Chapter 16
Microsurgical Approach for the Treatment of Juxtafacet Synovial Cysts of the Lumbar Spine

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Introduction

Synovial cysts and ganglia can arise from any synovial-lined articulation or tendon sheath, affected by osteoarthritis or rheumatoid arthritis. They are encountered predominantly in the extremities, especially at the wrist and knee. However, they can be associated with any diarthrodial joint in the body. The disease is caused by cystic dilatation of the synovial membrane of the joints. Compared with the number of lesions involving the extremities, spinal localization is considered a rare finding. Nevertheless, over the last few years, synovial cysts of the spine have been increasingly reported, probably due to the availability of high-quality CT and MRI [1]. Intraspinal development of this kind of cystic lesion may be asymptomatic or responsible for back pain and neurological disorders. Classically, there is a predilection for these cysts to develop at the L4–L5 facet joint, which is known to be the most mobile segment and the point of maximum axial loading of the spine. This particular predilection for cysts to occur adjacent to the L4–L5 facet joints has also been attributed to the amount of degenerative spondylosis at that level of the spine. Synovial cysts can also be detected in the presence of L4–L5 degenerative spondylolisthesis [2].

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History and Nomenclature

In 1877, Baker originally described synovial cysts as being secondary to processes occurring within an adjacent degenerated joint. He reported a cyst in a patient with osteoarthritis of the knee, a condition since named for him. Soon after Baker published his description, in 1880 Von Gruker reported an intraspinal cyst found at autopsy. Subsequently, many cases of these lesions that arise from the facet joints of the spine have been reported in the neurosurgical, orthopedic, rheumatological, and radiological literature. In 1950, Vosschulte and Borger were the first to report associated nerve root compression secondary to a cyst adjacent to the facet joint [3].

Regarding the nomenclature of synovial cysts arising from (or adjacent to) the lumbar zygapophyseal joint, the literature presents a broad range of variation. Historically, the term *juxtafacet cyst* was first introduced by Kao et al. in 1974 to characterize two types of periarticular cystic alterations, synovial and ganglion, that can occur in the paraspinal region. It often is not possible to distinguish clearly between these two forms of periarticular cysts. Also, synovial or ganglion cysts have been described in the ligamentum flavum, interspinous ligament, and lumbar annulus. In 1992, Goffin et al. used the term *spinal degenerative articular cysts* to identify such lesions arising specifically from the facets [4].

Therefore, some confusion still exists today over the terms *synovial cyst* and *ganglion cyst*, used interchangeably with respect to cysts found within the spine.

Histological Pictures

In 1997, Rosenberg and Schiller pointed out that the distinction between synovial and ganglion cysts is of pathological interest only. With respect to clinical presentation and treatment, the two lesions share identical characteristics and responses.

It is thought that, over time, microtrauma associated with the degeneration process leads to weak areas in a joint's capsule. A herniation of synovium occurs and the newly formed cavity is filled by the synovial fluid, until the formation of a cyst directly communicating with the joint. When the cyst loses its connection with the adjacent joint, mixoid degeneration, typical of ganglion, may begin.

A synovial cyst is filled with clear or xantochromic fluid, has a synovial-like epithelial lining, and, as indicated earlier, a demonstrable communication to a synovial sheath or joint capsule. In most instances, such operation to remove the cystic formation takes place a shorter or longer time after a synovial cyst has formed and produced clinical symptoms. During that time period, secondary changes due to mechanical pressure, inflammation, and hemorrhage into the cyst lumen can alter the delicate synovial villi originally lining the cystic wall.

In the preserved cysts, there are synovial villi with well-vascularized stalks covered by multiple layers of normal-appearing synovial cells and, generally, the formation of a precipitated fibrin layer on their luminal side. In the more advanced stage, the synovial lining cells completely disappear and are replaced by layers of

fibrin. Sometimes, the stroma contains hemosiderin-laden macrophages or, in other cases, chondroid metaplasia takes place. In the final stage, the cyst wall is transformed into dense, acellular hyalinized scar tissue with moderate to severe calcification.

