

**LUMBAR**

# The normal disc

## **Nucleus pulposus and the cartilaginous vertebral endplate:**

Chondrocyte-like cells  
Synthesise type II collagen,  
Proteoglycans

## **Annulus fibrosus**

Fibroblast-like cells  
Synthesise type I and type II collagen for the.

## **Proteoglycans**

A core protein from which radiate chains of glycosaminoglycans containing keratan sulphate and chondroitin sulphate.  
Multiple proteoglycans are joined to a hyaluronic acid chain to form aggregates.

Aggregates are held together by type II collagen, which is cross-linked by type IX collagen.<sup>1</sup>

The hydroscopic properties of the proteoglycan matrix endow the nucleus with hydrostatic properties,<sup>2</sup> allowing it to accommodate compression loads and to brace the annulus.

However, the constituents of the matrix are not static.

Continually degraded by enzymes, the matrix metalloproteinases (MMPs), which are secreted by the chondrocytes. 3-5 Degradation of the matrix allows it to be refreshed by newly-synthesised components.

Growth factors:

Fibroblast growth factor (bFGF),  
Transforming growth factor (TGF)  
Insulin-like growth factor (IGF),

-

# Prevalence of MRI findings:

Spine 2012 ; 37 : 1231 –

1239 FINLAND

- Herniations 20%,
- Schmorl's nodes 17%,
- Radial tears 10%,
- High-intensity zone 3.2%,
- Spondylolytic defects 5.8%
- Modic changes 0.7%.

# PREVALENCE MRI Vs Age:

Spine (Phila Pa 1976). 2009 Apr

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20;34(9):934-40.

- Lumbar spine MRIs were obtained in 1043 volunteers between 18 to 55 years of age.
- 40% <30 years of age had lumbar intervertebral disc degeneration
- 90% by 50 to 55 years of age.
- L5-S1 and L4-L5 were the most commonly affected levels.
- **CONCLUSION:**
- LDD is common, and its incidence increases with age. In a population setting, there is a significant association of LDD on MRI with back pain.

# MRI spine changes in asymptomatic Vs Age Japanese 2012

MRI indicated degenerative changes in the lumbar [spine in 84 %:]

Decreased disc signal intensity in 75 %,

Posterior disc protrusion in 79 %,

Anterior compression of the dura in 82 %,

Disc space narrowing in 21 %,

Spinal canal stenosis in 13 %.

- These findings were more common in older subjects at caudal levels.
- MRI showed degenerative changes in both the lumbar and cervical spine in 78.7 % of the volunteers.
- Conclusions Degenerative findings in both the lumbar and cervical spine, suggesting tandem disc degeneration, was common in asymptomatic subjects.

# Prevalence of degenerative in Young MRI [Finish]

- **METHODS:** The study population was a subcohort of the Northern Finland Birth Cohort 1986. Subjects living within 100 km of Oulu (n = 874)
- **RESULTS:**
  - The prevalences of disc bulges and radial tears were 25% and 9.1%
  - Herniations were significantly more common among men (5.6% vs. 2.5%,  $P = 0.047$ ).
  - All degenerative disc findings were more common at the L5-S1 level except HIZ lesions, which were most likely at L4-L5.
  - The prevalence of the Modic changes was 1.4%, without gender difference, type I being more common than type II. Typically, Modic changes were located adjacent to a DD Grade 4 disc and at the 2 lowest levels.
- **CONCLUSION:** Almost half of young Finnish adult aged 21 years had at least one degenerated disc, and a quarter had a bulging disc. Modic changes and disc herniations were, however, relatively rare.
- Spine (Phila Pa 1976). 2009 Jul 15;34(16):1716-21.

# Asymptomatic back

*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 al<sup>62</sup>

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



# Tx/Cx asymptomatic lesion. SPINE

Volume 35, Number 14, pp 1359–1364

- 94 asymptomatic volunteers (48 men and 46 women, mean age of 48.0 ± 13.4 years) underwent MRI of the thoracic and cervical spine.
- The following 4MR findings related to intervertebral disc degeneration were evaluated using a numerical grading system:
  - (1) decrease in the signal intensity of the intervertebral discs (DSI),
  - (2) posterior disc protrusion (PDP),
  - (3) anterior compression of the dural sac (ACD),
  - (4) disc space narrowing (DSN).
- Degenerative MRI findings at 1 or more intervertebral levels in the thoracic spine were positive in 44 (46.8%) subjects.
- The percentages of the subjects with positive MRI findings were 37.2% in DSI, 30.9% in PDP, 29.8% in ACD, and 4.3% in DSN.
- DSI was significantly associated with age; PDP with age, smoking, and presence of PDP in the cervical spine; and ACD was associated with smoking.

# MRI on first episode of injury: • The Spine Journal

6 (2006) 624–635

- MRI : Common degenerative findings are often interpreted as recent developments and the probable anatomic cause of the new symptoms
- To date no prospective study has established a baseline MR status of the lumbar spine in subjects without significant LBP problems and prospectively surveyed these subjects for acute changes shortly after new and serious LBP episodes.
- LBP intensity (visual analogue scale), Oswestry Disability Index, and work loss. MRI outcomes: disc degeneration, herniation, annular fissures, end plate changes, facet arthrosis, canal stenosis, spondylolisthesis, and root impingement.
- 200 subjects with a lifetime history of no significant LBP problems, and a high risk
- for new LBP; Subjects were followed every 6 months for 5 years

Subjects with a new severe LBP episode were assessed for new diagnostic tests.

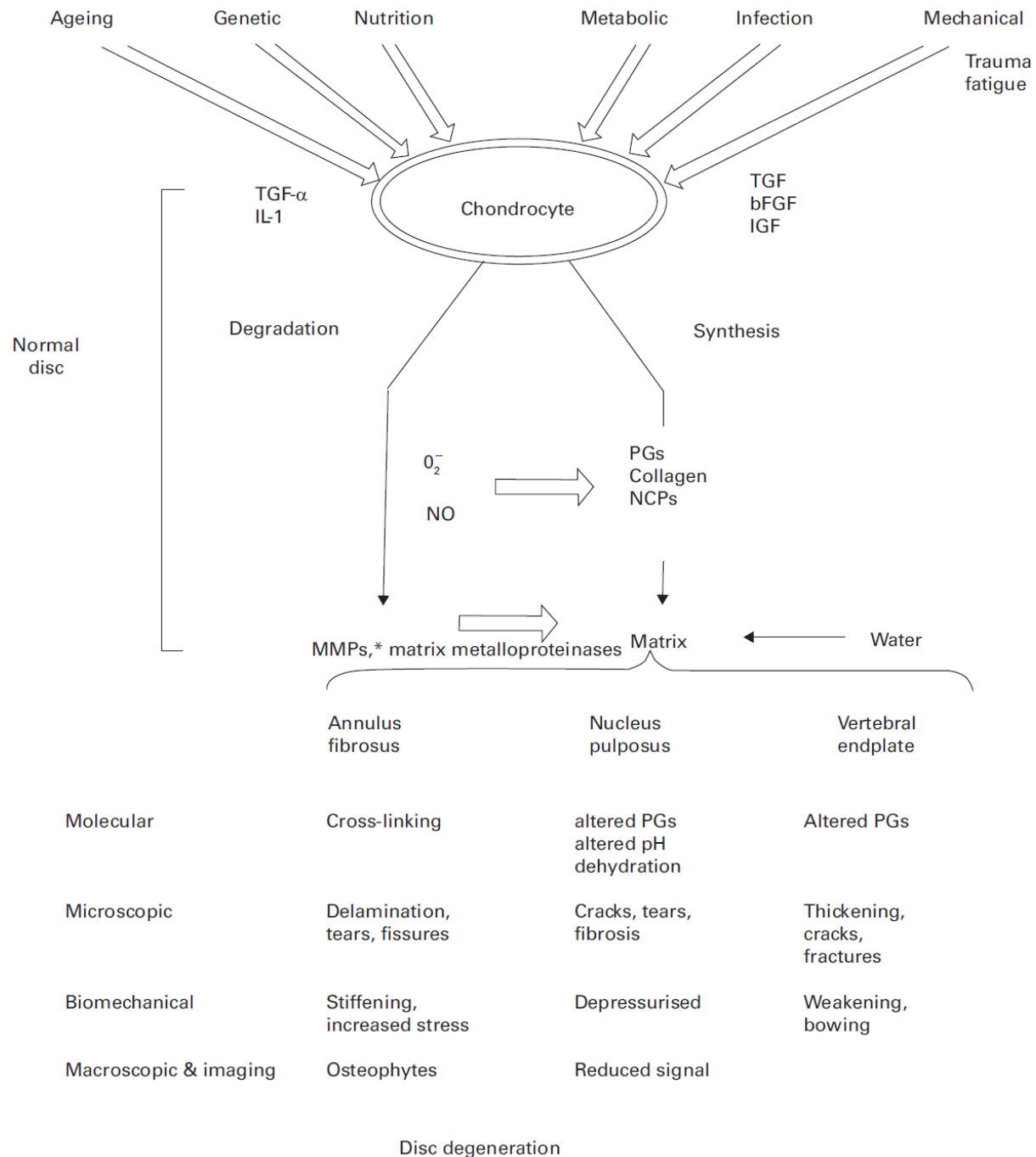
- **CAUSES OF DISC DEGENERATION**

. JBJS 90 b ; 126

# DEGENERATION

## MULTIFACTORIAL

- Constitutional  
Genetic  
Constant wear and tear
- Nutrition
- Smoking
- Increased load, osmotic pressure stress-induced premature senescence.
- **Metabolic disorders.**  
Diabetes mellitus, the NP demonstrates a significant decrease in hexosamine content
- **Alkaptonuria** develop intradiscal deposits of a black pigment, inducing disc degeneration
- **Low-grade infection in disc degeneration** :31% of discs harvested after microdiscectomy tested positive for low-virulence Gram-positive bacteria, and 84% of these were infected with *P. acne*



