Diagnostic and therapeutic spinal interventions

Diskography

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Summary

Diskography (provocation diskography, disk stimulation) is an invasive diagnostic test performed to confirm or exclude internal disk disruption as the cause of axial spine pain. Diskography involves injecting fluid into the nucleus of the disk under manometric control; a positive response is reproduction of typical pain. Extensive but indirect literature validates diskography in the lumbar spine; it is less well-supported in the cervical or thoracic spine. Risks include rare instances of infection and neural injury; lumbar diskography may be associated with accelerated disk degeneration. Diskography has utility in establishing a diagnosis of diskogenic pain. When negative, it prevents inappropriate interventions directed at the disk; when positive, it prevents interventions directed at other axial pain generators. Its role in selecting patients for therapies directed at diskogenic pain is limited by the lack of available validated treatments.

Axial spine pain is common; low back pain is estimated to affect 66%–80% and neck pain 67% of people during their life.^{1,2} The most common cause of chronic low back pain is internal disk disruption (IDD) or diskogenic pain. Distinct from radicular pain or radiculopathy, this describes pain originating from the disk itself. It accounts for approximately 40% of chronic low back pain; the differential diagnosis also includes facet joint pain (~30%), sacroiliac joint pain (~20%), pain from vertebral insufficiency fractures (~3%–5%), and myofascial pain.³ Diskogenic pain is more prevalent in young adults and declines with age while pain of facet and sacroiliac origin increases with age.³

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The pathophysiology of diskogenic pain is complex, and supported by a synthesis of biomechanical, histologic, and physiologic studies.⁴ The process in the lumbar disk can be summarized as follows: degradation of the nuclear matrix of the disk, likely precipitated by endplate fractures, reduces the nucleus pulposus' ability to bear axial load. Load bearing is transferred to the posterior annulus. The posterior annulus may undergo structural failure, resulting in radially directed fissures extending from the nucleus to the outer annulus. This creates the anatomic substrate for diskogenic pain. The native nociceptive innervation of the disk is confined to the outer annulus; reparative granulation tissue in annular fissures results in neovascularization and ingrowth of additional nociceptive afferents that may extend deep into the disk. The native and acquired innervation is subject to mechanical stimulation by the increased load on the posterior annulus; inflammatory cytokines from nuclear degradation are present within radial fissures and may provoke chemical stimulation of nociceptors. By these mechanisms, a disk may become painful. The purpose of diskography (also termed provocation diskography or disk stimulation) is to make the diagnosis of IDD or diskogenic pain. Diskography is most commonly performed by interventional pain specialists, typically anesthesiologists, physiatrists, or radiologists. Neurologists will encounter patients with chronic axial pain, and should be familiar with the indications, contraindications, procedure, validity, utility, and risks of diskography.

Indications, contraindications, imaging, and performance

In general, diskography is only performed in patients with significant, persistent axial spine pain of at least 6 months' duration that is undiagnosed despite noninvasive testing and unresponsive to conservative therapy.^{5,6} Contraindications include any local or systemic infection, inability to assess patient response during the procedure, allergy to pharmaceutical agents used, bleeding diathesis/anticoagulation, and pregnancy. MRI, CT myelography, or plain CT of the affected spine segment is a prerequisite, primarily to exclude rare sinister causes of axial pain (e.g., tumor, infection, fracture, spondyloarthropathy). Imaging alone has major limitations in the diagnosis of diskogenic pain. Typical "degenerative" changes such as loss of disk space height, osteophyte formation, nuclear T2 signal loss on MRI, and disk herniations are usually simply age-related changes, and have no association with pain.⁷ Studies correlating MRI findings to diskography have, however, identified 2 useful findings: 1) T2 hyperintensity in the posterior disk annulus, the high intensity zone, as a marker of an inflammatory fissure; and 2) inflammatory endplate change of either type 1 or type 2, as a marker of endplate infraction or fracture. These MRI findings provide approximately 70% confidence that that disk will be positive on diskography.⁴ While diskography may be performed in any spine segment, supporting evidence is far stronger in the lumbar spine than in the cervical or thoracic levels.

