

LUMBAR

Define Disc Degeneration NASS

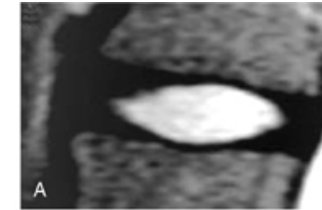
- Nucleus: Dessication, cleft vacuum, fibrosis
- Annulus: Fissure, mucinous degenration or calcification
- Endplates: Defects/ sclerosis
- Apophyses: Osteophytes

- **GRADING OF DISC
DEGENERATION**

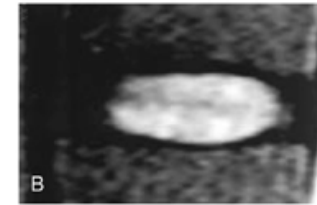
Grading system Pfirrmann, Spine

2001:26: 1873

Grade I Homogenous, hyperintense
signal intensity;
Normal height.



Grade II inhomogenous white
signals with normal height.
Normal adult disc



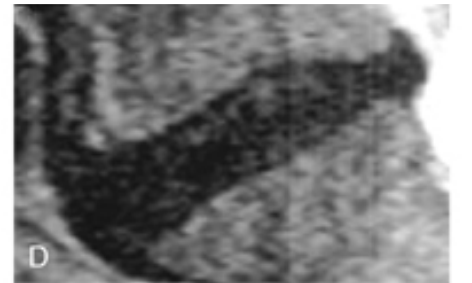
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Grade III An intermediate gray signal
within the nucleus pulposus



Grade IV changes are characterized by hypointense dark gray signals with mild loss of disc height.

-



Grade V disks have space collapse with complete loss of height.

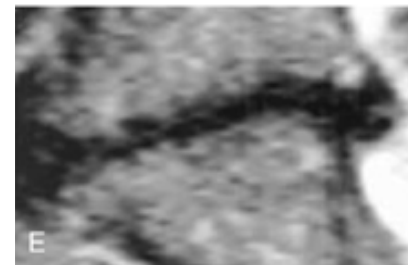


Table III. Degeneration patterns according to Buirski⁶⁵

Pattern type	Intranuclear cleft	Prolapse/bulge	Disc intensity	Disc height	Asymptomatic (n = 63) (%)	Symptomatic (n = 115) (%)
1	Thick	-	No	No	0	0
2	Thick	-	Reduced	No	5	4
3	No	Yes	No	No	4	4
4	Thick	Yes	Reduced	Reduced	42	29
5	Thick/ incomplete	Yes	Focal signal voids (HIZ)*	More reduced	31	47
6	Not seen	Yes	Severely reduced	Severely reduced	18	16

* high-intensity zone

Degeneration of disc Buirski

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- In conventional MRI, the first sign of degeneration is inhomogeneity of the intranuclear cleft followed by bulging of the disc.
- Late signs are decreased signal intensity and reduced disc height.

Modic changes

Eur Spine J

DOI 10.1007/s00586-011-1964-6 : 2011

Purpose

- (1) To assess the prevalence of Modic changes,
(2) to determine if Modic changes influence the clinical course of LBP, and
(3) to identify prognostic factors for recovery.

Results

5% had a normal MRI

50% had Modic 1 and Modic 2 changes.

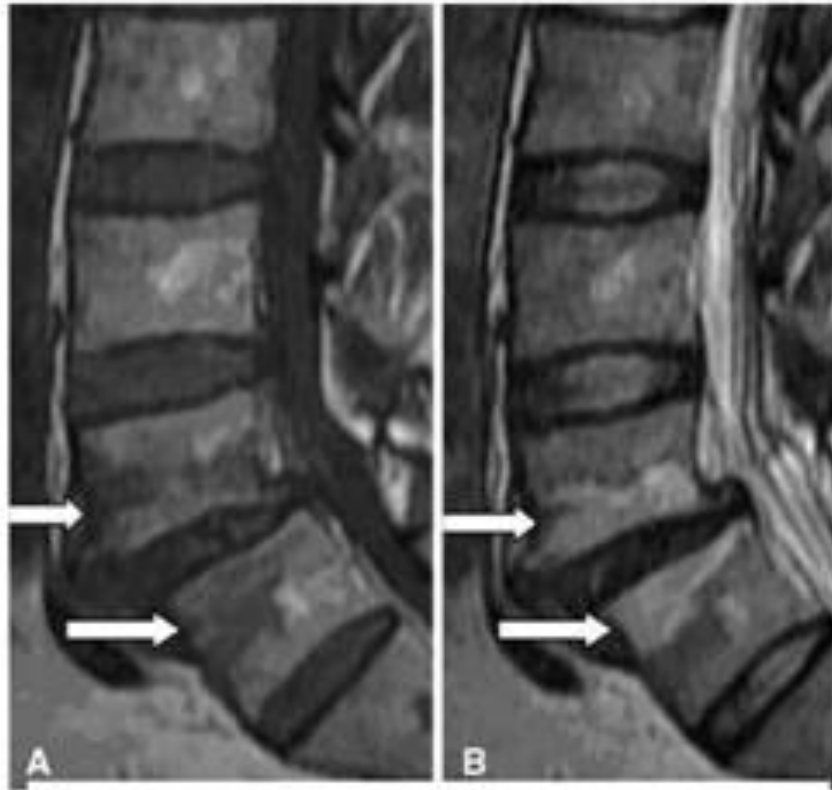
Modic changes were not significant covariates for the clinical course of pain, function or fear avoidance beliefs.

Conclusions

Modic changes did not influence the clinical course of back pain and were not prognostic factors for recovery. Education was strongly associated with recovery.

- **MODIC CHANGES** [reaction of adjacent subchondral bone]

Modic 1



MC type I (arrows): hypointense on T1WI (A) and hyperintense on T2WI (B)

- Hypo on T1 and Hyper on T2
- No relation to pain
- May resolve in 12 months or become Modic II
- Early cartilage fissuring and increasing vascularity

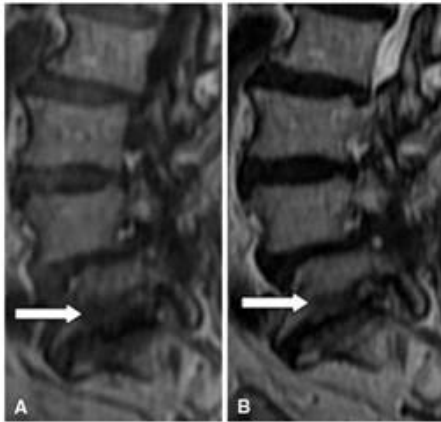
Type II



MC type II (arrows): hyperintense on T1WI (A)
and isointense or hyperintense on T2WI (B)

- Hyper on T1 and on T2
- Fatty replacement of the marrow

Type III



MC type III (arrows): hypointense on T1 (A) and hypointense on T2WI (B)

- Hypo on T1 and T2
- Advanced arthritis

'Modic changes Spine J 11: 402

Type	MRI		Pathology
	T1-weighted	T2-weighted	
I	SI reduced	SI increased	Fissures of the cartilaginous endplate, increased vascularity within the subchondral bone
II	SI increased	SI increased or isotense	Fatty replacement of the marrow, perhaps a result of marrow ischaemia
III	SI reduced	SI reduced	Subchondral sclerosis
None			

Importance of Modic changes

- Modic changes, **most commonly Type II**, were found in 81% of patients studied and were associated with disc degeneration, spondylolisthesis, and disc contour abnormalities.
- Associations with body mass index and male gender
- The findings are consistent with the current literature and suggest that Modic changes are common findings in patients with **significant degenerative lumbar processes.**
- Questions regarding correlation with pain and impairment, causation, and prognostic importance remain open.

