Systematic Review

A Systematic Evaluation of Prevalence and Diagnostic Accuracy of Sacroiliac Joint Interventions

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Background: The contributions of the sacroiliac joint to low back and lower extremity pain have been a subject of considerable debate and research. It is generally accepted that 10% to 25% of patients with persistent mechanical low back pain below L5 have pain secondary to sacroiliac joint pathology. However, no single historical, physical exam, or radiological feature can definitively establish a diagnosis of sacroiliac joint pain. Based on present knowledge, a proper diagnosis can only be made using controlled diagnostic blocks. The diagnosis and treatment of sacroiliac joint pain continue to be characterized by wide variability and a paucity of the literature.

Objective: To evaluate the accuracy of diagnostic sacroiliac joint interventions.

Study Design: A systematic review of diagnostic sacroiliac joint interventions.

Methods: Methodological quality assessment of included studies was performed using Quality Appraisal of Reliability Studies (QAREL). Only diagnostic accuracy studies meeting at least 50% of the designated inclusion criteria were utilized for analysis. Studies scoring less than 50% are presented descriptively and analyzed critically.

The level of evidence was classified as good, fair, or limited (or poor) based on the quality of evidence developed by the United States Preventive Services Task Force (USPSTF).

Data sources included relevant literature identified through searches of PubMed and EMBASE from 1966 to December 2011, and manual searches of the bibliographies of known primary and review articles.

Outcome Measures: In this evaluation we utilized controlled local anesthetic blocks using at least 50% pain relief as the reference standard.

Results: The evidence is good for the diagnosis of sacroiliac joint pain utilizing controlled comparative local anesthetic blocks. The prevalence of sacroiliac joint pain is estimated to range between 10% and 62% based on the setting; however, the majority of analyzed studies suggest a point prevalence of around 25%, with a false-positive rate for uncontrolled blocks of approximately 20%. The evidence for provocative testing to diagnose sacroiliac joint pain was fair. The evidence for the diagnostic accuracy of imaging is limited.

Limitations: The limitations of this systematic review include a paucity of literature, variations in technique, and variable criterion standards for the diagnosis of sacroiliac joint pain.

Conclusions: Based on this systematic review, the evidence for the diagnostic accuracy of sacroiliac joint injections is good, the evidence for provocation maneuvers is fair, and evidence for imaging is limited.

Key words: Chronic low back pain, sacroiliac joint pain, sacroiliitis, sacroiliac joint injection, sacroiliac joint dysfunction, provocation manuevers, controlled diagnostic blocks, intraarticular injection, extraarticular injection.

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Chronic low back pain, with or without lower extremity pain, that arises from various structures of the spine constitutes a majority of pain complaints (1-11). The high prevalence of chronic low back pain, the numerous modalities of treatments for managing the problem, and the growing social and economic costs continue to influence medical decision-making (1,2,5,12-35). Even though low back pain is a common complaint in primary care and tertiary care, it is often difficult to reach a definitive diagnosis (2,35-45). Controlled studies have established intervertebral discs, facet joints, and sacroiliac joints as potential sources of low back and lower extremity pain (2,35-49). Thus, the sacroiliac joint is accepted as a potential source of low back and/or buttock pain with or without lower extremity pain (2,36,39,41-44,46-53). The sacroiliac joint has been implicated as the primary source of pain (2,36,39,44,47-49,53) in 10% to 27% (41,54,55) of patients with mechanical low back pain below L5 utilizing controlled, comparative local anesthetic blocks.

A major source of the exponential growth in treatment modalities is the inherent difficulty in obtaining an accurate diagnosis (1-5,14-36,56-71). An inaccurate or incorrect diagnosis may lead not only to treatment failure, but also results in wasted health care dollars, diverting essential health care resources. Fundamental to an accurate diagnosis is the reliability of the test used to make the diagnosis (2,39,40,44,47,48,49,53,72-77). Attempts have been made to improve the accuracy of diagnosing sacroiliac joint pain by multiple means, including physical examination, imaging techniques, and controlled local anesthetic blocks (2,36,39,41,42,44,47,49,53-55,78-84).

However, there is no universally accepted gold standard for the diagnosis of low back pain, regardless of whether the suspected source is the sacroiliac joint(s), intervertebral disc(s), or facet joint(s) (2,35-49,53-55,79-86). The recommended reference standards typically involve anesthetic or provocative injections (2,35-49,53). Multiple arguments have been made in favor of and against the diagnostic accuracy of controlled local anesthetic blocks (2,27,39-49,53,74,75,85-89), but controlled local anesthetic blocks continue to be the best available tool to identify intervertebral discs, facet, or sacroiliac joint(s) as the source of low back pain. Yet, these reference standards are invasive, expensive, and often difficult to interpret, and therefore may not be suitable for routine clinical use as a primary diagnostic modality.

The sacroiliac joint is a true diarthrodial joint; matching articular surfaces separated by a joint space containing synovial fluid and enveloped by a fibrous capsule, but, with unique characteristics not typically found in other diarthrodial joints (90-96). The sacroiliac joint contains fibrocartilage in addition to hyaline cartilage (97), and is characterized by discontinuity of the posterior capsule, with ridges and depressions that minimize movement and enhance stability (51). Consequently, the sacroiliac joint has been described as a true synovial joint only in the anterior portion. In contrast, the posterior connection is a syndesmosis consisting of the ligamenta sacroiliaca, the musculus gluteus medius and minimus, and the musculus pyriformis (57).

The sacroiliac joint is well imbued with nociceptor and proprioceptors. Information on the innervation pattern is the subject of considerable controversy. Solonen (98) examined data from earlier studies (1857-1944) that collectively identified branches from the lumbosacral plexus, superior gluteal nerve, dorsal rami of S1 and S2, and the obturator nerve, as providing innervation. But despite multiple studies (99-105), the exact innervation continues to be unclear. The anterior portion may be innervated by the sacral plexus, whereas the posterior portion may have innervation from the spinal nerves. It has been proposed that the predominant innervation is via the L4 to S1 nerve roots, with some contribution from the superior gluteal nerve (106). Even though there may be input from ventral rami, several authors have argued that the joint is innervated only by the sacral dorsal rami (104,107). Bernard (108) proposed that the posterior innervation is from the lateral branches of the posterior rami of L4 to S3, whereas the anterior innervation stems from the L2 to S2 segments.

Nakagawa (109) reported that the nerve filaments to the joint are derived from the ventral rami of L4 and L5, the superior gluteal nerve, and the dorsal rami of the L5, S1, and S2. In contrast, Grob et al (104) found that the innervation of the sacroiliac joint is almost exclusively derived from the sacral dorsal rami. Dissections of fetal pelvises confirmed that innervation of the sacroiliac joint originates in the dorsal rami because neural filaments are noted solely in the dorsal mesenchyme (107,109).

Murata et al (101) evaluated the sensory innervation of the sacroiliac joint in rats and concluded that the sacroiliac joint was innervated by sensory neurons in dorsal root ganglia ipsilateral to the joint from the L1 to S2. They also concluded that sensory fibers from

the L1 and L2 dorsal root ganglia passed through the paravertebral sympathetic trunk.

Histologic analyses of chronically painful sacroiliac joints has verified the presence of nerve fibers within the joint capsule and adjoining ligaments (107,110,111). A recent cadaveric study by McGrath and Zhang (112) found that the long posterior sacroiliac ligament received afferent input from S2 (96%) and S3 (100%) in almost all specimens, from S4 in 59% of cases, and only occasionally from S1 (4%). The nerve fascicles contain both myelinated and unmyelinated nerve fibers, 2 morphotypes of paciniform-encapsulated mechanoreceptors, and a single nonpaciniform mechanoreceptor, suggesting that both pain and proprioception are transmitted from the sacroiliac joint (99,103,110,111,113). Szadek et al (105) concluded that the presence of calcitonin gene-related peptide and substance P immunoreactive fibers in the anterior capsular and interosseous ligaments provide a morphological and physiological base for pain signals originating from these structures. They further hypothesized that infiltration techniques used to diagnose sacroiliac joint pain should consider extraarticular as well as intraarticular approaches. Sakamoto et al (103) showed that most mechanoreceptor units in the sacroiliac joint are high-threshold group 3 units that likely serve a nociceptive function. However, they contend that the sacroiliac joint has little proprioceptive function.

Forst et al (51) described extensive communication between the sacroiliac joint and nearby neural structures. Patterns of extracapsular extravasation from the sacroiliac joint have been observed on postarthrography computed tomography (CT) (114). These patterns include posterior extension into the dorsal sacral foramina, extravasation into the L5 epiradicular sheath via the superior recess, and ventral leakage into the lumbosacral plexus (111,114). Thus, it is plausible that in the setting of capsular disruption, inflammatory mediators could leak out from the sacroiliac joint into nearby neural structures, causing radicular pain in certain patients (111,114).

Several mechanisms of injury have been linked to the development of sacroiliac joint pain, including a direct fall on the buttocks, a rear-end or broad-side type motor vehicle accident, and an unanticipated step into a hole or from a miscalculated height (90,91). In a study performed in 54 patients with suspected sacroiliac joint syndrome, Chou et al (115) found that 44% of patients cited a specific traumatic event, 21% reported a cumulative injury, and 35% had had spontaneous or idiopathic onset of sacroiliac joint pain. Among the various inciting events, motor vehicle accidents and falls comprise a majority (82,115,116). Other described causes include fusion surgery (83,117-119), anterior dislocation (120), inflammatory and degenerative sacroiliac joint disease (121), and multiple other etiologies (36,46,47,50,78,79,122,123). In a study by Ha et al (124), the authors found that sacroiliac joint degeneration is nearly universal 5 years following fusion to the sacrum, and considerably more common than in non-operated controls after floating fusions.

In a systematic review evaluating a battery of tests to identify the disc, sacroiliac joint, or facet joint as the source of low back pain, Hancock et al (49) suggested that a combination of sacroiliac joint pain provocative maneuvers appears to be useful in pinpointing the sacroiliac joint as the principal source of symptoms in patients with pain below the 5th lumbar vertebra. A systematic review by Szadek et al (80) showed that the thigh thrust test, the compression test, and 3 or more positive stressing tests contain sufficient discriminative power for diagnosing sacroiliac joint pain. A systematic literature review performed by Song et al (81) concluded that scintigraphy is of limited value at best in establishing sacroiliitis in patients with ankylosing spondylitis. In a best-evidence review of diagnostic procedures for neck and low back pain, Rubinstein and van Tulder (44) concluded that there was moderate evidence for the validity and accuracy of injections identified 3 systematic reviews (49,125,126). An evidence-based review by Laslett (53) determined that among chronic back pain patients, the presence of 3 or more positive provocation sacroiliac joint tests in conjunction with the absence of "centralization" are associated with a 77% probability of sacroiliac joint pain, 89% in pregnant women. In contrast, in an evidence-based medicine series, Vanelderen et al (57) concluded that it was difficult to distinguish sacroiliac joint pain from other forms of low back pain based on history and physical exam alone. They also reported that provocative maneuvers have weak predictive value, though combined batteries of tests can help ascertain a diagnosis.

The primary purpose of this review is to systematically assess the literature on diagnostic sacroiliac joint interventions. The secondary objectives are to analyze studies for quality, and factors that can affect generalizability.

1.0 Methods

The methodology utilized in this systematic review

followed the review process derived from evidence-based systematic reviews and meta-analysis of diagnostic accuracy studies (22,44,49,72-77,127,128).

1.1 Criteria for Considering Studies for This Review

1.1.1 Types of Studies

Diagnostic accuracy studies evaluating sacroiliac joint pain

1.1.2 Types of Participants

Participants of interest were adults aged at least 18 years with chronic low back and lower extremity pain of at least 3 months duration.

Participants must have failed previous pharmacotherapy, exercise therapy, etc., prior to starting diagnostic interventional pain management techniques.

1.1.3 Types of Interventions

The interventions were diagnostic sacroiliac joint interventions appropriately performed with proper technique under fluoroscopic or CT guidance.

1.1.4 Types of Outcome Measures

- The primary outcome parameter was pain relief concordant with the type of controlled diagnostic blocks performed.
- The secondary outcome measures were the ability to perform previously painful movements without significant pain or complications.
- At least 2 of the review authors independently, in an unblinded standardized manner, assessed the outcomes measures. Any disagreements between reviewers were resolved by a third author and consensus.

