

Pre-operative Discography: Appropriate Indications and Clinical Interpretation

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Introduction

Hirsch [11] and Lindblom [16] first described the use of discography for the clinical evaluation of intervertebral disc pathology in 1948. It was initially utilized to help determine the level of a possible disc herniation with patients presenting with sciatica. Over the past 60 years, discography has evolved into a technique almost exclusively used for the diagnosis of discogenic pain or pain emanating from internal disruption of the disc including tears in the annulus. In spite of a large body of literature on discography, the purpose of this technique remains extremely controversial. One reason for controversy reflects the fact that conflicting reports on the sensitivity, specificity and predictive value of discography have been published. In addition, discography has more recently become an important part of the decision making process for some spine surgeons in determining which patients would benefit from lumbar arthrodesis for treatment of unrelenting low back pain. Because the results of surgery for lumbar discogenic pain have been disappointing, controversy exists as to the validity and positive predictive importance of this invasive procedure of discography.

Historical Review

Holt [12] reported the results of discography in 30 inmates who had no history of low back pain or sciatica. He performed a transdural puncture of the L2-3, L3-4, L4-5, and L5-S1 disc spaces in 72 patients followed by an injection of 1-2 cc of 50% sodium diatrizoate (Hypaque). Anteroposterior and lateral radiographs were taken and graded as normal, degenerative, or ruptured. Pain with disc injection

was recorded as a positive response. No pain was present in 45 (63%) discs with a normal radiographic pattern. However, 16 (22%) discs demonstrated dye leakage with associated reported severe back and leg pain during the injection procedure. Holt believed that the pain was caused by irritation of pain sensitive structures by the radiographic contrast dye. He noted a 37% false positive rate (positive discography in the presence of radiographic disc degeneration in the absence of a history of back complaints).

As pointed out by Simmons et al., the study of Holt contains several methodological problems that limit its applicability to modern discography [22]. First, the study subjects were prison inmates with unclear motivations to participate in such a study. Second, the false positive rate quoted by Holt was the incidence of pain provocation without reference to concordancy in the setting of radiographic degeneration in clinically asymptomatic patients. It is clearly known that many patients have radiographic evidence of disc degeneration in the absence of symptoms as shown by the MRI studies of Boden et al. [2]. Contemporary discogram interpretation relies on the reproduction of "concordant" pain by disc injection and not the presence of radiographic degeneration or complaints of nonspecific pain upon dye injection. Third, the author demonstrated pain with all disc injections where dye leakage occurred. This was correctly inferred as resulting from direct stimulation of nerve endings by the contrast irritant. Modern contrast materials are non-irritating and should not cause pain simply by contacting innervated tissues. Therefore, the study of Holt is not applicable to modern discography techniques and interpretation.

Walsh et al. repeated the study of Holt by performing discography in 10 paid volunteers with no history of low back pain and 7 patients with chronic low back pain according to a strict protocol [26]. To interpret a discogram as positive, the disc had to show signs of degeneration, and the patients were to experience significant pain with associated pain behavior on disc injection. Five of the 10 asymptomatic patients were noted to have at least one radiographically abnormal disc with discography. The overall rate of radiographic disc abnormalities for all levels tested in the asymptomatic patients was 17%. However, none of the asymptomatic patients had significant pain with dye injection. Six

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of the 7 patients with low back pain had provocation of concordant back pain with dye injection. This yielded a specificity of 100% and a false positive rate of 0%.

Vanharanta et al. compared the relationship of pain produced by disc injection to the degree of disc degeneration [25]. Ninety-one patients (225 discs) undergoing discography for evaluation of low back pain were studied. The patients' pain response was divided into no pain, dissimilar pain, similar pain, and exact pain reproduction. The discs were classified according to the Dallas discogram description: normal (0), slight (1), moderate (2), and severe (3) degeneration. Although the study documented that discs with higher levels of degeneration were more likely to be symptomatic, the relationship between disc degeneration and pain was not exact. For instance, over 20% of the discs classified as normal by the degeneration scale demonstrated some pain upon injection. Six percent of the severely degenerated discs were noted to be painless with injection. Overall, 3% of the normal discs had exact pain reproduction while 77% of the severely degenerated discs had exact pain reproduction.