END PLATE LESIONS

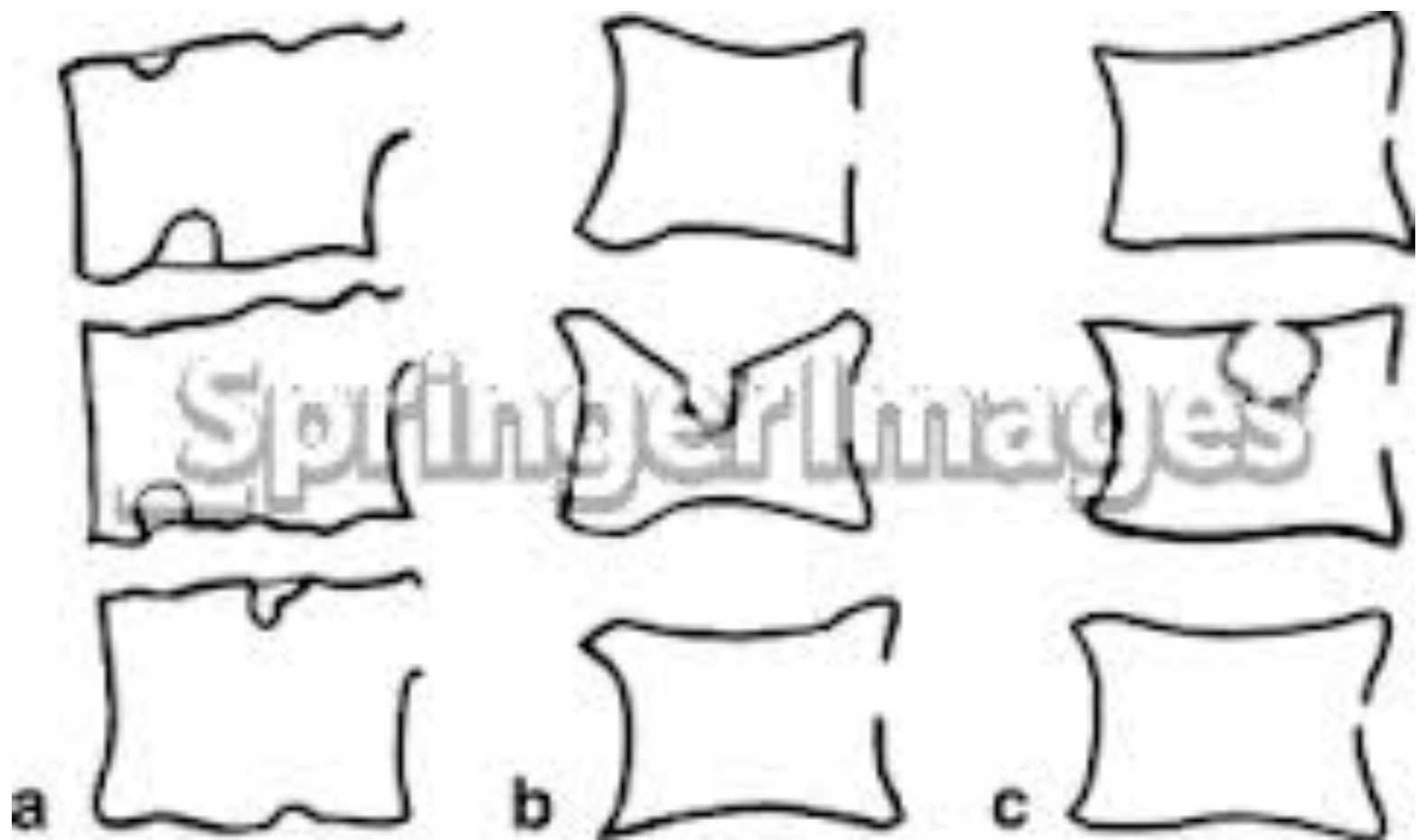
Spine (Phila Pa 1976) 2012 ; 37 : 1432 – 9 .

Orthopaedic Surgery and Traumatology:43;NO.11;PAGE.1261(2000)

- **Wang Classification** and association with age .
- Endplate lesions are the common lumbar disorder observed among young sports players.
- Most patients are cured after conservative management.

The problem is that they show residual spinal deformities even if the lesion has healed, which may cause future lumbar disorders such as spinal canal stenosis.

Types



Pain in disc herniation

1. The combination of mechanical compression (mass effect of herniated NP)
2. Chemical irritation (inflammation around nerve root) may induce more nerve root injury than each factor *per se*. **Spine 2003;28:435–441**

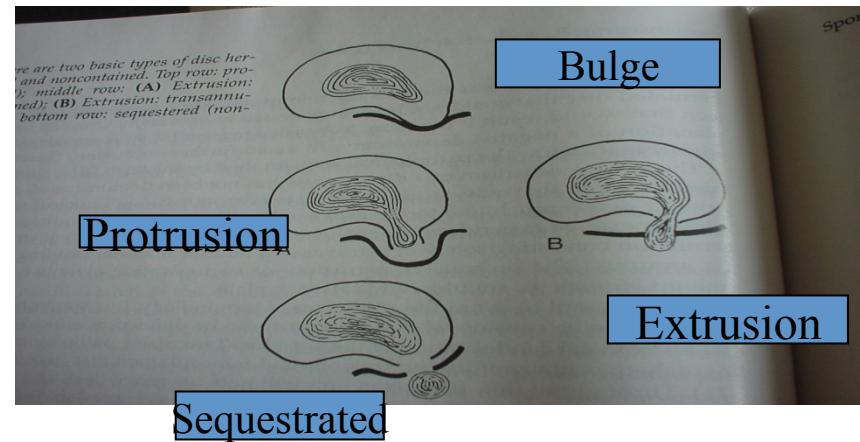
It has been demonstrated that application of NP induces pain-related behavior in rats^{8,19} and histologic changes such as axonal degeneration, intraneural edema, and Schwann cell edema in the nerve root and dorsal root ganglions.

It has been demonstrated that the disrupted blood-nerve barrier is an important mechanism producing intraneural edema, and it may be that the **cytokine components** of the herniated NP also affect the blood-nerve barrier directly.

