50 Technical and Anatomical Considerations for the Placement of a Posterior Interspinous Stabilizer

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50.1 Terminology

Interspinous spacers/stabilizers are implants which are introduced between the spinous processes of the lumbar spine to achieve a segmental distraction.

50.2 Surgical Principles

The behavior of a functional spinal unit is related to the displacement of the center of rotation, making it possible to balance the moments and thus control the transferred loads. When a lordotic posture is used, the downward transmission of forces results in redistribution of loads which tend to be transferred posteriorly to the facet joints. The facet joints have an absorbing and a stabilizing role. Their impairment results from an ongoing aging process.

The Device for Intervertebral Assisted Motion (DIAM) acts as a shock absorber and displays a non-linear behavior. This implant is a silicone "bumper" that is inserted between the spinous processes. Both the height of the implant and the load applied to the implant influence the degree of mobility. It is used in various indications.

50.3 History, Advantages, and Disadvantages (see also Chapter 45)

Ligamentoplasty is an alternative technique to posterior arthrodesis. Ligamentoplasty devices can be classified into two groups: pedicle screw-based devices and interspinous ligamentoplasty implants. The interspinous implant is comprised of a silicone core wrapped into a polyester sheath connected to artificial ligaments of the same material. The DIAM is an interspinous stabilizer designed to assist the degenerated segment in both flexion and extension through its novel dynamic ability to stretch and compress in synchronization with the normal movement of the functional spinal unit.

50.4 Indications

50.4.1 Disc Herniation

This indication mainly interests the L4-5 level which is often unstable. The device is used to prevent pain resulting from overloading of the facets following a discectomy. Image analysis and intraoperative observation are most important because they may reveal hypertrophy of the posterior facets, synovial cyst, and stretching of the posterior supraspinous ligament with abnormal approximation of the spinous processes (Fig. 50.1). It is important to note that the consequences of the posterior transfer of loads are evidenced by indirect signs which need to be identified. These include:

- Retrolisthesis
- Discal hyperlordosis
- Disc tilt (often clearly visible with the patient under general anesthesia in the prone position)

Fig. 50.1. Combined dehydration of the disc and interspinous ligament

Note: The posterior interspinous stabilizer restores the vertical component of the posterior moment arm, which helps reestablish ligamentotaxis.

50.4.2 Lumbar Spinal Stenosis

Acquired spinal stenosis (Fig. 50.2) is by far the most frequent cause of neurogenic claudication (sciatica resulting from effort). A retrolisthesis worsens the stenosis and requires its reduction. Implantation of the device is always associated with nerve root decompression. There are three anatomical diagnoses (with a possible combination of two or all of them): foraminal stenosis, soft stenosis (disco-ligamentous; Figs. 50.3–50.5), and kissing spines. The implant acts on the foraminal bony elements to change local conditions (reducing venous congestion and traction on the spinal ganglion).

50.4.3 Facet Syndrome and Black Disc

In these cases, the device is implanted at one or several levels to assist in unloading the disc and the posterior articular columns which are subjected to excessive loads due to the degenerative process. A block-test helps identify the source of pain. In such cases, the conservative technique is valuable because it allows insertion of the implant with minimal tissue disruption, staying away from the nerve structures, and it is a time-saving procedure. One or more levels can be addressed with combinations of stand-alone implants and/or implants associated with decompression procedures.

Fig. 50.3. Soft stenosis

Fig. 50.2. Dynamic stenosis according Fuentes definition

Fig. 50.4. L4 retrolisthesis

Fig. 50.5. Postoperative X-ray

50.4.4 Topping-off

This indication addresses the adjacent segment after lumbar fusion. Degeneration of the adjacent segment results from stress concentration above or below the fusion. A posterior translation with hyperlordosis results in a foraminal narrowing due to a "pinch" effect. Therefore, this device should prove useful when used in association with fusion in cases where decompression and/or instrumentation may compromise the adjacent facets. This procedure can be used for both the cranial and caudal segments adjacent to a fusion. It might be used above/below a multiple-level fusion to delay degeneration of the segments adjacent to a fused level.

