Epidural Fibrosis Seen from a Different Angle: Extraforaminal Lumbar Interbody Fusion

Arthur Robert Kurzbuch[1] Didier Recoules-Arche[1]

[1] Neurochirurgie, Groupe Hospitalier du Havre, Le Havre, France

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Address for correspondence Arthur Robert Kurzbuch, MD, Neurochirurgie, Groupe Hospitalier du Havre, BP 24 Le Havre 76083, France (e-mail: kurzbuch@web.de).

Abstract

Background Postoperative epidural fibrosis (PEF) localized around the exposed dura and nerve roots is a known radiologic entity seen after lumbar surgery. Although excessive PEF is associated with residual and new lumbar pain and radiculopathy, its role as the generator of the pain is still discussed. Various materials acting as an adhesion barrier have been tested. There is no undebated class I evidence that any one of them is suitable to reduce or avoid PEF and provide a better clinical outcome. In revision surgery, the dissection of epidural scar tissue is time consuming and related to an elevated risk of dural tear and nerve damage. To avoid the formation of posterior PEF, we propose a surgical approach whose working corridor is situated lateral to the dural sac and the nerve roots: the extraforaminal lumbar interbody fusion (ELIF) technique.

Methods Description of ELIF surgical technique.

Conclusions The ELIF technique is a muscle-sparing approach to the intervertebral disk space and the spinal canal that avoids the formation of posterior PEF. It represents an option to treat various degenerative lumbar spinal diseases as well as offering another approach for revision surgery in patients who have developed PEF.

Keywords
- epidural fibrosis
- complication
- lumbar interbody fusion
- muscle preservation
- extraforaminal approach

Introduction

In 1948, Key and Ford attributed the appearance of epidural fibrosis to the iatrogenic injury of the anulus fibrosus after lumbar diskectomy.[1] In 1974, LaRocca and Macnab observed the formation of a "laminectomy membrane" after lumbar laminectomy.[2] The peridural fibrosis filled the laminectomy defect completely, covering the exposed dura and nerve roots.

It is still being debated whether postoperative epidural fibrosis (PEF) should be considered a consequence or a complication of spinal surgery. Today it is generally recognized that PEF is to a certain extent an ubiquitous finding around the exposed dura and nerve roots.[3–8] The formation of this tissue can be excessive and is associated with lumbar pain, radiculopathy, and disability.[3,9] Up to now, however, the diagnostic and prognostic impact of epidural scarring is not undoubted.[10] It is partially considered as a radiologic finding not correlated with clinical symptoms[10] and partially as the cause of recurring pain and failed back surgery syndrome (FBSS).[8,10–16] Clinical studies have affirmed and others denied a positive correlation between excessive fibrosis and clinical course.[5,15,17–19]

Despite some optimistic descriptions of reoperations for excessive PEF, it is generally discouraged because it may cause even more excessive scaring and also because the role of PEF in the generation of pain is questioned.[18–21] PEF complicates the reexposure of the surgical site with an elevated risk for dural tear and nerve damage, and it is time consuming. Reoperations for spinal fusion are associated with more complications because of wider surgical exposure than revision surgery for herniated disks or laminectomy.[22]

Etiology of Postoperative Epidural Fibrosis

By exposing and opening the bony spine, the extra- and intracanal compartments of the spine merge. Due to surgical manipulation, the single elements of this newly created unit interact and are the object of chemical reactions and mechanical alterations. The emerging scar tissue then

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connects the former separated structures and has to be dealt with in a reoperation.

The single steps of the surgical procedure and the related trauma of the structures supposedly contribute to the development of fibrous scar formation. After muscle dissection and bone removal, fibroblasts descend from the periosteum and the paraspinal muscles, and invade the postoperative hematoma.[23] The hematoma is then organized and converted to granulation tissue and finally to epidural scar tissue.[24] The damage of the annulus fibrosus releases inflammation-mediating substances like interleukin 6 and 8 and tumor necrosis factor enclosed in the intervertebral disk that favor the development of scar tissue.[25–27]

Particles of cotton from surgical swabs remaining in the surgical field are also considered a factor in promoting PEF.[28,29] The same applies to the manipulation and compression of epidural veins, the mobilization of nerves with the root retractor, and the use of bipolar coagulation, whereas the thermic damage of monopolar cautery is not well examined.[4,19,29,30]

Epidural fat is especially localized in the posterior epidural compartment and reaches the intervertebral foramina.[31] Its sliding function is attributed to its semifluid texture. PEF replaces epidural fat and attaches to the dural sac and nerve roots. The resulting tethering and compression reduce mobility and may provoke mechanical or ischemic damage of neural and vascular structures when the spine moves.[11,23,24,32] Mechanical alterations of the spine like postoperative instability and sagittal plane deformity may also favor PEF formation.[4]