Grubb et al. [9] evaluated 108 patients with back and leg pain using plain roentgenograms, myelography, and discography. Organic pathology believed to be the cause of the pain was identified in 101 of the patients using this combination of studies. Twenty normal appearing discs were noted to produce pain with dye injection. Of these, 9 were noted to be adjacent to a degenerative disc and 11 were in patients with significant psychopathology on Minnesota Multiphasic Personality Inventory (MMPI) testing. Eighty-two percent of the discs that extravasated dye on injection were noted to be painful. Eighty-two percent of the degenerative discs that contained the dye were also noted to be painful with injection. Overall, discography was noted to be much more sensitive in identifying disc pathology than either plain radiographs or myelography.

Vanharanta et al. also evaluated 300 patients classified with common clinical syndromes including disc herniation, degenerated disc disease, lumbar syndrome, and lumbar radicular syndrome with discography [24]. The majority of the patients in each group (65%–91%) were shown to have similar or exact pain reproduction at one or more levels by discography. A small number of patients in each group (2%–15%) also demonstrated similar or exact pain reproduction in spite of normal discographic appearance. The authors believed that painful discs were a common source of pain in these clinically distinct syndromes.

In 1988, the North American Spine Society issued a position statement on discography [7]. The indications, procedure, and interpretation of results were discussed. The use of discography was recommended only as a preoperative test in patients with severe enough pain to warrant surgery. The use of water-soluble contrast and sterile technique when performing discography was stressed. The report recommended that patient sedation be minimized to allow accurate quantitation of patients' pain by verbal descriptions, pain drawings, and pain behavior.

Although discography was shown to be highly specific in

the study of Walsh, a study by Carragee et al. questions the specificity of discography in patients with psychological disturbances. In his study, Carragee evaluated 26 patients without a history of low back pain who underwent lumbar discography [4]. The criteria of Walsh et al. were used for interpretation of the results. To increase the chance of positive discography, only patients with disc degeneration on magnetic resonance imaging (MRI) were included in the study. The patients were divided into one of three groups: a group with good results following cervical disc surgery ($n = 10$), a group with poor results following cervical disc surgery ($n = 10$), and a group with a diagnosed somatization disorder ($n = 6$). In the group of patients with good results following cervical disc surgery, only 1 (10%) patient reported pain with lumbar discography. In the group of patients with poor results following cervical disc surgery, 4 (40%) reported pain with lumbar discography. In the group of patients with a somatization disorder, 2 patients stopped the test after just a single disc injection due to severe pain and 3 of the remaining 4 patients reported pain with dye injection. No patients reported pain with injection of radiographically normal levels. There was a strong correlation between positive findings on the psychological tests (Zung depression index and the Modified Somatic Pain Questionnaire, MSPQ) and a false positive discogram. In addition, 80% of patients receiving disability payments had false-positive discography and 80% of patients with pending legal cases had positive discography. This study highlights the need to utilize great care in the interpretation of discography in patients with positive psychological variables.

Carragee et al. also performed a study to determine if patients could accurately recognize the difference between disc pain and pain from other nearby structures. Eight patients with disc degeneration on MRI but no history of low back pain underwent discography [5]. The patients had all previously undergone a bone graft harvest from the posterior iliac crest for other unrelated surgeries. The patients were asked to describe any pain experienced during discography as different, similar or exactly the same as the pain experienced after bone graft harvest. Although, 4 patients experienced some pain with disc injection, 4 patients had significant pain plus 2 showed signs of pain behavior as described by Walsh et al. [26]. Pain with discography was noted in patients with an annular disc disruption. Half of the patients with an annular disruption seen on discography described their pain as similar to or exactly the same as the pain experienced after their bone grafting harvest procedure. Four patients who experienced severe pain with injection described their pain as exactly the same as that experienced with the bone grafting harvest procedure. Four of 8 (50%) patients met the criteria of Walsh's for a positive discogram.