Ganglion cysts have a collagenous capsule without a mesothelial cell lining, are filled with a mixoid material, and do not communicate with the joint cavity. For these characteristics, it has been proposed that a synovial cyst may evolve into a ganglion cyst by losing its communication to the facet joint and subsequently may undergo mucinous degeneration. Unfortunately, to add further confusion, it has been reported that, within a ganglion cyst, the synovial-like lining can reproduce [5].

Hemorrhagic Variant

The hemorrhagic variant is a rare occurrence: few cases of acute intracystic bleeding have been described in the literature. It is likely that intracystic bleeding leads to severe compression of the nerve roots and/or the spinal cord, thus justifying the patients' acute symptomatology [6–9]. The hemorrhagic nature of these cysts is attributable to neoangiogenesis due to chronic inflammation. In our report, we distinguished blood or hemosiderin deposits that indicate bleeding; the former were observed when there had been recent massive hemorrhages, while the latter were associated with smaller hemorrhages. The presence of vascular neoendothelium was observed within the cystic formation. Tatter and Cosgrove [10], on the basis of that demonstrated by Koch et al. [11] and by others [12, 13] regarding the release of angiogenic factors during inflammation, suggested a correlation between the production of the vascular neoendothelium, proliferation of new vessels into the synovial structures, and the chronic inflammatory processes that accompany the evolution of a synovial cyst. We endorse the etiological hypothesis that attributes repeated hemorrhage to the rupture of these neo-formed vessels. Furthermore, the neoangiogenetic nature of these vessels justifies their fragility and consequent tendency to rupture, even in the absence of a significant traumatic event [14].

Classification

From a morphological point of view, cysts are generally classified into:

- Juxtafacet cysts
  - Synovial cyst: in continuity with the capsule of the facet joints
  - Ganglion cyst: the cyst loses continuity with the capsule of the facet joints and it is free inside and/or outside the spinal canal
- Cysts of the ligamentum flavum
- Cysts of the posterior longitudinal ligament

As outlined above, true synovial cysts have a synovial lining membrane that communicates with the facet joint. Ganglion cysts, in opposition, have no synovial lining and develop from mucinous degeneration of the periarticular tissue and usually contain proteinaceous fluid.

True synovial juxtafacet cysts are thought to be more commonly located on the dorsal aspect of the facet joint and, therefore, they are asymptomatic. Other cysts are dumbbell shaped or purely ventral. In a large series reported by Sachdev et al. in 1991, 31 of 42 cysts (73 %) were incidental dorsal nodules and only 11 (27 %) were ventral and symptomatic [15].

Ligamentum flavum and posterior longitudinal ligament cysts usually contain clear or xanthochromic fluid and also present no real communication with the facet joint.

Although some authors have previously defended that such morphological differentiation does not bear any clinical significance, as one cyst type could evolve into the other and, ultimately, all of them would receive the same surgical treatment based on cystectomy, it is possible to distinguish such entities after a careful preoperative evaluation of the neuroradiological investigations. In our opinion, this is essential for the decision-making process and useful to apply the best surgical procedure to correctly remove the real cause of pain.

Etiology

The etiology of synovial cyst is still unclear. Possibilities include extrusion of synovial fluid from a defect in the joint capsule, myxoid degeneration of cyst formation in collagenous connective tissue, increased production of hyaluronic acid by fibrobrast, and nonspecific proliferation of mesenchimal cells [16, 17].

Abnormal or increased motion appear to have some role in many synovial cysts. The relationship to increased motion is strong, as most cysts arise at L4–L5 level, in presence of spondylolistesis or scoliosis, as reported by Sabo et al. in 1996 [15].

The role of trauma has been frequently questioned. The hemosiderin in many of the pathological specimens seems to be one of the stronger arguments for the role of trauma [18].