# 1. CONSTITUTIONAL Ageing

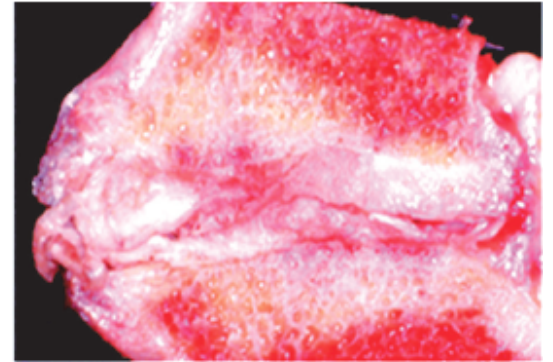
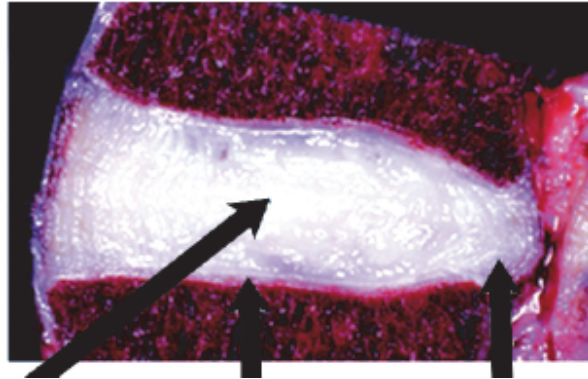
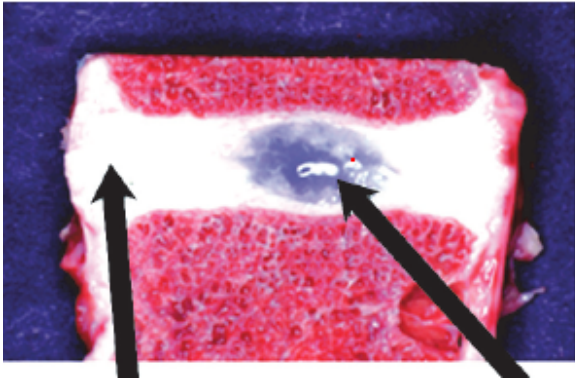
- The concentration of cells in the disc declines with age, especially in the annulus.
- The rate of synthesis of proteoglycans decreases. The Pg's produced are **smaller and less aggregated**
- The concentration of CS falls, Hence **a rise in the ratio of keratan sulphate** to chondroitin sulphate.
- The **collagen content of the nucleus** increases and changes from type II to type I, Hence NP is more fibrous.
- Fewer polar groups of the proteoglycans available to bind water. The nucleus becomes solid & dry
- **Herniated discs are associated with an increased degree of senescence :apoptosis.**

# Conclusions

- 84% had either unchanged MR or showed regression of baseline changes.
- The most common progressive findings were disc signal loss (10%), progressive facet arthrosis (10%), or increased end plate changes (4%).
- 2/200 with primary radicular complaints, had new findings of probable clinical significance
- **New findings were not more frequent in subjects with LBP episodes developing after minor trauma than when LBP developed spontaneously.**
- Findings on MR imaging within **12 weeks of serious LBP inception** are highly unlikely to represent any new structural change. Primary radicular syndromes may have new root compression findings associated with root irritation.
- Support an alternative hypothesis: degeneration begin very early in life- the basis of nutritional, developmental, and genetic factors. Later minor traumatic or repetitive occupational events play a minor role, if any, in eventual structural changes and serious disability

# Young → adult → Deg Disc

*Hughes J Bone Joint Surg Br*  
2012;94-B:1298–1304.





## 2. Genetic

- 1. Taq I and Fok I of the **vitamin D receptor gene** have been implicated in disc degeneration in several studies.
- 2. The prevalence of the **t-allele of Taq I, and hence the risk for disc degeneration, differs among races. It is present in 43% of Caucasians** and 31% of Africans, but in only 8% of Asians.
- Among the genes that code for interleukin-1, the alleles (IL-1 $\alpha$ T889 and IL-1 $\beta$ T3954) are associated with disc bulging, suggesting a genetic predisposition to disc degeneration through alterations in the function of pro-inflammatory mediators.

# Genitic.

*J Bone Joint Surg Am. 2011;93:225-229.*

- Twin sibling studies and subsequent genetic marker studies.
- The Utah Population
- Relative risks in relatives were estimated
- The Genealogical Index of Familiality test for 1264 patients with lumbar disc disease
- Relative risk in relatives: In both first-degree (relative risk, 4.15;  $p < 0.001$ )
- Conclusions: Strongly supporting a heritable contribution to the development of symptomatic lumbar disc disease.

# 3. Mechanical factors

- Discs immediately above a **transitional vertebra** tend to exhibit significantly more degenerative changes than those between the transitional vertebra and the sacrum.
- *Vibration has been incriminated in the pathogenesis of disc degeneration.*
- [ helicopter pilots, and drivers of trucks, buses and tractors, have a high rate of back pain]
- *Torsional movements generate tension in half of* the collagen fibres in the annulus, whereas the other fibres tend to become slack. For the fibres to incur damage, they must be elongated by more than 4% of their resting length, and this is feasible only when axial rotation at each individual segment exceeds 3°.
- For this to occur, the facet must be damaged first, as they resist rotation beyond 1.5° to 3°. However, *when the spine is flexed, the gaping facet joints offer less constraint to rotation,*
- *leading to an annular tear without damage to the facets.*

- In the degenerative spine, the tear may start in the inner fibres of the annulus and extend toward the periphery.
- That torsion injury may lead to disc degeneration can be supported by clinical imaging studies.
- Professional bowlers in cricket with a chronic stress reaction of the pars
- *Compression.* The lumbar disc is designed to sustain compression loads which are beneficial to the disc. Loading is the physiological stimulus for matrix turnover. However, excessive loading can lead to deleterious changes in the disc by reducing gene expression of all anabolic proteins with significant effects on aggrecan formation, while simultaneously increasing gene expression of MMPs.
- The most vulnerable component of a lumbar disc is the vertebral endplate. When subjected to compression, the endplate fails by fracturing.




- Repeated application of loads amounting to between 50% and 80% of the ultimate tensile strength of the endplate can cause a fracture after as few as 100 cycles.
- There is a strong association between degeneration and defects in the endplate from
- Schmorl's nodes, Scheuermann's disease and fractures, with an increased incidence of disc prolapse, particularly at the lower lumbar levels.
- Damage to the endplate rapidly leads to depressurisation of the nucleus and a simultaneous increase in stress in the posterior annulus.
- Destruction of cartilage from an endplate fracture would provoke an IL-1-mediated inflammatory response, inducing enzymes that destroy proteoglycans.
- Mechanical factors can trigger biochemical reactions which, in turn, may promote the normal biological changes of ageing, which can also be accelerated by genetic factors.

# Inciting event and disc herniation. Boston

- **144 adults with lumbosacral radicular pain and LDH confirmed by MRI**
- **Inciting event, which were categorized as** spontaneous onset, nonlifting physical activity, heavy lifting (>35 lbs), light lifting (<35 lbs), nonexertional occurrence, or physical trauma.
- **62% LDH did not have a specific patient-identified event associated with onset of symptoms.**
- **26% Nonlifting** activities were the most common inciting event,
- **6.5% Heavy lifting**
- 2%, light lifting
- **CONCLUSIONS: The majority of LDH occurred without specific inciting events. A history of an inciting event was not significantly** associated with a more severe clinical presentation.
- There was no significant association between the occurrence of a lifting related event and the severity of the clinical presentation.
- **Spine J. 2010 May;10(5):388-95. Epub 2010 Mar 29.**

# Vibration.

• SPINE Volume 36, Number 5, pp 386–392

- The relevance to real life appears to be that once disc damage is initiated, **it can be made worse with vibration** and that a flexed posture may add to this damage exacerbation.
- The loads and conditions tested here were designed to mimic exposures obtained from ATV driving farmers. These loads appear to worsen already initiated disc damage.
- **Key Points**
-  Vibration and shock exposures resulted insufficient mechanical injury to exacerbate existing partial IVD herniations.
-  Although dynamic flexion postures were influential in the development of IVD herniations, static flexion postures did not enhance nucleus tracking but did make the joint marginally stiffer.
-  Repeated dynamic flexion initiated disc damage and produced more damage to the disc than subsequent vibration was able to exacerbate.

- This has been confirmed on electrophysiological study in dogs.
- Nerve injury caused by the combination of chronic compression and application of NP may induce a more pronounced delay of nerve conduction velocity and a more significant reduction of amplitude in ascending CEAPs, compared with nerve injury caused by only chronic compression or only application of NP.
- Histologically, changes such as intraneural edema, Schwann cell edema, and nerve fiber injury in nerve injury caused by the combination of chronic compression and application of NP seemed to induce more pronounced changes than nerve injury caused



- It has been reported that the pathophysiologic findings of the nerve root and dorsal root ganglion associated with mechanical compression are intraneural edema formation and reduced blood flow (ischemia)
- The findings associated with chemical irritation are circulatory changes, such as hyperemia in and around the nerve root, acceleration of vascular permeability, and activation of endothelial cells, which then may induce hypertrophy and reduce diameter of the vessels
- It is necessary to assess how to associate the data of this experimental study with the clinical symptoms. In the next step, the effects of treatment, such as removing compression or antiinflammation therapy, can be analyzed using the current experimental model. The results of the current study may be the basis of the future studies.

