Systematic Review

An Update of the Systematic Appraisal of the Accuracy and Utility of Discography in Chronic Spinal Pain

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Background: The intervertebral disc has been implicated as a major cause of chronic spinal pain based on clinical, basic science, and epidemiological research. There is, however, a lack of consensus regarding the diagnosis and treatment of intervertebral disc disorders. Based on controlled evaluations, lumbar intervertebral discs have been shown to be the source of chronic back pain without disc herniation in 26% to 39% of patients, and in 16% to 53% of patients with pain in the cervical spine. Lumbar, cervical, and thoracic provocation discography, which includes disc stimulation and morphological evaluation, is often used to distinguish a painful disc from other potential sources of pain. Despite the extensive literature on point, intense debate continues about lumbar discography as a diagnostic tool.

Study Design: A systematic review of the diagnostic accuracy of lumbar, cervical, and thoracic provocation and analgesic discography literature.

Objective: To systematically assess and re-evaluate the diagnostic accuracy of lumbar, cervical, and thoracic discography.

Methods: The available literature on discography was reviewed. A methodological quality assessment of included studies was performed using the Quality Appraisal of Reliability Studies (QAREL) checklist. Only diagnostic accuracy studies meeting at least 50% of the designated inclusion criteria were included in the analysis.

To assess the level of evidence, a modified grading of qualitative evidence criteria was utilized, with grading of evidence into 5 categories from Level I to Level V incorporating evidence obtained from multiple high quality diagnostic accuracy studies for Level I and opinion or consensus of a large group of clinicians and/or scientists for Level V. Data sources included relevant literature identified through searches of PubMed and EMBASE from 1966 to June 2017, and manual searches of the bibliographies of known primary and review articles.

Results: Over 100 manuscripts were considered for inclusion. Of these, 8 studies met inclusion criteria for diagnostic accuracy and prevalence with 5 studies assessing lumbar provocation discography and 3 studies assessing cervical discography. The results showed variable prevalence from 16.9% to 26% for discogenic pain and 16.9% to 42% for internal disc disruption. The cervical discogenic pain prevalence ranged from 16% to 53%. Based on methodological quality assessment criteria the strength of evidence for lumbar provocation discography is Level III and for cervical discogenic pain is Level IV.

Limitations: Despite multiple publications in the lumbar spine, value and validity of discography continues to be debated. In reference to cervical and thoracic discography, the available literature and value and validity continues to be low.

Conclusion: This systematic review illustrates that lumbar provocation discography performed according to the International Association for the Study of Pain (IASP) criteria may be a useful tool for evaluating chronic lumbar discogenic pain. The evidence is weaker for cervical and nonexistent for thoracic discography.

Key words: Lumbar intervertebral disc, cervical intervertebral disc, thoracic intervertebral disc, discography, provocation discography, analgesic discography, diagnostic accuracy, prevalence

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1.0 INTRODUCTION

The increasing socioeconomic burden imposed by chronic spinal pain, the resources utilized in managing chronic spinal pain with the growing number of modalities applied together with alleged low quality and the high cost of interventions has led to multiple negative health policy implications (1-35). Dieleman et al (5), in an assessment of US spending on personal health care and public health from 1996 to 2013, showed that the conditions with highest spending levels from 1966 to 2013 included low back and neck pain at the top, followed by diabetes. They also showed that in 2013, low back and neck pain accounted for the third highest amount, with estimated health care spending of $87.6 billion; however, for overall musculoskeletal disorders the spending was $183.5 billion. These expenditures correlate well with other previous estimations by Martin et al (6,7) and Gaskin and Richard (10). The intervertebral discs, the zygapophysial (facet) joints, and sacroiliac joints have all been demonstrated, with controlled diagnostic techniques, to be common causes of chronic spinal pain (1,34-71). However, there continues to be significant debate in reference to accuracy and clinical utility of multiple diagnostic techniques applied in interventional pain management (1,34-71). Based on these evaluations, discogenic low back pain, with or without internal disc derangement, is estimated to affect between 16.9% and 39% of chronic low back pain sufferers without radicular symptoms (47,50-55), 16% to 53% of patients with chronic pain in the cervical spine (58-60), and without estimated prevalence in the thoracic spine (61,62). The intervertebral disc has been implicated as a source of spinal pain based on decades of pre-clinical, clinical, and epidemiological research, though the precise mechanisms continue to be debated as the literature evolves (1,34,44-50,87). The intervertebral disc is responsible for causation of pain by means of disc herniation or without disc herniation. Disc herniation has been well described in the literature. However, the pain emanating from pathologic changes within the disc itself, without disc herniation (1,34,35,88-99), was described before the classic description of disc herniation. Mixter and Barr described lumbar discectomy in 1934 (100). Thus, chronic spinal pain with or without extremity pain from an intervertebral disc has been described with 2 inter-related, but distinct etiologies, namely disc herniation and discogenic pain. Discogenic pain without disc herniation is variably termed discogenic pain, internal disc disruption, and painful degenerative disc disease (1,34-41,44,50-57). Despite numerous advances in outcomes assessment, diagnosis based on history, physical exam, and radiological imaging has low sensitivity and specificity in determining whether or not the disc is a primary source of spinal pain (1,34,35,37-41,48-73,100-120).