Diskography is performed under fluoroscopic guidance, with minimal anxiolytic sedation, as the patient's pain responses are critical to the interpretation. Small-caliber (25-gauge) needles are placed into the target disk and 1 or 2 adjacent control disks from a posterolateral vector in the prone lumbar or thoracic pain patient or an anterolateral vector in a supine cervical patient. Under manometric control, contrast material is slowly instilled into the nuclear compartment of each disk while the patient's pain response is monitored. Injection into lumbar disks is continued until pressure reaches at least 50 psi, there is pain production, injected volume reaches 3 mL, or contrast extravasation from the disk is observed. Cervical

Figure Diskography

(A) Sagittal T2-weighted MRI shows desiccation (decreased T2 signal) in L4 disk and an annular fissure associated with bulging disk at L4-5 (arrow). (B) Lateral and (C) anteroposterior views of a 3-level diskogram. The L3 and L5 levels are normal, but at L4 there is a posterior radial fissure with a small disk protrusion (white arrow) and a greater than 180-degree circumferential fissure anteriorly, which tracks the annular laminae (black arrows). (D) Axial CT image after instillation of contrast material into the abnormal L4 intervertebral disk and (E) the normal L3 disk. The arrows in (D) show contrast material in the superficial layers of the annulus fibrosus well beyond the bounds of the nucleus pulposus, while the contrast in (E) is confined to the nucleus pulposus. From Bartleson JD, Deen HG. *Spine Disorders: Medical and Surgical Management*, 2009. Copyrighted by and used with permission of Mayo Foundation for Medical Education and Research.

and thoracic disks accept much lower volumes (0.5 mL) and injection is terminated with pain production, extravasation, or resistance to further injection. Local anesthetics may be injected into the disk after pain provocation to avoid confounding the results of testing additional disks or to alleviate provoked pain. However, diskography is not a therapeutic intervention. There is as yet no clearly defined role for purely analgesic diskography. The patient's response to the injection is monitored and documented. The patient is asked to compare any provoked pain with their typical spine pain in terms of its intensity, location, and character. In lumbar diskography, CT is performed after the procedure to better define the presence and grading of annular fissures (figure). Cervical and thoracic disks are structurally unique from lumbar disks and postdiskography imaging has no role in diagnosis. Provocation of the patient's characteristic spine pain is the key outcome measure and the lumbar target disk is positive if the pain is significant ($\geq 6/10$), concordant with the patient's baseline pain, caused by no more than moderate pressure (≤ 50 psi), not brought on by stimulation of at least 1 adjacent

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control disk, and occurs in the presence of high-grade fissures on postdiskography CT.⁵ In the cervical or thoracic regions, the diagnosis is dependent on production of concordant pain.⁵

Validity and utility of diskography

Validation of any test for the diagnosis of diskogenic pain is hampered by the lack of a pathoanatomic reference standard; there is no histologic marker of a painful disk. Conventional sensitivity and specificity cannot be assessed. There is, however, a substantial body of evidence supporting the assertion that diskography can identify a painful disk, and that the false-positive rate for lumbar diskography, as assessed by studies of asymptomatic volunteers, is low.⁴ This has been challenged in several studies,^{8,9} but a systematic review of the original data for all studies of diskography in asymptomatic volunteers, with the meticulous application of manometric, patient response, and imaging criteria, found that the false-positive rate for diskography did not exceed 10%, and may be as low as 6%.¹⁰ Interpretation of diskography responses may be more challenging in patients with multiple positive disks and in the presence of somatization disorders.

Diskography can identify a painful disk, but what is its utility in clinical practice? Diskography might be used to identify patients who would benefit from a proven treatment, but there is no consensus on an appropriate interventional therapy. Surgical fusion as a treatment for diskogenic pain remains highly controversial. A recent meta-analysis of the randomized controlled trials of surgical arthrodesis vs conservative care did not show a significant difference in functional recovery in surgical vs conservative care patients.¹¹ Only one study has provided modest evidence that diskography improves surgical outcomes through better patient selection.¹² In the cervical spine, only observational trials are available, the evidence is more tenuous, and the role of diskography is less certain. Diskography is often utilized to define the extent of a proposed fusion, or qualify patients for disk arthroplasty, but there is no high-quality evidence to support these uses. A host of destructive techniques (lasers, conductive heating, plasma field or radiofrequency lesioning, ozone or methylene blue instillation) have been applied to diskogenic pain patients, with generally disappointing results. Regenerative disk therapies are on the horizon, but are not yet validated.