1.2 Literature Search

Searches were performed from the following sources without language restrictions:

1. PubMed from 1966
   www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed
2. EMBASE from 1980
   www.embase.com/
3. Cochrane Library
   www.thecochranelibrary.com/view/0/index.html
4. U.S. National Guideline Clearinghouse (NGC)
   www.guideline.gov/
5. Previous systematic reviews and cross references
6. Clinical Trials
   clinicaltrials.gov/

The search period was from 1966 through December 2011.

1.3 Search Strategy

The search strategy emphasized chronic low back pain, sacroiliac joint pain/arthritis, and diagnostic sacroiliac joint interventions and techniques.

This systematic review focused only on diagnostic studies, including invasive and noninvasive techniques and reports of complications. Only sacroiliac joint injections performed under fluoroscopy or CT imaging techniques were evaluated. Interventional techniques performed blindly or using other identification modalities were excluded. All studies describing appropriate outcome evaluations with proper statistical evaluations were reviewed. Reports without appropriate diagnosis, nonsystematic reviews, book chapters, and case reports were excluded.

At least 2 of the review authors independently, in an unblinded standardized manner, performed each search. Accuracy was confirmed by a statistician. All searches were combined to obtain a unified search strategy. Any disagreements between reviewers were resolved by a third author and consensus.

1.4 Data Collection and Analysis

The quality of each individual article used in this assessment was based on Quality Appraisal of Reliability Studies (QAREL) checklist (Table 1) (73). This checklist has been validated and utilized in multiple systematic reviews (73). Each study in the final sample of eligible manuscripts was assessed using a 12-item appraisal checklist designed to assess the quality and applicability of studies. The face validity of these checklists was established by consultation with methodology experts (73) and comparison with quality appraisal checklists used in other systematic reviews examining diagnostic reliability (129-134). This checklist was also developed in accordance to the Standards for Reporting Studies of Diagnostic Accuracy (STARD) (76), and the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) (76,77) 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."

1.4.1 Selection of Studies

- In an unblinded standardized manner, 2 review authors screened the abstracts of all identified studies

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

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

Lucas N, Macaskill P, Irwig L, Moran R, Bogduk N. Reliability of physical examination for diagnosis of myofascial trigger points. *Clin J Pain* 2009; 25:80-89 (72).

against the inclusion criteria.

- All articles with possible relevance were then retrieved in full text for comprehensive assessment of internal validity, quality, and adherence to inclusion criteria.

1.4.2 Inclusion and Exclusion Criteria

The following are the inclusion and exclusion criteria.

1. Are the patients described in sufficient detail to allow one to decide whether they are comparable to those who are treated in interventional pain management clinical practices?
   A. Setting – office, hospital, outpatient, inpatient.
   B. Physician – interventional pain physician, general physician, anesthesiologist, physiatrist, neurologist, rheumatologist, orthopedic surgeon, neurosurgeon, etc.
   C. Patient characteristics - duration of pain.
   D. Noninterventional techniques or surgical intervention in the past.
2. Is the intervention described in sufficient detail to enable one to apply its use to patients in interventional pain management settings?
   A. Nature of intervention.
   B. Frequency of intervention.
   C. Duration of intervention.
3. Were clinically relevant outcomes measured?
   A. Proportion of pain relief.
   B. Disorder/specific disability.
   C. Functional improvement.
   D. Allocation of eligible and noneligible patients to return to work.
   E. Ability to work.

1.4.3 Clinical Relevance

The clinical relevance of the included studies was evaluated according to 5 questions recommended by the Cochrane Back Review Group (Table 2) (135,136). Each question was scored as positive (+) if the clinical relevance item was met, negative (–) if the item was not met, and unclear (?) if data were not available to answer the question.

Table 2. *Clinical relevance questions*.

	P (+)	N (-)	U (unclear)
A) Are the patients described in detail so that one can decide whether they are comparable to those who are treated in clinical practice?			
B) Are the interventions and treatment settings described in sufficient detail to apply its use in clinical practice?			
C) Were clinically relevant outcomes measured and reported?			
D) Is the size of the effect clinically meaningful?			
E) Do the likely treatment benefits outweigh the potential harms?			

Scoring adapted and modified from Staal JB, et al. Injection therapy for subacute and chronic low-back pain. *Cochrane Database Syst Rev* 2008; 3:CD001824 (136).

1.4.4 Methodological Quality or Validity Assessment

Each study was evaluated by at least 2 authors for stated criteria and any disagreements discussed with a third reviewer. Authors with a perceived conflict of interest for any manuscript were recused from reviewing the manuscript.

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.

1.4.5 Data Extraction and Management

Two review authors independently, in an unblinded standardized manner, 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.

1.4.6 Assessment of Heterogeneity

Whenever meta-analyses were conducted, the I-squared (I2) index was used to identify heterogeneity (137). Combined results with I2 > 50% were considered substantially heterogenous.

Analysis of the evidence was based on diagnostic criteria as follows: 1) blocks in which the reference standard for diagnosis was between 50% to 80% pain relief with a single block; 2) blocks in which the reference standard for diagnosis was between 50% to 80% pain relief with dual blocks; 3) blocks in which the reference standard for diagnosis was between 80% to 100% pain relief with a single block; and 4) blocks in which the reference standard for diagnosis was between 80% to 100% pain relief with dual blocks, to reduce clinical heterogeneity.

1.4.7 Measurement of Treatment Effect in Data Synthesis (Meta-Analysis)

Data were separately summarized using meta-analysis when at least 5 studies per type of diagnostic criteria were available that met the inclusion criteria (e.g., single block, double blocks, and 50% to 80% relief.)

The minimum acceptable relief was considered to be 50%; however, data were sub-analyzed for ≥ 80% and 50% to 80% relief as the cutoff threshold for a positive block during the performance of previously painful movements. Four separate diagnostic categories were evaluated (i.e., 50% to 80% relief as the cutoff threshold with single and dual blocks; and 80% to 100% relief as the cutoff threshold with single or dual blocks). For dual blocks, there had to have been concordant response with short-acting and long-acting local anesthetics, or placebo.

1.4.8 Integration of Heterogeneity

A meta-analysis was performed only if there were at least 5 studies meeting inclusion criteria for each variable.

Statistical heterogeneity was explored using univariate meta-regression (137).

1.5 Summary Measures

Summary measures included 50% to 80% or 80% to 100% pain relief with the capability of performing previously painful movements concordant with the duration of local anesthetic.

1.6 Analysis of Evidence

The analysis of the evidence was performed based on United States Preventive Services Task Force (USPSTF) criteria (138) as illustrated in Table 3, which has been utilized by multiple authors (22,23,27,28,139-147).

Table 3. *Method for grading the overall strength of the evidence for an intervention.*

Grade	Definition
Good	Evidence includes consistent results from well-designed, well-conducted studies in representative populations that directly assess effects on health outcomes (at least 2 consistent, higher-quality RCTs or studies of diagnostic test accuracy).
Fair	Evidence is sufficient to determine effects on health outcomes, but the strength of the evidence is limited by the number, quality, size, or consistency of included studies; generalizability to routine practice; or indirect nature of the evidence on health outcomes (at least one higher-quality trial or study of diagnostic test accuracy of sufficient sample size; 2 or more higher-quality trials or studies of diagnostic test accuracy with some inconsistency; at least 2 consistent, lower-quality trials or studies of diagnostic test accuracy, or multiple consistent observational studies with no significant methodological flaws).
Limited or Poor	Evidence is insufficient to assess effects on health outcomes because of limited number or power of studies, large and unexplained inconsistency between higher-quality trials, important flaws in trial design or conduct, gaps in the chain of evidence, or lack of information on important health outcomes.

Adapted and modified from methods developed by U.S. Preventive Services Task Force (22,138).

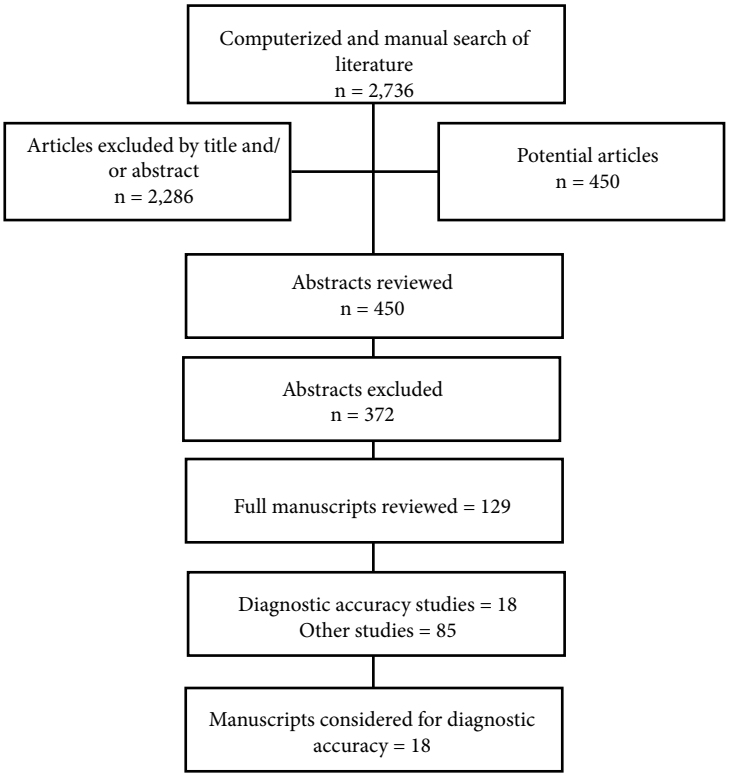

Fig. 1. *Flow diagram illustrating published literature evaluating the diagnosis of sacroiliac joint pain by sacroiliac joint injections.*

The analysis was conducted using 3 levels of evidence ranging from good to fair to limited (or poor) (22,23,138).

At least 2 of the review authors independently, in an unblinded standardized manner, analyzed the evidence. Any disagreements between reviewers were 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.

1.7 Outcome of the Studies

Outcomes included the prevalence of sacroiliac joint pain and false-positive rate. Based on the above parameters, the reliability of the data derived from each study was assessed.

2.0 Results

Figure 1 shows a flow diagram of study selection. There were 103 studies considered for inclusion (41,42,54,55,71,78,79,82,83,89,119,123,148-237) Among these, 18 evaluated diagnostic sacroiliac joint injections (41,42,54,55,78,79,82,83,119,148, 152,154,155,157,159,160,175,194,195), 13 evaluated provocative testing and clinical evaluation (54,82,148,154,155,157,159,160,175,189,199-201), 43 evaluated diagnostic imaging (83,152,156,166-168,171,176,202-205,207-237), 4 evaluated the accuracy of sacroiliac joint injections with fluoroscopy, CT or magnetic resonance imaging (MRI) (191-193,198), and 8 evaluated pain patterns (82,148,153,161-165). Table 4 shows the list of the 23 excluded studies

Table 4. *List of excluded studies*.