Rhyné et al. reported on 25 patients with more than 6 months of incapacitating low back pain unresponsive to conservative therapy. All patients had single-level positive discography and refused surgery for a variety of reasons [21]. Sixty percent of the patients were receiving workers compensation while 32% of the patients were actively being treated for a psychiatric diagnosis. At an average follow-up

of 4.9 years, 68% were noted to have improvement in their low back pain while 8% were unchanged and 24% worsened. On average, patients who improved had a shorter duration of symptoms (3.5 years vs. 11 years) and were older (45 years of age vs. 33 years of age) compared with patients whose pain worsened. Of the patients who worsened, 66.7% were diagnosed with a current psychological disturbance. Disc level, gender, and smoking were not found to affect the outcome.

Psychological overlay was found to effect the rate of false-positive discography by Ohnmeiss et al. who compared pain drawings to provocative discography [18]. False-positive pain was defined as pain reported by the patient upon injection of a disc with a normal radiographic appearance. Pain drawings were graded according to a previously reported method that identified exaggerated or non-anatomic pain. False positive discography was noted in 12.3% of patients with normal pain drawings while patients with abnormal pain drawings demonstrated a 50% incidence of false-positive discography.

Arthrodesis for Discogram Positive Pain

Knox et al. reviewed the results of 22 patients undergoing anterior lumbar interbody fusion (ALIF) for patients with low back pain and a positive discogram [15]. Results were noted to be poor in all ALIF procedures involving 2 levels. In single level ALIF procedures, there were 35% good, 18% fair, and 47% poor results. Patients with previous back surgery and/or those who were receiving workman's compensation were noted to have universally poor results in spite of positive concordant discography.

Parker et al. reviewed 23 patients treated with a posterolateral fusion for discogram concordant low back pain [20]. At a mean follow-up of 47 months, 39% were noted to have either good or excellent results, 13% were fair, and 48% had poor results. Ninety percent of the patients with workers compensation claims had poor results while 80% of the patients with a pseudarthrosis had poor results. However, overall 56% of the patients were satisfied with the results of surgery.

Collins et al. prospectively examined 29 patients with chronic low back pain using discography to identify symptomatic levels [6]. Twelve patients with a positive provocative discography underwent a posterolateral lumbar arthrodesis. Nine of the patients (75%) reported improvement in their symptoms while 3 patients (25%) had no pain relief.

Calhoun et al. retrospectively compared patients who had undergone a technically successful lumbar arthrodesis for chronic low back pain [3]. Eighty-nine percent of 137 patients with a positive provocative discography reported relief from arthrodesis surgery. In 25 patients with disc degeneration without a positive discography only 52% of the patients benefited from an arthrodesis.

Complications following Discography

Complications following discography are relatively rare and include bacterial discitis, cerebral spinal fluid leakage,

retroperitoneal bleeding, and chronic pain. McCulloch et al. reported on 1,500 patients undergoing provocative discography by a posterolateral approach [17]. Four patients developed a complication including 3 cases of discitis and 1 retroperitoneal hemorrhage. All were managed successfully with conservative treatment. Fraser et al. reviewed 432 patients following discography [8]. They reported a rate of discitis in single needle disc punctures without a stylet to be 2.7% in 222 patients. The use of a two-needle technique reduced the rate to 0.7%. Guyer et al. reviewed 9 patients who developed discitis following discography. All patients presented with an increase in axial back or neck pain [10]. The erythrocyte sedimentation rate became elevated at an average of 20 days and bone scans became positive at an average of 33 days post-discography. Plain radiographs demonstrated changes consistent with infection between 14 and 51 days. The clinical symptoms of discitis lasted on average between 8 and 11 weeks. Osti et al. studied the effect of antibiotics on disc injections with bacteria in sheep [19]. Both intravenous antibiotics and the addition of antibiotics to the injected suspension prevented the development of discitis. They recommended that prophylactic antibiotics be administered prior to discography for the prevention of discitis.