50.4.5 Precautions

- In osteoporotic bone, it is important to properly position the distractor which must rest on the junction between the spinous process and the lamina.
- Stable degenerative spondylolisthesis (grade I): this borderline indication is a matter of surgical experience.

50.5 Contraindications

- Unstable spondylolisthesis
- Neoplasia
- Fracture
- Isthmic Spondylolysis
- Idiopathic scoliosis

50.6 Patient's Informed Consent

This is a minimally invasive procedure which does not involve neural structures directly. A specific complication may be a dislocation of the implant and lack of efficiency.

50.7 Surgical Technique

50.7.1 Anatomical Considerations

The DIAM is a dynamic stabilization device (Fig. 50.6). To the extent that we disrupt the normal segmental musculature we damage the inherent dynamic stabilization of the spine and degrade our surgical outcome. The implant conforms to the interspinous anatomy and allows placement with minimal disturbance to the segmental muscles. While a simple midline approach with dissection of muscles from the spinous process is possible, attention to the details of segmental anatomy can preserve the neuromuscular integrity of the back.

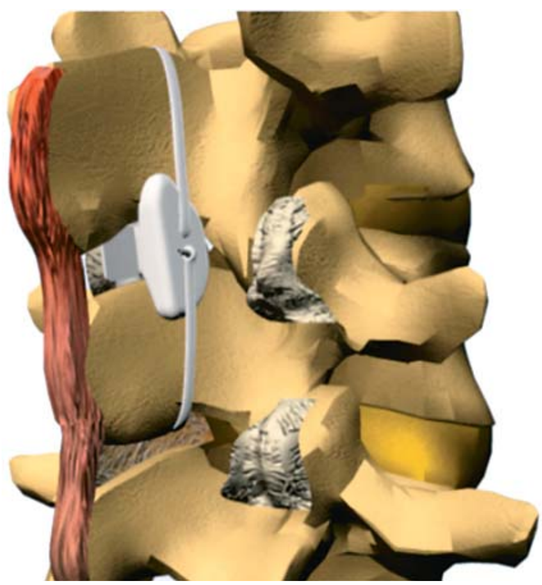
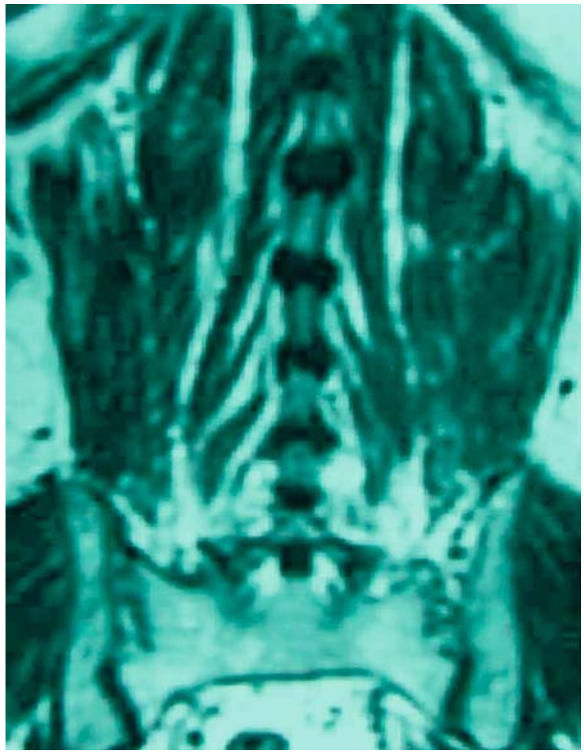


Fig. 50.6. DIAM positioning between the posterior arches



▷
Fig. 50.7. MRI view of the multifidus muscle

The midline muscle group in the back is the multifidus (Fig. 50.7). This is a series of muscles, with each arising from its spinous process and developing insertions to more caudal articular processes and to the sacrum. As seen on MRI images (Fig. 50.8) there is a relatively robust pair of tendons originating from the caudal aspect of each spinous process. The major portion of the tendon arises from the dorsal two thirds of the caudal spinous process. The more ventral aspect of the tendon thins out dramatically as it continues to the medial aspect of the caudal lamina. As the sagittal image demonstrates, there is a plane along the spinous process and over the lamina free of any attachments. Entry in this plane allows retraction of the cephalic fascicles of the multifidus with preservation of the origin of the caudal segment.