Hancock et al (38) performed a systematic review with inclusion of 28 studies, evaluating the ability of different diagnostic modalities to identify the disc as the source of low back pain. They showed that, in the majority of studies, various features observed on magnetic resonance imaging (MRI) (i.e., high-intensity zone, endplate changes, and disc degeneration) provided information that increased the probability of the disc being the source of low back pain. However, centralization was the only clinical feature found to increase the likelihood of the disc being the primary source of pain (111,112). The absence of degeneration on MRI was the only test found to reduce the likelihood of the disc being the source of pain (111). The authors also found that the presence of a high-intensity zone significantly increased the probability of the disc(s) being a source of pain. However, a negative test does not meaningfully reduce the chances of the disc(s) being the pain generator. Clinical examination of a patient presenting with discogenic pain with inclusion of multiple provocative maneuvers has been helpful in identifying patients with potential discogenic pain, even though accurate diagnosis of discogenic pain may not be achieved (111,112). However, multiple studies also based the diagnostic accuracy on provocation discography, another invasive modality which continues to face substantial controversy. The difficulty faced with physical examination is related to the fact that patients with facet joint pain and discogenic pain may present with somewhat of a similar clinical picture (1). Multiple investigators (111,112) have shown centralization during repeated movements as a highly specific feature for positive discography; however, the overall sensitivity of this finding was low and there was reduced specificity when either severe disability or psychological distress was present.

MRI is known to provide exquisite anatomic detail facilitating surgical interventions. However, its use in discogenic pain has been described not only to have little value, but have an adverse effect by identifying incidental findings, leading to multiple unnecessary diagnostic and variable findings (117-119). Even though, there is significant importance provided to the high-intensity zone on MRI suggesting a highly specific marker of a painful lumbar disc, these findings are debatable.
The other diagnostic modality commonly utilized in the diagnosis of discogenic pain is provocation discography. Provocation discography is the most specific procedure to diagnose discogenic low back pain; however, its accuracy has been reported to be low or at best unknown (34,36,37,42,101). Bogduk et al (36), in a comprehensive review of provocation discography, provided an anatomic and physiological basis for the procedure. In addition, they dispelled the null hypothesis that has been raised against the concept of discogenic pain and its diagnosis. They refuted multiple arguments raised that discs cannot and do not hurt, there is no discogenic pathology, and discogenic pain cannot be diagnosed or doing so is not clinically useful. In fact, Ohtori et al (120) provided the pathomechanism of discogenic low back pain in human and animal models, and clues about the pathomechanisms of discogenic low back pain with a confluence of biomedical and psychosocial factors including innervation, inflammation, and mechanical hypermobility, in conjunction with multiple biopsychosocial factors.

In a systematic review of lumbar discography as a diagnostic test for chronic low back pain (39), based on modified U.S. Preventive Services Task Force (USPSTF) level of evidence criteria, Manchikanti et al reported the strength of evidence was fair for the diagnostic accuracy of lumbar provocation discography utilizing International Association for the Study of Pain (IASP) criteria (121), limited for cervical discogenic pain (40); and no evidence for thoracic discography (41). Based on this systematic review, the authors (39) recommended that lumbar provocation discography performed according to IASP criteria may be a useful tool for evaluating chronic lumbar discogenic pain, but provided a limited recommendation for cervical and thoracic discography (40,41).

When discography is combined with pain provocation and analgesia, its diagnostic capabilities are considered superior to the single dimensional tools (50-53,74,122-130). However, others insist, rather vigorously, that discography fails to improve diagnostic capabilities (131-143). Furthermore, there is ongoing debate regarding the gold standard evaluation of discogenic pain (52,140,141), and the conservative, minimally invasive, and surgical management of discogenic pain (1,34,36,37,42,57,101,141-143).

The purpose of this review is to systematically evaluate the diagnostic accuracy of discography utilizing provocation or analgesia, determine its applicability in clinical practice identifying deficiencies in the available evidence, and to describe implications for clinical practice and further research in this area. This systematic review is an update of previously published systematic reviews (39-41).

2.0 Methods

The IASP criteria (121) for discogenic pain includes reproduction of a patient’s typical pain with disc stimulation, while injection of 2 adjacent intervertebral discs fails to provoke pain. In addition, the pain cannot be ascribed to some other source innervated by the same segments that innervate the putatively symptomatic disc.