Ultimately, the most likely hypothesis attributes these cysts to a natural process of degeneration of the facet joints, although a less plausible correlation with injury at the same level has been proposed. In particular, we believe that synovial cyst is an epiphenomenon of spinal motor unit degeneration. It can be configured in a more complex picture of metameric degeneration. In fact, the articular processes represent only one of the multiple components of the motor unit that may be degenerated: many other components of active and passive movement control may be involved in the pathological degenerative process, such as intervertebral disk, LLA, LLP, ligamentum flavum, inter- and supraspinous ligaments and paravertebral muscles, particularly longissimus dorsi and multifidus. Clearly, a more complex picture of degeneration, involving more than two elements, may define a condition of “suspect

instability." In the advanced stages of metameric degeneration, true synovial cysts can be considered the last involvement of the zygapophysial joint, which, after becoming loose and widened, presents partial herniation of the synovial content to the periarticular space. In such cases, even if part of the facet joint is preserved, the long-term risk of instability is high, and various grades of spondylolisthesis may accompany cyst formation [19].

The association between juxtafacet synovial cysts and instability has been discussed in literature. Onofrio and Mih [20] reported that, in a series of 13 patients, two of five patients who had postoperative radiographic control had signs of instability. Eight of twelve lumbar cysts examined by these authors were associated with spondylolisthesis. However, they performed no fusions and a number of their patients continued to have chronic back pain. Freidberg et al. described only 1 patient with late instability out of 26 patients, following surgical cyst excision. Feldman and McCulloch reported 6 cases of juxtafacet cyst requiring surgery. Of their 4 patients with spondylolisthesis, 2 required fusion, 1 at the original cyst resection and the other at 2-year follow-up for backache. Kurz and colleagues described 4 patients with symptomatic synovial cyst and found 3 with spondylolisthesis. They performed no fusion and the patients did well. In contrast, Yarde et al. reported [21] that 2 patients from a series of 8 who had spondylolisthesis underwent lumbar fusion in addition to cyst excision. Finally, Sabo et al. [15] performed 7 fusions in 15 spondylolistheses, concluding that fusion should be considered at the time of first operation if the patient is deemed unstable or at high risk of becoming unstable following mesial facetectomy.

Clinical Presentation

Most of the patients with lumbar synovial cyst tend to be in their sixth decade of life with a slight female predominance. The incidence of lumbar synovial cyst is thought to be less than 0.5 % of the general population with back pain. It may be asymptomatic and found incidentally [22].

Epidural expansion of lumbar synovial cyst into the spinal canal can cause, more or less rapidly, compression of neural structures. Most of the symptomatic patients present with radicular pain and neurological deficits (claudicatory pain), located more often at L4–L5 level. More frequently, symptoms are unilateral and monoradicular, though some authors report bilateral and/or multilevel disturbances [23]. Rapid enlargement of the cyst may be responsible for cauda equina syndrome [24].

The onset of symptoms is usually progressive, according to the slow degeneration of the spinal motor unit. But, in particular cases, onset may be sudden, due to a rapid increase in volume or as a result of massive bleeding within the cyst. In fact, the hemorrhagic variant of lumbar synovial cyst usually differs from the nonhemorrhagic one in terms of onset, pain intensity, and response to pharmacological treatment.

The cause of the acute onset of symptoms in case of sudden bleeding is still a matter of debate. It is not clear whether pain is due to the rapid expansion of the cyst or to nerve root irritation subsequent to an inflammatory reaction to the hemorrhage. In our opinion, expansion of the cyst after bleeding is the cause of symptoms because this occurs even in rare cases of rapid growth of the cyst without hemorrhage [25].

As stated by Roessaux et al. [26], when there is internal bleeding, a massive hemorrhage (macro-hemorrhage) might occur, producing a sudden increase in size and, consequently, a mass effect responsible for an acute and severe compression of the nervous structures. It is likely that in cases of micro-hemorrhage that might occur repeatedly, the compressive mass effect is usually moderate, producing a persistent subacute symptomatology.

Radiological Investigation

Sophisticated and newer imaging capabilities have resulted in increased reporting and treatment options of lumbar synovial cyst.

Diagnosis is currently made easier by MRI, which is the gold standard [27, 28]. The imaging signal can be variable, depending on the type of fluid within the cyst. When there is a serous fluid, as in case of simple synovial cyst, there is a low-intensity T1 signal and a hyperintensity on T2-weighted images. With the proteinaceous content of the ganglion cyst, there is hyperintensity in comparison to cerebrospinal fluid on all sequences. Usually, a low-intensity rim surrounds the cyst on T2-weighted images of both ganglion and synovial cyst. After gadolinium administration, ring enhancement, associated with inflammatory processes, is visible.