The segmental neurovascular supply to the multifidus is the medial branch of the dorsal ramus and the accompanying artery of the pars interarticularis

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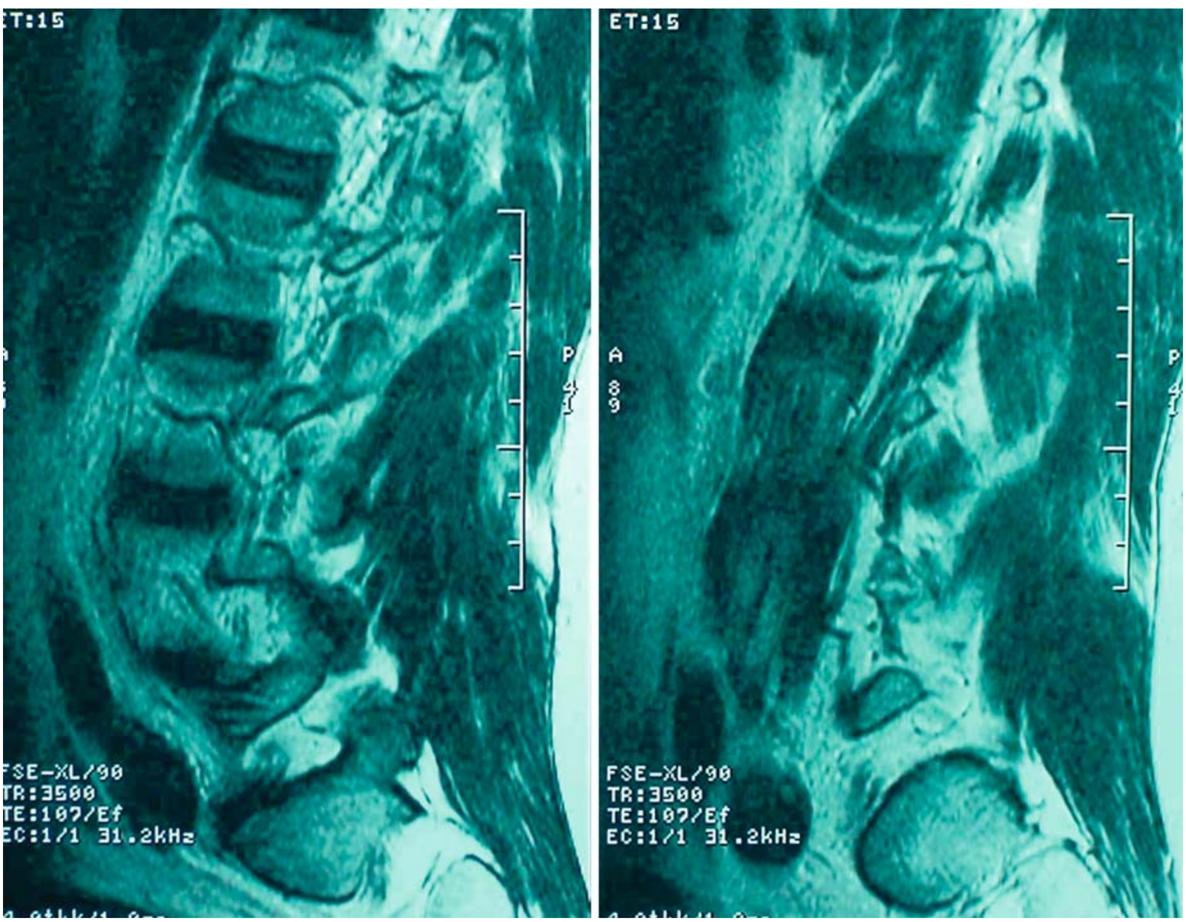
Fig. 50.8. MRI image of the tendons' origin