The degree of relief following local anesthetic injected into one or more discs is, theoretically, a more robust method to determine the degree to which the discs are contributing to the patient’s symptoms (122). Thus, combining local anesthetic in equal concentration with contrast media injected into one or more discs during provocation discography confirms a positive provocative response and estimates the degree of pain caused by the one or more discs injected. Mixing local anesthetic with contrast is less traumatic than functional anesthetic discography, which requires using a large bore needle to enable the insertion of a catheter (122,123,144-146). Although the addition of local anesthetic to all injected discs cannot always distinguish symptomatic from asymptomatic discs, the degree of post-procedure relief experienced may help assuage concerns of false-positive responses (41,126,127,130,144-148).

2.1 Criteria for Considering Studies for the Review

2.1.1 Types of Studies

Diagnostic accuracy studies of lumbar, cervical, and thoracic discs provocation and/or analgesic discography.

2.1.2 Types of Participants

Participants of interest were adults aged at least 18 years with chronic spinal pain of at least 3 months duration.

2.1.3 Types of Interventions

The interventions were lumbar, cervical, and thoracic provocation and/or analgesic discography.

2.1.4 Types of Outcome Measures

- The primary outcome parameter was either pain provocation and/or pain relief with analgesic discography.
2.2 Literature Search

Searches were performed from the following sources without language restrictions:

1. PubMed from 1966
2. Cochrane Library
   www.thecochranelibrary.com/view/0/index.html
   www.guideline.gov/
4. Previous systematic reviews and cross references
5. Clinical Trials
   clinicaltrials.gov/

The search period was from 1966 to August 2016.

2.3 Search Strategy

The search strategy emphasized chronic spinal pain and diagnostic interventional techniques with special emphasis on provocation and/or analgesic discography.

The search criteria is as follows:

2.4 Data Collection and Analysis

This systematic review focused only on invasive diagnostic studies, provocation and analgesic discography. The population of interest was patients suffering from chronic spinal pain, with or without extremity pain, for at least 3 months. Only the diagnostic accuracy of discography studies with or without prevalence estimates of chronic spinal pain were evaluated. Reports without appropriate diagnosis, non-systematic reviews, book chapters, and case reports were excluded.

2.4.1 Inclusion and Exclusion Criteria

Only studies utilizing controlled discography with IASP standards or analgesic discography were utilized or were included.

Only the studies with appropriate assessment and statistical evaluation were utilized.

2.4.2 Data Extraction & Management

Two review authors independently, in an unblinded standardized manner, developed search criteria, searched for relevant literature, selected the manuscripts and extracted the data from the included studies. Disagreements were resolved by discussion between the 2 reviewers; if no consensus could be reached, a third author was called in to break the impasse. Data were analyzed separately based on whether the intervention was provocative or analgesic.

Methodological quality assessment was performed by the review authors. The assessment was carried out independently, in an unblinded standardized manner to assess the methodological quality and internal validity of all the studies considered for inclusion. The methodological quality assessment was performed in a manner to avoid any discrepancies, which were evaluated by a third reviewer and settled by consensus. Continued issues were also discussed with the entire group and resolved.

If there was conflict of interest with a reviewed manuscript (concerning authorship), if the reviewer was also one of the authors or had any type of conflict, the involved authors did not review the manuscript for methodological quality assessment.

2.4.3 Methodological Quality or Validity Assessment

The quality of each individual article used in this assessment was assessed using the Quality Appraisal of Reliability Studies (QAREL) checklist (Table 1) (149,150). Each study in the final sample of eligible manuscripts was assessed using the 12-item checklist designed to assess quality and applicability. The face validity of this checklist was established by consultation with methodology experts (149,150) and comparison with similar checklists used in other systematic reviews examining diagnostic reliability (1,25,26,39-41,149,150). This checklist was also developed in accordance with the Standards for the Reporting Studies of Diagnostic Accuracy Studies (STARD) (151) and the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) (152) appraisal tool. Studies were not given an overall numeric quality score; instead each item was considered separately and graded as “yes,” “no,” “unclear,” or “not applicable.”

Only diagnostic accuracy studies meeting at least 50% of applicable inclusion criteria were included for analysis. Studies scoring less than 50% are reported descriptively with critical analysis.

2.5 Analysis of Evidence

The analysis of the evidence was performed based on the American Society of Interventional Pain Physicians’ (ASIPP) modification of multiple available criteria including those of United States Preventive Task Force (USPSTF) criteria as illustrated in Table 2 (153). The analysis was conducted using 5 levels of evidence ranging from Level I to V.

At least 2 of the review authors independently, in an unblinded standardized manner, analyzed the evidence. Any disagreements between reviewers were
Systematic Appraisal of the Accuracy and Utility of Discography

resolved by a third author and consensus. If there were any conflicts of interest (e.g., authorship), those reviewers were recused from assessment and analysis.

2.6 Outcome of the Studies

Outcome evaluations included the prevalence of lumbar discogenic pain and false-positive results.

