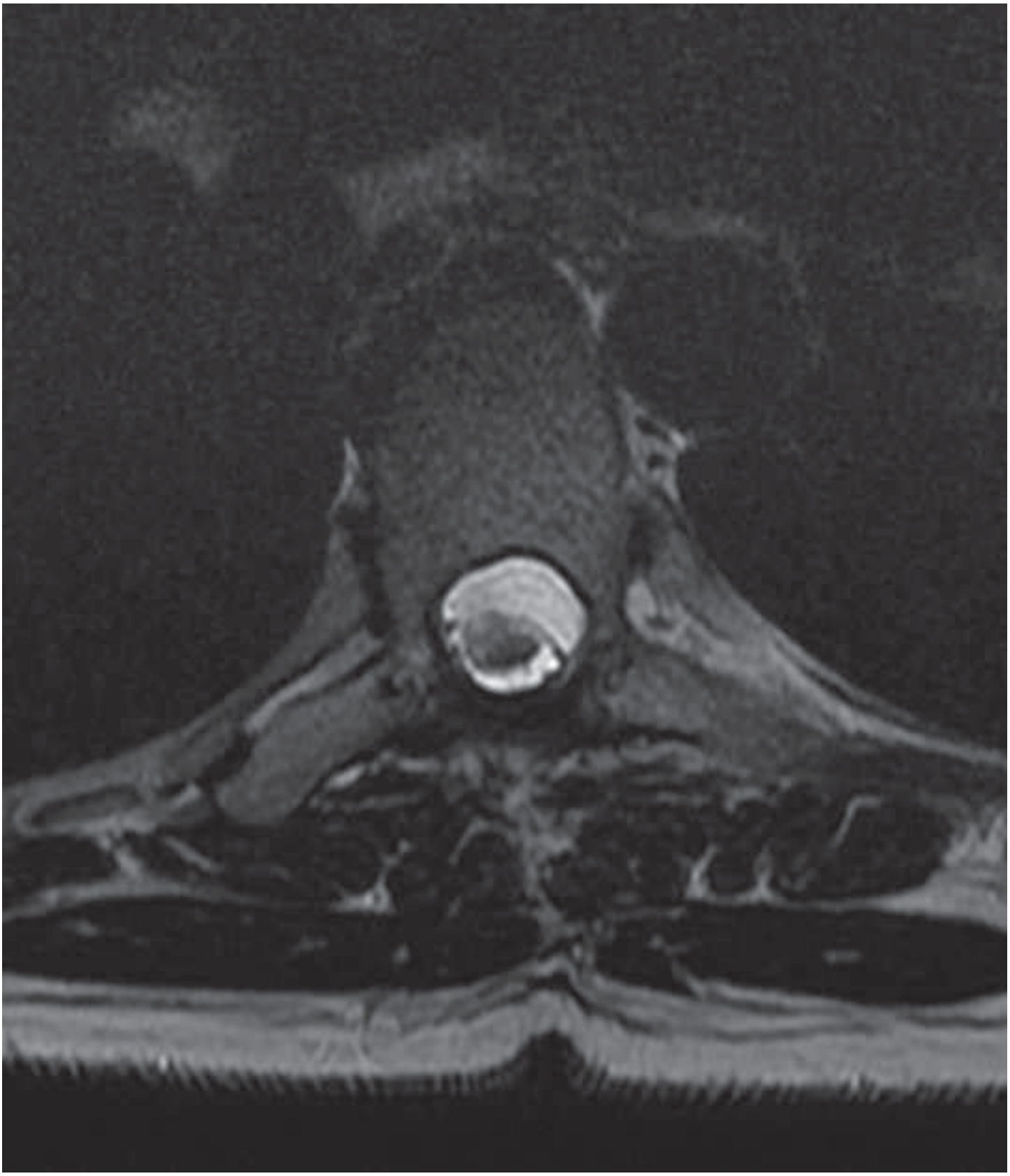

Video Legend

00:33 Mobilisation of spinal cord from dural defect
01:30 Artificial patch insertion
02:10 Sealant inserted into epidural space
02:48 Hitch stitches inserted
06:01 Contralateral sealant and hitch stitches inserted

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Supplemental Digital Content - Video (must include audio narration)

Repair of spinal cord herniation.mp4