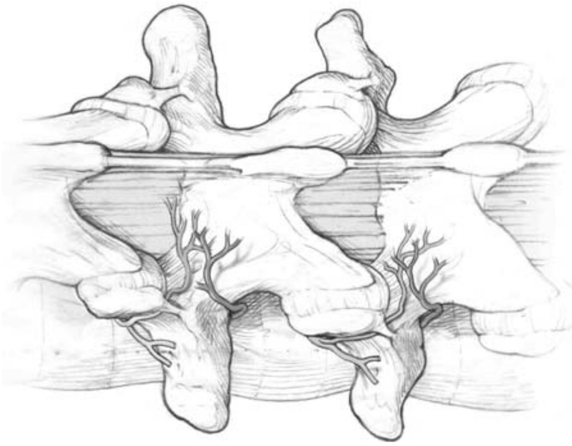


Fig. 50.9. Segmental neurovascularization

Fig. 50.10. Origin of multifidus

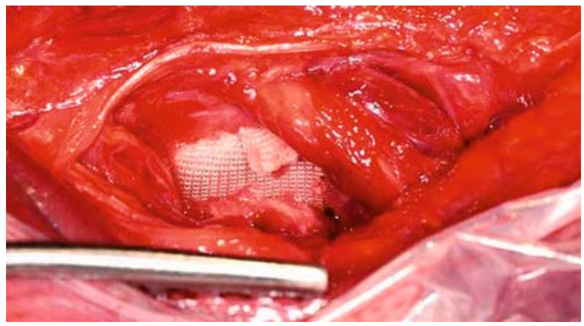


Fig. 50.11. Preserving implantation

(Fig. 50.9). The neurovascular complex penetrates the muscle from the ventral and ventromedial aspect of the fascicle. If one respects this plane with careful retraction of the muscle, the neurovascular supply is generally not compromised. As long as the insertion of the multifidus to the superior articular process is maintained and retraction kept against the bone or facet capsule, the cephalic artery is unlikely to be injured. If exposure in this plane is continued caudal to the joint to the dorsal lamina of the level below there is potential to injure the vessel below; however, this exposure is not typically necessary for foraminal decompression or discectomy. It is a very simple matter to perform a segmental exposure with preservation of the tendon at each level.

The erector spinae is a broad flat tendon covering the back muscles. It is the tendon of the pars thoracis of the erector spinae complex. When viewed from the back the fibers are seen to converge from cephalic to caudal. This tendon has a stout insertion developed at each level to the spinous process. This insertion is to the upper aspect of the spinous process and continues along the dorsolateral margin of the process. When viewed in surgery it is seen as a broad flat tendon. It frequently is appreciated as having a banded appearance with thinned areas allowing visualization of the underlying muscle. It is important to appreciate what happens with flexion and extension of the back. In a young person the disc segment will flex in the order of 15°. With this flexion the spinous processes will separate in the range of 15–20 mm. The banding seen in the aponeurosis allows for a relative shearing motion of the segments of the tendon to deal with changes occurring with flexion.

Approaching the spine from an approach 10 mm or thereabouts from the midline allows preservation of the integrity of the erector spinae insertion while making an approach along the spinous process. One needs to be far enough lateral to the midline to divide the aponeurosis and retract the portion inserting to distal spinous processes adequately for the desired approach to the spine.

The superficial layer of the dorsal lumbar fascia is the aponeurosis of the latissimus. For a discreet approach a medial lateral orientation to open this layer works well or a vertical opening provides as much exposure as desired.