Table 1. Quality Appraisal of Diagnostic Reliability (QAREL) checklist.

<table>
<thead>
<tr>
<th>Item</th>
<th>Yes</th>
<th>No</th>
<th>Unclear</th>
<th>N/A</th>
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<tbody>
<tr>
<td>1. Was the test evaluated in a spectrum of subjects representative of patients who would normally receive the test in clinical practice?</td>
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<td>2. Was the test performed by examiners representative of those who would normally perform the test in practice?</td>
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<td>3. Were raters blinded to the reference standard for the target disorder being evaluated?</td>
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<td>4. Were raters blinded to the findings of other raters during the study?</td>
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<td>5. Were raters blinded to their own prior outcomes of the test under evaluation?</td>
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<td>6. Were raters blinded to clinical information that may have influenced the test outcome?</td>
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<td>7. Were raters blinded to additional cues, not intended to form part of the diagnostic test procedure?</td>
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<td>8. Was the order in which raters examined subjects varied?</td>
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<td>9. Were appropriate statistical measures of agreement used?</td>
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<td>10. Was the application and interpretation of the test appropriate?</td>
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<td>11. Was the time interval between measurements suitable in relation to the stability of the variable being measured?</td>
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<td>12. If there were dropouts from the study, was this less than 20% of the sample.</td>
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<td>TOTAL</td>
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</table>


Table 2. Modified grading of qualitative evidence.

<table>
<thead>
<tr>
<th>Level</th>
<th>Evidence obtained from multiple relevant high quality randomized controlled trials or Evidence obtained from multiple high quality diagnostic accuracy studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level II</td>
<td>Evidence obtained from at least one relevant high quality randomized controlled trial or multiple relevant moderate or low quality randomized controlled trials or Evidence obtained from at least one high quality diagnostic accuracy study or multiple moderate or low quality diagnostic accuracy studies</td>
</tr>
<tr>
<td>Level III</td>
<td>Evidence obtained from at least one relevant moderate or low quality randomized controlled trial with multiple relevant observational studies or Evidence obtained from at least one relevant high quality nonrandomized trial or observational study with multiple moderate or low quality observational studies or Evidence obtained from at least one moderate quality diagnostic accuracy study in addition to low quality studies</td>
</tr>
<tr>
<td>Level IV</td>
<td>Evidence obtained from multiple moderate or low quality relevant observational studies or Evidence obtained from multiple relevant low quality diagnostic accuracy studies</td>
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<tr>
<td>Level V</td>
<td>Opinion or consensus of large group of clinicians and/or scientists</td>
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</table>


3.0 Results

Figure 1 shows a flow diagram of study selection. There were 8 studies considered for inclusion (47,51,52,54,55,58-60).

There were multiple studies of discography assessing accuracy, prevalence, and outcomes (30-34,50-53,55,58-62,70,71,72,110-113,126,130,131,133-136,140,142,154-216).
3.1 Methodological Quality Assessment

A methodological quality assessment of prevalence or diagnostic studies meeting inclusion criteria was carried out utilizing QAREL criteria as shown in Table 3. Studies achieving 4 of 12 or higher scores were included. Scores of 8 of 12 were considered to be high quality, 5 to 7 were considered to be moderate quality, and studies scoring less than 4 were considered to be of poor quality and excluded.

There were 8 studies assessing prevalence and which met inclusion criteria (47,51,52,54,55,58-60).

3.2 Diagnostic Studies of Prevalence

Prevalence studies included 8 studies of which 5 described lumbar discogenic pain (47,51,52,54,55) and 3 described cervical discogenic pain (58-60). There were no thoracic studies. There were 2 studies assessing the role of thoracic discography in the thoracic spine; however, they did not assess the prevalence (61,62). All the included studies were shown to be of high quality. The studies of prevalence in lumbar discogenic pain showed variable prevalence of 26% (51), 39% (52), 42% (54), 16.9% (47), and 21.8% (55) as shown in Table 4.

In the cervical spine, there were 3 studies by the same group of investigators (58-60) showing the prevalence to range from 16% (58) to 20% (59) to 53% (60) with a high variability.
### Table 3. Methodological quality appraisal of diagnostic accuracy studies of prevalence.