Manuscript Author(s)	Reason for Exclusion
Berthelot et al (89)	This was a review article rather than a diagnostic accuracy study.
DePalma et al (123)	This was a study of patients with or without surgical discectomy with only 11 patients being included who had surgical discectomy with 0% prevalence of sacroiliac joint pain in patients with surgical discectomy and 18.1% in patients without surgery.
Maigne et al (156)	Inclusion criteria was of patients suffering with 7 weeks of pain pattern compatible with sacroiliac joint pain – acute pain.
Klauser et al (169)	This study evaluated the feasibility of ultrasound-guided sacroiliac joint injection with landmarks at 2 different levels.
Harmon & Alexiev (170)	Sonoanatomy and injection technique of iliolumbar ligament was evaluated.
Gupta (172)	An alternative method with a double needle technique for performing difficult sacroiliac joint injections was evaluated.
Hart et al (173)	Intraarticular injections of the sacroiliac joint were evaluated after lumbar stabilization as a therapeutic modality.
Morimoto et al (174)	This was a case description of abdominal pain associated with sacroiliac joint dysfunction.
Hamauchi et al (177)	This was a case report presenting acute low back pain secondary to sacroiliac joint arthritis arthropathy.
Migliore et al (178)	A technical contribution for ultrasound-guided injection of sacroiliac joints was evaluated.
Streitparth et al (179)	Evaluation included image-guided spinal injection procedures in open high field MRI with vertical field orientation studying its feasibility and technical features.
Khurana et al (180)	Therapeutic intervention with percutaneous fusion was evaluated.
Dreyfuss et al (181)	An evaluation of the ability of single site, single depth sacral lateral branch blocks to anesthetize the sacroiliac joint complex showed significant anatomic limitations with single site, single depth lateral branch injections rendering them physiologically ineffective on a consistent basis.
Dreyfuss et al (182)	The evaluation of the ability of multi-site, multi-depth sacral lateral branch blocks to anesthetize the sacroiliac joint complex showed that there is physiologic evidence that the intraarticular portion of the sacroiliac joint is innervated from both ventral and dorsal sources.
Sadreddini et al (183)	An evaluation of unguided sacroiliac joint injections showing effectiveness.
Borowksy & Fagen (184)	This study evaluated the sources of sacroiliac region pain to gain insight into intraarticular injection compared to a combination of intraarticular and periarticular injection rather than determining prevalence. The prevalence estimates were not available. Only outcomes were available.
Harmon & O'Sullivan (185)	Injection technique with ultrasound guidance was evaluated.
Günaydin et al (186)	This study was an evaluation of the therapeutic effectiveness of repeat injections under magnetic resonance imaging.
Murakami et al (187)	This study was a comparative evaluation of periarticular and intraarticular lidocaine injections for sacroiliac joint pain.
Haufe & Mork (188)	This is a description of a technique for the treatment of sacroiliac joint pain with sacroiliac joint debridement.
Pekkafahli et al (190)	Sacroiliac joint injections were performed with sonographic guidance.
Bokov et al (196)	An evaluation of the reasons for failed back surgery syndrome and partial results after different types of surgical lumbar nerve root compression; however, there was no evaluation for sacroiliac joint.

(89,123,156,169,170,172-174,177-188,190,196).

2.1 Diagnostic Accuracy Studies

Table 5 illustrates the characteristics of studies considered for inclusion. There were 3 studies utilizing a single block with 50% to 80% relief as the cutoff threshold (82,83,157), 7 studies utilizing dual blocks with 50% to 80% relief as the cutoff threshold (54,55,78,79,119,160,194,195), and one duplicate study (78,195). There were 6 studies utilizing 80% to 100% relief as the cutoff threshold with a single block (42,148,152,154,155,175), and 2 studies utilizing dual

Table 5. *Characteristics of reported diagnostic accuracy studies.*

	Participants	Objective(s)	Interventions(s)	Result(s)
50% TO 79% RELIEF WITH SINGLE BLOCK				
Schwarzer et al (82) Utilized 75% relief	43 consecutive patients with chronic low back pain maximal below L5/S1 were investigated.	To establish the prevalence of sacroiliac joint pain, the validity of pain provocation, whether any arthrographic abnormalities predict a response to joint block, and whether certain pain patterns discriminate patients with this diagnosis.	Intraarticular injection of 1 mL of 2% lignocaine.	Prevalence = 30%
Maigne & Planchon (83) Utilized 75% relief	This was a prospective series of 40 patients with persistent low back pain after technically successful fusion who received a sacroiliac anesthetic block under fluoroscopic control.	To determine if the sacroiliac joint could be a possible source of pain and to search predictive factors for a positive block.	Intraarticular injection with 2 mL of 2% lidocaine.	Prevalence = 35%
Broadhurst & Bond (157) Utilized 70% relief	Double-blind trial of 40 patients to determine the sensitivity and specificity of 3 commonly used pain provocation tests for sacroiliac joint dysfunction if suppression of pain by 70% with injection of either normal saline or lidocaine.	To determine the sensitivity and specificity of 3 commonly used pain provocation tests for sacroiliac joint dysfunction.	Intraarticular injection of 4 mL of 1% lignocaine or 4 mL of normal saline into the painful joint in 20 patients in each group.	Prevalence = not available
50% TO 79% RELIEF WITH DUAL BLOCKS				
Maigne et al (54) Utilized 75% relief	54 patients aged 18-75 with chronic unilateral low back pain with or without radiation to the posterior thigh for > 50 days (median 4.2 months). Patients had failed epidural or lumbar facet injections.	To determine the prevalence of sacroiliac joint pain in a selected population of patients with low back pain and assess certain pain provocation tests.	Successful blockade of the sacroiliac joint in 54 patients. A screening block was done with 2% lidocaine and a confirmatory block was performed with bupivacaine 0.5%. Greater than 75% relief was considered a positive block.	Prevalence = 18.5% False-positive rate = 20%
Irwin et al (55) Utilized 70% relief	158 patients underwent sacroiliac joint injections with average duration of symptoms being 34 months. Patients failed conservative modalities prior to injection therapy.	To evaluate the prevalence and correlation among age, sex, and body mass index with dual, comparative local anesthetic blocks.	The fluoroscopically guided contrast medium-enhanced sacroiliac joint injections were performed initially with 2 mL of 2% lidocaine for the first injection, followed by 2 mL of 0.25% bupivacaine, a local anesthetic, for the confirmatory injection. A patient was required to have at least 70% reduction of familiar painful symptoms after the initial injection for 3 or 4 hours for a positive response.	Prevalence = 26.6% False-positive rate = Not available

Table 5 (cont.). *Characteristics of reported diagnostic accuracy studies.*

	Participants	Objective(s)	Interventions(s)	Result(s)
DePalma et al (78,195) Utilized 75% relief	156 patients underwent diagnostic procedures including discography, dual diagnostic facet joint blocks, and intraarticular sacroiliac joint injections to evaluate the source of chronic low back pain based on age. A screening block was performed with 1% lidocaine and a confirmatory block was performed with 0.5% bupivacaine.	To estimate the prevalence, mean age, and association of prevalence and age of lumbar internal disc disruption, facet joint pain, sacroiliac joint pain, spinal and pelvic insufficiency fractures, interspinous ligament injury/ Baastrup Disease, and soft tissue irritation by fusion hardware.	Intraarticular sacroiliac joint injections with 2 mL of 1% lidocaine and 0.5% bupivacaine.	Prevalence = 18.2% False-Positive Rate = Not available
DePalma et al (79) Utilized 75% relief	Retrospective evaluation of 27 motor vehicle collision-induced chronic low back pain patients undergoing multiple types of diagnostic interventions.	To estimate prevalence rates of discogenic, facet, and sacroiliac joint pain, and describe clinical features of chronic low back pain patients whose symptoms were initiated by motor vehicle collision.	Intraarticular sacroiliac joint injections with 2 mL of 1% lidocaine and 0.5% bupivacaine.	Prevalence = 18.2% False-Positive Rate = Not available
DePalma et al (119) Utilized 75% relief	The diagnoses of 28 fusion cases identified from 170 low back pain patients undergoing diagnostic procedures included 12 with sacroiliac joint pain.	To estimate the prevalence of lumbar internal disc disruption, zygapophysial joint pain, sacroiliac joint pain, and soft tissue irritation by fusion hardware in postfusion low back pain patients compared to nonfused patients utilizing diagnostic spinal procedures.	Intraarticular sacroiliac joint injections with 2 mL of 1% lidocaine and 0.5% bupivacaine.	Prevalence = 18.2% False-Positive Rate = Not available
van der Wurff et al (160) Utilized 50% relief	Total number of 140 patients with chronic low back pain visiting a pain clinic in the Netherlands; 60 patients entered the study.	To compare the diagnostic accuracy of a multi-test regimen of 5 sacroiliac joint pain provocation tests with fluoroscopically controlled double sacroiliac joint blocks using a short- and long-acting local anesthetic.	The fluoroscopically guided contrast medium-enhanced sacroiliac joint injections were performed initially with 2 mL of 2% lidocaine and then with 0.25% bupivacaine. A reduction in the patient's characteristic pain of 50% or more on the visual analog scale (VAS) lasting for at least one hour for lidocaine or 4 hours for bupivacaine was considered as positive. When a patient showed a VAS reduction after both intraarticular sacroiliac joint blocks, this was considered a positive response. Any other outcome was considered a negative response.	Prevalence = 38% False-positive rate = 21%

Table 5 (cont.). *Characteristics of reported diagnostic accuracy studies.*

	Participants	Objective(s)	Interventions(s)	Result(s)
Liliang et al (194)	130 patients who underwent lumbar or lumbosacral fusion were evaluated for sacroiliac joint pain. Of these, 52 patients obtained positive findings with 3 of the provocative tests for sacroiliac joint pain. They were selected to receive dual diagnostic blocks. Among the 52 patients, 20 were considered to have sacroiliac joint pain on the basis of 2 positive responses to diagnostic blocks with 75% as the criterion standard.	To ascertain whether sacroiliac joint pain represents a potential source of pain in patients who have undergone lumbar or lumbosacral fusions.	Intraarticular injections of either lidocaine or bupivacaine, 1 mL, with 40 mg of triamcinolone acetonide.	Prevalence = 40% False-positive rate = 26%
80% TO 100% RELIEF WITH SINGLE BLOCK				
Pang et al (42) Utilized 90% relief	104 consecutive adult patients who underwent spinal pain mapping were examined and analyzed. They found in this group a total of 87% of the patients with a diagnosed pain source and 13% without a source. In this evaluation, sacroiliac joint pain was identified in 10% of the patients from the total sample.	To evaluate the usefulness of this modality in diagnosing low back pain of uncertain etiology.	Intraarticular injection with 2 mL of 2% lidocaine.	Prevalence = 10% of total sample
Dreyfuss et al (148) Utilized 90% relief	This prospective study included 85 patients based on historical data with 12 tests performed by 2 examiners. 90% or more relief was considered a positive response, and less than 90% relief was considered a negative response.	To identify a single sacroiliac joint test or ensemble of tests that are sufficiently useful in diagnosing sacroiliac joint disorders to be clinically valuable.	Intraarticular injection of 1.5 mL of 2% lignocaine and 0.5 mL of Celestone® Soluspan® (betamethasone) unless a firm endpoint was reached before this volume.	Prevalence = 53%
Slipman et al (152) Utilized 80% relief	50 consecutive patients meeting a pre-established criteria from a chronic spine practice.	To determine the sensitivity and specificity of radionuclide imaging in establishing a diagnosis of sacroiliac joint syndrome in patients with low back pain.	Intraarticular injection of 1 mL of betamethasone sodium phosphate and acetate suspension, 60 mg per mL, 3 mL of 1% lidocaine hydrochloride, or 3 mL of 2% lidocaine hydrochloride. Among the patients with positive response, there were 27 patients with negative scans and 4 patients with positive scans.	Prevalence = 62%
Laslett et al (154) Utilized 80% relief	Prospective evaluation of 48 patients satisfying inclusion criteria from a total of 62 patients agreeing to participate and were evaluated. Patients with buttock pain, with or without lumbar or lower extremity symptoms were included.	To examine the diagnostic power of pain provocation sacroiliac joint tests singly and in various combinations in relation to an accepted criterion standard.	Intraarticular injection of 1 mL of 2% lignocaine. All patients underwent provocation testing.	Prevalence = 33%

Table 5 (cont.). *Characteristics of reported diagnostic accuracy studies.*

	Participants	Objective(s)	Interventions(s)	Result(s)
Young et al (155) Utilized 80% relief	A prospective evaluation of 81 patients with chronic lumbopelvic pain to evaluate the correlation of the clinical examination characteristics with 3 sources of chronic low back pain with diagnostic injections as criterion standard. 57 patients were suspected to have sacroiliac joint pain.	To identify significant components of a clinical examination that are associated with symptomatic lumbar discs, zygapophysial joints, and sacroiliac joints.	Intraarticular injection with 1.5 mL of lidocaine.	Prevalence = 39%
Stanford & Burnham (175) Utilized 80% relief	Evaluation of 34 patients with suspected unilateral mechanical sacroiliac joint pain.	To evaluate the diagnostic usefulness of repeating sacroiliac joint provocative tests postblock.	Intraarticular injection of 1.5 mL of 2% lidocaine and 1 mL of corticosteroid.	Prevalence = 32%
80% TO 100% RELIEF WITH DUAL BLOCKS				
Manchikanti et al (41) Utilized 80% relief	120 patients (age 18-90) presenting to the clinic with > 6 months of low back pain and no structural basis for the pain by radiographic imaging. 20 patients were evaluated for SI joint pain.	To determine the frequency of various structures responsible for low back pain.	All patients had facet blocks. Those not responding who fit the criteria had double injection sacroiliac joint blocks. The screening block was done with 2% lidocaine and the confirmatory block was performed using 0.5% bupivacaine.	Prevalence = 10% False-positive rate = 22%
Laslett et al (159) Utilized 80% relief	48 patients received an initial sacroiliac joint diagnostic injection, derived from 62 patients with buttock pain with or without lumbar or lower extremity symptoms.	To assess the diagnostic accuracy of clinical examination in identifying symptomatic and asymptomatic sacroiliac joints using double-diagnostic injections as the reference standard.	16 patients had a positive response to sacroiliac joint injections and 5 of them did not receive a confirmatory diagnostic injection because they derived such symptomatic relief from the initial procedure that a confirmatory injection could not be justified. 11 patients received a confirmatory injection and all of them tested positive. Overall 32 patients had negative sacroiliac joint injections and did not require a confirmatory injection.	Prevalence = 25.6% False-positive rate = NA

blocks with a > 80% cutoff threshold (41,159).