Types of Disc Rupture

Types:

- I Annular Bulge: Circumferential
- II Disc Protrusions [Annulus fibrosus is still intact
[diameter at the base of the protrusion is more than the diameter of the disc extending the disc space]
- III. Extruded [Out of annulus but in continuity: the displaced disc has larger diameter than at the base]
- IV. Sequestered [not continuous with the disc]
- V Far out disc



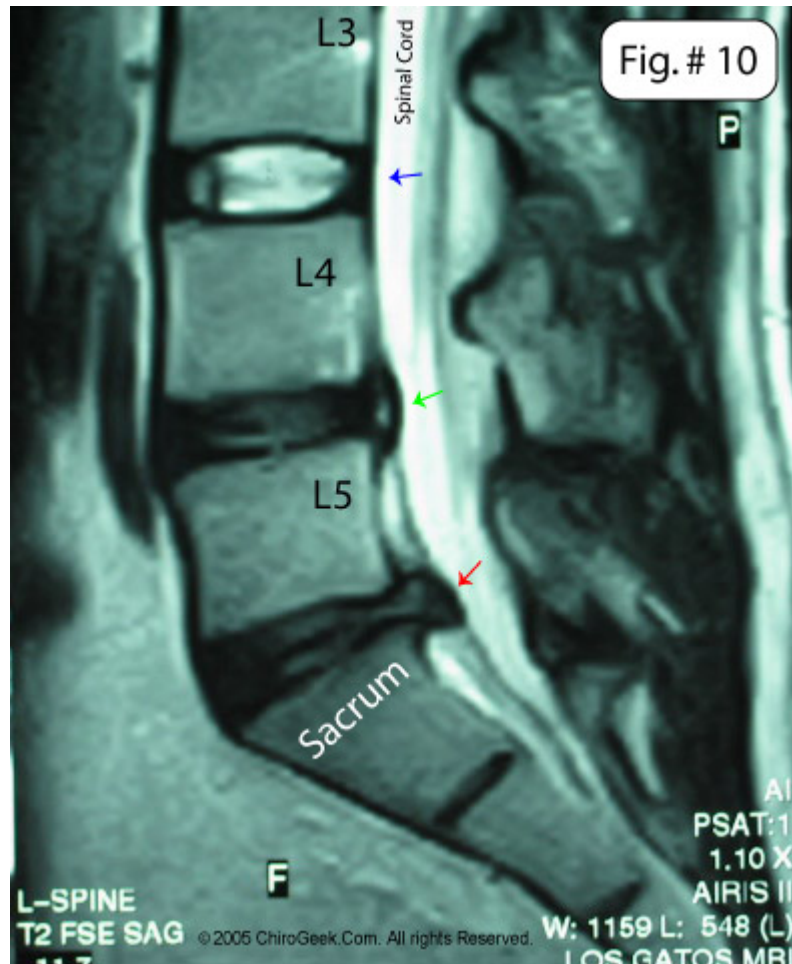
On Axial

1. Central
2. Postero-central
3. Foraminal
4. Extra-foraminal

On sagittal:

1. At disc space level
2. Foraminal level
3. At pedicle level

Types of disc lesions



- L5/S1 disc extrusion
- L4/5 disc protrusion ,Type IV
- L3/4 Type II changes
- L4/5 & L5/S1 "black" desiccation, Type IV

Fate of Herniated Disc

- Royal Adelaide Hospital, Adelaide, South Australia, Australia.
- 98 % of sequestrations contained some nuclear material indicating that nucleus pulposus is the principal substance extruded from the disc. None contained annulus alone. **Although vascular repair was present in 89% of specimens**, it did not correlate with several clinical parameters.
- Conclusions: The autopsy study confirmed the model of nuclear fragmentation, migration, and extrusion along radiating annular clefts. Neovascularization of extruded fragments bore no relationship with duration of sciatic pain symptoms or clinical outcome.

The classic view, that the turgid nucleus is extruded under pressure after a traumatic rupture of the annulus, may explain the few cases of herniation seen in the young.

However, as the mean age of presentation of clinically symptomatic disc protrusions exceeds 40 years, when the nucleus has lost its turgescence, [there is a strong indication that in middle age and beyond, herniation is associated with age-related disc degeneration.](#)

[Disruption of the annulus and the formation of radiating clefts can result from, respectively, mechanical tearing or degenerative changes. It has been postulated that nuclear degeneration imparts abnormal stress on the annular fibers.](#)

Adams and Hutton ¹ proposed that activities involving low loads on the spine may lead to chronic mechanical fatigue of annular fibers, and a slow progression to prolapse.

Mechanical tearing refers to those movements that place undue stress on the anular fibers, causing sudden rupture. Such movements could include torsion with flexion, axial rotation and lateral bending, hyperflexion beyond physiologic limits,¹ or cyclic flexion, compression, and rotation.

In the autopsy discs examined, nuclear degeneration was seen in the second decade. As described previously, degeneration becomes evident first as large clefts toward the periphery of the nucleus as it becomes less hydrated and shrinks and is followed by nuclear clefting and fragmentation, which are well established by the third decade.

Only two transligamentous prolapses were observed in the younger discs in this study, and they were associated with significantly less nuclear degeneration, consistent with the concept that mechanical rupture probably plays a greater role in herniations in young people.

Whether tearing of the ligament is an extension of the degenerative process, or an acute traumatic event, is again unclear. It is possible that, in adults, the former plays a greater role in the formation of the annular clefts, whereas the latter is more involved in tearing of the longitudinal ligament.

More than 10% of spines examined in this study had prolapses, more than one third of which had

- affected discs at more than one level. This is similar to the frequency of prolapse in autopsy spines reported by others.

Our study suggests that lumbar disc herniation in adults results from degenerative changes beginning within the disc in the second decade of life.

Nuclear desiccation and fragmentation leads to the eventual formation of clefts in the anulus, followed by the extrusion of mainly nuclear material through these pre-existing annular clefts.

Isolated fragments of annulus and endplate are much less common than nucleus in extruded material and probably also originate as part of the degenerative process.

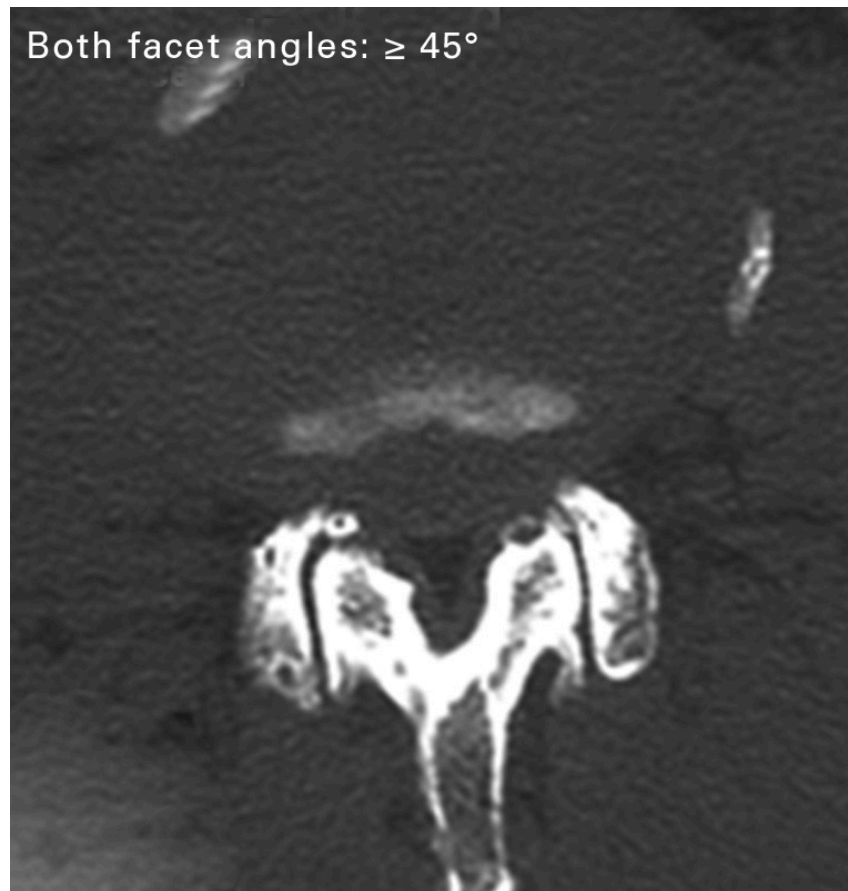
Finally, pathologic features of herniated disc are, at best, imprecise markers for clinical characteristics. Neovascularization of disc fragments is not related to the time between onset of pain and surgery, the type of herniation that has occurred, or the clinical outcome. We cannot, however, rule out a potential role for vascularization in pain production.