In presence of intracystic bleeding, the MRI signal is extremely variable owing to the hematic content of the cyst that differs according to the amount of time that has passed since hemorrhage. Intracystic hemorrhage, generally referred to as subacute, typically appears as heterogenous hyperintensity on all sequences due to the metahemoglobin it contains. However, when there are blood products older than 7 days, there may be areas of hypointensity on T2-weighted sequences. The hypointense rim reflects a combination of hemosiderin deposits, fibrous capsule, and calcification in the cystic wall. After gadolinium, ring enhancement is detected.

MRI is also important for a correct differential diagnosis from other pathologies that may have a similar clinical presentation. The differential diagnosis of synovial cyst includes a herniated nucleus pulposus, especially a free extruded fragment. With the accuracy of MRI, signal characteristics can often distinguish a cyst from a disk fragment. Neurofibroma, hematoma, meningioma, abscess, lipoma, and metastatic disease also may be included in differential diagnosis. The use of gadolinium, as well as the signal change, should assist in an accurate diagnosis. One other rare but important process that needs to be considered in the differential diagnosis is

pigmented villonodular synovitis. In 1996, Giannini et al. described a series of 12 patients with pigmented villonodular synovitis of the spine. This is a benign neoplasm of histiocytic origin that is noted histopatholocically and a hypercellular area with hemosiderin and multinucleated giant cells. Pigmented villonodualr synovitis located at other joints has undergone malignant transformation and, therefore, requires synoviectomy [15].

Juxtafacet cysts also require differentiation from perineural and arachnoid cysts. The perineural cyst arises from the posterior root ganglion. It is usually quite small and its cyst wall contains nerve fibers. The arachnoid cyst has a pedicle attachment to the spinal dura near the nerve root. It is usually single and may be longitudinally elongated over several spinal levels. The arachnoid cyst has a connective tissue capsule and may fill with contrast material approximately 50 % of the time.

Although MRI is indicated as the best instrument for diagnosing of juxtafacet lumbar synovial cyst, CT scan also provides abundant information regarding the nature, type, and evolution of the lesion [29]. The cyst often has a calcified rim and there may be gas in association with the facet joint space. Bone erosion has been described, but is uncommon. Hemorrhage increases the density of the soft tissue mass that originates from the articular processes, which are generally severely arthrotic. Peripheral and internal calcification may be present at the chronic stage after hemorrhage. Moreover, CT may be useful to evaluate the inclination of the facet joints, which can be a predisposing factor for instability. Finally, dynamic X-rays are important preoperatively to exclude instability and indication for spinal fusion [15, 30].

Treatment Options

Treatment options are various, ranging from conservative to standard open surgical procedures. Conservative treatment modalities include no treatment, bed rest, oral analgesics, physical therapy, brace, chiropractic care, CT-guided needle aspiration, or intraarticular injection of corticosteroid drugs. Surgical procedures are different, from minimally invasive technique to standard open procedures, with or without instrumentation and fusion. The literature describes simple laminotomy with cystectomy, laminectomy, foraminotomy, mesial facetectomy, and/or fusion when necessary.

There are some considerations regarding treatment:

1. Nonsurgical treatment can achieve unsafe and nondurable results (aspiration of the cyst, instillation of steroids, physiokinesitherapy, and more)
2. Surgical treatment can obtain a complete resolution of symptoms in a high percentage of patients with a low incidence of complications.
3. Identification of the best surgical option requires knowledge of the biomechanics of each individual patient's spine.