<table>
<thead>
<tr>
<th>Study</th>
<th>1.</th>
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<th>3.</th>
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<th>6.</th>
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<th>9.</th>
<th>10.</th>
<th>11.</th>
<th>12.</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>Manchikanti et al 2001 (51)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>8/11</td>
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<tr>
<td>Schwarzer et al 1993 (52)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<tr>
<td>DePalma et al 2011 (54)</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<tr>
<td>Bokov et al 2013 (47)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
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<td>Verrills et al 2013 (55)</td>
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<tr>
<td>Schellhas et al 1994 (62)</td>
<td>N</td>
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<tr>
<td>Wood et al 1999 (61)</td>
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<td>N</td>
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<tr>
<td>Bogduk and April 1993 (59)</td>
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<tr>
<td>Yin and Bogduk 2008 (58)</td>
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<td>April and Bogduk 1992 (60)</td>
<td>N</td>
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<td>N</td>
<td>N</td>
<td>8/11</td>
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</table>

Y=yes; N=no; U=unclear; N/A=not applicable

3.3 Diagnostic Accuracy

The number of studies available to assess the prevalence and diagnostic accuracy remained the same as in our previous review of lumbar discography (39). All of these studies assessed lumbar discogenic pain. Table 5 shows the characteristics and descriptions of prevalence and diagnostic accuracy studies of lumbar discography (47,51,52,54,55). Multiple others included anesthetic discography, subgroup analysis in 5 additional manuscripts, and confounding factors, which raise questions about the accuracy of diagnostic provocation discography (122-142).

The number of studies available assessing the diagnostic accuracy remained the same in cervical dis-

<table>
<thead>
<tr>
<th>Study</th>
<th>Methodological Quality Scoring</th>
<th>Participants</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LUMBAR SPINE</strong></td>
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<tr>
<td>Manchikanti et al, 2001 (51)</td>
<td>8/11</td>
<td>From a group of 120 patients with low back pain, 72 patients negative for facet joint pain underwent discography.</td>
<td>The prevalence of discogenic pain was established in 26% of total patient sample and 43% of patients negative for facet joint pain.</td>
</tr>
<tr>
<td>Schwarzer et al, 1995 (52)</td>
<td>8/11</td>
<td>92 consecutive patients with chronic low back pain and no history of previous lumbar surgery referred for discography.</td>
<td>The diagnostic criteria for internal disc disruption were fully satisfied in 39% of the patients, most commonly at L5/S1 and L4/5.</td>
</tr>
<tr>
<td>DePalma et al, 2011 (54)</td>
<td>8/11</td>
<td>Of the 156 patients, 71 underwent provocation discography. They also underwent other diagnostic blocks including facet joint nerve blocks and sacroiliac joint injections.</td>
<td>The prevalence of internal disc disruption in this study was 42%.</td>
</tr>
<tr>
<td>Bokov et al, 2013 (47)</td>
<td>8/11</td>
<td>Authors evaluated 83 patients. Of these 61 patients underwent discography with 14 of them showing final positive results with a prevalence of 16.9%.</td>
<td>The prevalence of discogenic pain was 16.9%.</td>
</tr>
<tr>
<td>Verrills et al, 2015 (55)</td>
<td>8/11</td>
<td>In low back pain cases during the study of 756, the authors have evaluated 225 consecutive cases of chronic low back pain with lumbar discography to identify symptomatic and flanking asymptomatic discs. In a subset of 185 patients receiving both discography and diagnostic blocks, 63% had proven discogenic pain.</td>
<td>The prevalence of discogenic pain based on the large sample of 756 was shown to be 21.8%. This manuscript also showed a large percentage of mixed etiology pain of 18%, with 14% remaining undiagnosed, and 63% with proven discogenic pain.</td>
</tr>
<tr>
<td><strong>CERVICAL SPINE</strong></td>
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<tr>
<td>Bogduk and Aprill 1993 (59)</td>
<td>8/11</td>
<td>The prevalence of disc pain and zygapophysial joint pain occurring simultaneously in the same segment of the neck, was determined in 56 patients with post traumatic neck pain, with provocation discography and cervical zygapophysial joint blocks.</td>
<td>The prevalence of discogenic pain was 20% in the cervical spine, however, in combined discogenic pain and zygapophysial joint pain prevalence was 41%.</td>
</tr>
<tr>
<td>Yin and Bogduk 2008 (58)</td>
<td>8/11</td>
<td>Authors in this study evaluated 88 patients from a sample of 167 patients with provocative discography and controlled zygapophysial joint blocks.</td>
<td>The prevalence of discogenic pain in this sample was 16% with prevalence of zygapophysial pain in 55% of the patients.</td>
</tr>
<tr>
<td>April and Bogduk 1992 (60)</td>
<td>8/11</td>
<td>In this evaluation, prevalence of discogenic pain was evaluated with provocation discography and controlled cervical zygapophysial joint blocks in 318 consecutive patients. Provocation discography was the sole investigation in 152 patients. In 76 patients, both provocation discography and zygapophysial joint blocks were performed.</td>
<td>Overall prevalence of discogenic pain was 53%.</td>
</tr>
</tbody>
</table>
### Table 5. Characteristics of prevalence and diagnostic accuracy studies of lumbar discography.