Spinal instability

J Bone Joint Surg [Br]

2011;93-B:650-7.

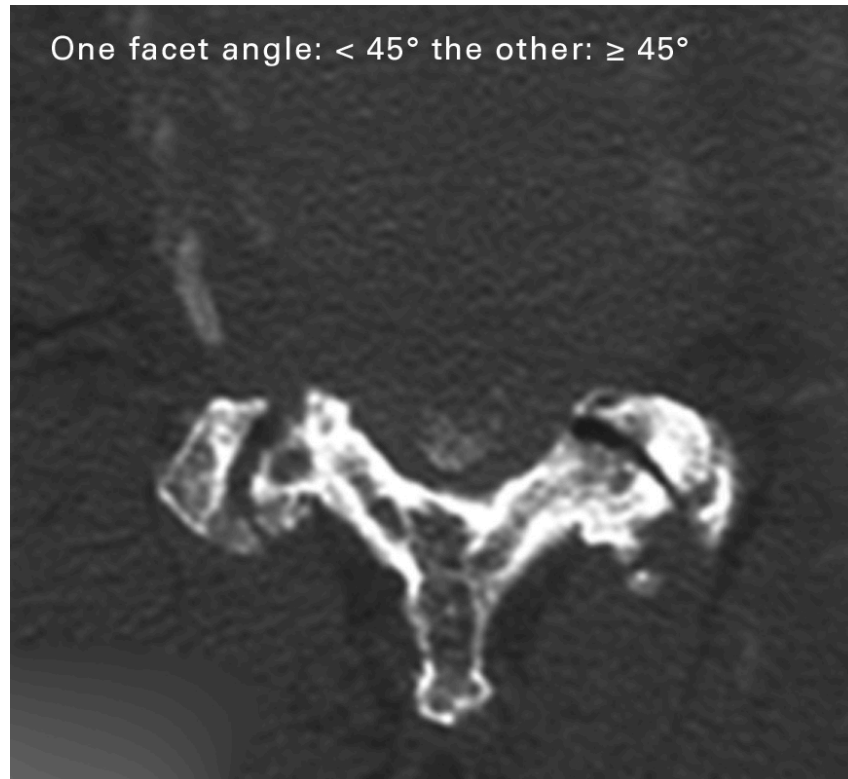
Sagittal Oriented



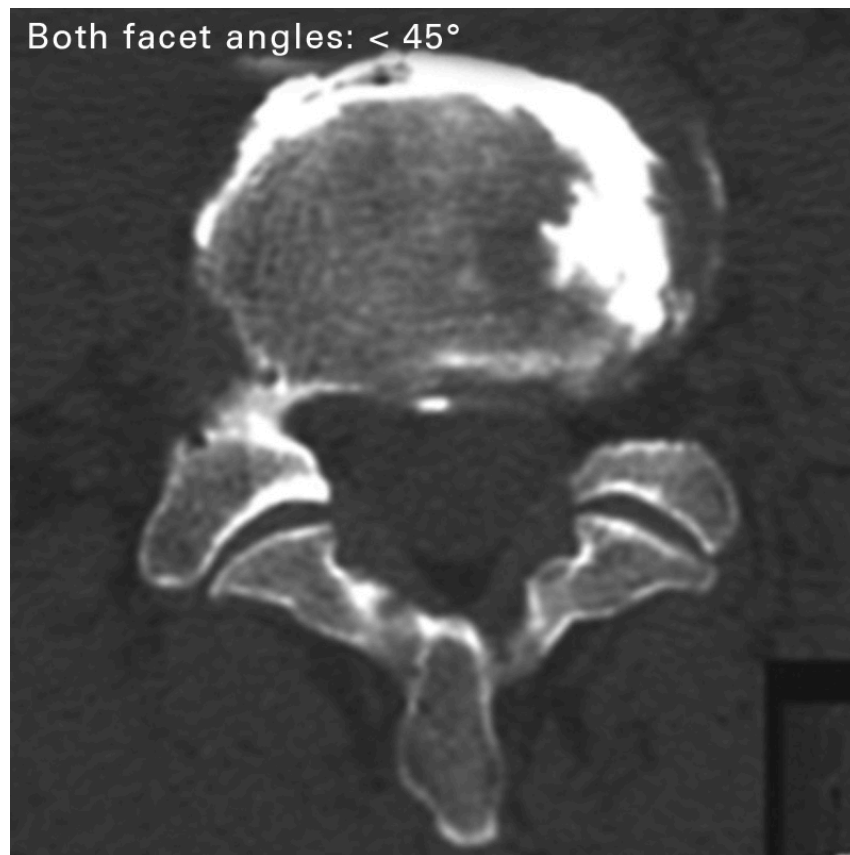
- A CT scan with 2.5 mm thick slices
- The middle image on the axial plane was used for evaluation of the facet.
- The facet joint angle was measured using the
- method of Boden.

The facet shape was classified into four types as follows:
sagittally orientated,
coronally orientated,
anisotropic
wrapped