Microsurgical Approach

Operative Technique

Under general anesthesia, the patient is positioned prone and intraabdominal pressure is minimized. After surgical preparation, draping, and level control by means of fluoroscopy, a 2 cm midline incision is made. We perform a monolateral lamina exposure without using a monopolar device to prevent muscle damage and with the aid of a dedicated bivalve retractor. Exposing the bone more laterally, we can completely identify the articular process. Using curets, rongeurs, Kerrison punches, and/or high-speed drill, laminotomy is performed. After removal of the ligamentum flavum, the intraspinal cyst is identified. With microscope, as for microdiscectomy, the lesion is dissected off the adjacent dura and nerve root to the level of its attachment to the facet joint. The associated capsule is sharply removed along with the cyst. The laminotomy is then safely widened, with preservation at least of two-thirds of the medial facet. The root is retracted medially and the canal is explored to exclude disk herniation (no disk tissue was discovered to be causing of radicular pain in any of our patients). Nerve root mobility is tested to exclude any residual stenosis. A free fat graft or anti-adhesions gel is placed over the exposed dura and closure is routine.

The patient may be allowed out of the bed on the following day. The remaining postoperative management and rehabilitation are the same as after disk surgery.

Personal Experience

In our experience, the surgical approach has always been microsurgical [30]. Laminotomy with preservation of the medial articular facet is our preferred technique to expose the cyst, so that it can be entirely removed. This particular attention in bone resection is extremely useful in order not to jeopardize vertebral stability and to avoid the need for fusion. In fact, correlation between total removal of the facets and the onset of symptomatic spondylolisthesis is reported in literature.

Bone exposure, performed without using the monopolar device, is useful to prevent muscle atrophy. By using operative microscope, performing a light removal of the one-third of the medial facet of the articular mass, we can identify the capsular origin of the cyst and excise it completely. Resection of the joint capsule ensures prevention of any recurrence.

Another microsurgical option is a decompression and removal of the cysts through a contralateral laminectomy approach [31]. A comparison between the angle of approach, provided by the contralateral laminectomy, and the ipsilateral one shows that the contralateral laminectomy achieves additional access to the lateral recess, which is not obtainable through an ipsilateral approach without resection of the facet. We have never used this approach; however, this approach is described as useful in case of extension of the cyst through the lateral recess.

Recently, minimally invasive techniques for removal of the synovial cyst have been described [32]. The technique most widely used is performed by an 18-mm incision approximately 15 mm lateral to the midline. A K-wire under fluoroscopic control is

used to penetrate fascia and muscles. Serial dilators are passed over the wire and docked at the junction of the lamina and facet. Lateral fluoroscopy is again used, this time to confirm proper positioning of the tubular retractor. With visualization provided by the operative microscope, the thin layer of soft tissue over the lamina and medial facet is removed using monopolar cautery. A curette is used to expose the inferior edge of the lamina. A Kerrison instrument and/or high-speed drill is then used to perform the laminotomy and medial facetectomy. If a complete hemilaminectomy is required, the tubular retractor can be angled more medially and the patient tilted away from the surgeon to provide a more contralateral view. The pedicle frequently serves as an excellent landmark from which to determine the extent of necessary lateral bone removal and to maintain anatomical orientation. The ligamentum flavum is opened either cephalad or caudal to the cyst. At this point, the cyst should be carefully separated from the dura mater by using curved curettes as well as sharp dissection. The traversing nerve root should be identified. In some cases, the cyst can be resected en bloc, but commonly it requires piecemeal removal, particularly with larger cysts. Careful dissection and establishment of the proper anatomical planes can minimize the risk of cerebrospinal fluid leakage, but, in some cases, dural tearing is unavoidable.

In 2010, Bydon et al. [31] carried out a wide review of all possible treatment options, including minimally invasive and open procedures, comparing decompression alone with decompression plus instrumented fusion. They concluded that it is fundamental to include an appraisal of any micro-instability in preoperative planning in order to decide when to perform fusion and emphasize that fusion must be planned whenever there are signs of instability. These authors also compared open and minimally invasive techniques for decompression alone and did not find any substantial differences in terms of outcomes: these results support our hypothesis according to which the presence of active instability makes fusion mandatory.