# Back Pain in Active Duty United States Military

- Incidence rate of low back pain was 40.5 per 1000 person-years.
- Women, compared with men, had a significantly increased incidence rate ratio for low back pain of
- 1.45.
- The incidence rate ratio for the 40 + age group compared with the 20 to 29 years of age group was 1.28.
- Each service, when compared with the Marines as the referent category, had a significantly increased incidence rate
- Army: 2.19, Navy: 1.02, and Air Force: 1.54.
- Compared with single service members, significantly increased incidence rate ratio for low back pain were seen in married service members: 1.21.
- SPINE Volume 36, Number 18, pp 1492–

# Facts

- 1. Degeneration at 63 Y: 100%
- 2. Degenerated disc → acidic → sensitive due to ingrowth
- 3. Damage to disc is by twisting and bending. Compression causes endplate injury
- 4. Function of a disc: The balance between expansion of the NP and tension in the AF leads the IVD to resist compression. Consequently the whole composite disc can be weight-bearing, while allowing flexion and torsion in an otherwise rigid structure.

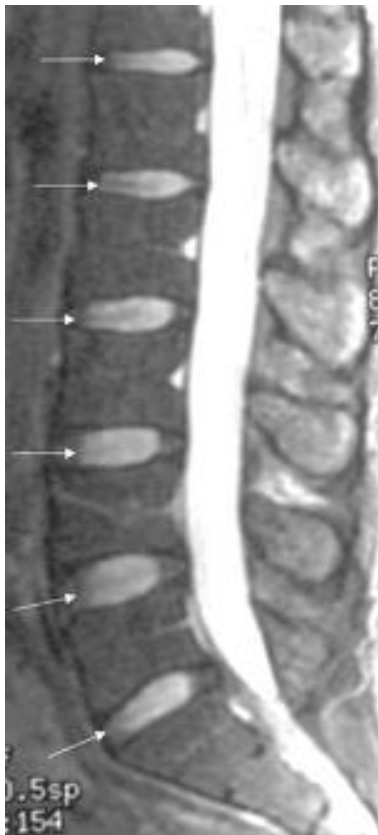
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# Causes for pain

- 1. Altered stress on the facet joints and other spinal tissues
- 2. Loss of disc height can contribute further to compression of the exiting nerve root
- 3. TNF which is produced in the degenerate IVD can stimulate nerve.
- 4. Chronic: changes within the spinothalamic tract.[*J Bone Joint Surg [Br]* 2004;86-B:74–80]
- 5. Neurohumeral marker: substance P, nerve growth factor (NGF), brain-derived neurotrophic factor (BDNF) and platelet endothelial cell adhesion molecule (PECAM)
- 6.The growth of nociceptive nerves into the usually aneural IVD is a well-recognised feature of painful degenerative IVD.[*Lancet* 1997;350:178–181]
- 7. Chemical irritation (inflammation around nerve root) may induce more nerve root injury than each factor *per se*. **Spine 2003;28:435–441**

# Early Evidence of disc degeneration

Normal



Degenerated

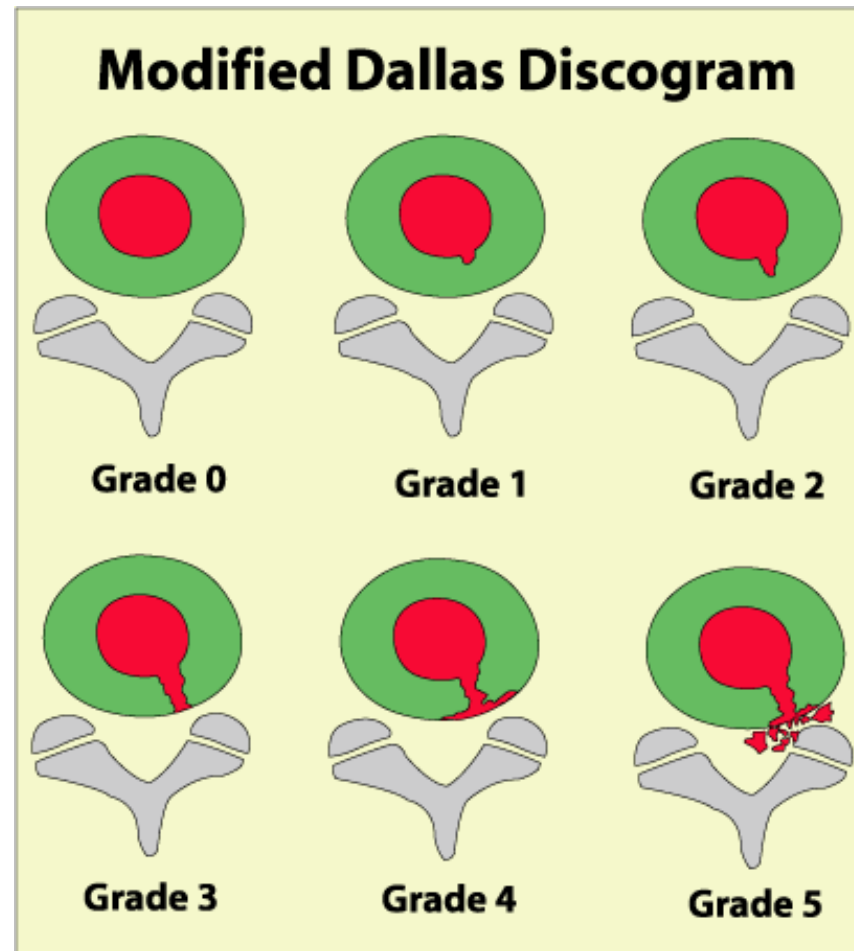


# Discography:

Orthop Clin N Am 35 (2004) 7 – 16

- Highly individualized.
- Determine whether degeneration within a disc seen on imaging studies is the primary clinically significant source of a patient's LBP illness.
- First, anatomically normal discs at discography are not painful
- Second, discs that prove to be intensely painful and clinically concordant when injected are more likely to have annular fissures into or through the outer third of the disc annulus

# Modified Dallas Discogram

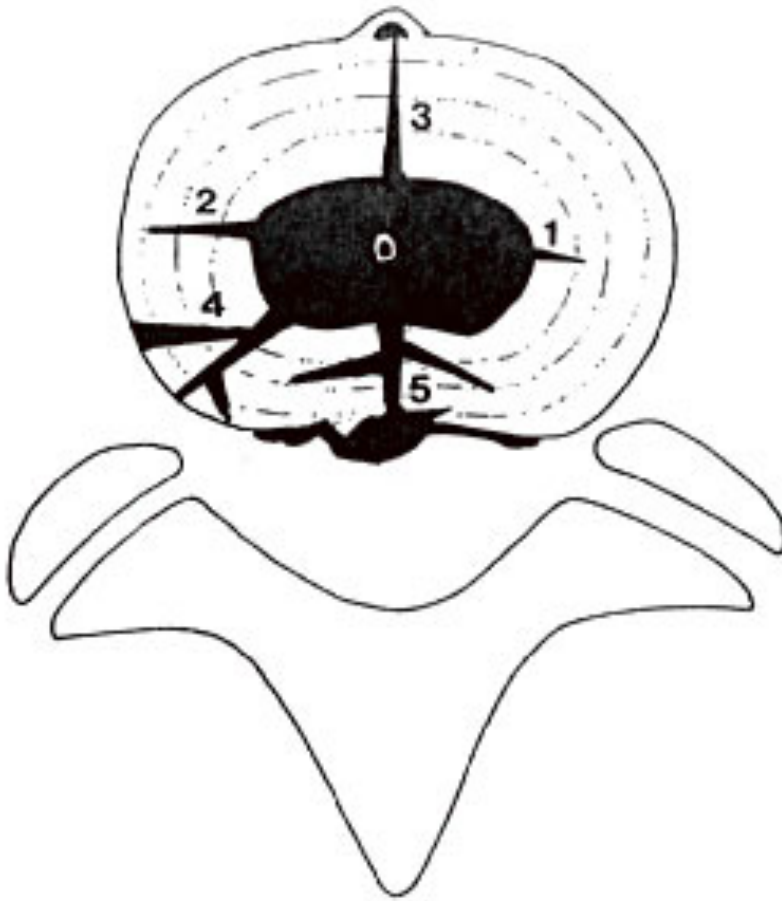


- Provocation discography is perhaps one of the rare techniques which is helpful in indicating the need for lumbar spinal fusion in patients with degenerative discs.
- It is, however, invasive, and a small amount of antibiotics should be added to the dye to protect against iatrogenic discitis.
- Provocation discography should be combined with psychometric testing. The painful disc should be fused and a 360° fusion is perhaps better than a posterior fusion in patients with positive provocation discography.