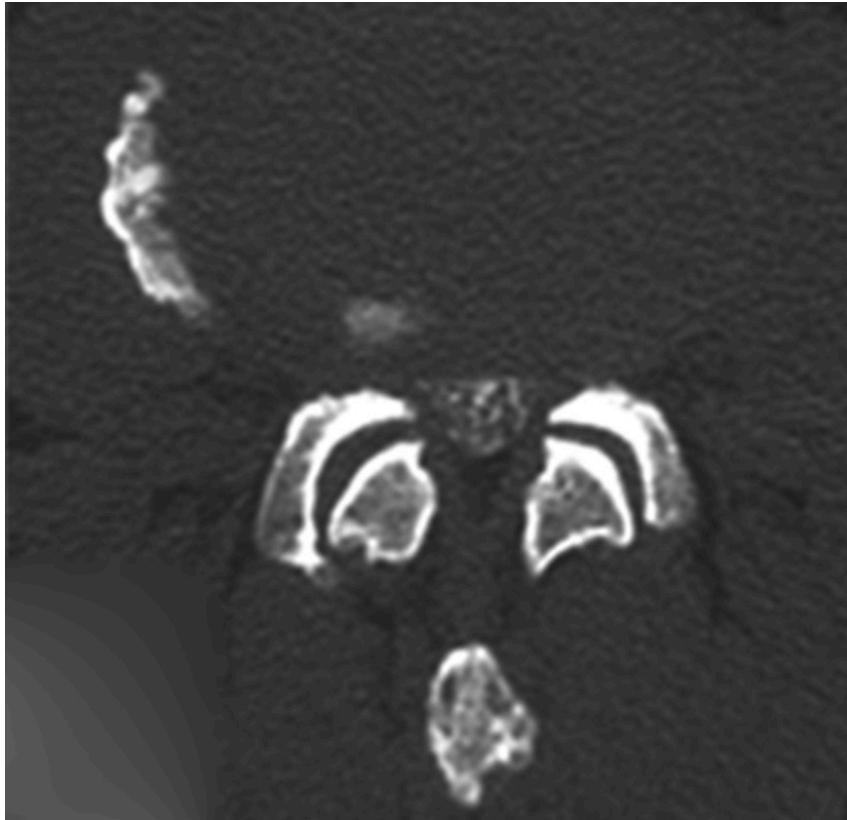
Anisotropic

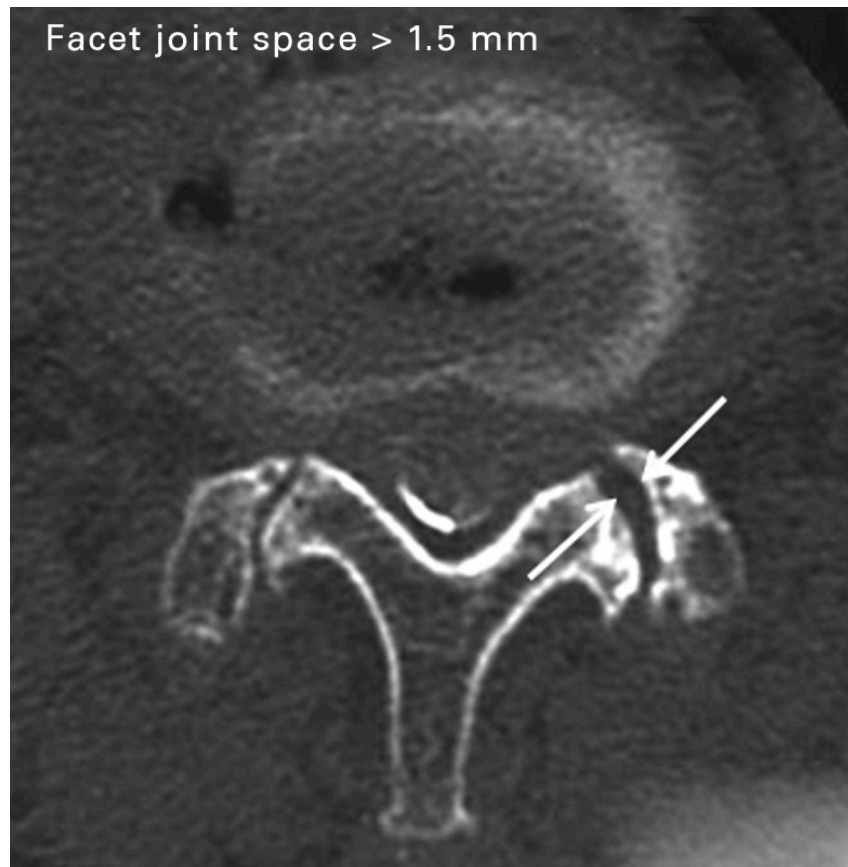


Coronal



Wrapped facet





- The width of the facet joint space was measured perpendicular to the joint at its widest portion, and the facet-opening was defined as a width greater than 1.5 mm

- If the neutral zone of the segment was $< 2 \text{ mm/N}$, the segment was considered to be stable and laminoplasty was carried out.
- If the neutral zone was $\geq 2 \text{ mm/N}$, the segment was considered to be unstable and decompression and transforaminal interbody fusion were performed.
- The facet joint is a crucial component in stability of the lumbar spine. The facet joints prevent excessive movement from damaging the discs and the posterior annulus is protected during torsion by the facet surfaces and during flexion by the capsular ligaments.²⁴⁻²⁶
- The compliance of the joint for torsion in a normal segment, however, is quite low. The physiological range of rotational movement is approximately 10° for the entire lumbar spine, or approximately 1° on each side for each joint.²⁷
- Joint failure can occur after approximately 10° to 30° of torsion and irreversible damage to the joints will occur when torsion exceeds 3° .²⁸ Therefore, radiological abnormalities of the facet joints contribute to the diagnosis of segmental instability.

MRI for spinal instability

- Recent MRI studies of the degenerative lumbar spine have shown that the presence of a large fluid-filled joint, giving a high signal change on T2-weighted axial images, especially in the upright position, is related to instability.

- They concluded that large (> 1.5 mm) facet joint effusions are highly predictive of degenerative spondylolisthesis at L4-5 in the absence of a measurable anterolisthesis on supine MRI
- In our study, facet type (Fig. 3) was not a predictor of stability, but comparison of the neutral zone among the facet types revealed that the sagittally-orientated type tended to be unstable, while the wrapped type tended to be stable.
- In our study the segments with MRI grade 3 or 4, which corresponds to mild disc degeneration, were more prone to being 'unstable' than those with MRI grade 5.

- Increased range of movement on flexion-extension radiographs was not a significant predictor of instability and neither was degenerative spondylolisthesis as a single factor.
- The natural history suggested that degenerative spondylolisthesis did not always lead to instability in elderly patients who had probably reached a stabilisation phase corresponding to MRI grade 5.
- Segmental instability is merely the biomechanical failure of a lumbar segment and does not necessarily correlate with the degree of pain.

Discography

The Spine Journal 3 (2003) 11S–27S

- Indications
- 1. correlation of the abnormality with the clinical symptoms. Such symptoms may include recurrent pain from a previously operated disc and lateral disc herniation.
- 2. Persistent, severe symptoms in whom other diagnostic tests have failed to reveal
- clear confirmation of a suspected disc as the source of pain.
- 3. Assessment of patients who have failed to respond to surgical intervention to determine if there is painful pseudarthrosis or a symptomatic disc in a posteriorly fused segment and to help evaluate possible recurrent disc herniation.
- 4. Assessment of discs before fusion to determine if the discs within the proposed fusion segment are symptomatic and to determine if discs adjacent to this segment are normal.
- 5. Assessment of candidates for minimally invasive surgical intervention to confirm a contained disc herniation or

Fusion surgery

VOL. 84-B, NO. 6, AUGUST 2002

- conclusions:
- 1) There is no acceptable evidence (strength D) of the efficacy of any form of fusion for degenerative lumbar spondylosis, back pain, or 'instability'.
- 2) There is limited evidence (strength C) that adjunct fusion to supplement decompression for degenerative spondylolisthesis produces less progressive slip and better clinical outcomes than decompression alone.
- 3) There is limited evidence (strength C) that fusion alone may be as effective as combined decompression and fusion for patients with grade-I or grade-II isthmic spondylolisthesis and no significant neurology.
- 4) There is strong evidence that instrumented fusion may produce a higher rate of fusion (strength A), but does not improve clinical outcome (strength A).
- Lumbar spinal fusion should therefore be undertaken with caution. It should be borne in mind that there is little evidence to suggest that it has a beneficial effect on patients.
- Psychosocial screening should be performed and if psychosocial distress is shown a thorough evaluation should follow. If both a psychosocial and organic disorder are found, both should be treated, with discussion between the psychiatrist and the surgeon as regards the sequence of treatment.