Postoperative Epidural Fibrosis: Strategies for Avoidance and Reduction

Because epidural scarring is categorized as one of the major causes of FBSS,[8] numerous publications have presented strategies to avoid or reduce its occurrence:

Restricting the surgical field potentially reduces the amount of PEF but may increase the risk for neurovascular lesions and dural tears due to limited exposure. Bipolar coagulation can be used sparingly to reduce its thermic damage, but nevertheless accurate hemostasis should be done to avoid postoperative hematoma. The insertion of a drain after surgery possibly decreases the incidence and the volume of postoperative hematoma and consecutive PEF, but a better clinical outcome is controversial.[7,8]

To shield the dura and the nerve roots with autologous material, the deposit of fat grafts was performed. The effect on clinical benefit, however, is debated, and its use is not without risks.[5,9,33–36]

A vast number of substances and materials acting as an adhesion barrier between the dura and the surrounding structures have been tested: nanofiber nets,[3] hyperbaric oxygen,[37] mesna,[23] hemostatic agents,[38] sodium hyaluronate,[39] viscous carboxymethylcellulose,[40] Gelfoam,[36] ADCON-L gel (Gliatech, Cleveland, Ohio, United States),[41–43] anti-adhesion gels,[27] Manuka honey,[12] mitomycin C,[44] morphine-vaseline sterile-oil,[45] medicated adhesion barrier,[46] and dehydrated human amnion/chorion membrane.[47] The use of some of the materials was restricted or related to complications.[48] For other substances there are contradictory studies promoting or negating their efficacy on the amount of PEF and the clinical benefit.[41–43,48] There is no undebated class I evidence that one of these materials or substances is suitable to reduce or avoid PEF and furnishes a better clinical outcome.

Methods

Postoperative Epidural Fibrosis Seen from a Different Angle

Because PEF probably has a multifactorial origin and affects the dural sac and the nerves roots, we aimed to develop a surgical technique that bypasses these key structures. We created a surgical approach without traumatization of the paraspinal muscles that leaves the bone of the lamina, the yellow ligament, and the posterior epidural fat intact, thus avoiding the formation of PEF.[49] Extraforaminal lumbar interbody fusion (ELIF) surgery targets the intervertebral disk space and structures within the spinal canal with a working corridor situated laterally from the dural sac and the nerve roots.

From a posterior position, the lumbar spine is accessible with midline or paraspinal approaches. The ELIF and the Wiltse concepts are paraspinal approaches suitable for lumbar interbody fusion surgery that have in common the same intermuscular cleavage plane.[50,51] However, both approaches diverge from the angle at which the disk is targeted. The Wiltse technique accesses sagittally or slightly angled relative to the midline the facet joints that are removed to realize transforaminal surgery.[51] The ELIF approach, on the contrary, is angled 45 degrees relative to the midline, so the dural sac and the nerve root are bypassed and the disk is approached laterally from the facet joints that do not have to be removed (►**Fig. 1**).[50]

Description of the Extraforaminal Lumbar Interbody Fusion Surgical Technique

We describe the ELIF technique that from the beginning of the procedure respects an angle of 45 degrees relative to the midline (►**Fig. 1**):

For all levels from L1 to S1, the skin is incised at 10 cm from the spinous process line in a curvilinear fashion of 8 cm in length along the iliac crest. The subcutaneous tissue is cut, and the thoracolumbar fascia and the erector spinae aponeurosis (ESA) are exposed. One of the key structures is the intertransverse space situated under the ESA. It is accessible by following the natural cleavage plane between the multifidus muscle and the longissimus thoracis muscle pars lumborum (►**Fig. 1**). The ESA is first cut along the inner edge of the iliac crest and then cranially 5 to 6 cm in length. The fatty cleavage plane between the multifidus muscle and the longissimus thoracis muscle pars lumborum is then opened bluntly and followed to the junction of the lateral part of the facet joint and the transverse process. The superior edge of the inferior transverse process runs parallel to the intervertebral space and serves as an anatomical landmark for access to the disk.