- **ANNULAR TEAR**

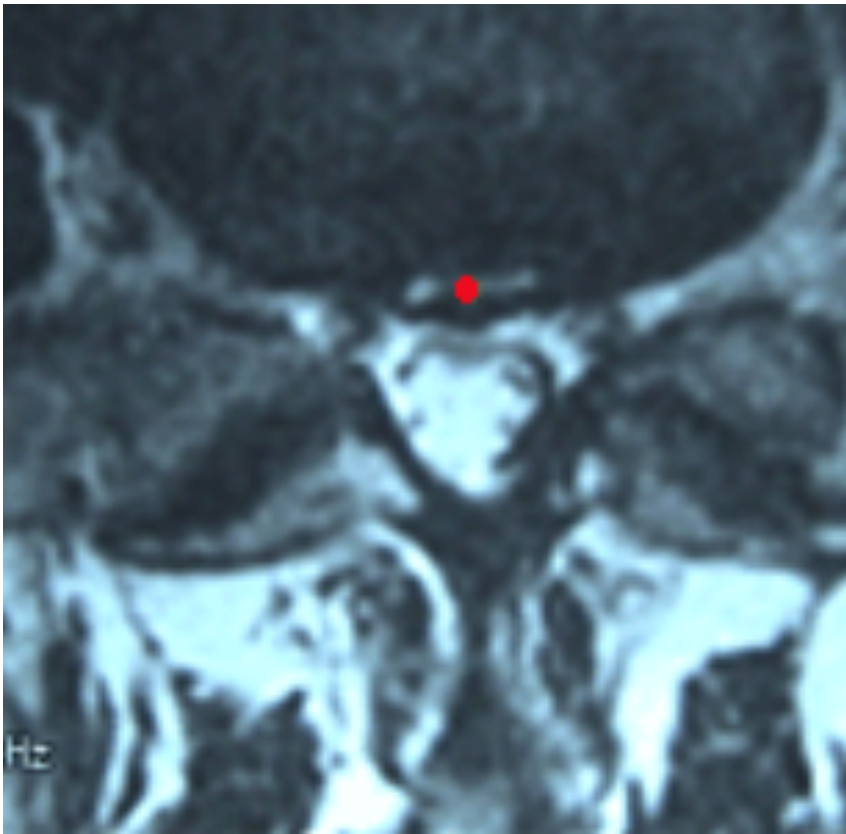
# Types of Annular tear



- 1. incomplete
- 2. incomplete
- 3. anterior
- 4. Radial posterolateral
- 5. Posterior

# Types of annular tear

**Central**



**Paracentral**



# Possible importance of Annular tear

## Wheelas

- - lesion labeled annular tear or internal disruption is based on concept of leaking disc, one which permits the irritating liquid material normally restricted to the center of the disc to come into contact with the innervated tissue;
- - annular tissue that permits egress of this liquid has a poor capacity for healing;
- - at most, a thin layer of scar tissue at the periphery of the tear may seal the leak but leave the disc highly susceptible to retearing;
- - where as herniated disc has a significant capacity to be resolved w/ time, annular tear continues to produce symptoms indefinitely;
- - clinical picture is based on pain related to increased intradiscal pressure and irritability of neural structures;

- - annular tear is usually produced by injury that increases intradiscal pressure significantly;
- - predominant element in the history is back pain, either alone or in excess of leg pain;
- - leg pain may be either unilateral or bilateral;
- - increases in intradiscal pressure exacerbate the pain;
- - pain is often worse when sitting than when standing;
- - coughing & sneezing worsen the pain as do forward bending and lifting;
- - key finding is positive sciatic stretch test that produces back pain or back pain greater than leg pain;

- - positive test is presummably produced by tension on irritated dural tissue or possibly by increased intradiscal pressure;
- - myelogram, MRI, & CT, tests show **no compression** of neural structures;
- - key test is discography with **CT discography**; - positive examination will show dye extending into the epidural space or extending to the periphery of the disc where it can contact innervated portion of the annulus fibrosus;
- - positive test also requires a reproduction of pain accompanying injection of dye;
- - reproduction of back pain to greater degree than leg pain by sciatic stretch test;
- - no neurologic deficit;
- - reproduction of pain by discography and discographic dye extending to or beyond the periphery of the annulus fibrosis

# Annular tear

- The assumption that the location of a patients' low back pain coincides with the side of the lesion has permeated the nonsurgical treatment perspective for decades.
- A more likely explanation may come from the mechanism of somatically referred pain.
- Somatic referred pain occurs as a result of stimulation of nerve endings in adult tissue derived from the embryologic somite, such as the intervertebral disc. This noxious sensation occurs as a result of a misperception of the origin of the signal, which reaches the brain by a convergent sensory pathway. In theory, this could account for contralateral pain from a nociceptive source.

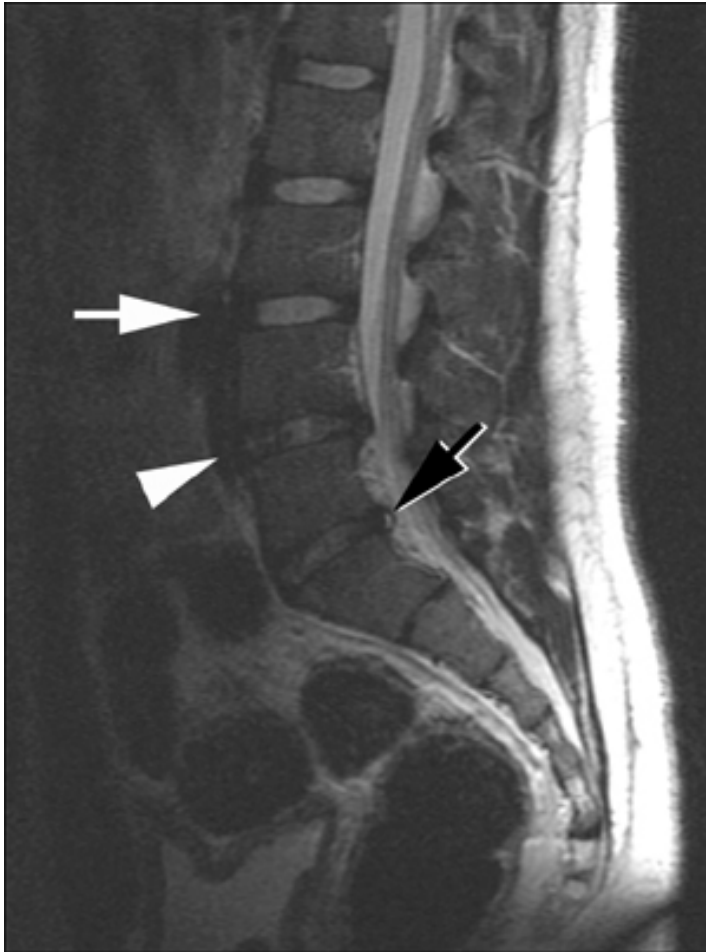
# Causation of pain:

- 1. The sinuvertebral nerves constitute the vast majority of the visible elements of the posterior plexus, but the majority of the nerve fibers are microscopic.
- It has been suggested that somatic afferent fibers from the discs and ligaments course with the rami communicantes to return to the ventral rami.
- 2. The presence of phospholipase A2 in the human intervertebral disc provides the biochemical mechanism by which an inflammatory process could be induced.
- The premise of discography is that stimulation of the nerve endings through a fissure extending to the innervated outer one-third of the annulus which elicits a concordant pain response, identifies that tear as the nociceptive source.



- 3. It is also feasible that the **posterior longitudinal ligament** or the dorsal root ganglion could be stimulated during provocative discography.
- These structures are juxta positioned to the intervertebral disc and could be sensitized
- by the contact of contrast fluid through an annular fissure, acting as a conduit to the epidural space.
- In conclusion, this study demonstrates that there is a **random correlation between the side of a patients' pain and the side of that patients' concordantly painful annular tear.**

# Annular tear



- At L5-S1 : an area of high signal intensity within the posterior annulus, indicative of an annular tear

# Can it cause pain: Eur Spine J. 2000 Feb;9(1):36-41

## The value and significance of provocative discography

- Disagreement still exists
  - As a potential pain indicator in patients with low back pain.
  - A prospective blind study
  - 92 cases, mainly occurring at L4/5 (48%) and L5/S1 (35%).
  - - In morphologically abnormal discs (grades 3, 4 and 5), there was a significant correlation between the HIZ and exact or similar pain reproduction
  - The sensitivity, specificity and positive predictive value for pain reproduction were high, at 81%, 79% and 87% respectively.
- The nature of the HIZ remains unknown**, but it may represent an area of secondary inflammation as a result of an annular tear.
- Patients with low back pain is likely to represent painful internal disc disruption.

# Importance of HIZ

Eur Spine J. 2006 May;15(5):583-7.

- Aroused great interest
- The HIZ was closely associated with a concordant pain response on awake discography.
- 52 patients with low back pain without disc herniation underwent MRI and discography
- 11 specimens of lumbar intervertebral discs which contain HIZ
- The consecutive sagittal slices through the HIZ lesion showed that a notable histologic feature of the formation of vascularized granulation tissue
- The current study suggests that the HIZ of the lumbar disc on MRI in the patient with low back pain could be considered as a **reliable marker of painful outer annular disruption**.