3.OA after Discectomy

- Eur Spine J. 2010 Jan;19(1):136-43. Epub 2009 Nov 6.. **Frequency and clinical meaning of long-term degenerative changes after lumbar discectomy visualized on imaging tests.** Mariconda M, Galasso
- Retrospective controlled study was to evaluate radiographic degeneration in the lumbar spine of patients who had undergone lumbar discectomy minimum 21 years earlier
- 50 patients who had undergone discectomy for lumbar disc herniation.
- The mean length of follow-up: 25.3 +/- 3.0 years. Short Form-36, Oswestry Disability Index, and a study-specific questionnaire. Radiographic views

- A five-step published classification was used to assess the increasing severity of radiographic changes.
- CT or MRI scans were also available for 27 patients who had undergone discectomy.
- Moderate to severe radiographic changes were present in 45 patients (90%) and 34 controls (68%), respectively ($P = 0.013$).
- The most prevalent MRI/CT changes were loss of disc height (89%), facet joint arthritis (89%), and endplate changes (57%).
- Thirty-two of 33 subjects (97%) reporting pain during the last 12 months had significant degeneration on their radiographs, and the frequency of changes was higher with respect to subjects without pain ($P = 0.040$).
- In conclusion, standard lumbar discectomy frequently leads to long-term degenerative changes on imaging tests. The presence of moderate to severe degeneration is associated with self-reported pain.

4.MRI [post-disc]: Scar Vs Recurrence

- Clin Radiol. 2002 Nov;57(11):969-81.
- **Abstract**
- Complications of such surgery include recurrent/residual disc herniation, epidural scar formation, discitis, arachnoiditis and pseudo-meningocele.
- Gadolinium-enhanced MRI is the technique of choice for investigating recurrent symptoms following discectomy.
- This article reviews the normal early and late post-laminectomy MR appearances, as well as the pathological findings associated with the above-mentioned complications.

The postoperative lumbar spine

- Acta Radiol Suppl. 1998;414:1-23.
- Disc herniations were found in 16% of the disc levels in asymptomatic patients and in 38% of the disc levels in the symptomatic patients. Significantly more disc herniations were found in patients who had only a short duration of recurrent symptoms (maximum 3 months) before MR investigation than in the asymptomatic patients. Nerve-root displacement due to disc herniation was also significantly more frequent in patients with the short symptom duration than in patients with a longer symptom duration.
- True intradural nerve-root enhancement was found in 7% of symptomatic patients, and focal enhancement in the root sleeve was found in 26% of them; there was good correlation to clinical symptoms and other pathological findings. Thickened nerve roots were found with equal frequency in asymptomatic and symptomatic patients. Epidural scar tissue diminished with time, showing no significant difference between asymptomatic and symptomatic patients.
- Out of 6 patients with septic post-operative discitis, 3 showed extensive MR changes; the remaining 3 showed moderate changes which were similar to those in another 6 patients who had aseptic discitis.
- Nerve-root displacement and nerve-root enhancement caused by recurrent disc herniation may strengthen the indication for repeat discectomy.
- On the other hand, the finding of a thickened nerve root seems to be of no diagnostic value. The MR features in postoperative discitis develop only gradually and the differentiation between septic and aseptic forms of discitis is thus difficult at the early stage.

Adjacent segment Spine J. 2011 Jan;11(1):11-20.

- **Incidence and prevalence of surgery at segments adjacent to a previous posterior lumbar arthrodesis.**
- [Sears WB, Sergides IG, Kazemi N, Smith M, White GJ, Osburg B.](#)
- Department of Neurosurgery, Royal North Shore Hospital, Sydney, NSW 2065, Australia. sears.public@mac.com
- Comment in:
- [Spine J. 2011 Jan;11\(1\):21-3.](#)
- **Abstract**
- **BACKGROUND CONTEXT:** Adjacent segment disease (ASD) after lumbar spinal fusion has been an important reason behind the development of nonfusion stabilization technology. However, the incidence, prevalence, and factors contributing to adjacent segment degeneration in the lumbar spine remain unclear. A range of prevalence rates for ASD have been reported in the lumbar spinal literature, but the annual incidence has not been widely studied in this region. Conflicting reports exist regarding risk factors, especially fusion length.
- **PURPOSE:** To determine the annual incidence and prevalence of further surgery for adjacent segment disease (SxASD) after posterior lumbar arthrodesis and examine possible risk factors.
- **STUDY DESIGN:** Retrospective cohort study.
- **PATIENT SAMPLE:** Nine hundred twelve patients who underwent 1,000 consecutive posterior lumbar interbody fusion procedures, with mean follow-up duration of 63 months (range, 5 months-16 years).
- **OUTCOME MEASURES:** Further surgery for ASD or surgery-free survival.
- **METHODS:** A postal and telephone survey. Follow-up rate: 91% of patients. The annual incidence and prevalence of ASD requiring further surgery were determined using Kaplan-Meier survivorship analysis. Cox proportional-hazards (Cox) regression was used for multivariate analysis of possible risk factors. Significance was set at $p < .05$.
- **RESULTS:** Further surgery for ASD occurred following 130 of 1,000 or 13% of procedures at a mean time of 43 months (range, 2.3-162 months). The mean annual incidence of SxASD over the first 10 years, in all patients, was 2.5% (95% confidence interval [95% CI], 1.9-3.1) with prevalences of 13.6% and 22.2% at 5 and 10 years, respectively. Cox regression modeling found that the number of levels fused ($p \leq .0003$), age of the patient, fusing to L5, and performing an additional laminectomy adjacent to a fusion all independently affect the risk of SxASD. The mean annual incidence figures in the first 10 years after a lumbar fusion were 1.7% (95% CI, 1.3-2.2) after fusion at single levels, 3.6% (2.1-5.2) after two levels, and 5.0% (3.3-6.7) after three and four levels. The 5- and 10-year prevalences were 9% and 16%, 17% and 31%, and 29% and 40% after single-, two-, and three-/four-level fusions, respectively. The risk of SxASD in patients younger than 45 years was one-quarter (95% CI, 10-64) the risk of patients older than 60 years ($p = .003$). A laminectomy adjacent to a fusion increases the relative risk by 2.4 times (95% CI, 1.1-5.2; $p = .03$). Stopping a fusion at L5 is associated with a 1.7-fold increased risk (95% CI, 1.2-2.4; $p = .007$) of SxASD compared with a fusion to S1, for fusions of the same length.
- **CONCLUSION:** The overall annual incidence and predicted 10-year prevalence of further surgery for ASD after lumbar arthrodesis were 2.5% and 22.2%, respectively. These rates varied widely depending on the identified risk factors. Although young patients who underwent single-level fusions were at low risk, patients who underwent fusion of three or four levels had a threefold increased risk of further surgery, compared with single-level fusions ($p < .0001$), and a predicted 10-year prevalence of 40

Adjacent disc. JAAOS 2013, Vol 21, No 1:3

- Cervical spine surgery is broadly divided into fusion and nonfusion
- procedures. Anterior cervical discectomy and fusion (ACDF) is a
- common procedure, although adjacent segment disease following
- the surgery is an ongoing clinical concern. Adjacent segment
- cervical disease occurs in approximately 3% of patients per year,
- with an expected incidence of 25% within the first 10 years
- following fusion. Nonfusion procedures such as anterior discectomy
- and posterior foraminotomy do not decrease the rate of adjacent
- segment disease compared with ACDF. Recently, enthusiasm has
- developed for artificial disk replacement as a motion-sparing
- alternative to fusion. To date, however, multiple clinical trials and
- subsequent follow-up studies have failed to demonstrate significant
- reduction of adjacent segment disease when artificial disk
- replacement is performed instead of fusion.