2.1.1 Clinical Relevance

Among the 18 studies assessed for clinical relevance (41,42,54,55,78,79,82,83,119,148,152,154,155,157,159,160,175,194,195) with one duplicate publication (78,195), 17 studies met criteria, scoring 5 out of 5 (41,42,54,55, 78,79,82,83,119,148,152,154,155,159,160, 175,194,195). Table 6 illustrates the assessment of clinical relevance.

2.1.2 Methodological Quality Assessment

A methodological quality assessment of diagnostic accuracy studies meeting inclusion criteria was carried out utilizing QAREL criteria as shown in Table 7. Studies achieving 50% or higher scores were included. Scores of 67% or higher were considered to be high quality, 50% were considered to be moderate quality, and studies scoring less than 50% were considered to be of poor quality and excluded.

There were 3 studies utilizing a single block with 50% to 80% relief as the cutoff threshold (82,83,157), 7 studies utilizing 50% to 80% relief following dual blocks (54,55,78,79,119,160,194,195), with one duplicate study (78,195). There were 6 studies utilizing > 80% relief following a single block as the reference standard (42,148,152,154,155,175), and 2 studies in which > 80% relief following dual blocks was used as the diagnostic criterion (41,159).

There were 18 studies evaluating diagnostic accuracy (41,42,54,55,78,79,82,83,119,148,152,154,155,157,159,160,175,194,195), with one study being published in duplicate (78,195). Seventeen studies were considered to be high quality (41,42,54,55,78,79,82,83,119,148,152,154,155,157,159,160,194,195)

Table 6. *Clinical relevance of included studies.*

Manuscript Author(s)	A) Patient description	B) Description of interventions and treatment settings	C) Clinically relevant outcomes	D) Clinical importance	E) Benefits versus potential harms	Total Criteria Met
Manchikanti et al (41)	+	+	+	+	+	5/5
Pang et al (42)	+	+	+	+	+	5/5
Maigne et al (54)	+	+	+	+	+	5/5
Irwin et al (55)	+	+	+	+	+	5/5
DePalma et al (78,195)	+	+	+	+	+	5/5
DePalma et al (79)	+	+	+	+	+	5/5
Schwarzer et al (82)	+	+	+	+	+	5/5
Maigne & Planchon (83)	+	+	+	+	+	5/5
DePalma et al (119)	+	+	+	+	+	5/5
Dreyfuss et al (148)	+	+	+	+	+	5/5
Slipman et al (152)	+	+	+	+	+	5/5
Laslett et al (154)	+	+	+	+	+	5/5
Young et al (155)	+	+	+	+	+	5/5
Broadhurst & Bond (157)	+	-	-	-	+	2/5
Laslett et al (159)	+	+	+	+	+	5/5
van der Wurff et al (160)	+	+	+	+	+	5/5
Stanford & Burnham (175)	+	+	+	+	+	5/5
Liliang et al (194)	+	+	+	+	+	5/5

+ = positive; - = negative

Scoring adapted from Staal JB, et al. Injection therapy for subacute and chronic low back pain. *Cochrane Database Syst Rev* 2008; 3:CD001824 (136).

Table 7. *Quality Appraisal of Diagnostic Reliability checklist.*

	Manchikanti et al (41)	Pang et al (42)	Maigne et al (54)	Irwin et al (55)	DePalma et al (78,195)	DePalma et al (79)	DePalma et al (119)	van der Wurff et al (160)	Schwarzer et al (81)	Maigne & Planchon (83)	Dreyfuss et al (148)
1. Was the test evaluated in a spectrum of subjects representative of patients who would normally receive the test in clinical practice?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Was the test performed by examiners representative of those who would normally perform the test in practice?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Were raters blinded to the reference standard for the target disorder being evaluated?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4. Were raters blinded to the findings of other raters during the study?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Were raters blinded to their own prior outcomes of the test under evaluation?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6. Were raters blinded to clinical information that may have influenced the test outcome?	N	N	N	N	N	N	N	N	U	U	N
7. Were raters blinded to additional cues, not intended to form part of the diagnostic test procedure?	N	N	N	N	N	N	N	N	N	N	N
8. Was the order in which raters examined subjects varied?	Y	N	U	N	N	N	N	Y	Y	U	U
9. Were appropriate statistical measures of agreement used?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. Was the application and interpretation of the test appropriate?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Was the time interval between measurements suitable in relation to the stability of the variable being measured?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12. If there were dropouts from the study, was this less than 20% of the sample.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TOTAL	9/11	8/11	8/11	8/11	8/11	8/11	8/11	9/11	9/11	8/11	8/11

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

Lucas N, Macaskill P, Irwig L, Moran R, Bogduk N. Reliability of physical examination for diagnosis of myofascial trigger points. *Clin J Pain* 2009; 25:80-89 (72).

Table 7 (cont.). *Quality Appraisal of Diagnostic Reliability checklist.*

	Slipman et al (152)	Laslett et al (154)	Young et al (155)	Broadhurst & Bond (157)	Stanford & Burnham (175)	Laslett et al (159)	Liliang et al (194)
1. Was the test evaluated in a spectrum of subjects representative of patients who would normally receive the test in clinical practice?	Y	Y	Y	Y	Y	Y	Y
2. Was the test performed by examiners representative of those who would normally perform the test in practice?	Y	Y	Y	Y	Y	Y	Y
3. Were raters blinded to the reference standard for the target disorder being evaluated?	NA	NA	NA	NA	NA	NA	NA
4. Were raters blinded to the findings of other raters during the study?	Y	Y	Y	Y	U	Y	Y
5. Were raters blinded to their own prior outcomes of the test under evaluation?	Y	Y	Y	Y	NA	Y	Y
6.Were raters blinded to clinical information that may have influenced the test outcome?	N	N	N	Y	N	N	N
7. Were raters blinded to additional cues, not intended to form part of the diagnostic test procedure?	N	N	N	Y	N	N	N
8. Was the order in which raters examined subjects varied?	U	N	N	Y	N	N	N
9. Were appropriate statistical measures of agreement used?	Y	Y	Y	Y	Y	Y	Y
10. Was the application and interpretation of the test appropriate?	Y	Y	Y	Y	Y	Y	Y
11. Was the time interval between measurements suitable in relation to the stability of the variable being measured?	Y	Y	Y	Y	Y	Y	Y
12. If there were dropouts from the study, was this less than 20% of the sample.	Y	Y	Y	Y	Y	Y	Y
TOTAL	8/11	8/11	8/11	11/11	6/11	8/11	8/11

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

Lucas N, Macaskill P, Irwig L, Moran R, Bogduk N. Reliability of physical examination for diagnosis of myofascial trigger points. *Clin J Pain* 2009; 25:80-89 (72).

and one study was rated as being of moderate quality (175).

2.1.3 Meta-Analysis

All diagnostic accuracy studies were evaluated for homogeneity for inclusion in the meta-analysis (Table 8). There was only one placebo-controlled study (157). There were 7 studies in the dual block group using 50% to 80% relief as the cutoff threshold (54,55,78,79,119,160,194,195), with one duplicate study (78,195). Six studies met inclusion that utilized a single block with a cutoff threshold > 80% pain relief (42,148,152,154,155,175). In the single block studies with a cutoff threshold between 50% and 80%, 2 studies utilized 75% pain relief as the criterion standard (82,83) and one study utilized 70% relief (157). In the studies with a cutoff between 50% and 80% pain relief that employed dual blocks as the criterion standard, 3 studies utilized 75% pain relief as the criterion threshold (54,78,79,119,195,195); with 4 of these publications (78,79,119,195) from one retrospective study (78). Another retrospective evaluation utilized 70% pain relief as the criterion standard (55), and one prospective study used 50% relief following double comparative blocks as the criterion standard (160). Thus, the studies

were not homogenous.

A second category was comprised of 6 studies using a single block with a criterion standard ranging between 80% and 100% relief. In this evaluation, 2 studies utilized 90% pain relief (42,148), whereas 4 studies utilized 80% or greater relief as criterion standard (152,154,155,175). Inclusion criteria were different. Thus, there was no homogeneity among the studies. In the double block group using a cutoff threshold between 80% and 100% pain relief, only 2 studies were identified (41,159).

Consequently, there was no meta-analysis performed.

2.1.4 Study Characteristics

Table 9 illustrates the characteristics of the included studies utilizing cutoff thresholds between 50% and 80% pain relief, and > 80% relief, following single and dual blocks.

2.1.5 Analysis of Evidence

The evidence was synthesized based on the relief criteria when sacroiliac joint injections were performed. Table 9 illustrates the results of diagnostic studies.

2.1.5.1 Single Block with 50% to 80% Pain Relief

Two of the studies evaluating the prevalence

Table 8. *Data of prevalence of sacroiliac joint pain by controlled diagnostic blocks.*

Study	% Relief Used	Methodological Criteria Score	Number of Subjects	Prevalence Estimates	False-Positive Rate
50%-79% RELIEF WITH A SINGLE BLOCK					
Schwarzer et al (82)	75%	9/11	43	30%	---
Maigne & Planchon (83)	75%	8/11	40	35%	---
Broadhurst & Bond (157)	70%	11/11	40	NA	---
50%-79% RELIEF WITH A DUAL BLOCK					
Maigne et al (54)	75%	8/11	54	18.5%	20%
Irwin et al (55)	70%	8/11	158	26.6%	NA
DePalma et al (78,195)	75%	8/11	156	18.2%	NA
DePalma et al (79)	75%	8/11	27	18.2%	NA
DePalma et al (119)	75%	8/11	170	18.2%	NA
van der Wurff et al (160)	50%	9/11	60	38%	21%
Liliang et al (194)	75%	8/11	52	40.4%	26%
80%-100% RELIEF WITH A SINGLE BLOCK					
Pang et al (42)	90%	8/11	104	10%	---
Dreyfuss et al (148)	90%	8/11	85	53%	---
Slipman et al (152)	80%	8/11	50	62%	---
Laslett et al (154)	80%	8/11	48	33%	---
Young et al (155)	80%	8/11	81	39%	---
Stanford & Burnham (175)	80%	6/11	34	32%	---
80%-100% RELIEF WITH DUAL BLOCKS					
Manchikanti et al (41)	80%	9/11	20	10%	22%
Laslett et al (159)	80%	8/11	43/48	25.6%	NA

NA = Not available

Table 9. *Summary characteristics of studies utilizing 50% and 70% relief for single and dual blocks.*

Reference, Year	Number of Patients Selection Criteria	Intervention	Outcome Measures	Results	Strengths Weaknesses	Methodological Quality Assessment Score	Comments
50%-79% RELIEF WITH SINGLE BLOCK							
Schwarzer et al (82)	43 consecutive patients with chronic low back pain maximal below L5/S1 were investigated.	Intraarticular injection of 1 mL of 2% lignocaine.	A positive response was classed as definite if there was a 75% or greater reduction of pain over the sacroiliac joint and buttock.	Prevalence = 30%	Strengths: This study from 1995 is the earliest performed, with strict selection criteria and performed by experts in the field. Weakness: A single block.	9/11	Well performed study, but with a single block which may result in lesser prevalence with a certain false-positive rate with dual blocks.
Maigne & Planchon (83)	This was a prospective series of 40 patients with persistent low back pain after technically successful fusion who received a sacroiliac anesthetic block under fluoroscopic control.	Intraarticular injection with 2 mL of 2% lidocaine.	The study was performed appropriately in patients after lumbar fusion.	Prevalence = 35%	Strengths: The study was performed appropriately in patients after lumbar fusion. Weaknesses: There were 5 unsuccessful blocks out of 45 patients indicating a high number. Further, the study evaluated only the patients with postfusion pain with a single block with 75% pain relief.	8/11	The study was a single block study with a 35% prevalence. Further, this study showed that a past history of posterior iliac bone graft harvesting had no significant value in contrast to Carragee et al's (243) proposition that the site of the bone graft is painful in asymptomatic patients.
Broadhurst & Bond (157)	Double-blind trial of 40 patients to determine the sensitivity and specificity of 3 commonly used pain provocation tests for sacroiliac joint dysfunction with suppression of pain by 70% with injection of either normal saline or lidocaine.	Intraarticular injection of 4 mL of 1% lignocaine or 4 mL of normal saline into the painful joint in 20 patients in each group.	70% pain suppression.	Prevalence = Not available 100% suppression of pain provocation in patients receiving lignocaine in 3 provocation pain tests	Strength: The study evaluated the immediate suppression of pain with provocative testing with injection of local anesthetic or sodium chloride solution. Local anesthetic injection showed 100% suppression of pain provocation tests with a specificity of 100% for each test and a sensitivity range of 77% to 87%. Weakness: The study was performed with high volumes of solution which have a tendency to leak out. Injection of intraarticular sodium chloride solution is not an appropriate model for placebo testing (216-223).	11/11	The authors had an excellent concept of proving that placebo is not effective yielding 100% results with lidocaine injection, which was rather high volumes, questioning the accuracy and validity of the study.