<table>
<thead>
<tr>
<th>STUDY</th>
<th>PARTICIPANTS / RESULTS</th>
<th>AUTHORS’ CONCLUSION</th>
<th>REVIEW CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manchikanti et al, 2001 (51)</td>
<td>120 patients with a chief complaint of low back pain were evaluated with precision diagnostic injections, which included medial branch blocks, provocative discography, and sacroiliac joint injections.</td>
<td>The facet joint is the most common pain generator in chronic low back pain, with identification of the facet joint in 40% of patients, followed by the disc in 26% of patients, and the sacroiliac joint in only 2% of the patients.</td>
<td>Prevalence of discogenic pain was present in 26% of the sample.</td>
</tr>
<tr>
<td>Schwarzer et al, 1995 (52)</td>
<td>92 consecutive patients with chronic low back pain and no history of previous lumbar surgery were studied. Each patient underwent a standard physical examination. Computed tomography discography was performed at a minimum of 2 levels. Authors also used both discography and blocks of the zygapophyseal joints.</td>
<td>A diagnosis of internal disc disruption can be made in a significant proportion of patients with chronic low back pain, but no conventional clinical test can discriminate patients with internal disc disruption from patients with other conditions. In patients with chronic low back pain, the combination of discogenic pain and zygapophyseal joint pain is uncommon.</td>
<td>This study provided prevalence of internal disc disruption. This study provided confirmation that combined discogenic and facet joint pain is rare.</td>
</tr>
<tr>
<td>DePalma et al, 2011 (54)</td>
<td>A total of 156 patients underwent diagnostic procedures including provocation discography, dual diagnostic facet joint blocks, and sacroiliac joint injections. All patients suffered with chronic low back pain and failed conservative management. Positive discography was defined as concordant or partial concordant low back pain above 6 or 10 at low pressure (below 50 psi) over opening pressure due to Grade III or higher annular tears. 71 patients underwent provocation discography with a prevalence of 41.8%.</td>
<td>The authors concluded that the prevalence of internal disc disruption was present in 42% of the patients. Patients with internal disc disruption were significantly younger than those with facet joint pain or sacroiliac joint pain. Increased age was associated with a definitive probability of internal disc disruption and increased probability of facet joint pain and sacroiliac joint pain.</td>
<td>Well-performed evaluation in a group of patients with chronic low back pain yielding a prevalence of internal disc disruption of 42%.</td>
</tr>
<tr>
<td>Bokov et al, 2013 (47)</td>
<td>The authors evaluated 83 patients. Of these, 61 patients underwent discography with 25 of them showing positive results. 11 patients or 44% of these failed to respond to nucleoplasty.</td>
<td>The authors concluded that in choosing diagnostic criteria, not only should the success rate of a particular technology be taken into consideration, but also the rate of false-negative results. Consequently, acceptable diagnostic criteria should be based on a rational balance of sensitivity and specificity.</td>
<td>Based on the assessment of 25 of the 61 patients with the concordant elicitation of pain, the prevalence is estimated to be 40.98%; however, the authors of this manuscript have made the argument, due to failure of response to nucleoplasty, they were considered as negative, leading to a prevalence of discogenic pain of 16.9%.</td>
</tr>
<tr>
<td>Verrills et al, 2015 (55)</td>
<td>In this prospective, 3-year study of 223 consecutive cases of chronic low back pain, lumbar discography was used to identify symptomatic and flanking asymptomatic discs. A subset of patients (N = 195) had previously undergone posterior column blocks to investigate spinal facet and/or sacroiliac joints as contributing pain sources. The testing of 644 discs showed positive discograms in 74% of patients, with 22.9% negative and 3.1% as indeterminate. Taking into account all low back pain cases during this study (N = 756), discogenic pain prevalence was 21.8%.</td>
<td>The authors concluded that prevalence of discogenic pain in their community practice was below the range, but within confidence intervals, previously reported levels of 26% to 42%. They showed prevalence of discogenic pain of 21% and they commented that in well selected patients, discography enabled a firm diagnosis and they hypothesized that it would be found in a higher proportion of patients.</td>
<td>The prevalence of discogenic pain as determined by the authors is 21.8%, well within the limits of other assessments. However, in highly selected patients discogenic pain is higher with 34% in this study or it could be projected as high as 74%. This study emphasizes the importance of prevalence calculations in highly selected patients and also assessing them in a larger sample.</td>
</tr>
</tbody>
</table>
cography also (40). Table 6 shows the characteristics and descriptions of prevalence and diagnostic accuracy studies of cervical discography (58-60).

3.4 Analysis of Evidence

Based on the available evidence the prevalence of lumbar discogenic pain appears to range from 16.9% to 26% in patients with discogenic pain and 16.9% to 42% in patients with internal disc disruption.

The strength of evidence is Level 3 due to various inconsistencies among the studies and diagnostic accuracy of lumbar discography.

Prevalence of cervical discogenic pain is determined to be 16% to 53% with multiple internal inconsistencies. Consequently, the level of evidence is 4 based on the lack of significant diagnostic accuracy of cervical discography and the prevalence studies.