Acute Disc pain

Eur Spine J. 2011 Aug 6

- We compared rates of MRI findings between 30 cases with low back pain and 30 pain-free controls. Cases were patients presenting for care with likely discogenic low back pain (demonstrated centralisation with repeated movement testing), of moderate intensity and with minimal past history of back pain. Controls were matched for age, gender and past history of back pain. Cases and controls underwent MRI scanning which was read for the presence of a range of MRI findings by two blinded assessors.
- **RESULTS:**
- The presence of disc degeneration, modic changes and disc herniation significantly altered the odds of a participant being a case or control. For example subjects were 5.2 times more likely to be a case than a control when disc degeneration grade of ≥ 3 was present, and 6.0 times more likely with modic changes. The presence of a high-intensity zone or annular tear was found to significantly alter odds for one assessor but not the other assessor.
- **CONCLUSION:**
- MRI findings including disc degeneration, modic changes and herniation are more common in selected people with current acute (likely discogenic) low back pain than in controls without current low back pain. Further investigation of the value of MRI findings as prognostic factors and as treatment effect modifiers is required to assess the potential clinical importance of these findings.
- PMID

Spine arthrodesis:

SPINE Volume 27, Number 22, pp 2555–2562

- 1. A successful fusion does not always correlate with a successful clinical result.
- 2. >4mm of translation; >10° of angular motion may suggest segmental mechanical dysfunction. Although many surgeons rely on these guidelines, there is no data that clearly links pain with instability.
- 3. Degenerative spondylolisthesis: Fischgrund : randomized into pedicle screw instrumentation or noninstrumented groups. Successful arthrodesis occurred in 82% of the instrumented cases, as compared with 45% of the noninstrumented. Interestingly, although instrumentation significantly improved the fusion rates, the clinical outcomes between the two groups were similar.
- 4.

Painful Degenerative Disc Disease and Discogenic Pain

Crock postulated that the most likely cause of chronic low back pain is internal disruption of the disc.

Discography can provide useful information about discogenic pain, but the results must be interpreted carefully.^{8,26,46,97,101}

The most common indication for reconstructive surgery in patients with painful degenerative disc disease is disabling low back pain. These patients' pain typically is mechanical as well as load and sitting intolerant, and often is worse with activity.

Successful clinical outcomes in these studies range from 45% to 90%. Whereas 63% of the surgical group rated themselves as "much better" or "better," only 29% in the nonsurgical group

- Consideration of fusion for patients with discogenic syndromes remains controversial and, as always, careful patient selection is critical. For most spine surgeons, a posterolateral fusion is a useful and relatively familiar arthrodesis procedure.
- ALIF allows for more extensive and complete disc excision with less risk to the nerve roots and dura. Complications related to the anterior approach include vascular injury and In addition
- To the diagnostic workup to identify the pain generators, the surgeon should carefully consider any psychological risk factors that may be active in a surgical candidate.

Spine 2010;35:S245–S258

- The literature supports and the consensus panel recommended that there is no indication for direct decompression at the time of initial injury specifically for the purpose of limiting future risk of syringomyelia.
- The literature supports and the consensus panel gave a strong recommendation for surgical intervention in the setting of motor neurologic deterioration as a consequence of posttraumatic syrinx/tethered cord.
- The panel gave a weak recommendation against surgical intervention for patients developing sensory loss/pain syndrome or for asymptomatic but expanding syrinx.
- Finally, the literature does not provide strong evidence to support the superiority of one surgical technique over the others; however, the consensus panel gave a weak recommendation that spinal cord untethering with expansile duraplasty is the preferred first-line surgical technique.

PTS Summary

- Causes late motor and sensory deterioration following spinal cord injury.
- It is diagnosed, on average, 9 years after the initial injury.
- A high index of suspicion for post-traumatic syrinx when new onset of any of the above conditions occurs in the chronic phase after spinal cord injury.
- The incidence of PTS is higher in patients with complete ASIA A spinal cord injuries, in patients with posttraumatic kyphotic deformities, and in patients with residual axial stenosis.
- It is well-known that decompression at the time of injury/initial surgery may correlate with root or segmental recovery.
- However, the literature supported and the consensus panel recommended that, given the low incidence of symptomatic syrinx, there is no indication for direct decompression beyond realignment and stabilization at the time of initial injury
- There is very little published evidence regarding the natural history of asymptomatic, but radiographically expanding PTS.
- The panel also gave a weak recommendation against surgical intervention for asymptomatic but expanding syrinx.

Recent concepts on Degeneration

JBJS 2012;94-B:1298–1304.

- IVD and its association with low back pain (LBP).

The normal IVD is a largely avascular and aneural structure with a high water content, its nutrients mainly diffusing through the end plates.

-

IVD degeneration occurs when its cells die or become dysfunctional, notably in an acidic environment. In the process of degeneration, the IVD becomes dehydrated and vascularised, and there is an ingrowth of nerves. Although not universally the case, the altered physiology of the IVD is believed to precede or be associated with many clinical symptoms or conditions including low back and/or lower limb pain, paraesthesia, spinal stenosis and disc herniation.

- New treatment options have been developed in recent years. These include biological
- therapies and novel surgical techniques (such as total disc replacement), although many of
- these are still in their experimental phase. Central to developing further methods of
- treatment is the need for effective ways in which to assess patients and measure their
- outcomes. However, significant difficulties remain and it is therefore an appropriate time to
- be further investigating the scientific basis of and treatment of LBP.

- 1. >63 years: >95 % have degeneration
- 2. Poor clinical and radiological correlation
- 3. Normal disc: can withstand applied pressures varying from 0.1 MPa when prone to 2.3 Mpa when lifting with a flexed back.[*Spine (Phila Pa 1976)* 1999;24:755–762]
- 4. Proteoglycans (mainly aggrecan) in the NP are hydrophilic because of their constituent glycosaminoglycans (GAGs) and generate a pressure by swelling from the attraction of water into the IVD from surrounding tissues – which results in the vertebral bodies being pushed apart. This pressure is resisted by tension in the collagen fibres of the AF.

Pathogenesis of disc degeneration

- The IVD cells can synthesise many enzymes that are capable of degrading disc components. [collagenases, elastases, aggrecanases, proteinases, stromelysins and MMPs.

IVD cells promote further degradation by synthesising cytokines [IL-1, or TNF

The cells maintain the production of MMPs better in an acid environment (such as reported in degenerate IVDs), while GAG synthesis is drastically reduced, thereby leading to a

- vicious spiral of degeneration
- Many studies have examined different noxious stimuli including increased load, osmotic pressure and reduced glucose, and have shown they can lead to altered cell function,
- not only directly but also via stress-induced premature senescence. These senescent cells not only stop dividing but can also produce increased levels of cytokines and matrix-degrading enzymes.
- Once the disc becomes degenerate, it can cause LBP in different ways. One effect of disc degeneration is a loss of disc height with subsequent altered stress on the facet
- joints and other spinal tissues, such as ligaments and muscles that can potentially lead to LBP.