Table 9 (cont.). *Summary characteristics of studies utilizing 50% and 70% relief for single and dual blocks.*

Reference, Year	Number of Patients Selection Criteria	Intervention	Outcome Measures	Results	Strengths Weaknesses	Methodological Quality Assessment Score	Comments
50%-79% RELIEF WITH DUAL BLOCKS							
Maigne et al (54)	54 patients aged 18-75 with chronic unilateral LBP with or without radiation to the posterior thigh for > 50 days (median 4.2 months). Patients had failed epidural or lumbar facet injections.	A screening block was done with 2% lidocaine and a confirmatory block was performed with bupivacaine 0.5%.	Greater than 75% relief was considered a positive block.	Prevalence = 18.5% False-positive rate = 20%	Strengths: The study was performed in a prospective manner with dual blocks and a thorough clinical examination including pain provocation tests. Weaknesses: The selection criteria is somewhat rigid with pain provocation testing.	8/11	The study questions the accuracy of some of the presumed sacroiliac pain provocation tests.
Irwin et al (55)	158 patients underwent sacroiliac joint injections with average symptoms duration of 34 months. Patients failed conservative modalities prior to injection therapy.	A screening block with 2 mL of 2% lidocaine for the first injection, followed by 2 mL of 0.25% bupivacaine, a local anesthetic, for the confirmatory injection.	At least 70% reduction of familiar painful symptoms after the initial injection for 3 or 4 hours for positive response.	Estimated false-positive rate = 53.8% Prevalence = 26.6% False-Positive Rate = NA	Strengths: The study included a large proportion of patients with sacroiliac joint pain inducing minimal bias due to a retrospective nature. Weaknesses: A retrospective nature of the study.	8/11	The largest study to date utilizing dual blocks yielding prevalence of 26.6% with an estimated false-positive rate of 53.8%.
DePalma et al (78,195)	156 patients underwent diagnostic procedures to evaluate the source of chronic low back pain based on the age.	Intraarticular injection of 0.5 mL of anesthetic, 1% lidocaine for first block with 0.5% bupivacaine for the second.	At least 75% pain relief for 2 hours for lidocaine and 8 hours for bupivacaine.	Prevalence = 18.2% False-Positive Rate = Not available	Strengths: The study was performed in a heterogenous population in a practical setting in a retrospective manner overall in a large proportion of patients. Weaknesses: Retrospective evaluation without identification of number of patients undergoing sacroiliac joint blocks, thus not providing actual prevalence in only sacroiliac joint patients.	8/11	

Table 9 (cont.). *Summary characteristics of studies utilizing 50% and 70% relief for single and dual blocks.*

Reference, Year	Number of Patients Selection Criteria	Intervention	Outcome Measures	Results	Strengths Weaknesses	Methodological Quality Assessment Score	Comments
DePalma et al (79)	Retrospective evaluation of 27 motor vehicle collision-induced chronic low back pain patients undergoing multiple types of diagnostic interventions.	Intraarticular injection of 0.5 mL of anesthetic, 1% lidocaine for first block with 0.5% bupivacaine for the second.	Diagnostic blockade of sacroiliac joints was deemed positive if the patient's index pain was relieved by 75% or greater after injection of each anesthetic.	Prevalence = 18.2% False-Positive Rate = Not available	Strengths: The study performed only in patients with motor vehicle collision with a retrospective analysis. Weaknesses: Retrospective analysis in a small proportion of patients involving multiple etiologies and with 7 of 27 patients or 25.9% positive response rate to dual blocks. Further, no data is provided with regards to the number of patients undergoing sacroiliac joint injections.	8/11	
DePalma et al (119)	The diagnosis of 28 fusion cases identified from 170 low back pain patients undergoing diagnostic procedures included 12 with sacroiliac joint pain.	Intraarticular injection of 0.5 mL of anesthetic, 1% lidocaine for first block with 0.5% bupivacaine for the second.	Diagnostic blockade of sacroiliac joints was deemed positive if the patient's index pain was relieved by 75% or greater after injection of each anesthetic.	Prevalence = 42.9% False-positive = NA	The study included 28 fusion cases which were separated from others. Weaknesses: Retrospective evaluation with rather small proportion of patients yielding very high sacroiliac joint pain prevalence of 42.9% with 12 out of 28 patients.	8/11	A small retrospective study yielding a high percentage of sacroiliac joint pain.
van der Wurff et al (160)	Total number of 140 patients with chronic low back pain visiting the pain clinic in the Netherlands, 60 patients entered the study.	The fluoroscopically guided contrast enhanced sacroiliac joint injections were performed initially with 2 mL of 2% lidocaine and next time with 0.25% bupivacaine.	A reduction in the patient's characteristic pain of 50% or more on the VAS remaining for at least one hour for lidocaine or 4 hours for bupivacaine was considered as positive. When a patient showed a VAS reduction after both intraarticular sacroiliac joint blocks, this was considered a positive response. Any other outcome was considered a negative response.	Prevalence = 38% False-positive rate = 21%	Strengths: The study is performed in a group of patients drawn from a large proportion with a large proportion of patients in sacroiliac joint pain group itself. Weaknesses: There was leakage of the fluids in 5 of 60 patients with sciatic nerve palsy. 60 patients of 140 with suspected sacroiliac joint pain appears to be the Center is more geared towards sacroiliac joint pain. The second weakness is of the 50% or greater pain relief rather than a criterion standard of 80% or greater.	9/11	Well performed study in a large proportion of patients with a weakness of 50% pain relief, thus maybe resulting in higher prevalence rate of 38%.

Table 9 (cont.). *Summary characteristics of studies utilizing 50% and 70% relief for single and dual blocks.*

Reference, Year	Number of Patients Selection Criteria	Intervention	Outcome Measures	Results	Strengths Weaknesses	Methodological Quality Assessment Score	Comments
Liliang et al (194)	52 patients were selected from 130 patients after undergoing lumbar or lumbosacral fusions who met the criteria for at least 3 of the provocative tests for sacroiliac joint pain.	Intraarticular injection with either lidocaine (2%) or bupivacaine (0.5%), 1 mL, mixed with 40 mg of triamcinolone.	75% pain relief for 1 to 4 hours following the sacroiliac joint blocks.	Prevalence = 40% False-positive rate = 26%	Strengths The study is one of the more recent and well performed large studies, specifically in sacroiliac joint fusion. Weaknesses: Only 52 patients and utilized 75% pain relief.	8/11	With 75% pain relief, the results appear to be highly appropriate with highly selected population.
80% TO 100% RELIEF WITH A SINGLE BLOCK							
Pang et al (42)	In this prospective evaluation, 104 consecutive adult patients who underwent spinal pain mapping were examined and analyzed. They found in this group a total of 87% of the patients with diagnosed pain source and 13% without a source. In this evaluation, sacroiliac joint pain was identified in 10% of the patients from the total sample.	Intraarticular injection with 2 mL of 2% lidocaine	90% pain relief	Prevalence = 10% of total sample.	Strengths: This study was performed in a large proportion of patients for spinal mapping purposes identifying various causes. Weaknesses: The study does not provide detailed data on sacroiliac joint pain.	8/11	Even though this is a well performed study in a large proportion of patients, it is not known the number of patients included for sacroiliac joint pain, thus we do not know the true prevalence of sacroiliac joint pain even with a single block.
Dreyfuss et al (148)	The prospective study included 85 patients based on historical data with 12 tests performed by 2 examiners.	Intraarticular injection of 1.5 mL of 2% lignocaine and 0.5 mL of Celestone Soluspan unless a firm endpoint was reached before this volume.	90% or more relief was considered a positive response, and less than 90% relief was considered a negative response.	Prevalence = 45 out of 85 (53%)	Strengths: The study was performed collaboratively with extremely careful patient selection undergoing 12 clinical tests, which included multiple provocative maneuvers. Weaknesses: 5 patients were excluded from the analysis. Single block with a specific selection criteria.	8/11	The results showed fairly high proportion of patients with sacroiliac joint pain due to strict selection criteria. However, there were no historical features, with none of the 12 sacroiliac joint tests and any combination of these 12 tests demonstrating worthwhile diagnostic value.

Table 9 (cont.). *Summary characteristics of studies utilizing 50% and 70% relief for single and dual blocks.*

Reference, Year	Number of Patients Selection Criteria	Intervention	Outcome Measures	Results	Strengths Weaknesses	Methodological Quality Assessment Score	Comments
Slipman et al (152)	50 consecutive patients meeting a pre-established criteria from a chronic spine practice.	Intraarticular injection of 1 mL of betamethasone sodium phosphate and acetate suspension, 60 mg per mL, 3 mL of 1% lidocaine hydrochloride, or 3 mL of 2% lidocaine hydrochloride. Among the patients with positive response, there were 27 patients with negative scans and 4 patients with positive scans.	A reduction of the VAS rating by at least 80% was considered a positive response to sacroiliac joint block.	Prevalence = 62%	Strengths: The study was performed to evaluate the value of radionuclide imaging in the diagnosis of sacroiliac joint syndrome in patients who were positive for at least 3 positive responses to include 2 specific stress maneuvers. All the patients underwent radionuclide imaging. Weaknesses: Stringent selection criteria yielding high prevalence of sacroiliac joint pain with a single block.	8/11	This study shows low sensitivity and high specificity of nuclear imaging in the evaluation of sacroiliac joint syndrome.
Laslett et al (154)	Prospective evaluation of 48 patients satisfying inclusion criteria from a total of 62 patients agreed to participate and were evaluated. Patients with buttock pain, with or without lumbar or lower extremity symptoms were included.	Intraarticular injection of 1 mL of 2% lignocaine. All patients underwent provocation testing.	At least 80% pain relief	Prevalence = 16 of 48 (33%)	Strengths: All patients underwent provocation testing. Authors essentially were comparing validity of individual provocation tests and composites of tests. They reported sensitivity and specificity for 3 or more of 6 positive sacroiliac tests were 94% and 78% respectively. Well performed study with evaluation of validity of individual provocation tests and composites of tests. Weaknesses: Strict selection criteria probably yielding higher prevalence.	8/11	The authors concluded that composites of provocation sacroiliac joint tests are of value in clinical diagnosis of symptomatic sacroiliac joint pain when 3 or more of the 6 tests were positive, with the greatest applicability when 4 tests were positive. When none of the provocation tests provoked familiar pain, the sacroiliac joint can be ruled out as a source of current low back pain.