# Significance

Zhonghua Yi Xue Za Zhi. 2008 Sep 16;88(35):2478-81

- The data of 1000 unselected cases, 566 males and 434 females, aged 49.49 (12 - 86), who underwent lumbar MRI were analyzed to examine the prevalence of HIZ.
- 200 of the 1000 cases with HIZ which had complete clinical history records,
- Male : Female      5:4
- Most located in L4/5 and L5/S1 (74.8%) and the location in left side (153 HIZs) was more common than that in right side.
- Shown in superior region (15.4%), middle region (28.8%), as well as inferior region (55.8%)
- 57.5% were symptomatic
- Discogram scale, LBP could be provoked in 8 of the 9 patients with grade IV and could not be provoked in 6 of the 7 patients with the grade III.
- **CONCLUSION:** Whether HIZ is accompanied with LBP is related to the degree of disc degeneration. When CTD showed the degree of modified Dallas' grade IV and over most of the patients will show LBP. HIZ only indicates the possibility of discogenic LBP and can not replace provocation

# DDD [dark disk disease]

## **Ideal**

- >6 M of conservative: failed
- Single level degeneration
- Absence of Psychiatric or II gain
- Concordant pain on diskography

## **Poor**

- Benefit/gain
- High level of opioid use
- Abnormal psychometric tests
- Exaggerated pain behaviors
- Off work > 3 M
- Over reliance of MRI , high cases of failure

# Annular Tears and Disk Degeneration:

AJNR March 2009 30: 500-506

## SPINE

- Annular tears and nuclear degeneration often occur concurrently, but their temporal association remains unknown. Annular tears occur in the early stages of disk degeneration and are associated with a faster subsequent nuclear degeneration.[strong association- *Acta Radiol* 1995;**36**:497–504, *AJNR Am J Neuroradiol* 1989;**10**:1077–81]
- **Definition of AT:** The presence of any hyperintense signal intensity within the peripheral annulus was considered to represent an annular tear.
- **Grading system**                      **Pfarrmann, Spine**

MRI:It detects annular tears with a fairly high sensitivity of approximately 67% and a specificity of nearly 100%.

- The relative distribution of signal-intensity and degeneration grades in disks without and with annular tears in our study seems to support our first hypothesis that annular tears precede nuclear degeneration.



- 1. More in the lower lumbar
- 2. Vast majority: a vast majority 95.6% demonstrated annular tears at both the L4–5 and L5-S1 levels.
- 3. The mean signal-intensity grade for disks with annular tears was noted to be 3, which was significantly higher than the corresponding value of 1.43 for disks without annular tears [Pfirferman]
- 4. Ten percent of all tears occurred in disks without any loss of signal intensity.
- 5. Disc degeneration is more in the annular tear. ?accelerate degeneration
- 6. In contrast, it was rare to find disks with more advanced nuclear degeneration in the absence of annular tears.

- The appearance of new annular tears was noted on follow-up examination in 33% of initially normal disks. Of these tears, one third occurred without any change in signal-intensity grade. This would support the notion that **annular tears precede** nuclear degeneration.

However, the fact that 4 of the initially normal disks demonstrated a change in the signal **intensity grade in the absence of annular tears** contradicts this hypothesis.

- The presence of biochemical changes in the nucleus occurring at a relatively young age, leading investigators to hypothesize that degenerative changes in the nucleus precede the annular tears.[*Radiology* 1990;**177**:332–33, discussion 333–34, *Spine* 2006;**31**:1522–31]
- Our results indicate that annular tears are probably one of the earlier imaging manifestations of the degenerative process affecting the intervertebral disks, and their presence is associated with a more rapid appearance of nuclear degeneration in subsequent imaging studies.

- The loss of the signal intensity of the central aspect of intervertebral disks on T2-weighted images is frequently seen in degenerative disk disease

It is one of the most frequent changes noted in the longitudinal studies of the intervertebral disks.



# Pain

- LBP 80% at 60 Y
- Acute Vs Chronic 3 M
- 90% Acute resolves and 10% chronic
- 85% no pathology is identified in Acute LBA and is nonspecific
- MRI abnormalities [desiccation, annular tear and facet arthrosis] and its relation to pain is poor
- To sort out: Discogram, Facet block, SI joint injection: controversial
- Mainstay: History and clinical assessment

# Type of Pain

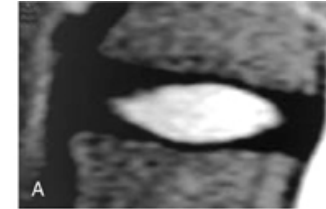
- 1. Sciatica                      Specific nerve root [disc, listhesis, stenosis]
- 2. Non-mechanical              Pain is constant; minimally affected by activity and  
unrelieved by rest; worse at night [tumor/infection]
- 3. Mechanical                      Activity or changing position or prolonged sitting
- Relieved by rest [Disc, degeneration, instability]
- 4. Neurogenic claudication

- **GRADING OF DISC  
DEGENERATION**

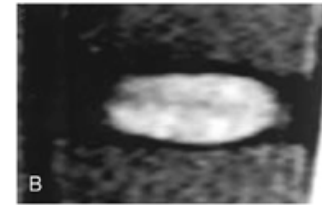
# Grading system Pfirrmann, Spine

2001:26: 1873

**Grade I** Homogenous, hyperintense  
signal intensity;  
Normal height.

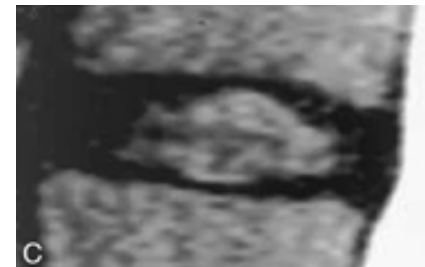


**Grade II** inhomogenous white  
signals with normal height.  
Normal adult disc



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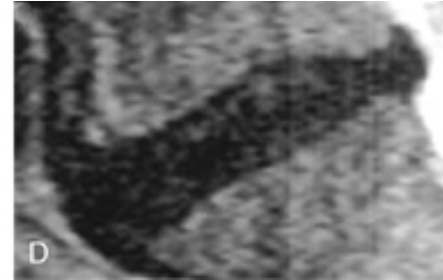
**Grade III** An intermediate gray signal  
within the nucleus pulposus



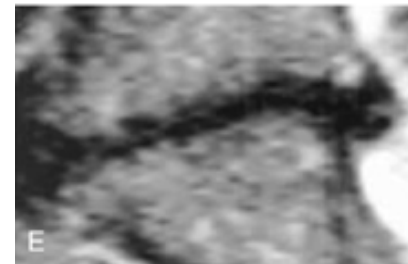


Grade IV changes are characterized by hypointense dark gray signals with mild loss of disc height.

- 



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



**Table III.** Degeneration patterns according to Buirski<sup>65</sup>

<b>Pattern type</b>	<b>Intranuclear cleft</b>	<b>Prolapse/ bulge</b>	<b>Disc intensity</b>	<b>Disc height</b>	<b>Asymptomatic (n = 63) (%)</b>	<b>Symptomatic (n = 115) (%)</b>
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

**Table III.** Degeneration patterns according to Buirski<sup>65</sup>

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

- 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.

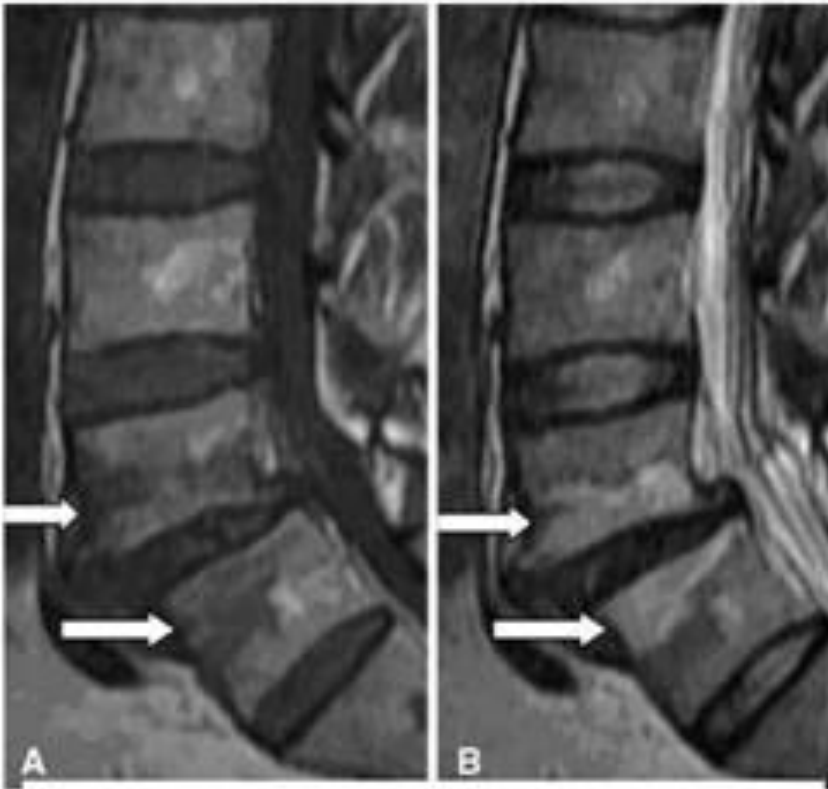
Modic changes were not significant covariates for the clinical course of pain, function or fear avoidance beliefs.