- 1. Loss of disc height and secondary effect on the facet joint.
- 2. Loss of height and compression of nerve root [IVF stenosis]
- 3. Loss of height and release of TNF sensitising nerves.
- 4. Long standing changes lead to changes within the spinothalamic tract.[*J Bone Joint Surg [Br]* 2004;86-B:74
- 5. The growth of nociceptive nerves into the usually aneural IVD is a well-recognised feature of painful degenerative
- Future: “it could prove fruitful to study the link between pain and degenerate disc disease and to determine exactly how stem cells might prevent or reverse disc degeneration.”

Degeneration of the spine: *J Bone Joint Surg*

[Br] 2002;84-B:783-94.

- Prevalence: Low back pain (LBP) is a common complaint with various studies indicating a point prevalence of from 12% to 33%, a one-year prevalence from 22% to 65%, and lifetime prevalence from 11% to 84%.
- Fusion surgery:
 - a. Regional variation
 - b. The decision to operate may also be influenced by the financial and personal interests of the doctor.
- C. 68% satisfactory results: but again: The rate of satisfactory outcome was lower in prospective than in retrospective studies.
- Outcome
In chronic LBP, and especially in patients who have been on sick leave for more than a month, resumption of work can be predicted almost exclusively by psychosocial factors, disability, and comorbidity.[Int Soc Study Lumbar Spine, Adelaide, 2000:6.]
- After fusion and outcome: There was a strong association between psychological distress and Oswestry disability.[*Spine* 1999;24:1833-8.]

- The intention of lumbar spinal fusion is to treat an organic disease not a psychological or social problem. Such problems should be clearly defined before spinal fusion is undertaken since they are strongly related to disability and outcome.
- Annular tear: A condition occurring with the same frequency in patients with and without pain is likely not to be the cause of pain, and should therefore not be treated by fusion. Disability seems to play a role in the assessment by most surgeons, as preoperative disability in patients treated operatively is much greater than in those treated conservatively. [*Spine* 2000;25:115-20]
- Annular tear in degeneration: Degenerated discs with a radiating cleft behave differently. Axial rotation is considerably increased.^{55,56} As soon as the cleft has reached the surface of the annulus, the height of the disc decreases and flexion/extension and side bending are reduced. Signs of tears of the annulus as seen on MRI such as the HIZ correlate with provoked discographic pain. Nevertheless, not all discs with a radiating tear are painful.

MRI and degeneraton

- In conventional MRI,
 - I sign Inhomogeneity of the intranuclear cleft
 - II Bulging of the disc.
 - III Reduced disc height.
- IV Disc protrusion, Herneatiaon, Extrusion
- Finnish study of 151 men aged from 40 to 45 years in whom MRI was performed twice with a four-year interval, a clear sequence of these signs was shown.[Int Soc Study Lumbar Spine, Adelaide, 2000;23].

Age related disc changes

J Bone Joint Surg [Am]
1990;72-A:403-8.

Table II. Incidence of MRI findings in individuals who had never had LBP according to Boden et al⁶²

Age (yrs)	Number	Herniated disc (%)	Spinal stenosis (%)	Bulging disc (%)	Disc degeneration (%)
20 to 39	35	21	1	56	34
40 to 59	18	22	0	50	59
60 to 80	14	36	21	79	93

- Boos et al⁶⁶ have shown in 46 asymptomatic individuals followed for a mean of five years that herniations of the disc and neural compromise did not become significantly worse at follow-up, whereas degeneration of progressed in 19 individuals (41%), six of whom had to seek medical treatment with another five having to stop work temporarily.
- Nevertheless, medical consultation for LBP was predicted with higher accuracy by listlessness, job satisfaction, and working in shifts.
- Work incapacity was best predicted by physical job characteristics, job disaffection, and working in shifts.
- There is no strong correlation between MRI changes in the intervertebral disc and LBP.

High-intensity zone (HIZ)

- It is surrounded by a low-intensity black signal of the annulus, and is appreciably brighter than that of the nucleus.
- Provocative discography revealed that the HIZ represented painful internal disruption of the disc with a positive predictive value of 86%.
- However, the HIZ is not necessarily associated with a painful disc.
- The nature of the HIZ is unclear. It may represent an area of secondary inflammation as a result of a tear in the annulus.
-

Modic changes and Pain

- The specificity of Modic changes for identification of a painful disc at discography is high, but sensitivity, however, is low.

The presence of Modic changes is therefore perhaps an indication for lumbar spinal fusion, although the literature is not very conclusive.

Facet joint arthritis

- Butler [*Spine* 1990;15:111-3.] performed CT and
- MRI of 330 discs;

108 Degeneration without changes in the facet joint

- 40 both the disc and the facet joints were degenerate
- 1 facet joint degeneration without corresponding changes in the disc.
- Isolated facet joint arthritis can occur but is rare.

Facet Joint block

- 1. No correlation between the outcome of fusion and the result of facet blocks. [*Spine* 1993;18:185]
- **Instability.**
Knutsson: flexion/extension radiographs to determine instability.
These were often found to be inconsistent. Shaffer et al⁹¹ found in experiments that only relatively large translations (± 5 mm) could be observed in flexion-extension radiographs in a reproducible:threshold value of ± 5 mm.
-

Fusion for spondylolisthesis

- In 111 patients with painful adult spondylolisthesis, 62% reported LBP and sciatica, 31% LBP only and 7% sciatic pain only
- In a study on 936 asymptomatic soldiers and 662 with LBP, the incidence of spondylolisthesis was 5.3% in the symptomatic group, and 2.2% in the asymptomatic group.[*Int Orthop* 1982;6:259-61.] Spondylolisthesis seems therefore to be associated with a higher incidence of LBP.
- Adult spondylolisthesis of minor degrees is therefore perhaps not very different from pure degenerative disc disease.
- Fusion in high grades of spondylolisthesis and of spondylolisthesis in children usually has a good outcome.
- Patient satisfaction was 100% in the children and in patients with high grades of slip and 84%, 76% and 69% in the low grade, degenerative disc disease, and post-discectomy groups, respectively.

Fusion for post discectomy

Patients with psychosocial comorbidity have a less favourable result after operative treatment of lumbar disc herniation. Nevertheless, some studies report promising results of lumbar fusion in patients who had residual symptoms after discectomy [*J Spinal Disord* 1998;11:383-8.]

Evidence based

- 1) There is no acceptable evidence (strength D) of the efficacy of any form of fusion for degenerative lumbar spondylosis, back pain, or 'instability'.
- 2) There is limited evidence (strength C) that adjunct fusion to supplement decompression for degenerative spondylolisthesis produces less progressive slip and better clinical outcomes than decompression alone.
- 3) There is limited evidence (strength C) that fusion alone may be as effective as combined decompression and fusion for patients with grade-I or grade-II isthmic spondylolisthesis and no significant neurology.
- 4) There is strong evidence that instrumented fusion may produce a higher rate of fusion (strength A), but does not improve clinical outcome (strength A).