Table 9 (cont.). *Summary characteristics of studies utilizing 50% and 70% relief for single and dual blocks.*

Reference, Year	Number of Patients Selection Criteria	Intervention	Outcome Measures	Results	Strengths Weaknesses	Methodological Quality Assessment Score	Comments
Young et al (155)	A prospective evaluation of 81 patients with chronic lumbopelvic pain to evaluate correlation of clinical examination characteristics with 3 sources of chronic low back pain with diagnostic injections as criterion standard. 57 patients were suspected with sacroiliac joint pain.	Intraarticular injection with 1.5 mL of lidocaine	At least 80% pain relief	Prevalence = 39%	Strengths: The authors evaluated correlation of clinical examination characteristics with 3 sources of chronic low back pain including sacroiliac joint pain simulating practical setting. They found strongest relationships were seen between sacroiliac joint pain and 3 or more pain provocation tests. Weaknesses: Highly selective group of patients with positive provocation tests	8/11	The authors illustrate the positive correlation with strongest relationships between sacroiliac joint pain and 3 or more positive pain provocation tests.
Stanford & Burnham (175)	Evaluation of 34 patients with suspected unilateral mechanical sacroiliac joint pain.	Intraarticular injection of 1.5 mL of 2% lidocaine and 1 mL of corticosteroid.	A positive block was defined as greater than 79% index pain relief within the first 2 hours post-injection.	Prevalence = 32%	Strengths: The study was performed in a practical setting to evaluate usefulness to repeat sacroiliac joint provocative testing post block. Weaknesses: The small number of patients with a single block and strict selection criteria.	6/11	The study illustrates utility of pre-block sacroiliac joint provocative tests.
80% TO 100% RELIEF WITH DUAL BLOCKS							
Manchikanti et al (41)	120 patients (age 18-90) presenting to the clinic with > 6 months of low back pain and no structural basis for the pain by radiographic imaging. 20 patients were evaluated for SI joint pain.	The screening block was done with 2% lidocaine and the confirmatory block was performed using 0.5% bupivacaine.	At least 80% pain relief with ability to perform previously painful movements with concordant relief based on the local anesthetic injected.	Prevalence 10% False-Positive Rate 22%	Strengths: The study was performed to evaluate relative contributions of various structures in chronic low back pain in 120 patients, even though only 20 patients were evaluated for sacroiliac joint pain. Dual blocks were utilized with 80% pain relief as the criterion standard. Weaknesses: Of the 120 patients, only 20 patients were suspected of sacroiliac joint pain or underwent sacroiliac joint blocks.	9/11	The study illustrates a low proportion of sacroiliac joint pain in 10% of the patients with suspected sacroiliac joint pain.

Table 9 (cont.). *Summary characteristics of studies utilizing 50% and 70% relief for single and dual blocks.*

Reference, Year	Number of Patients Selection Criteria	Intervention	Outcome Measures	Results	Strengths Weaknesses	Methodological Quality Assessment Score	Comments
Laslett et al (159)	48 patients received initial sacroiliac joint diagnostic injection, derived from 62 patients with buttock pain with or without lumbar or lower extremity symptoms.	Intraarticular injection of less than 1.5 mL of local anesthetic lidocaine for initial block followed by bupivacaine for the confirmatory block.	At least 80% reduction in pain for the duration of anesthetic effect.	Prevalence = 25.6%	Strengths: Provocation sacroiliac tests were used to identify sacroiliac joint pain as part of the clinical reasoning process. The study also illustrated the diagnostic accuracy of the clinical examination and clinical reasoning process was superior to the sacroiliac joint pain provocation tests alone. Weaknesses: This is a validity study of sacroiliac provocation tests.	8/11	The authors show the prevalence of 45.6% in a select group of patients with clinical reasoning in addition to provocation testing being superior to provocation testing alone.

showed a prevalence rate of between 30% and 35% (82,83).

2.1.5.2 Dual Blocks with 50% to 80% Pain Relief

There were 7 studies evaluating 50% to 80% relief with dual blocks (54,55,78,79,119,160,194,195) with one duplicate study (78,195).

As one might expect, the prevalence rate was lower in the 50% to 80% dual block category, especially when 75% pain relief was utilized as the criterion standard with approximate prevalence of 18% (54,78,79,119,195). It was higher (40.4%) in one study in highly selected population (194). However, when 50% relief with dual blocks was utilized as the criterion standard, the prevalence rate was shown to be 38% with a false-positive rate of 21% (160). Increasing the threshold to 75% does not appear to reduce the accuracy. Irwin et al (55), in a large retrospective evaluation, found a prevalence rate of 26.6% using 70% pain relief. These findings suggest that increasing the cutoff threshold results in lower estimated prevalence rates.

2.1.5.3 Single Block with 80% to 100% Relief

There were a total of 6 studies meeting the inclusion criteria evaluating sacroiliac joint pain using a cutoff threshold between 80% and 100% relief following a single block (42,148,152,154,155,175).

The prevalence in this group ranged from a low of 10% to a high of 62%. The 53% and 62% prevalence rates reported by Dreyfuss et al (148) and Slipman et al (152), respectively, were found in highly selected populations. Dreyfuss et al (148) employed a reference standard of greater than 90% pain relief during the blocks, and enrolled study patients who had pain predominantly below L5. Slipman et al (152) used 80% pain relief as the criterion standard, and studied a population who had a positive response to 3 sacroiliac joint pain provocation tests. Overall, a single block using 80% to 100% pain relief as the reference standard appears to yield prevalence of around 35%.

2.1.5.4 Dual Blocks with 80% to 100% Relief

There were a total of 2 studies meeting the inclusion criteria (41,159).

Using between 80% and 100% pain relief with dual blocks as the criterion standard has been advocated by some as the most rigorous means for diagnosing sacroiliac joint pain (2,35,38,39,88). In a small study that included only 20 patients, Manchikanti et al (41) found a low prevalence rate of 10%. In contrast, Laslett et al (159) showed a prevalence rate of 25.6% in a study involving 48 subjects. False-positive rate was 22% (41). Laslett et al have not estimated the false-positive rate, but looking at the data, it appears to be 0% (159).

2.2 Level of Evidence

Based on the USPSTF criteria, the evidence was classified to be either good, fair, or limited (or poor).

2.2.1 Single Block with 50% to 80% Relief

Based on 3 high quality studies (82,83,157), the evidence is fair.

2.2.2 Dual Blocks with 50% to 80% Relief

Based on 7 high quality studies (54,55,78, 79,119,160,194,195) containing over 500 patients, the evidence in this group was good, especially when greater than 70% pain relief was utilized as the criterion standard (n = 5).

2.2.3 Single Block with 80% to 100% Relief

The evidence is good based on the results of 6 studies (42,148,152,154,155,175), with 5 of them rated as high quality (42,148,152,154,155).

2.2.4 Dual Blocks with 80% to 100% Relief

The evidence is good based on 2 high-quality studies (41,159) using dual blocks.

2.2.5 Summary of Evidence

Overall, there was no significant difference when 70% or greater relief is utilized as the criterion standard with dual blocks, with good evidence based on multiple high quality studies.

2.3 Pain Patterns

Sacroiliac joint pain patterns, referral zones, and intensity mapping have all been evaluated (148,153,158,161-165). In 1994, Fortin et al (162) generated pain referral maps based on provocative injections performed in asymptomatic volunteers, and pain diagrams drawn by patients with low back pain secondary to sacroiliac joint pathology or other sources (i.e., facetogenic and discogenic pain). The authors found that individuals whose point of maximum discomfort fell within an area that extended 10 cm caudal and 3 cm lateral to the posterior superior iliac spine were more likely have sacroiliac joint pain (162,163). This finding is supported by the work of Murakami et al (187), who found that patients who responded to low-volume periarticular sacroiliac joint injections could pinpoint their pain to within 2 cm of the posterior superior iliac spine. In a cross-sectional study by Schwarzer et al (82), the authors found groin pain to be the best means to distinguish sacroiliac joint pain from other causes of back pain. In contrast, Dreyfuss et al (148) found that groin pain was not a discriminating feature of sacroiliac joint pain.

Slipman et al (153) performed an analytical study that sought to identify sacroiliac joint referral patterns in 50 patients who obtained > 80% pain relief after a single intraarticular injection. The most frequent referral zones were the buttocks (94%) and lower lumbar region. Fifty percent of patients experienced extension into the lower extremity, 28% reported pain in the lower leg, and 14% described groin pain. A study by van der Wurff et al (161) compared pain referral patterns in patients with sacroiliac joint pain and those with other sources of back pain, based on response to dual comparative local anesthetic blocks. They concluded that pain diagrams could not reliably distinguish between low back pain patients suffering from sacroiliac joint pain and those with other primary pain generators. Finally, Jung et al (164) evaluated the usefulness of pain distribution pattern assessment in decision-making in 419 patients with either lumbar facet joint pain or sacroiliac joint pain. The authors found several different patterns for sacroiliac joint pain, such as buttock pain, buttock pain extending into the posterolateral thigh, and buttock pain radiating into the groin. They concluded that pain diagrams could be useful in predicting outcomes from injections and radiofrequency neurotomy.

In summary, although pain patterns may be helpful in identifying patients who might benefit from diagnostic injections, they are not pathognomonic.

2.4 Necessity for Fluoroscopically Guided Injections

Sacroiliac joint injections have been performed by many means including without imaging guidance based on clinical examination and tenderness (183). However, the present gold standard is to perform them under fluoroscopy using controlled diagnostic blocks for diagnostic purposes. In an observational study performed in 60 patients, Hansen (191) found that blind injections done by a single practitioner with 2 ml of contrast resulted in intraarticular spread in only 12% of patients.

In a double-blind study, Rosenberg et al (192) evaluated the accuracy of clinically guided sacroiliac joint injections using computerized tomography. Among the 39 injections performed in 33 patients, intraarticular injection was accomplished in only 22% of the patients, though the injected contrast was noted to be within one cm of the joint in 68% of individuals. Furthermore, injected material was found to be within the sacral foramina in 44% of cases- usually at S1- and in the epidural space following 24% of injections. The authors concluded that the low rate of intraarticular injection observed with landmark-guided techniques warranted the use of image guidance in those

at high risk for failure and complications.

Although expensive and not feasible in routine practice, MRI-guided corticosteroid injections of the sacroiliac joints have been reported to be effective (171,179,186).

Multiple authors have described the feasibility of ultrasound-guided sacroiliac joint injections with consideration of anatomic landmarks (166,169,176,178,183,185,190), but no systematic evaluation has been performed. Further, Hartung et al (166) performed a small study in which ultrasound was used to guide 20 sacroiliac joint injections in 14 patients with sacroiliitis. MRI verification revealed that only 40% of injections were intraarticular, with the rest being outside the joint cavity. No differences in outcomes were noted between the intra- and extraarticular groups. Unguided sacroiliac joint injections also have been shown to be effective in some studies (183).

In summary, there is no evidence to support the use of ultrasound or landmark-guided injections for sacroiliac joint pain. These injections must be performed under fluoroscopic or radiologic guidance.

2.5 Accuracy of Testing of Provocation Maneuvers

Provocation testing has been extensively employed in an attempt for diagnosing sacroiliac joint pain. Multiple studies have also been performed to evaluate the validity of clinical examination, which incorporates provocation testing. The recommended reference standard involves either anesthetic or provocative injections; however, doubts have even been cast on the validity of a sacroiliac joint block as a diagnostic gold standard. A review by Berthelot et al (89) concluded clinical signs and maneuvers to be unreliable for diagnosing pain originating within the sacroiliac joint; they are fraught with both low sensitivity and specificity. But the authors also concluded that sacroiliac joint blocks were similarly unreliable, since pain patterns formerly attributed to the sacroiliac joint can be related to extraarticular structures, most notably the numerous ligaments surrounding the joint. However, multiple studies evaluated in the same studies have reached different conclusions.

In 2 separate systematic reviews, Szadek et al (80) and Hancock et al (49) showed a positive correlation between a battery of provocation testing and diagnostic blocks. Hancock et al (49) included 6 studies in their analysis, while Szadek et al (80) included 15 studies. In a systematic appraisal of the literature assessing the accuracy of multiple tests for back pain utilizing QUADAS criteria, Simpson and Gemmell (200) identified 5 studies that focused on sacroiliac joint pain. They found no single test to be consistently valid.

Among the multiple studies utilized to evaluate provocative testing and clinical evaluation (54,82,148, 154,155,157,159,160,175,189,200,201), different conclusions were reached. All studies were performed utilizing fluoroscopically guided intraarticular injections as the reference standard (54,82,148,154,155,157,159, 160,175,189). Schwarzer et al (82) found that none of the conventional sacroiliac joint examination procedures tested could reliably discriminate patients with sacroiliac joint pain from those with other sources of back pain. Dreyfuss et al (148) evaluated the value of medical history and physical examination in diagnosing sacroiliac joint pain by assessing 12 overall tests, along with pain diagrams. These provocation tests included the Gillet test, thigh thrust, Patrick test, Gaenslen test, and midline sacral thrust. The results refuted the notion that any single historical or exam finding could reliably identify a painful sacroiliac joint.

