

The pathogenesis of discogenic low back pain
Journal of Bone and Joint Surgery - British Volume,
January 2005, Vol. 87-B, Issue 1, 62-67

B. Peng, MD, PhD, W. Wu, MD, S. Hou, MD, C. Zhang, MD, P. Li, MD
Y. Yang, MD,

FROM ABSTRACT:

Discogenic low back pain is a common cause of disability, but its pathogenesis is poorly understood.

We collected 19 specimens of lumbar intervertebral discs from 17 patients with discogenic low back pain during posterior lumbar interbody fusion, 12 from physiologically ageing discs and ten from normal control discs.

We investigated the histological features and assessed the immunoreactive activity of neurofilament (NF200) and neuropeptides such as substance P (SP) and vasoactive-intestinal peptide (VIP) in the nerve fibres.

The distinct histological characteristic of the painful disc was the formation of a zone of vascularised granulation tissue from the nucleus pulposus to the outer part of the annulus fibrosus along the edges of the fissures. **[Important]**

SP-, NF- and VIP-immunoreactive nerve fibres in the painful discs were more extensive than in the control discs.

Growth of nerves deep into the annulus fibrosus and nucleus pulposus was observed mainly along the zone of granulation tissue in the painful discs.

[NOTE: nerve fibers grow into the nucleus of painful discs!]

This suggests that the zone of granulation tissue with extensive innervation along the tears in the posterior part of the painful disc may be responsible for causing the pain of discography and of discogenic low back pain.

THESE AUTHORS ALSO NOTE:

“Discogenic low back pain is non-radicular and occurs in the absence of spinal deformity, instability and signs of neural tension. It arises from the disc itself.”

“It may be impossible to localize a painful disc from the symptoms and the signs elicited on physical examination.”

“Although MRI may identify a degenerative disc (a ‘black disc’), it will not differentiate between a disc which is pathologically painful and one which is physiologically ageing.”

“Intervertebral disc degeneration is commonly seen on MRI in asymptomatic subjects.”

“Discography is the most important test for diagnosing discogenic back pain.”
 “The key feature of discography is the reproduction of the pain felt by the patient on stimulation of the disc.”

The nerve fibers in the disc contain nociceptive neurotransmitters such as substance P (SP), calcitonin-gene-related peptide (CGRP), and vasoactive intestinal peptide (VIP).

THE NORMAL CONTROL DISCS:

- 1) The annulus fibrosus has normal lamellar structure of collagen fibers.
- 2) The nucleus pulposus showed sparse collagen fibers.
- 3) Blood vessels were seen in the posterior longitudinal ligament and the outermost layers of the annulus fibrosus.

IN OLDER CONTROL DISCS (PHYSIOLOGICALLY AGEING DISCS)

- 1) The annulus was histologically similar to NORMAL CONTROL DISCS discs, with a few disrupted and confused lamellar structures in the middle and inner layers of the annulus fibrosus.
- 2) The nucleus pulposus had increased density of the matrix and the formation of clusters of chondrocytes. “The distinction between the nucleus pulposus and the inner annular fibrosus became blurred, and there was a tendency for this to become more evident with increasing age.”

PAINFUL DISCS FROM PATIENTS WITH DISCOGENIC LOW BACK PAIN

- 1) “The most notable feature was the formation of a zone of vascularised granulation tissue which extended from the nucleus pulposus to the outer region of the annulus fibrosus along the tears shown on CT after discography.”
- 2) The adjacent tissues surrounding the tears in the posterior part of the nucleus pulposus and the annulus fibrosus were replaced by disorganised and vascularised granulation and scar tissue. **[Fibrosis of Repair]**
- 3) “The distinction between the nucleus pulposus and the inner annulus fibrosus had disappeared. In the nucleus pulposus, fibrosis and increased density of the matrix were observed. The round chondrocytes were transformed into oval fibroblasts.”

“Both bundles of nerve fibres and free fibres were seen in the painful and control discs, and myelinated and unmyelinated free fibres were identified.”

In all the control, ageing, and painful discs, the posterior longitudinal ligaments contained nerve fibers.

“In control discs sparse nerve fibres were seen only in the outermost layers of the annulus fibrosus.”

In the ageing discs, nerve fibers were occasionally (17%) observed growing into the inner annulus fibrosus.

In the painful discs, staining showed ingrowth of nerve into the nucleus pulposus in 32% of specimens.