4.0 Discussion

This systematic review of cervical, thoracic, and lumbar discography shows Level 3 evidence for the prevalence and accuracy of lumbar provocation discography and Level 4 evidence for cervical provocation discography based on diagnostic accuracy studies, prev-

Table 6. Characteristics of prevalence and diagnostic accuracy studies of cervical discography.

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients and Interventions</th>
<th>Results</th>
<th>Comments</th>
<th>Summary of Results</th>
</tr>
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<tbody>
<tr>
<td>Bogduk and April 1993 (59)</td>
<td>To determine the prevalence of disc pain and zygapophysial joint pain occurring simultaneously in the same segment of the neck, 56 patients with post traumatic neck pain underwent both provocation discography and cervical zygapophysial joint blocks.</td>
<td>Both a symptomatic disc and a symptomatic zygapophysial joint were identified in the same segment in 41% of the patients. Discs alone were symptomatic in only 20% of the sample.</td>
<td>Authors indicated that the investigation of neck pain by discography alone or by zygapophysial blocks alone constitute an inadequate approach to neck pain which fails to identify the majority of patients whose symptoms stem from multiple elements in the 3 joint complexes of the neck.</td>
<td>Since provocation discography was positive along with a zygapophysial joint block in 41% of the patients and discs were positive alone in 20% of the sample, a high prevalence of 61% may be the final result of discogenic pain in the cervical spine. In addition, 35% of the patients did not undergo any investigations. Authors also postulated that if cervical segments are fully investigated it emerges that cervical discs are not the most common, primary source of neck pain.</td>
</tr>
<tr>
<td>Yin and Bogduk 2008 (58)</td>
<td>This evaluation was undertaken to determine the prevalence of different cause of neck pain in a private practice clinic. Overall 88 patients were evaluated from a sample of 167 patients with 46% of the patients completing the investigations.</td>
<td>A large proportion of patients did not pursue investigations. Among the 46% of patients who completed investigations, the prevalence of discogenic pain was 16% and the prevalence of zygapophysial joint pain was 55% with diagnosis remaining elusive in 32% of those patients who completed investigations.</td>
<td>In a private practice setting, authors were able to complete investigation in less than 50% of the patients; however, in patients who completed controlled blocks or more than one invasive test, a pathoanatomic diagnosis remained elusive in only 17%.</td>
<td>Authors described that this study was not designed to establish the prevalence of various causes of neck pain in the general community, or even a particular sample of that community. The prevalence was estimated in a private pain clinic with highly select group of patients. This study provided prevalence of discogenic pain in 16% of the patients even though a large proportion of the patients did not undergo the assessment.</td>
</tr>
<tr>
<td>April and Bogduk, 1992 (60)</td>
<td>This study evaluated prevalence of cervical zygapophysial joint pain in 318 consecutive patients with intractable neck pain who underwent provocation discography and cervical zygapophysial joint blocks. Provocation discography was the sole investigation in 152 patients. In 76 patients, both provocation discography and zygapophysial joint blocks were performed.</td>
<td>Provocation discography provided unambiguous information and was the sole investigation performed in 152 patients, in 127 of whom a symptomatic disc was found at one or more levels, whereas in 25 patients provocation discography was negative at the levels investigated.</td>
<td>In the 76 patients who underwent both provocation discography and zygapophysial joint blocks, discography was indeterminate in 6 patients, and discography as well as zygapophysial joint blocks were both positive in 26 patients and both negative in 12.</td>
<td>Overall, in this study, 33% of the sample suffered a symptomatic disc.</td>
</tr>
</tbody>
</table>
alence studies, and outcomes assessment. Even though multiple studies are available assessing the reliability of diagnostic accuracy, there are multiple variables including lack of standardization, limitations in technique, the paucity of studies evaluating outcomes, and various reports contradicting the diagnostic accuracy of discography. Thus, the evidence for use of discography at any site prior to fusion appears to be limited at best. These results are similar to the previous results published by multiple authors (36-42,44,45,68). This review included additional studies than previously included in systematic reviews; however, the results appear to be the same with no significant change. Consequently, diagnostic accuracy and false-positive rate assessment continues to be an issue of intense debate.