Laslett et al and colleagues (154,155,159,189) published multiple studies on the validity of pain provocation testing in the identification of sacroiliac joint dysfunction. In one study, Laslett et al (154) evaluated the validity of provocation tests individually and collectively to predict response to a single diagnostic sacroiliac joint injection. All patients with a positive response to a diagnostic injection reported pain during at least one sacroiliac joint test. The sensitivity and specificity for 3 or more of the 6 tests were 94% and 78% respectively. The greatest area under the curve of any of the 2 best 4 tests was 0.842. The authors concluded that composites of provocation sacroiliac joint tests were of value in the clinical diagnosis of symptomatic sacroiliac joint pain and 3 or more out of 6 tests or have the best predictive power in relation to the results of intraarticular anesthetic blocks. The most valid battery of maneuvers were the distraction, compression, and thigh and sacral thrust tests.Young et al (155) sought to determine whether clinical examination characteristics could be associated with 3 sources of chronic low back pain, including 57 patients with sacroiliac joint pain. The 5 pain provocation maneuvers utilized were shown above. The authors demonstrated a significant association between a positive sacroiliac joint injection and 4 of the 9 characteristics evaluated. They also found a negative relationship between injection response and the presence of midline lumbar pain and pain above L5.

The presence of 3 or more positive sacroiliac joint pain provocation tests was found to be significantly correlated with a positive block (phi coefficient of 0.6), resulting in an effect size of 36%. They also found that all patients with a positive block experienced pain when rising from sitting, as well as a strong correlation with the non-centralization of pain.

Laslett et al (159) concluded that the diagnostic accuracy of the clinical examination in conjunction with reasoning processes was superior to sacroiliac joint pain provocation maneuvers as stand-alone tests. Excluding patients whose pain peripheralized increased the positive likelihood ratio for identifying a symptomatic sacroiliac joint(s) in patients with 3 or more provocative tests.

Laslett et al (189) also evaluated the agreement between a diagnoses reached by clinical examination and the available reference standards in a prospective study of 216 patients with lumbopelvic pain. They compared blinded clinical diagnoses by physiotherapists with diagnoses based on available reference standards for known causes of low back pain, such as discography, facet joint nerve blocks, sacroiliac joint injections, epidural injections, advanced imaging studies, or any combination of these tests. The authors found that 66% and 76% of patients received a single diagnosis based on reference standards and physical examination, respectively. Overall, exact agreement between the clinical and reference standard diagnosis was 33%, and clinical agreement was 51%. For sacroiliac joint pain, the agreement between the clinical diagnosis and the diagnosis by reference standards was 57%. However, only 6 sacroiliac joint diagnoses were conferred by each method.

Broadhurst and Bond (157) also evaluated pain provocation tests for the assessment of sacroiliac joint dysfunction in a double-blind, controlled fashion. They found that local anesthetic injection suppressed approximately 70% of the pain that was elicited with provocative measures, while saline provided no meaningful relief. One flaw in this study was the large volume of local anesthetic (4 mL) utilized.

Maigne et al (54) determined the prevalence of sacroiliac joint pain in a selected population of patients suffering from low back pain and assessed the validity of various pain provocation tests. The patients underwent 7 sacroiliac pain provocation tests, which included the distraction test, compression test, sacral pressure test, Gaenslen test, Patrick test, resisted external rotation of the hip, and direct pressure on the pubic symphysis, before and after a screening block. No statistically significant association was found between the response to the blocks and any single clinical parameter. They concluded that no pain provocation test was a useful predictor of sacroiliac joint pain.

van der Wurff et al (160) evaluated the diagnostic accuracy of a multi-test regimen of 5 sacroiliac joint pain provocation tests by comparing it to the results of fluoroscopically guided double local anesthetic blocks. The 5 provocation tests included the distraction test, compression test, thigh thrust, Patrick sign, and Gaenslen test. Among the 60 patients studied, 45% obtained a positive response to both blocks. Whereas none of the provocation tools were specific as a stand-alone test, a combination of 3 or more positive tests was deemed to be a reliable indicator. Six of the 29 patients who responded to the initial block failed to experience relief after the confirmatory block and were thus categorized as false-positive blocks. The prevalence rate for this study was 38%, with a false-positive rate estimated to be around 21%. The sensitivity and specificity of the 3 or more positive provocation tests were 85% and 80%, respectively. The authors' conclusion that a correlation exists between the finding of 3 or more positive pain provocation tests and an analgesic response to double intraarticular sacroiliac joint blocks corroborates the results of Laslett et al (159).

Stanford and Burnham (175) evaluated provocative testing in 34 patients with suspected sacroiliac joint pain who underwent double comparative local anesthetic blocks. They found the sensitivity, specificity, and likelihood ratios for patients with 3 or more out of 6 positive tests were 0.82, 0.57, and 1.9 respectively. The provocative test utilized in this test were Patrick test, thigh thrust, ipsilateral Gaenslen test, contralateral Gaenslen test, lateral compression, and sacral thrust.

The review of provocative testing and clinical examination findings illustrates that 6 commonly performed provocative tests may be useful to select patients for further study provided 3 or more of them are positive. These include the distraction, compression, thigh thrust, Gaenslen's , and sacral thrust tests (154).

2.6 Accuracy of Imaging

The value of radiological imaging has been questioned in the diagnosis of sacroiliac joint pain. Multiple investigations have been performed, including evaluations using plain x-rays, plain CT, MRI (166-168,171, 176,194,202,206,208-210,213-237), single-photon emission computed tomography (SPECT) (83,152-156,207) and positron emission tomography (PET) scanning

(211,212).

Among the multiple systematic reviews, Vanelderen et al (57) concluded that radiologic imaging is important to exclude "red flags" but contributes too little to aid in diagnosis. Hancock et al (49) concluded that although a positive bone scan has high specificity, it is associated with a very low sensitivity, which means the majority of patients with sacroiliac joint pain will not be accurately identified. Gupta (238) concluded that medical history, clinical examination including sacroiliac joint provocative tests, plain radiography, and laboratory investigations were helpful in diagnosing sacroiliac joint pathology in only 39% of cases, with 46% needing a CT or MRI. In a narrative review, Tuite (239) noted that the sacroiliac joint has several unique anatomical features that make it one of the more challenging joints to image, and that the radiologic findings of sacroiliitis are often equivocal. The author stated that MRI performed with proper sequencing (i.e., gadolinium enhancement or short tau inversion recovery (STIR) was the imaging modality of choice for patients with suspected sacroiliitis but negative or equivocal radiographs; however, it was unlikely to be helpful in individuals with extraarticular pathology.

The majority of the systematic reviews and individual studies conducted were related to spondyloarthritis. Thus, these results may not be applicable to chronic pain settings for evaluating sacroiliac joint pain. Several studies have also evaluated sacroiliac joint pain using various imaging techniques.

Lawson et al (235) evaluated sacroiliac joints for their anatomy with plain x-rays and CT analysis. They found the accuracy of CT to be superior to conventional radiography in the detection of early erosive sacroiliitis and joint space narrowing. In all patients with a discrepancy between the 2 radiologic techniques, the changes were either only or better demonstrated by CT rather than conventional radiography.

Blum et al (229) assessed plain radiographs, quantitative sacroiliac scintigraphy, and MRI. The results showed that MRI was more sensitive (85%) than quantitative sacroiliac scintigraphy (48%) or conventional radiography (19%) for the detection of active sacroiliitis. For all modalities, specificity was significantly higher than sensitivity.

Jurik (240) noted that the sensitivity and specificity of conventional x-rays were relatively low, which can delay the diagnosis of sacroiliitis. CT was found to be superior to conventional x-rays for the diagnosis of sacroiliitis, but this has to be weighed against the higher radiation doses utilized. The author concluded that MRI should be the imaging modality of choice for diagnosing sacroiliitis.

Puhakka et al (202,203) performed 2 evaluations of MRI: one evaluated the modality in normal sacroiliac joints in asymptomatic volunteers with correlation to microscopic histology in cadavers; the second study assessed MRI abnormalities of the sacroiliac joints in early spondyloarthropathy with a one-year follow-up period. The authors concluded that coronal MRI is not conducive to the assessment of normal anatomy. But when there are variants or abnormalities of the ventral and dorsal margins of the cartilaginous sacroiliac joint and in early spondyloarthropathy, MRI can detect significant inflammatory and destructive changes over a one-year follow-up not observable on CT or plain x-rays, despite minimal changes in the clinical parameters. Thus, MRI may be a sensitive method, with minimal risk, for the early diagnosis and evaluation for disease progression in spondyloarthropathy. Radiologic studies can also assist in determining anatomical integrity (204). A retrospective study (205) showed that CT scans were negative in 42% of patients with symptomatic sacroiliac joint pain.

In a review of imaging for spondyloarthropathy, Braun et al (230) noted that because inflammatory back pain is not a specific indicator of sacroiliitis, there is a need for imaging techniques. They concluded that scintography lacks specificity, CT is a good method to demonstrate already established bony changes, and that MRI possesses the advantage of combining good visualization of the complicated anatomy of the sacroiliac joint with the ability to localize different degrees of inflammation and edema.

Song et al (81) evaluated the diagnostic value of scintography in detecting sacroiliitis in ankylosing spondylitis and those with probable sacroiliitis without x-ray changes. Following an extensive literature search, they concluded that scintography of the sacroiliac joints is of limited diagnostic value.

Slipman et al (152) evaluated the value of radionuclide imaging in the diagnosis of sacroiliac joint syndrome and concluded nuclear imaging had high specificity but very low sensitivity. Consequently, they did not recommend radionuclide imaging in the evaluation of sacroiliac joint pain syndrome.

In an evaluation of quantitative radionuclide bone scanning in the diagnosis of sacroiliac joint syndrome, Maigne et al (156) found the sensitivity, specificity, and positive and negative predictive values of the quantitative bone scanning to be 46%, 90%, 86%, and 72%

respectively.

In summary, MRI appears to be a useful test in detecting early sacroiliitis, and in following disease progression in individuals with spondyloarthropathy. Imaging may also be helpful in identifying patients who might benefit from further evaluation, especially in combination with provocative maneuvers.

3.0 Discussion

This systematic review reveals that there continues to be relatively few high-quality studies which have investigated the diagnostic accuracy of tests to identify the sacroiliac joint(s) as the source of low back and lower extremity pain. The majority of studies investigated the role of diagnostic sacroiliac joint injections or provocation maneuvers. The results of diagnostic accuracy studies evaluating controlled local anesthetic blocks illustrate good overall evidence based on multiple high quality studies. This review indicates the approximate prevalence rate based on dual blocks to be around 25%, with a false-positive rate of 20%. Although provocation maneuvers have been evaluated by multiple investigators, an evaluation of these studies suggests there is limited evidence that they are helpful in determining the likelihood of sacroiliac joint pain in patients with pain located primarily below the 5th lumbar vertebrae. Plain x-rays or advanced imaging appear to be of no significant value in chronic sacroiliac joint pain without inflammatory arthritis.

This systematic review included 18 diagnostic accuracy studies using controlled diagnostic blocks and 12 studies evaluating provocation maneuvers. The threshold was strict in that each study had to meet at least 50% of the methodological quality assessment criteria. In contrast to our previous review (36), in this evaluation we broadened our criteria to incorporate those studies that utilized a single block and various levels of pain relief as the reference standards. We found that studies that employed single blocks, and those that used cutoff thresholds < 80%, demonstrated a moderate correlation with those that utilized more stringent criteria, albeit with somewhat higher prevalence rates. There was only one placebo block available that did not provide prevalence or false-positive rates. The rationale behind using double comparative blocks is to eliminate false-positive responders, which is important to establish efficacy. The evidence for controlled dual blocks generally accepted for the diagnosis of facet joint pain (2,35,38-40,44,87,88,241-246). Yet as can be seen from this review, dual blocks are not universally accepted in the interventional pain medicine community, especially when the efficacy of a procedure has already been established.

There is a paucity of literature on the effectiveness of multiple therapeutic sacroiliac joint interventional techniques including intraarticular injections or radiofrequency neurotomy of the nerve supply. Barriers to effective treatment include the fact that sacroiliac joint pain is a heterogeneous condition (i.e. patients may exhibit either intra- or extra-articular sacroiliac joint pathology) and the complex and variable nerve supply, which can make radiofrequency denervation challenging.