DISCUSSION

These authors propose that disc pain is from inflammatory granulation tissue that produces proinflammatory cytokines and mediators such as prostaglandin E2, which sensitize the nociceptors within the painful discs. **[Very Important]**

“Once acted on by a painful substance, the threshold for mechanical stimulation of the nociceptors may be lowered, and physical loading within the physiological range of the disc may cause pain.” **[Important]**

“Our findings suggest that pain may arise from the nucleus pulposus due to innervation accompanying the ingrowth of granulation tissue.” **[Important]**

“An extensive network of nerve fibres was seen in the posterior part of the annulus fibrosus in the ageing discs, but there was no pain since there were no tears and no surrounding granulation tissue in this region of the annulus fibrosus.”

“Abnormalities of the disc are commonly seen on MRI in asymptomatic subjects.”

“It is difficult to distinguish the ageing disc from the pathological disc but the presence of a zone of vascularised granulation tissue accompanying the nociceptors along the tears of the annulus fibrosus is an almost constant finding in a pathological disc.”

“Of the 17 patients with discogenic low back pain in our study, six were adults below the age of 30 years. It is unlikely that the changes in their discs were age-related, but injury to the posterior annulus fibrosus may have played a role in their pathogenesis.”

“Structurally, the weak posterior part of the annulus fibrosus may be subjected to damage, and it is a consistent site for tears shown on discography.”

Studies have shown that the healing of annular disc injury “is defective and probably initiates degeneration of the disc.” **[Important]**

“The formation of vascularised granulation tissue may be a physiological response to repair the injury to the annulus. However, because of the poor blood supply and the high tensile stress, inadequate healing seems to be inevitable.”
[Very Important]

“The recruitment of inflammatory cells may impede healing further, and the ingrowth of vascularised granulation tissue into the disc may produce growth factors and cytokines which may modulate the differentiation of cells such as chondrocytes in the nucleus pulposus. These may be transformed into fibroblasts leading to degeneration of the disc. In some patients these changes may be the principal cause of this back pain, and may be a contributory factor in other patients.”

KEY POINTS FROM DAN MURPHY

- 1) Discogenic low back pain is a common cause of disability.
- 2) Physical examination and symptoms cannot localize a painful disc.
- 3) The healing of annular disc injury is defective and probably initiates degeneration of the disc.
- 4) MRI cannot differentiate between a disc which is pathologically painful and one which is physiologically old. [This means that old degenerated but pain-free discs look the same on MRI as pathologically degenerated and painful discs.]
- 5) Disc degeneration is commonly seen on MRI in asymptomatic subjects.
- 6) Painful discs have tears with accompanying inflammatory vascularized granulation tissue which extends to the nucleus pulposus; scar tissue in the annulus and nucleus; a loss of distinction between the nucleus pulposus and the inner annulus fibrosus; fibroblasts instead of chondrocytes; and more extensive innervation, including nerves into the nucleus pulposus in 32% of specimens.
- 7) Pain may arise from the nucleus pulposus due to the increased innervation accompanying the ingrowth of inflammatory granulation tissue.
- 8) Disc pain is from inflammatory granulation tissue that produces proinflammatory cytokines and mediators such as prostaglandin E₂, which sensitize the nociceptors within the painful discs. **[The Key Point]**
- 9) Disc inflammation (primarily from prostaglandin E₂), alters the threshold for mechanical loading of the nociceptors so that physical loading within the physiological range of the disc may now cause disc pain.

10) Ageing discs also have more extensive innervation with nerve fibers, but there is no pain since there are no tears and no surrounding inflammatory granulation tissue. This indicates that inflammatory granulation tissue is a requirement to initiate discogenic back pain. **[Key Point]**

11) The disc has a poor blood supply, yet it also must handle high tensile stress. Therefore, it is inevitable that disc injury will heal inadequately. The formation of vascularised inflammatory granulation tissue is the physiological effort to repair injury to the disc.

12) Vascularized inflammatory granulation tissue in the disc modulates the differentiation of chondrocytes in the nucleus pulposus into fibroblasts, leading to disc degeneration. "In some patients these changes may be the principal cause of this back pain, and may be a contributory factor in other patients."

THE MODEL OF DISCOGENIC LOW BACK PAIN PROPOSED BY THIS STUDY IS:

The disc is injured.

The disc attempts to repair itself by developing vascularised inflammatory granulation tissue, which includes prostaglandin E2.

The vascularised inflammatory granulation tissue does three things:

#1 Increases the nociceptive innervation into the disc, including into the nucleus in 32% of specimens.

#2 Alters the threshold of these disc nociceptors so that normal physiological disc loading can cause disc pain.

#3 Directs the differentiation of disc chondrocytes into fibroblasts which causes more disc fibrosis and degeneration.