Once retraction of the cephalic fascicle of the multifidus is accomplished the lateral aspect of the origin of the multifidus from the spinous process is seen (Fig. 50.10). This is a well-developed robust tendon arising from the caudal margin of the spinous process. An instrument may be passed deep to the ligament across the midline through the interspinous space. This may entail penetrating the most ventral portion of the tendon as it sweeps to the caudal margin of the lamina, however, this is generally a very thinned out and relatively minor portion of the tendon. Some detachment of the ventral portion of the tendon may be required in some cases for comfortable placement of the device. This places the device in a ventral location on the lamina with preservation of tendon dorsal to preserve the natural dynamic stability of the spine and to help naturally secure the device in its most appropriate location (Fig. 50.11).

50.7.2 Surgical Procedure

General anesthesia is most commonly used for this type of procedure. However, local lumbar anesthesia may also be utilized: spinal or epidural anesthesia. Spinal anesthesia and postoperative epidural analgesia is the recommended protocol for implantation of an interspinous stabilizer:

1. Preparation of the patient.
2. Placement of a peridural catheter (creation of a 5-cm tunnel); the lumbar puncture site is located two levels above the theoretical superior dissected level.
3. Spinal anesthesia is performed one level above the catheter space by infusion of:
   – Bupivacaine chlorhydrate, 15 mg
   – Sufentanyl citrate, 5 µg
   – Clonidine chlorhydrate, 20 µg
   Supine position for 2–3 minutes.
4. Prone position.
5. Cutaneous pain may occur (in rare cases) during incision, due to lack of sensitive block (early prone position) and prevalent motor block.
6. Intraoperatively, systolic arterial pressure is maintained between 90 and 110 mm Hg using:
   – Nicardipine chlorhydrate
   – Ephedrine chlorhydrate
7. Infiltration of muscular compartments is performed prior to closure with ropivacaine chlorhydrate monohydrate. Thus, analgesia is optimized during the first 6 postoperative hours.
8. Postoperatively, continuous infusion of morphine (2–3 mg/day) is performed through the peridural catheter, together with oxymetric monitoring.

50.7.3 Patient Positioning

Preoperative standing lateral radiographs should be carefully evaluated to assess the sagittal balance prior to performing the stabilization procedure. Patient positioning is critical to proper implant sizing and restoration of the proper segmental lumbar lordosis. The patient is positioned prone on the operating table. The use of an adjustable spine frame is recommended to avoid abdominal pressure and vena cava compression. The knee-sitting position can be used, but in this case, the lumbosacral lordosis is lost.

50.7.4 Incision and Preparation of the Implant Site

The most frequently involved level is L4-5. Mean length of the incision is approximately 4–5 cm. Patient size, pathology, and number of levels involved should be taken into account when planning the surgical approach. The incision should be long enough to ensure adequate exposure. The surgical approach is performed using a standard midline incision or a slightly lateral incision (10 mm).

First, anatomical lesions are assessed. The use of a unilateral approach allows decompression of the nerve roots, which is highly recommended in the presence of positive symptoms. It can be a discectomy and/or a foraminotomy (or even a resizing). At this stage, the placement of a contralateral distractor facilitates decompression.

A counterincision is necessary for insertion of the device. A 3- to 4-cm incision is sufficient. It allows preparation for insertion and seating of the device. Whenever possible, care must be taken to maintain continuity of the supraspinous ligament by preserving a band at least 10 mm wide and as thick as possible. After identification of the interspinous space, resection of the remnants of the interspinous ligament is carried out down to the ligamentum flavum. A window is created in the interspinous space using a scalpel that is ideally curved upwards, and then enlarged with curved Kerrison forceps and a Sicard rongeur (modified), taking care to preserve cortical bone. This step is critical and requires extreme caution; using excessive force due to tissue entrapment may result in fracture of the spinous processes. In cases of overlapping and hypertrophic laminae (kissing laminae), trimming is recommended. Similarly, in cases of a kissing spine involving the spinous processes, trimming of their lateral hypertrophic aspect is necessary. At this stage, the interlaminar distractor can be inserted as far anteriorly as possible, at the junction between the base of the spinous process and the laminae.