In a retrospective study, Borowsky and Fagen (184) evaluated the sources of sacroiliac region pain to determine the contributions of intraarticular and periarticular components. One hundred and twenty patients were evaluated with either intraarticular (1.5 mL of bupivacaine and 80 mg steroid) or a combination of intra- (2 mL of bupivacaine and 40 mg steroid) and periarticular (2 mL of bupivacaine and 40 mg steroid) injections. The periarticular injections were performed in the posterior ligaments and around the lateral branches. The authors reported a success rate of 12.5% in the intraarticular group versus 31.25% for the combined injection. Further, anesthetic response rates were also higher in the combined injection group (62.5% versus 42.5%). They concluded that extraarticular sources comprise of significant proportion of sacroiliac joint pain, and that performing only intraarticular diagnostic blocks may underestimate the true prevalence.

Murakami et al (187) performed a prospective study comparing intraarticular to periarticular injections, which were performed in response to pain provocation tests. The authors found that the periarticular injections effectively relieved pain in all 25 patients, but intraarticular injection was effective in only 9 of 25 patients. All 16 patients in the intraarticular group who failed to respond to the initial injection experienced significant relief after they received an injection using the periarticular approach. Overall, the 96% improvement rate after the periarticular injection was significantly higher than the 62% success rate noted after the intraarticular injection.

Dreyfuss et al (181,182) evaluated the ability of single-site, single-depth, and multi-site, multi-depth sacral lateral branch blocks to anesthetize the sacroiliac joint complex. They concluded that single-site, single-depth sacral lateral branch blocks were ineffective in anesthetizing the lateral branches. In contrast, multi-site, multi-depth sacral lateral branch blocks were 91% effective

in anesthetizing the lateral branches, and blocked the pain from ligamentous probing in 70% of volunteers. However, these blocks did not block pain from the intraarticular portion of sacroiliac joint, elicited by capsular distension. This provides evidence for both a ventral and dorsal contribution to the innervation of the sacroiliac joint, and suggests that multi-side, multi-depth lateral branch blocks could be useful to identify extraarticular sources of sacroiliac joint pain, and to select candidates who might benefit from lateral branch radiofrequency neurotomy. Cohen et al (116) evaluated outcome predictors for sacroiliac joint lateral branch radiofrequency denervation. Fifty-two percent of patients obtained a positive outcome, with lower baseline pain scores, pain not extending below the knee, age < 65 years, no opioid use, and the use of cooled radiofrequency being associated with success. Cohen et al (116) also evaluated radiofrequency neurotomy in a double-blind, randomized controlled trial (68). Significantly greater pain relief and functional improvement were noted in patients who received cooled radiofrequency denervation. Based on these studies, it appears that sacroiliac joint pain is a heterogeneous condition containing both intraarticular and extraarticular components. One question that remains to be answered is how best to screen patients for denervation (i.e. intra- vs. periarticular injections; single vs. double blocks; whether or not lateral branch blocks are necessary).

The previous systematic review by Rupert et al (36) evaluating only dual blocks revealed moderate evidence for the diagnosis of sacroiliac joint pain. They estimated that sacroiliac joint pain prevalence rates ranged between 10% and 38% using a double-block paradigm, and that the false-positive rate of single, uncontrolled, sacroiliac joint injections was around 20%. The authors also concluded that the evidence for provocation testing to diagnose sacroiliac joint pain was limited.

There continues to be significant debate surrounding the accuracy of diagnostic tests (2,22, 27,28,39,87,88,247,248). Although numerous instruments are available for assessing methodological quality assessment, we utilized the latest available criteria. The issues pertaining to diagnostic accuracy are somewhat contentious (35-40,44,45,85-88,138-140,249-255). The reliability of controlled comparative local anesthetic blocks has been criticized, and their validity as precision instruments questioned (2,35,38,39,40,44,87,88,248-250,254-262). Issues related to the validity of controlled comparative local anesthetic blocks include the quality and quantity of pain relief, the utility of dual blocks, the reference standard employed, opioid use, the effects of sedation and local anesthetic use, and the placebo effect (261-268). Whereas the evidence behind using diagnostic blocks to identify the sacroiliac joint(s) as a pain generator is not robust, one may extrapolate from some of the ample evidence in support of using controlled lumbar facet joint nerve blocks to diagnose lumbar facet joint pain (2,35,38-40,44,49,87,88). The reference standard for surgical situations is clearly established by biopsy or autopsy. However, these standards are impossible to apply for pain conditions; hence, the long-term clinical follow-up of subjects appears to be the best means of establishing a reference standard with controlled blocks (87,88). In a retrospective study comparing cutoff values of 50% and 80% following dual facet joint nerve blocks, Manchikanti et al (88) reported that 89.5% of patients in the > 80% group continued to have pain relief after 2-years following therapeutic medial branch blocks or radiofrequency denervation, versus 51% of patients in the 50% cutoff group. This is in contradistinction to the findings of Cohen et al, who found no differences in lumbar facet joint radiofrequency outcomes in a retrospective evaluation between those subjects who obtained > 80% relief after a single medial branch blocks and those who obtained between 50% and 80% relief (269). The study by Manchikanti et al (88) also found a lower false-positive rate at 2 years in the > 80% pain relief group. The findings by Manchikanti et al are consistent with those of other investigators who reported sustained pain relief following multiple interventions when stringent diagnostic criteria were employed (88,241-245).

The use of double blocks is an area of considerable controversy. In one study, Manchikanti et al found that patients with suspected facet joint pain who tested negative using the strict criterion of > 80% pain relief following dual blocks obtained good relief following epidural steroid injections, which suggests that lowering reference standards may lead to misdiagnosis and inappropriate treatment. However, these results are in direct contrast to the findings of a randomized, comparative cost-effectiveness study published by Cohen et al (262) comparing 0, 1 or 2 diagnostic blocks to select patients for lumbar facet joint radiofrequency denervation. The authors found that although the double-block group had the highest proportion of successful denervation procedures, the 0-block group had the highest number of overall positive outcomes, and the lowest cost per successful procedure. This underscores the difference between efficacy studies, which by nature must

employ stringent selection criteria to screen out false-positive results and placebo responders, and those that seek to evaluate effectiveness, in which more liberal criteria should be employed. The Cohen study (262)was also conducted in a unique patient population, which may not be generalizable to other patient groups and also has been criticized for multiple deficiencies (247).

A diagnostic test is useful only to the extent that it distinguishes between the reference condition and other disorders that might otherwise be misdiagnosed. Many tests can differentiate healthy persons from severely affected ones, but being able to distinguish between these 2 groups reveals very little about the clinical utility of a test. The true pragmatic value of a test is therefore established only in a study that closely resembles clinical practice. The studies evaluating the accuracy of facet joint nerve blocks have provided us with reliability and validity data for controlled diagnostic blocks. A criterion standard using 80% pain relief during the performance of previously painful movements as the cutoff threshold following dual blocks has been established as accurate. However, due to the numerous studies that utilized less stringent criteria, we broadened the selection criteria for this review. In contrast to facet joint pain, the use of single blocks does not appear to result in unacceptably high false-positive rates, which in turn can lead to spurious prevalence estimates. The criterion standard of long-term follow-up used for the diagnosis of facet joint pain may also be applied to sacroiliac joint pain. Despite all the attention focused on establishing reference criteria, in the absence of a "gold standard" for diagnosis and treatment, any criteria utilized could be flawed (270). Although the use of multiple blocks and high cutoff thresholds will indubitably reduce the false-positive rate, an unintended consequence is that employing stricter diagnostic criteria may result in more false-negatives, the consequences of which include withholding a safe and effective treatment from a patient who might benefit – if no alternative treatment is available. Pearl (271) described a hierarchal outcome approach to test assessments using 6 criteria, which included technical aspects, diagnostic accuracy and validity, diagnostic thinking, therapeutic effectiveness, and the ability to improve patient or societal outcomes. We believe that based on long-standing experience, these criteria can be met through the use of controlled comparative local anesthetic blocks to diagnose sacroiliac joint pain.

In reference to noninvasive clinical testing for sacroiliac joint pain, since lab and imaging are non-specific, the majority rely on pain provocation tests that stress the sacroiliac joint structures and provoke pain concordant with a patient's typical complaints. The key tests include distraction, compression, high thrust, Gaenslen, and sacral thrust. None of these tests have been described in sufficient detail to establish a reference standard (i.e. there is considerably variability in how these tests are performed), and many suffer from low inter-examiner reliability. Multiple other insufficiently defined tests have also been described and advocated (53,154,155,159,189,251-253,272,273). Early studies reported mixed results on the interexaminer reliability of pain provocation tests evaluating sacroiliac joint pain (53). Subsequently these tests have been shown to possess acceptable levels of reliability provided that they are standardized appropriately (53,272,274-276). Multiple studies with replication of results have been published (53,154,155,159,189,251,253,272,273). Studies have shown that sacroiliac joint provocation tests are frequently positive in patients with other, or co-existing, sources of low back pain, such as discogenic pain, radiculopathy, and facet joint pain (189,277). One of the most reliable signs of sacroiliac joint pain may be the location of pain and tenderness (53,273). The centralization phenomenon is a common clinical sign observed when patients with low back pain are examined using standardized test movements and sustained postures first described by McKenzie (278). This phenomenon has been evaluated for reliability and validity in multiple contexts (279-284). Investigators have found that the centralization phenomenon is highly specific to discogenic pain, and is infrequently observed in patients with sacroiliac or facet joint pain. One may therefore assume that positive sacroiliac joint provocation tests in the presence of either centralization or a symptomatic disc herniation are likely to be falsely positive. Consequently, restricting the interpretation of sacroiliac joint provocation tests to noncentralization cases was shown to improve the specificity of 3 or more positive maneuvers from 78% to 87%, without compromising sensitivity, which remained at 91% (159). Satisfying these criteria result in a high probability that sacroiliac joint pain will be confirmed by diagnostic blocks. This reasoning process may be considered a clinical prediction rule for the identification of a subset of patients most likely to have pain emanating from the sacroiliac joint region (53). Laslett (53) noted that there was a 59% probability that 3 or more positive sacroiliac joint provocation tests would lead to an ultimate diagnosis of sacroiliac joint pain, assuming that that 30% of the

population selected will have the reference condition. If a McKenzie assessment of repeated movements fails to reveal the centralization phenomenon, there is a 77% likelihood that the pain is of sacroiliac joint origin (53). However, in most interventional pain management practices, prevalence rates of 30% are rarely seen. Consequently, the overall evidence for provocation maneuvers is limited to fair.

The limitations of this systematic review include the paucity of appropriate and high-quality literature available for analysis, the widespread variation in methodology, and the discrepancies in technical applications and reference standards. Only one placebo-controlled study was identified, which compared the effectiveness of local anesthetic blocks to intraarticular sodium chloride on the suppression of pain. However, placebo controlled injections in interventional pain management is not only impractical, but also subject to misinterpretation (2,27,28,33,34,39,154,246,285).

Some investigators have asserted that any local anesthetic injection which yields similar results to steroids should be considered a placebo response; however, this interpretations may be inaccurate. The difference between injections of sodium chloride solution and dextrose into various structures has yielded varying results (246,286-292). In addition, local anesthetics have been shown to provide long-term relief (293-296) in both clinical and experimental settings. Thus, local comparative anesthetic blocks appear may be more practical than placebo-controlled injections unless the latter are applied and interpreted appropriately. Ghahreman and Bogduk (297) illustrated the proper application of a placebo in a clinical trial evaluating transforaminal epidural steroid injections, which can be extrapolated in a similar fashion for sacroiliac joint injections.

The results of this systematic review may be used in future research to identify patients more likely to have pain originating from the sacroiliac joint, as well as to evaluate the effectiveness of therapeutic interventions targeting sacroiliac joint pain, but the conclusions are only as robust as the accuracy of the studies analyzed. As noted earlier, there continues to be considerable controversy surrounding the use of diagnostic controlled local anesthetic blocks.

In summary, sacroiliac joint injections are safe and reasonable tools when used for diagnosis after properly selecting candidates based on provocative maneuvers.

4.0 Conclusion

The results of this systematic review demonstrate fair to good support for diagnostic interventions using dual local anesthetic blocks in patients positive for sacroiliac joint provocation maneuvers who have failed conservative management.

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