The lack of a proven therapy does not discount the value of reaching a diagnosis; neurologists pursue the diagnosis of amyotrophic lateral sclerosis or multiple sclerosis despite limited therapeutic options. A diagnosis via diskography will allow diskogenic pain patients to participate in trials of emerging treatments. There is also utility in that a diagnosis provides closure, identifying the patient as having a medical condition, and protecting the patient from being labeled as malingering or having a psychological disorder. Negative diskography protects the patient from inappropriate therapies directed at diskogenic pain. Positive diskography, by establishing a diagnosis, protects the patient from futile, invasive, and expensive diagnostic and therapeutic endeavors directed to other causes of axial spine pain.

Risks

The primary risk of disk stimulation is bacterial diskitis, which is very low. In a systematic review, the prevalence of diskitis without prophylactic antibiotics was 0.24%; the prevalence of diskitis with antibiotics was stated to be 0%, but with confidence intervals (CI) of 0%–2.9%.¹³ Antibiotic prophylaxis is typically delivered into the disk, mixed with the contrast media. Meticulous aseptic technique is mandatory. Infection risks are higher in the cervical spine. There are very rare risks of spinal nerve or spinal cord injury, dural puncture, pneumothorax

in the thoracic spine, or vascular injury in the cervical spine. Recent evidence based on MRI 7–10 years postdiskography has raised concern that diskography may accelerate degenerative changes and increase the incidence of disk herniation.¹⁴ Disks undergoing diskography had a greater proportion with progression of degenerative change (35%) vs controls (14%), although the CI overlap.^{14,4} There were also more new disk herniations in injected disks than in control disks. Although the CI for disk herniations also overlap in the small samples, the twofold to fivefold increase in foraminal disk herniations and extrusions over controls raises concern. Larger studies are needed to better define this apparent risk. Diskography should always be applied selectively and thoughtfully as a means of establishing the diagnosis of internal disk disruption or diskogenic pain.

REFERENCES

1. Deyo RA. Low back pain. *N Engl J Med* 2001;344:363–370.
2. Rubin DI. Epidemiology, and risk factors for spine pain. *Neurol Clin* 2007;25:353–371.
3. DePalma MJ, Ketchum JM, Saullo T. What is the source of chronic low back pain and does age play a role? *Pain Med* 2011;12:224–233.
4. Bogduk N, Aprill C, Derby R. Lumbar discogenic pain: state-of-the-art review. *Pain Med* 2013;14:813–836.
5. Bogduk N, ed. *Practice Guidelines for Spinal Diagnostic and Treatment Procedures*, 2nd ed. San Francisco, CA: International Spine Intervention Society; 2013.
6. Slipman CW, Derby R, Simeone FA, Mayer TG, editors. *Interventional Spine: An Algorithmic Approach*. Philadelphia: Saunders; 2008.
7. Bogduk N. Degenerative joint disease of the spine. *Radiol Clin North Am* 2012;50:613–628.
8. Carragee EJ, Tanner CM, Khurana S, et al. The rates of false-positive lumbar discography in select patients without low back symptoms. *Spine* 2000;25:1373–1380; discussion 1381.
9. Carragee EJ, Alamin TF, Carragee JM. Low-pressure positive discography in subjects asymptomatic of significant low back pain illness. *Spine* 2006;31:505–509.
10. Wolfer LR, Derby R, Lee JE, Lee SH. Systematic review of lumbar provocation discography in asymptomatic subjects with a meta-analysis of false-positive rates. *Pain Physician* 2008;11:513–538.
11. Bydon M, De la Garza-Ramos R, Macki M, Baker A, Gokaslan ZL, Bydon A. Lumbar fusion versus non-operative management for treatment of discogenic low back pain: a systematic review and meta-analysis of randomized controlled trials. *J Spinal Disord Tech Epub* 2014 Feb 25.
12. Colhoun E, McCall IW, Williams L, Cassar Pullicino VN. Provocation discography as a guide to planning operations on the spine. *J Bone Joint Surg Br* 1988;70:267–271.
13. Willems PC, Jacobs W, Duinkerke ES, De Kleuver M. Lumbar discography: should we use prophylactic antibiotics? A study of 435 consecutive discograms and a systematic review of the literature. *J Spinal Disord Tech* 2004;17:243–247.
14. Carragee EJ, Don AS, Hurwitz EL, Cuellar JM, Carrino JA, Herzog R. 2009 ISSLS prize winner: does discography cause accelerated progression of degeneration changes in the lumbar disc: a ten-year matched cohort study. *Spine* 2009;34:2338–2345.

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