Johnson studied whether discography caused damage to the disc by evaluating 34 patients (80 levels) with repeat discography performed at a mean 16.7 months after the initial procedure [13]. Forty-two normal levels were carefully scrutinized to determine if there was evidence of a discographic abnormality on the second discogram. Three discs adjacent to fusions were noted to have degenerative changes. One disc demonstrated degenerative changes with no apparent cause. On the basis of the data, the authors believed there was no evidence of damage to the disc following discography.

Carragee et al. evaluated the incidence of chronic back pain one year following discography in a group of patients with no previous history of back pain. These patients had undergone discography as part of a study to determine the results of discography in asymptomatic patients. The study included patients with a successful cervical spine operation ($n = 10$), an unsuccessful cervical spine operation ($n = 10$), and somatization disorder ($n = 6$). The results of the initial study have already been discussed previously [4]. No patients with normal psychometric testing were found to have persistent back pain following discography. However, patients with abnormal psychometric testing reported a 40% incidence of significant new low back pain. Patients with somatization disorder demonstrated a 66% incidence of new low back pain.

Utility of Discography

In spite of the limitations with discography, it remains a valid tool in certain clinical situations. Other imaging modalities do not have the combined subjective and objective ability to identify a painful disc disruption. Simmons et al. compared discography with MRI and noted poor agreement

between these studies [23]. Abnormal discs on MRI were noted to produce concordant pain on discography 76% of the time. In addition, 7% of the normal discs by MRI were noted to be abnormal by discography and 5% recreated concordant pain with injection. Zucherman et al. reported 18 patients with clinically unresponsive low back pain who had normal discs by MRI scanning [27]. Each patient was noted to have abnormal discography including annular disruption and concordant pain. The authors believe that discography in this group of patients represented the only method available to identify the pain source.

Some authors have suggested that discography is useful in evaluating whether the disc adjacent to a spondylolisthesis is painful, indicating that it should be included in an arthrodesis [1]. In addition, discography has been successfully used to determine if the discs within a solid posterolateral fusion are a source of continual pain [10]. Other authors have suggested that discography may be useful when investigating pain from a posterolateral pseudarthrosis [19]. Johnson et al. reported that 19 of 24 patients with surgically confirmed pseudarthroses had reproduction of their typical back pain with discography [14]. Two of the 5 patients had pain with injection of the disc above the level of the pseudarthrosis and no pain from the disc at the pseudarthrosis site. The authors concluded that discography was a useful method of evaluating patients with continuing back pain following a lumbar arthrodesis.

Summary

Discography is a unique method of investigating spinal pain. It is said to be the only subjective means of identifying pain originating from the intervertebral disc. However, studies have shown wide variation in the sensitivity, specificity, and positive predictive value of discography. The principle difficulty in establishing the sensitivity and specificity of discography is that there is no other "gold standard" test for comparison. Available studies suggest that discography is positive in a fairly high percentage of radiographically degenerated discs and in a small percentage of radiographically normal discs. Discography has been found unreliable in patients with secondary gain and psychological conditions. Multiple studies suggest that discography is not a valid test in patients with psychological overlay, and if used in isolation, may lead to a high rate of poor outcomes following operative treatment. Discography may also be beneficial in identifying the probable pain generator in rare cases of isolated (single level) severe disc degeneration and axial low back pain unresponsive to conservative treatment. In spite of the limitations of discography, there is a useful role for this procedure as adjunct in determining fusion levels in adult deformity surgery. As with all invasive tests, the surgeon must weigh the risks and benefits of discography in each individual patient keeping in mind the inherent shortcomings of the procedure.