Pedicle screws are inserted and after distraction, an extraforaminal diskectomy is performed. The extraforaminal exposure also provides access to the foramen and space-

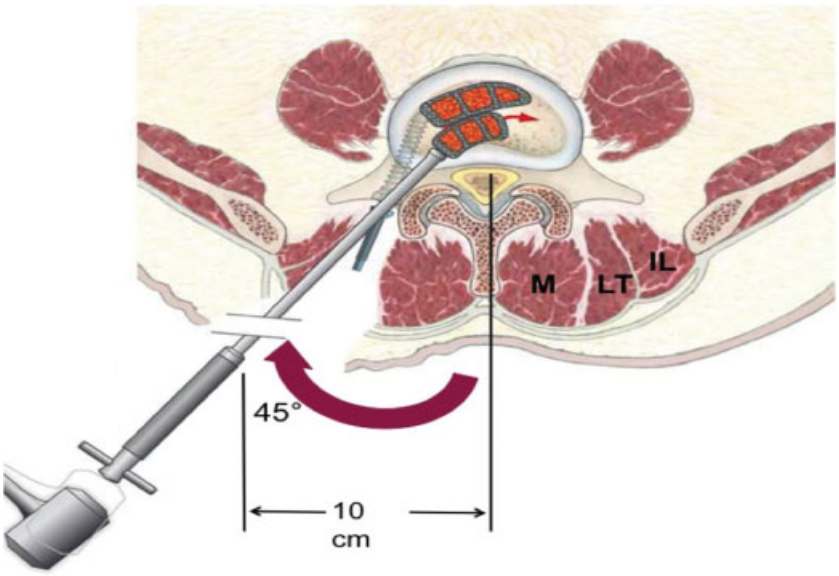

Fig. 1 The extraforaminal working corridor to the intervertebral disk space following the intermuscular cleavage plane between the multifidus muscle and the longissimus thoracis muscle pars lumborum. Two C-shaped cages are inserted. IL, iliocostalis muscle; LT, longissimus thoracis muscle pars lumborum; M, multifidus muscle.

occupying lesions within the canal that can be removed. Thus concomitant foraminal stenosis or herniated disks can be treated by performing the ELIF approach. Respecting an angle of 45 degrees relative to the midline, there is no risk for the exiting nerve root that transverses the disk space more laterally. Two special C-shaped carbon composite cages (coLigne AG, Zürich, Switzerland) filled with autologous bone marrow from the posterior iliac crest (►**Fig. 1**) are then inserted: The first and bigger one will be pushed forward to its final position by the second smaller one. Distraction is released and the pedicle screws are linked with a carbon composite plate or titanium rod.

Indications for ELIF

ELIF surgery is a muscle-sparing approach (►**Fig. 2**) that avoids the formation of PEF as confirmed by postoperatively performed magnetic resonance imaging with gadolinium:

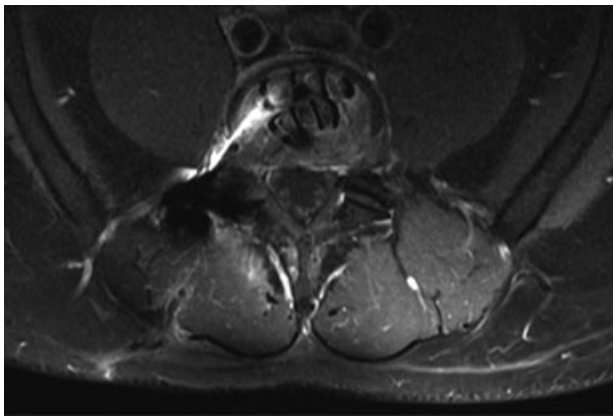

Fig. 2 T1-weighted axial magnetic resonance image with gadolinium 6 months after L4–L5 extraforaminal lumbar interbody fusion from the right side reveals the integrity of the paraspinal muscles. Note the absence of epidural contrast enhancement.

We applied this technique to the treatment of degenerative lumbar spinal diseases such as degenerative disk disease, disk herniation, recurrent disk herniation, foraminal stenosis, and Meyerding grade I and II isthmic spondylolisthesis.[50,52] For the revision surgery of patients who have developed PEF with another approach, the ELIF technique, due to its angle of 45 degrees, is a suitable option. It affords less operation time and there is less risk of dural tears or neural damage because the installed PEF is localized outside the working corridor.[49] ELIF is also an alternative for anterior lumbar interbody fusion surgery if an anterior approach is contraindicated.

Conclusions

The impact of PEF on the clinical course after lumbar spinal surgery is still unclear. There is no class I evidence indicating how excessive PEF after posterior or posterolateral spinal surgery can be avoided or reduced. ELIF surgery is an extraforaminal approach that does not cause posterior PEF due to its angle of 45 degrees relative to the midline. This technique represents an option to treat various degenerative diseases of the lumbar spine and is also suitable for reoperations of patients who have developed PEF after a previous surgery performed with another approach. Prospective studies are needed to compare the clinical and radiologic outcome of the ELIF procedure with other lumbar interbody fusion techniques.

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