## 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

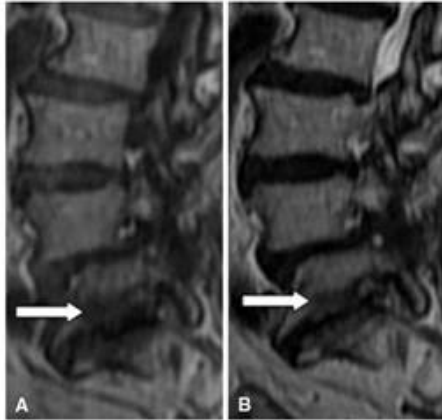


- Hyper on T1 and on T2
- Fatty replacement of the marrow

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



# 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

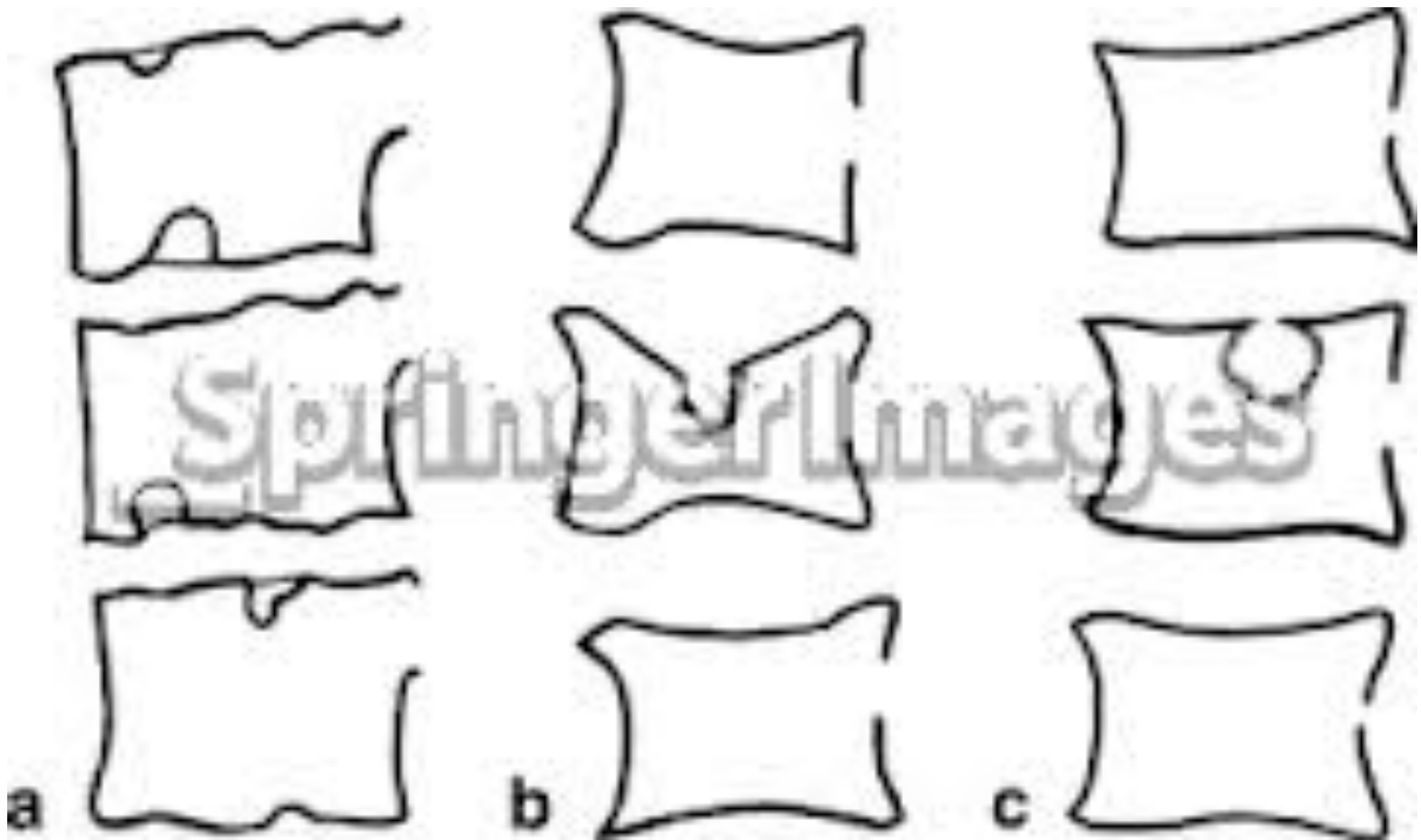
*Spine (Phila Pa 1976)* 2012 ; 37 : 1432 – 9 .

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**

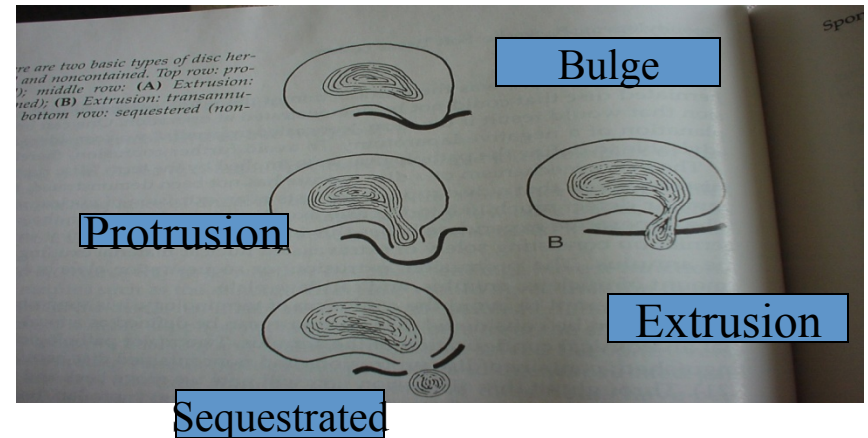
It has been demonstrated that application of NP induces pain-related behavior in rats<sup>8,19</sup> and histologic changes such as axonal degeneration, intraneural edema, and Schwann cell edema in the nerve root and dorsal root ganglions.

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 <sup>1</sup> 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,<sup>1</sup> 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.

**CLINICAL**

# The Association Between Lumbar Disc Degeneration and Low Back Pain

- SPINE Volume 35, Number 5, pp 531–536, 2010
- LDD [Lumbar disc deg] is characterized radiologic by the presence of osteophytes, endplate sclerosis, and disc space narrowing.
- Lumbar radiographs were scored for 1204 men, and 1615 women.
- Osteophytes were the most frequent radiographic feature observed, with men having the greatest frequency.
- Disc space narrowing was more frequent in women than men.
- Both radiographic features increased in frequency with age.
- Disc space narrowing appeared more strongly associated with LBP than osteophytes, especially in men. Disc space narrowing at 2 or more levels appeared more strongly associated with LBP than disc space narrowing at only 1 level

The explanation for the stronger association between LBP and disc space narrowing compared with the presence of osteophytes is unknown. It is possible that the reduction of space between the vertebrae as a consequence of the degenerative disc is more likely to lead to increased pressure on facet joints and spinal ligaments.

The height of the lumbosacral disc is difficult to score due to its narrowed height relative to disc L4–L5. The lumbosacral disc is also different in appearances among different individuals, independently of disease.

- From our data, a useful case definition for LDD can be deduced; specifically disc space narrowing at 2 or more levels from L1/2 to L4–L5. This definition shows the strongest relationship with LBP



# Discectomy and degeneration J Bone Joint

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

- Low back pain (LBP) is a common complaint with a one-year prevalence up to 65%, and lifetime prevalence up to 84%.
- The differing opinion of surgeons concerning the indications, however, appears to play an important role and the complexity of this process is high.
- Psychological and social predictors of the outcome of operative treatment are better evaluated in disc herniation than in degenerative disc disease. Hasenbring et al<sup>40</sup> found that persistent pain six months after discectomy was best predicted by a combination of somatic (the degree of disc displacement), psychological (depression, pain-coping strategies, endurance strategies, non-verbal pain behaviour, search for social support) and social parameters (social status, sitting position). *Spine* 1994;19:2759-65.

# Disc herniation and psychology *Pain*

1999;80:239-49.

- In herniation of a lumbar disc it was shown that psychosocial and work-related factors played a much more important role than morphology, as indicated by the MRI findings, in predicting outcome.

# **LUMBAR SURGERY**

# Timing of disc surgery

- Greater degree of satisfaction with those patients with a shorter duration of sciatica.
- Increased risk of a poor result if the duration of sciatica exceeded 12 months.
- No difference between patients who were operated upon at various intervals within 12 months
- Dvorak et al<sup>5</sup> concluded that patients with sciatica of less than six months duration had better long-term operative results. The most recent prospective cohort by Nygaard et al<sup>9</sup> suggested that the threshold for the duration of sciatica was eight months
- In view of the favourable natural course of herniation of the lumbar disc and the possible complications associated with surgery, most authors recommend a minimum period of conservative management of two months. This should not, however, exceed 12 months since the risk of poor functional outcome then increases.
- *J Bone Joint Surg [Br] 2004;86-B:546-9.*

# OSWESTRY DISABILITY INDEX

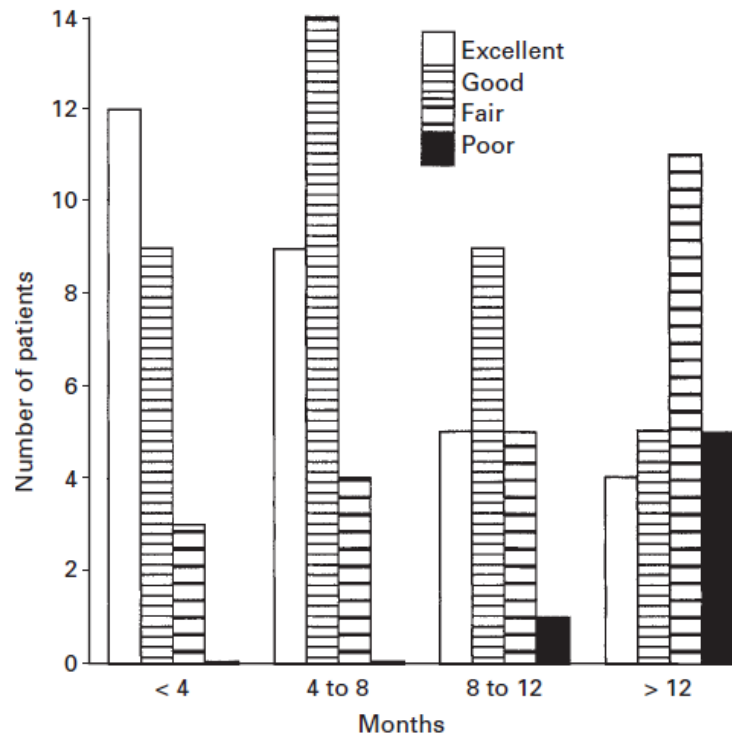


Fig. 5

Subgroup analysis of the level of patient satisfaction according to the duration of sciatica.