Carragee et al (131-140) have published multiple manuscripts questioning the value and validity of diagnostic provocation discography. Wolfer et al (57), in a systematic review and meta-analysis of lumbar provocation discography in asymptomatic participants, identified 11 studies meeting inclusion criteria for analysis and showed results contradictory to the opinions of Carragee et al (131-140). They combined all extractable data and arrived at a false-positive rate of 9.3% per patient and 6% per disc. Further analysis showed that data pooled from asymptomatic participants without low back pain or any confounding factors also showed a lower false-positive rate of 3% per patient and 2.1% per disc. They also analyzed chronic pain patients without low back pain and showed that the false-positive rate was 5.6% per patient and 3.85% per disc. Thus, Wolfer et al (57) concluded chronic pain does not appear to be a confounding factor and, patients with chronic pain possess the ability to distinguish between pathologic and nonpathologic discs, namely positive and negative discs. They also extensively analyzed other groups including those with iliac crest pain after bone grafting, chronic neck pain, somatization disorder, and post discectomy. They showed low false-positive rates in patients with iliac crest pain after bone grafting of 12% and 7.1%, whereas, false-positive rates in patients with chronic neck pain was 0% compared to post discectomy patients 15% and 9.1%, either per patient or per disc. However, they also showed a significantly high proportion of patients to be false-positive with somatization disorder with 50% per patient and 22.2% per disc. They were also unable to determine false-positive rates in patients with chronic back pain. The meta-analysis led them to recommend a more stringent, low-pressure positive criteria (< 15 PSI AOP), since it was associated with a low false-positive rate.

In addition, multiple reports by Carragee et al (131-140) and several guidelines based on the available literature (217-223) have suggested that discography may in fact result in unnecessary surgery and accelerated disc degeneration in addition to misdiagnosis (210-215). Much of the literature related to negative aspects of discography, as described earlier, is from Carragee et al (131-140,212-216). In a recent assessment of provocation discography causing clinically important injury to lumbar intervertebral disc (210), the authors concluded that the disc puncture and pressurized injection performed during provocative discography can increase the risk of clinical disc problems in exposed patients. The results of this study showed that at 10-year follow-up, there were 16 lumbar surgeries in the discography group compared with 4 in the control group. Further, medical visits, computed tomography (CT)/MRI examinations, work loss, and prolonged back pain episodes were all more frequent in the discography group compared with controlled participants. The study originally enrolled 71 discography patients and 72 controlled participants who completed the baseline evaluation. At 10-year follow-up, 57 discography and 53 controlled patients completed all surveillance evaluations at one, 2, 5, and 10 years after enrollment. In addition, cytotoxicity of local anesthetic and non-contrast agents on bovine intervertebral disc cells cultured in a 3-dimensional culture system has been reported (224). Further, influence of intradiscal medication or nucleus pulposus cells also has been described (225) with significant discount in cell counts. However, only a small decrease in cell viability was observed. An evaluation of cytokine in individuals with low back pain using discographic lavage concluded that potential inflammatory markers were elevated in degenerative discs, both positive and negative, emphasizing lack of value for discography (226). Thus, despite concordance of opinions in this respect, overall evidence for discography as a diagnostic test appears to be Level 3. In the past we have shown moderate or fair evidence for lumbar provocation discography. Overall these results are similar to multiple previous reviews (1,39,227).

The prevalence data and diagnostic accuracy of cervical discography seems to be with a lower level of evidence of 4. This is based on substantial internal inconsistency among the few studies available. These results are also similar to our previous reviews (1,40).

Provocation discography as a diagnostic test has faced substantial criticism. O’Neill (161) described all diagnostic tests for chronic low back pain as dismal.
Others also have provided contradictory perspectives on the role of discography in surgical decision-making or the diagnosis itself (131-140,162-168). A systematic review on the accuracy of tests for patient selection for spinal fusion for chronic low back pain by Willems et al (172) concluded that no subset of patients with chronic low back pain could be identified for whom spinal fusion is a predictable and effective treatment. They also opined that best evidence does not support the use of current tests for patient selection in clinical practice. In this analysis, they utilized 4 studies of provocation discography (170-173) prior to fusion resulting in the conclusion that discography has no significant value as a preoperative test prior to selection of lumbar fusion. In addition, advanced imaging continues to show failure to diagnose a painful disc from a painless disc as multiple abnormalities have been shown over the years (228,229). Kallewaard et al (69) have also shown lack of transfer of pressure to adjacent discs during human low-pressure controlled discography, leading to the impression that the majority of the misimpressions were related to high-pressure discography. In addition, multiple modalities of treatments have been published including those of epidural injections, which were shown to be superior to fusion in discogenic pain (99). Multiple intradiscal therapies (30-33,175,230,231) have been advocated without definitive results thus far.

Despite less reliable evidence of diagnostic accuracy and prevalence studies in the cervical spine, surgical outcomes have been described in multiple studies (39,185-202). The majority of these studies have been retrospective or observational with no randomized controlled trials. Thus, results instill very limited confidence and evidence is only empirical.

### 5.0 Conclusion

This systematic review illustrates that lumbar provocation discography performed according to IASP criteria may be a useful tool for evaluating chronic lumbar discogenic pain. Based on modified best evidence synthesis, the indicated strength of evidence was Level III for lumbar discography and Level IV for cervical discography due to significant internal inconsistency in the lumbar spine and extremely high internal inconsistency in the cervical discography.

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