Note: during mechanical distraction achieved by spreading the laminae, care should be taken to apply loads that do not exceed the bony stiffness. If resistance is felt, the interlaminar bony bridges must be resected. Otherwise, fracture of the base of the spinous processes may occur, which will make implantation of a prosthesis impossible.

The distractor is used to spread the overlapping laminae. It is important to rely on:

1. Retensioning of the supraspinous ligament.
2. Realignment of the facets and articular capsules.
3. Excessive distraction might result in excessive pressure on the anterior aspect of the disc. In case of doubt, interlaminar distraction must be readjusted under fluoroscopic guidance. Parallel alignment of the endplates can be used as a reference for retensioning of the posterior longitudinal ligament.

Note:

1. An optimal interlaminar space is maintained at all times thanks to the flexibility of the device, which provides pain relief.
2. Weight bearing results in preloading of the prosthesis; this, combined with posterior tension banding, provides restoration of local lordosis.

50.7.5 Implant Insertion

50.7.5.1 Implant Selection

The appropriate trial (sizes available in 2-mm increments, from 8 to 14 mm) is positioned between the grooves of the distractor to determine the appropriate implant size.

50.7.5.2 Inserter

The implant is positioned on the claw of the inserter. The tips of two lateral wings are grasped within the spatulated jaws. Approximation of the jaws results in folding of half of the implant (Fig. 50.12). Thus, the implant can be easily inserted into the space previously created with the distractor. The spatulated jaws can be readjusted to tightly hold the folded implant and prevent anterior bulging of the device.

At this stage, the distractor may be used to temporarily slightly overdistract the interlaminar space, and thus facilitate insertion of the implant. Then, while firmly holding the implant, the inserter is positioned in the interspinous space. First, the opposite ligament is passed beneath the supraspinous ligament. Then, the implant is inserted and driven to the opposite side with the claw. Pressing the trigger of the inserter both activates the claw and pulls back the arms of the inserter, which allows unfolding of the wings, bringing them into contact with the spinous processes (Fig. 50.13). Then, the inserter can be removed.

Note: In case of central stenosis (Fig. 50.14), partial laminectomy requires a midline approach, and the supraspinous ligament is sacrificed. In this case, the implant is inserted from posterior to anterior without using the inserter.