**Table II.** Mean change (%; SD) in the ODI score at one year for the groups of patients with varying duration of sciatica

Group	Mean change in ODI
Less than 4 months	36.16 (24.48)
4 to 8 months	40.11 (25.24)
8 to 12 months	41.40 (19.88)
More than 12 months	23.17 (16.10)

**SURGICAL OUT COME**

# Timing of surgery b

Bone Joint Surg Am. 2011;93:1906-14

- Significantly worse in patients who had had symptoms >6 months
- At 4 years: operative treatment group who had had symptoms for six months had better outcome.
- Differences in treatment effect between the two groups related to the duration of symptoms were not significant.
- Conclusions: Increased symptom duration due to lumbar disc herniation is related to worse outcomes following both operative and nonoperative treatment.
- The relative increased benefit of surgery compared with nonoperative treatment was not dependent on the duration of the symptoms.

# Causes for failure

- 1. Poor case selection
- 2. Sciatica for >12 M [>6 M]
- 3. Abnormal pain behavior
- 4. Compensation
- 5. Smoking
- 6. Psychosocial issues



# Long term outcome of surgery for lumbar disc herniation:

- **Ten- to 15-year follow up; retrospective**
- In the present study, 150 patients were selected for surgery with strict criteria and all treated with the standard technique.
- Radiographic studies showed vertebral instability in 30 cases, but only 9 were symptomatic. [<10%]
- Recurrences were not observed
- The standard procedure for lumbar disc herniation showed good results at 10- and 15-year follow-up.
- Eur Spine J. 1999;8(1):70-4.

# Long-term outcomes of standard discectomy >10 years.

- Spine (Phila Pa 1976). 2001 Mar 15;26(6):652-7.
- **Residual low back pain** was found in 74.6% of the patients, only 12.7% had severe low back pain.
- 
- The majority of the patients with severe low back pain were under 35 years of age at the time of operation, with preoperative advanced disc degeneration.
- **CONCLUSION:**
- **The long-term outcome of standard discectomy in this series was favourable.**
- **Although patients with preserved** disc height generally had favourable results, the risk of recurrent disc herniation was high in this population.

# conservative versus aggressive discectomy

**RESULTS: There is fair evidence that conservative discectomy will result in shorter operative times and a quicker return to work**

- despite similar lengths of hospital stay, similar pain levels at discharge, similar 6-month functional status, and a similar 2-year incidence of persistent/recurrent back and leg pain.
- There is poor quality evidence that conservative discectomy will result in a lower incidence of recurrent back pain beyond 2 years postoperatively.
- There is fair quality evidence that conservative discectomy will result in a higher incidence of recurrent disc herniation.

**CONCLUSIONS: There are no Level I studies to support conservative versus aggressive discectomy for the treatment of primary disc herniation.**

However, systematic review of the literature suggests that conservative discectomy may result in shorter operative time, quicker return to work, and a decreased incidence of long-term recurrent low back pain but **with an increased incidence of recurrent disc herniation**. Prospective randomized trials are needed to firmly assess this possible benefit.

- Spine J. 2009 Mar;9(3):240-57.

# Pediatric Disc Herniation.

*J Am Acad Orthop Surg* 2011;19:

649-656

- Pediatric disk herniation is a rare condition
- There is typically a delay in diagnosis compared with time to diagnosis of adult disk herniation.
- Pediatric disk herniations are often recalcitrant to nonsurgical care
- In patients who present with isolated pain symptoms and have a normal neurologic examination.
- Twenty-eight percent of adolescent disk herniations involve apophyseal fractures; this presentation has a higher rate of surgical intervention than do herniations without fracture.
- Surgical management of pediatric disk herniation involves laminotomy and fragment excision.
- Short-term data demonstrate excellent pain relief, with 1% of children requiring repeat surgery for lumbar disk pathology in the first year.
- Long-term data suggest that 20% to 30% of patients will require additional surgery later in life.

**COMPLICATION**

**Study Design.** Retrospective review and multivariate analysis.

**Objectives.** Recurrent lumbar disc herniation (rLDH) is a repeated disc herniation at a previously operated disc level in patients who experienced a pain-free interval of at least 6 months after surgery. We investigated whether the preoperative radiologic biomechanical factors (disc height index [DHI] and sagittal range of motion [sROM]) have any effect on rLDH.

**Summary of Background Data.** rLDH has been reported in 5% to 15% of patients. There have been many studies suggesting various risk factors for rLDH, such as disc degeneration, trauma, age, smoking, gender, and obesity. However, these factors did not reflect a biomechanical effect on the affected joint directly. Investigation of DHI and sROM would be helpful to understand the biomechanical impact on the occurrence of rLDH.

**Methods.** This study enrolled 157 patients who underwent surgery for L4–L5 LDH. We divided the patients into the recurrent and the nonrecurrent group and compared their clinical parameters (age, sex, body-mass index, symptom duration, diabetes, smoking, herniation type, preoperative visual analogue scale) and preoperative radiologic parameters (disc degeneration, DHI, sROM).

**Results.** rLDH occurred at  $40.8 \pm 15.5$  months (7–70 months) after primary surgery. Mean DHI was  $0.37 \pm 0.09$  and  $0.29 \pm 0.09$  in the recurrent and the nonrecurrent group, respectively ( $P < 0.05$ ). Mean sROM was  $11.3^\circ \pm 2.9^\circ$  and  $5.9^\circ \pm 3.7^\circ$  in the recurrent and the nonrecurrent group, respectively ( $P < 0.05$ ). Both smoking and disc degeneration were related with the development of rLDH ( $P < 0.05$ ).

**Conclusion.** Together with our data, DHI and sROM showed a significant correlation with the incidence of recurrent lumbar disc herniation, suggesting that preoperative biomechanical conditions of the spine can be an important pathogenic factor in the site of lumbar disc surgery.

# 1. Recurrent Disc

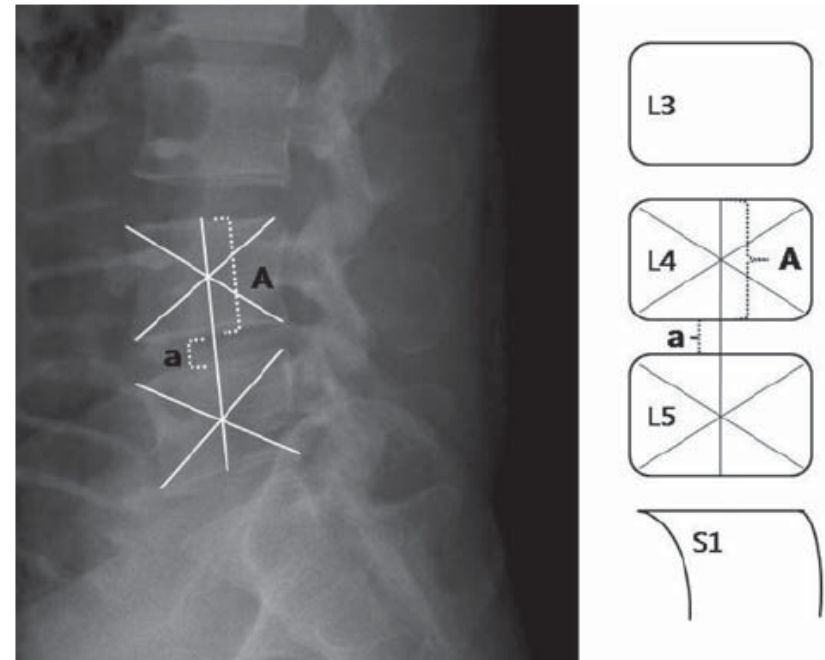


Figure 1. Radiographic measurement of the disc height index (DHI). Heights of the vertebral body and disc are measured using the midvertebral line. The midvertebral line is the line connecting the L4 and L5 centers. The center of the vertebral body is a crossing point of 2 diagonal lines of each vertebral body.  $DHI = a/A$ .

# Recurrent Disc

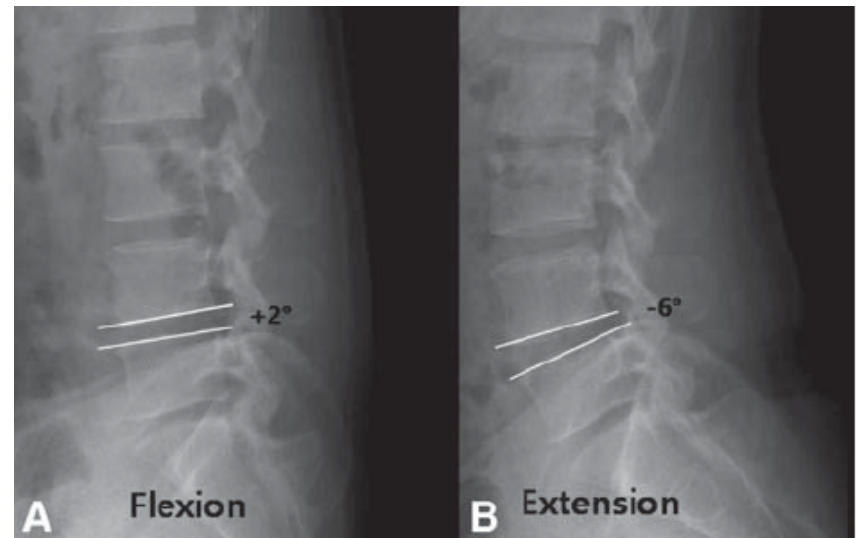


Figure 2. Method of measuring alignment using the superior and inferior endplate of L4–L5. The sagittal range of motion (sROM) of L4–L5 can be calculated by the difference between flexion (A) and extension (B) angles. The sROM at L4–L5 is 8° in this patient.