In the light of the evidence reported in the literature, we believe that the microsurgical technique has some advantages in comparison to minimally invasive procedures:

1. Duration of the procedure: the open microsurgical technique requires about 90 min compared to 156 min for minimally invasive techniques.
2. Risk of postoperative instability: the technique we adopted preserves the medial two-thirds of the articular facet, whereas the minimally invasive technique requires a total medial arthrectomy, which, in our opinion, can increases the risk of long-term instability in a spinal segment that already displays degeneration.
3. Minimization of the risk of cerebrospinal fistula: exposure of the lesion via microsurgical technique makes it easy to identify and repair any dural tears. This is far more difficult in mini-invasive techniques, also in view of the fact that synovial cyst may be the cause of dural adherences.

Outcomes

It is universally accepted that cystectomy is succesful. About 80–90 % of patients reported improvement or disappearance of their radicular pain immediately after surgery. Less satisfactory seems to be the improvement of back pain.

Recurrence and complication rates after surgical treatment are completely acceptable. There is a recurrence rate of 6 % at a mean 2-year follow-up. The most frequent complication is dural tear. Some patients develop spinal instability and require later fusion. In fact, the treatment of cyst does not end with this surgical excision, and follow-up is important to detect any possible late complications. Generally, the reappearance of symptoms could indicate a recurrence or the onset of instability. Dynamic X-rays, performed at 2-year follow-up, seem to be effective for recognizing an unstable spondylolisthesis, after a time interval sufficient to develop this late complication. Moreover, a questionnaire issued for assessing outcome was useful for finding out how patients perceive their disease and their prognosis. It also represents a possible means for the assessment of outcome. Recently, we administered a questionnaire for assessing patient outcome and satisfaction at 2-year follow-up. It was based on eight questions:

1. Is your overall pain better since surgery?
2. Any numbness or tingling in legs or feet?
3. Any problems with control of bladder and bowels?
4. Any leg or foot pain?
5. Any back pain?
6. Any walking difficulties?
7. List specific areas of pain since your operation.
8. Satisfaction of surgical outcome: yes, could repeat procedure or no, would have avoided surgery.

Our results, in a series of 18 synovial cysts, all treated by microsurgical procedure (laminotomy, light removal of medial facet, and radical cystectomy), were good or excellent in 80 % of cases and fair in 20 %. We observed one case of spondylolisthesis, clinically asymptomatic, and no recurrence [30] (Figs. 16.1, 16.2, and 16.3).

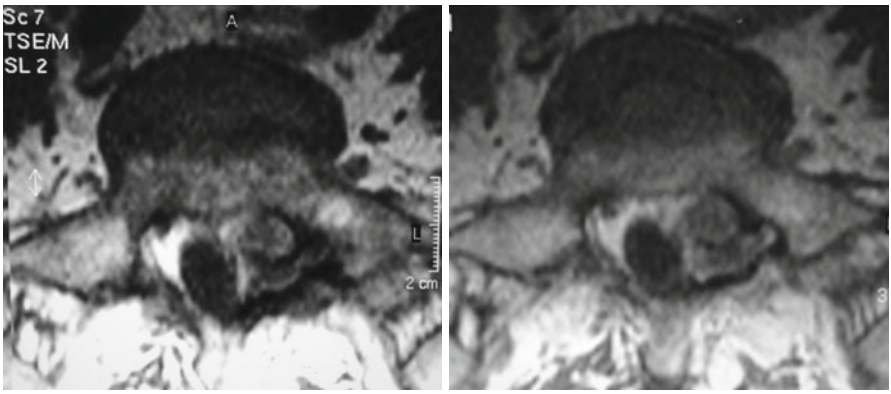

Fig. 16.1 Preoperative MRI. Comparison of axial T1-weighted images before (**a**) and after (**b**) gadolinium injection. The left L5–S1 heterogeneously hyperintense cystic lesion, compressing the cauda, shows a moderate increase of the signal after the contrast injection, particularly around the edges of the lesion. Diagnosis was lumbar hemorrhagic synovial cyst