References

1. Antti-Poika I, Soini J, Tallroth K, et al. Clinical relevance of discography combined with CT scanning. A study of 100 patients. *J Bone Joint Surg* 72-B:480-5, 1990.
2. Boden S, Davis D, Dina T, et al. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic patients: A prospective investigation. *J Bone Joint Surg* 72-A:403-8, 1990.
3. Calhoun E, McCall IW, Williams L, et al. Provocation discography as a guide to planning operations of the spine. *J Bone Joint Surg* 70-B:267-71, 1988.
4. Carragee EJ, Tanner CM, Khurana S, et al. The rates of false-positive lumbar discography in selected patients without low back symptoms. *Spine* 25:1373-80, 2000.
5. Carragee EJ, Tanner CM, Yang B, et al. False-positive findings on lumbar discography: Reliability of subjective concordance assessment during provocative disc injection. *Spine* 24:2542-7, 1999.
6. Collins CD, Stack JP, O'Connell DJ, et al. The role of discography in lumbar disc disease: A comparative study of magnetic resonance imaging and discography. *Clin Radiol* 42:252-7, 1990.
7. Executive Committee of the North American Spine Society: Position Statement on Discography. *Spine* 13:1349, 1988.
8. Fraser RD, Osti OL, Vernon-Roberts B. Discitis after discography. *J Bone Joint Surg* 69-B:26-35, 1987.
9. Grubb SA, Lipscomb HJ, Guilford WB. The relative value of lumbar roentgenograms, metrizamide myelography, and discography in the assessment of patients with chronic low-back syndrome. *Spine* 12:282-6, 1987.
10. Guyer RD, Collier R, Stith WJ, et al. Discitis after discography. *Spine* 13:1352-4, 1988.
11. Hirsch C. Attempt to diagnose the level of disc lesion clinically by disc puncture. *Acta Orthop Scand* 18:132, 1948.
12. Holt EP. The question of lumbar discography. *J Bone Joint Surg* 50-A:720-6, 1968.
13. Johnson RJ. Does discography injure the normal discs? An analysis of repeat discograms. *Spine* 1989;14:424-6.
14. Johnson RJ, Macnab I. Localization of symptomatic lumbar pseudoarthrosis by use of discography. *Clin Orthop* 197:164-70, 1985.
15. Knox BD, Chapman TM. Anterior lumbar interbody fusion for discogram concordant pain. *J Spinal Disord* 6:242-4, 1993.
16. Lindblom K. Diagnostic puncture of intervertebral discs in sciatica. *Acta Orthop Scand* 18:132, 1948.
17. McCullough JA, Waddell G. Lateral lumbar discography. *Br J Radiol* 15:498-502, 1978.
18. Ohnmeiss DD, Vanharanta H, Guyer RD. The association between pain drawings and computed tomographic/discographic pain responses. *Spine* 20:729-33, 1995.
19. Osti OL, Fraser RD, Vernon-Roberts B. Discitis after discography: The role of prophylactic antibiotics. *J Bone Joint Surg* 1990;72-B:271-4.
20. Parker LM, Murrell SE, Boden SD, et al. The outcome of posterolateral fusion in highly selected patients with discogenic low back pain. *Spine* 21:1909-17, 1996.
21. Rhyne AL, Smith SE, Wood KE, et al. Outcome of unoperated discogram-positive low back pain. *Spine* 20:1997-2000, 1995.
22. Simmons JW, Aprill CN, Dwyer AP, et al. A reassessment of Holt's data on: The question of lumbar discography. *Clin Orthop* 237:120-4, 1988.
23. Simmons JW, Emery SF, McMillin JN, et al. Awake discography: A comparison study with magnetic resonance imaging. *Spine* 16S:216-21, 1991.
24. Vanharanta H, Guyer RD, Ohnmeiss D, et al. Disc deterioration in low back syndromes: A prospective, multi-center CT/discography study. *Spine* 13:1349-51, 1988.
25. Vanharanta H, Sachs BL, Spivey MA, et al. The relationship of pain provocation to lumbar disc deterioration as seen by CT/discography. *Spine* 12:295-8, 1987.
26. Walsh TR, Weinstein JN, Spratt KF, et al. Lumbar discography in normal subjects: A controlled, prospective study. *J Bone Joint Surg* 72-A:1081-8, 1990.
27. Zucherman J, Derby R, Hsu K, et al. Normal magnetic resonance imaging with abnormal discography. *Spine* 13:1355-9, 1988.