# Summary

- Discectomy-related complications occur in 15% to 30% of patients, including hemorrhage, infection, nerve injury, epidural scar formation, dural injury, instability, and recurrent herniation.
- In particular, recurrent lumbar disc herniation (rLDH), one of the major causes of surgical failure, has been reported in 5% to 15% of patients.
- Suk young age, male gender, smoking, and traumatic events as risk factors.
- Cinotti *et al*6 reported that some risk factors were found to be associated
- with ipsilateral recurrent herniation; male patients with marked degenerated discs were more likely to experience recurrent herniation



# SPINE Volume 34, Number 24, pp 2674–2678, 2009

**Table 2. Risk Factors for rLDH Using Univariate Analyses**

	Recurrent Group (n = 14)	Nonrecurrent Group (n = 143)	<i>P</i>
Clinical parameters			
Sex (M:F)	11:3	88:55	0.167*
Mean age (yr)	49.7 ± 14.4	44.1 ± 15.6	0.194*
Mean symptom duration (mo)	3.1 ± 0.4	3.0 ± 0.6	0.579
DM (+): DM (–)	2:12 (14.3%)	14:129 (9.8%)	0.638
Smoking (+): smoking (–)	10:4 (71.4%)	55:88 (38.5%)	0.023†
Mean BMI	23.7 ± 3.8 kg/m <sup>2</sup>	24.0 ± 3.4 kg/m <sup>2</sup>	0.724
Preoperative VAS	7.1 ± 1.3	7.4 ± 1.2	0.453
Radiologic parameters			
Disc degeneration			0.067*
No. group A (grade I, II, VI)	1	45	
No. group B (grade III, IV, V)	13	98	
DHI	0.37 ± 0.09	0.29 ± 0.09	0.001†
SROM	11.3° ± 2.9°	5.9° ± 3.7°	0.000†

- Disc degeneration contributes to changes of annular collagen and induces annular tears.[Gruber *BMC Musculoskelet Disord* 2002;3:9.23]
- The healing processes which occur in the outer lamellas after annular injury may not be enough for effective reconstitution of the external annulus in degenerated discs.
- These reports support our finding that the incidence of rLDH was higher in discs with degeneration grades III, IV, and V than those with grades I and II.

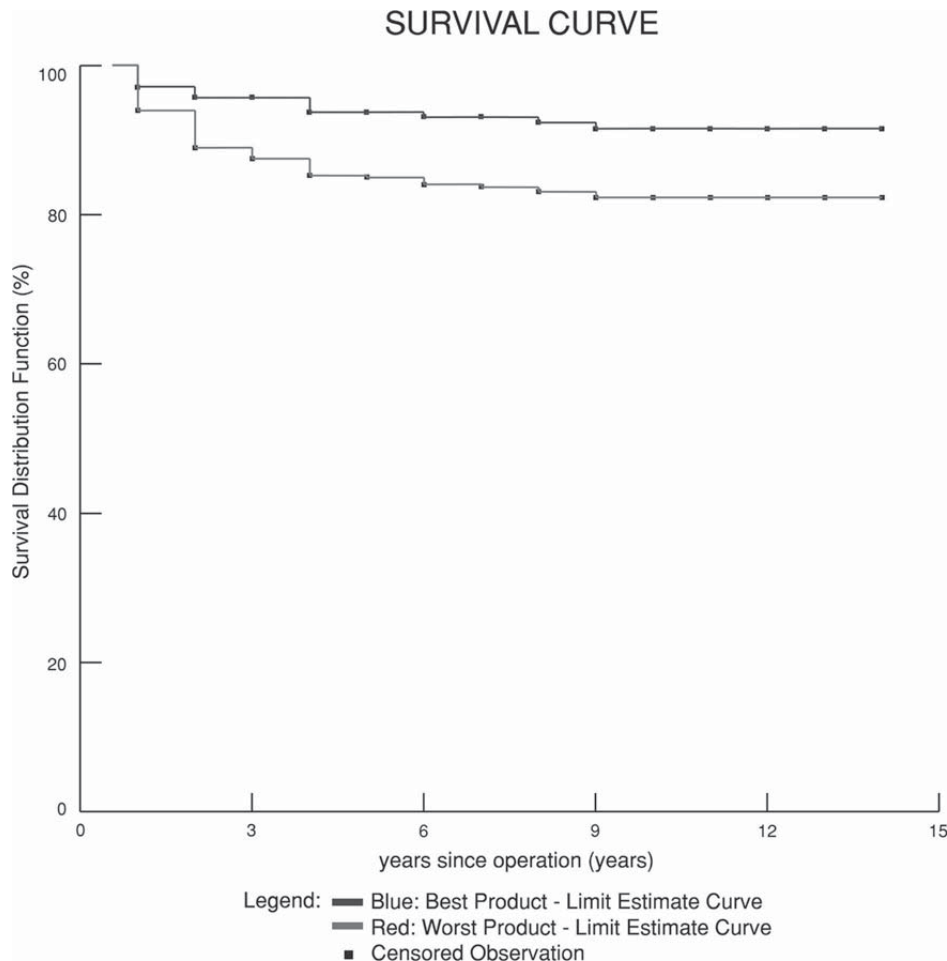
In disc degeneration grade VI reported that segmental motion decreased proportionally to the degree of disc degeneration. Kirkaldy-Willis and Farfan<sup>29</sup> proposed the concept of the progression of disc degeneration, which consists of dysfunction, unstable, and restabilization phases.

- These results suggest that collapsed discs (DHI 0.15) are biomechanically more stable than those with preserved disc height, resulting in a low incidence of rLDH.
- Among radiologic parameters, sROM appeared to be the most important risk factor of rLDH in our study ( $P$  0.01). In particular, if the sROM was more than  $10^\circ$ , the recurrent rate was 26.5% (9/34), whereas if it was less than  $10^\circ$ , the rate was 4.1% (5/123).
- The sROM is mostly affected by disc and facet joints<sup>26,30,31</sup> and is related with stress on the corresponding disc. This biomechanical stress would affect the development of rLDH.

# Kim. Spine • Volume 34 • Number 1 • 2009

- Higher incidence of recurrent herniation in young men, it has been suggested that the **annular incision made at primary surgery** makes the operated disc more susceptible to sudden prolapse, particularly under conditions of mechanical overload experienced during sports activity
- The present study defined recurrence as symptom recurrence after a pain-free interval greater than 6 months associated with compatible lesions demonstrated by MRI with gadolinium enhancement at the same level as that of the primary diagnosis.
- The association of recurrence rate with the type of disc herniation is still not conclusive.
- The recurrence rate continued to rise steadily as time goes by until 9 years after surgery in our series; it was 2.8% in patients followed at 1 year, 6.2% at 5 years, and 8.5% at 9 years

The recurrence rate of disc herniation increased with time after surgery. As such, survival analysis provides a more accurate estimation of true recurrence rate.



## 2.CAUDA EQUINA

*Acta Orthopaedica 2010; 81 (3): 391–395*

- We conclude that **bilateral radiculopathy or sciatica** are early stages of CES and indicate a high risk of development of advanced CES.
- Electrophysiological abnormalities and **reduced saddle sensation** are indices of early diagnosis.
- Patients at the preclinical and **early stages** have **better functional recovery** than patients in later stages after surgical decompression.

- CES refers to impairment of the cauda equina and clinically it may manifest as low back pain, saddle anesthesia, bilateral sciatica, motor weakness of the lower extremities, paraplegia, and bowel, bladder, or sexual dysfunction (Byrne 1993).
- Although this definition may include patients without CES, this concept of CES can allow the clinician to identify patients who have a high risk of developing “full-blown CES
- The common symptoms of early CES include low back pain and bilateral radicular leg pain.

- In addition, our results demonstrated that surgery could help patients with slight saddle sensory disturbance and bilateral sciatica (patients in group 2), or severe saddle sensory disturbance, bowel or bladder dysfunction, motor weakness of the lower extremities and reduced sexual performance (patients in group 3).
- Conversely, patients with extensive nerve damage from severe and prolonged compression (group 4) were not helped by surgical intervention.
- Surgical goals are treatment is less effective for late-stage patients, nonoperative treatment of late-stage patients delays appropriate management and most likely leads to poorer outcomes
- Disintegration of the bilateral reflex arches is believed to be the pathogenesis of cauda equina injury. Thus, bilateral radiculopathy may be the critical symptom that indicates a high risk of development of CES.



- Group 1      Low back pain with only BCR (bulbo-cavernosus reflex) and ICR (ischio-cavernosus reflex) abnormalities and no typical symptoms of CES.
- Group 2      He had slight saddle sensory disturbances and bilateral sciatica.
- Group 3      Patients had severe saddle sensory disturbances, bowel and/or bladder dysfunction, motor weakness of the lower extremities and reduced sexual function.
- Group 4      Patients had no saddle sensation, no sexual function, and uncontrolled bowel function.

# 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 studyspecific 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.**
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- 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.

# Facet joint arthritis

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

108	Degeneration without changes in the facet joint
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- 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 al<sup>91</sup> found in experiments that only relatively large translations ( $\pm 5$  mm) could be observed in flexion-extension radiographs in a reproducible:threshold value of  $\pm 5$  mm.
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# 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).