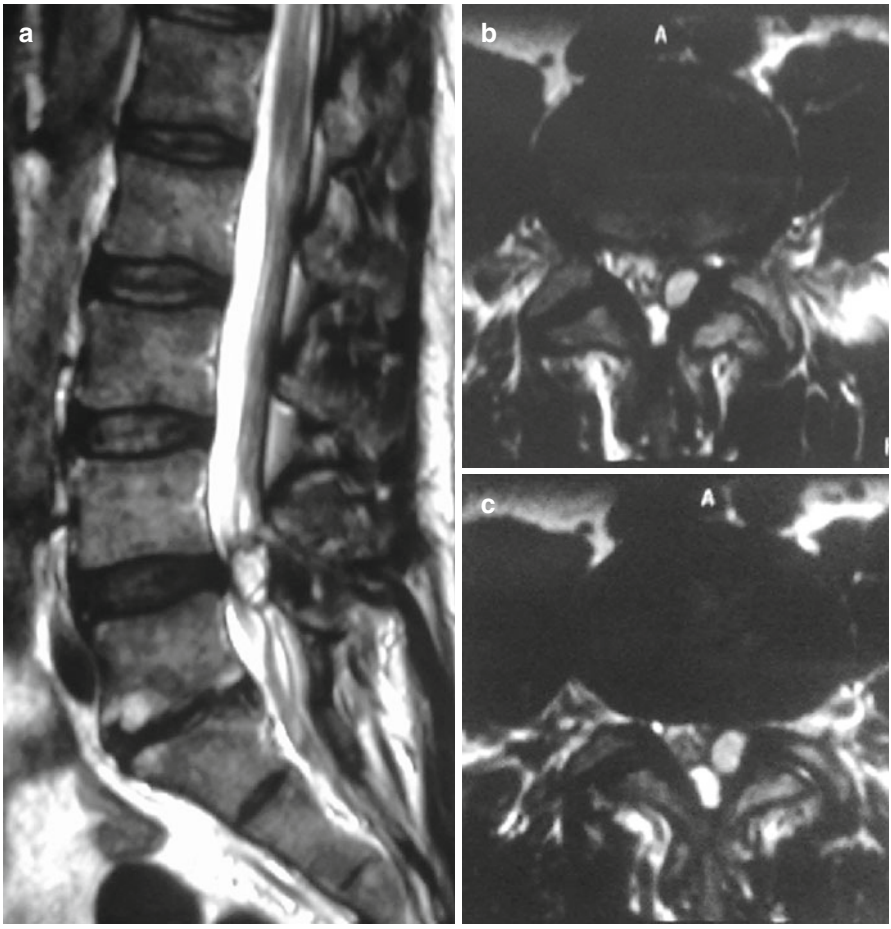

Fig. 16.2 Preoperative MRI. Sagittal (**a**) and axial (**b**, **c**) T2-weighted images that show an L4–L5 true synovial cyst arises from the left L4–L5 facet joint

Fig. 16.3 Same case as Fig. 16.2. Postoperative MRI. Sagittal (**a**) and axial (**c**) T2-weighted images that show complete excision of the cyst and preservation of the facet joint. Maintenance of vertebral stability is demonstrated by dynamic X-rays at 2-year follow-up (**b**)

Conclusion

Juxtafacet intraspinal synovial cysts are unusual lesions of the spine associated with facet arthropathy. Advances in neuroimaging have aided in improved preoperative recognition of this pathology. Debate continues regarding the cause of synovial cysts, with arthritis, trauma, or segmental instability being the most often reported.

In the lumbar spine, cysts can cause radicular symptoms. Rapid exacerbation of pain or cauda equina syndrome are possible if sudden enlargement or massive bleeding occur.

Although conservative procedures have been proposed, the gold standard for their treatment remains complete surgical excision. Resection and nerve root or cauda equina decompression can be performed with low risk and an expectation of

good to excellent surgery-related outcomes. Sound surgical judgment combined with pre- and intraoperative findings should be used to determine the indication for concomitant fusion in each patient. When preoperative radiological instability, detected by dynamic X-rays, is absent and bone demolition is minimal, no fusion is required.

A minimally invasive microsurgical approach, consisting of laminotomy and partial arthrectomy with preservation of the two-thirds of the medial facet, seems to be a viable treatment option with a low risk of complications and low rate of recurrence.

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