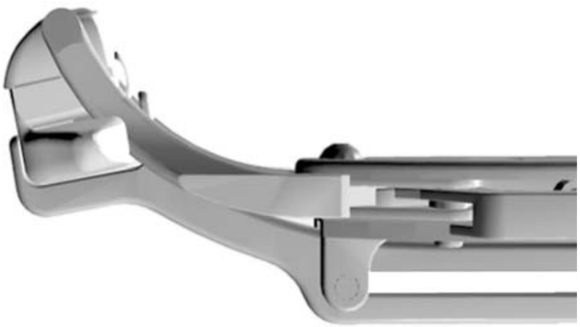


Fig. 50.12. Jaws folding the implant's wings

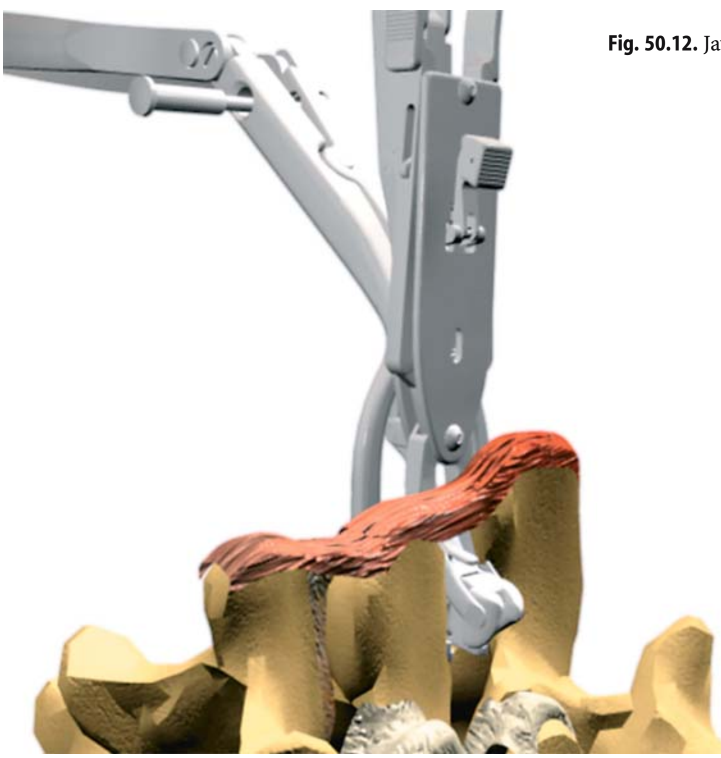


Fig. 50.13. Introduction of the implant

Fig. 50.14. Alternative indication of midline approach

50.7.6 Final Positioning

The impactor is placed on the top of the implant and the DIAM is pushed down using a few mallet blows, until it reaches the distractor legs. Then the distractor is removed, and the device is optimally seated as far anteriorly as possible, close to the facet joints. The wings of the device must rest on the laminae. The tag is sutured to the supraspinous ligament.

50.7.7 Ligament Fixation

The posterior interspinous stabilizer is packaged with two independent ligaments that attach to each adjacent spinous process. Each ligament is inserted into the adjacent overlying and underlying interspinous spaces and passed through the loop. The ligament is cut below the needle (at the rigid segment). This stiff portion must be carefully sectioned obliquely with a scalpel to facilitate insertion of the titanium rivet. Then the rivet is brought down to the loop (Fig. 50.15). The ligament is tensioned and secured with the crimper. The rest of the ligament is cut off and removed.

50.8 Postoperative Care

No special postoperative measures are necessary. The patient is allowed to mobilize within the first hours after surgery.

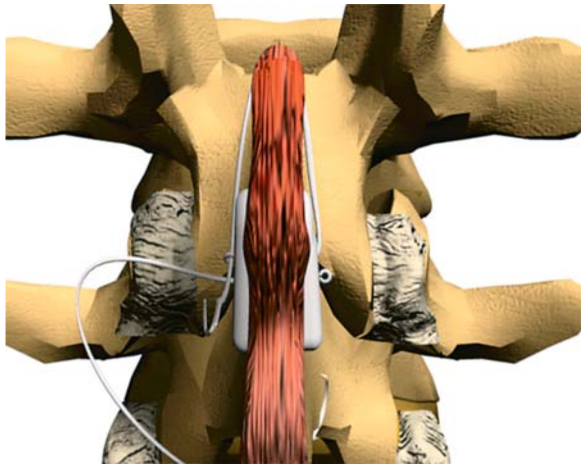


Fig. 50.15. Fixation of the independent ligaments

50.9 Hazards and Complications

Careful sizing of the implant will ensure the outcome of the procedure. Too small an implant may not provide adequate decompression and over sizing may create undesired discal kyphosis.

50.10 Conclusion

A posterior interspinous stabilizer is effective in reducing the increased segmental flexion–extension motion that is observed after a discectomy or partial facetectomy. Realignment of the facet interface restores the facet congruity. Distraction of the neural arch results in enlargement of the neural foramen, relieving neural compression.

Two retrospective studies have been performed by independent observers according to the Dallas Pain Questionnaire (DPQ) self-assessment protocol designed by Lawlis, McCoy, and Seldy. These studies involved 125 patients with 36 month follow-up, and 104 patients with 18 month follow-up, respectively. The mean age of the patients was approximately 50 years. Level L4-5 was the most frequently instrumented. Two in three patients had improvement in function. The failure rate was 10%, whereas the satisfaction rate exceeded 80%. Interestingly, in each study, results on pain kept improving for at least 18 months, and then diagrams showed progressive inversion of the curves.

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