Systematic Review

Clinical Effectiveness of Posterior Annular Targeted Ablative Decompression as an Alleviative Intervention for Lumbosacral Discogenic Pain: Systematic Review and Meta-analysis

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Background: Various percutaneous intradiscal procedures have been implemented to manage lumbosacral discogenic pain. But most of these procedures simply end up manipulating the central nucleus pulposus or the inner annulus, instead of accessing the posterior outer annulus where the actual, major pain generators exist. Thus, more localized percutaneous techniques, specifically derived to address the pathologic tissues creeped between the torn, posterior annulus and hyperplastic sinuvertebral nerve, have been devised. However, the clinical effectiveness of these "more" accurate procedures is still skeptical.

Objectives: This study has investigated whether the posterior annular targeted decompression was a useful method to treat lumbosacral discogenic pain in terms of pain control or functional improvement.

Study Design: A systematic review and meta-analysis.

Setting: Primary clinic and tertiary referral center.

Patients: Published past references that have dealt with the issue of clinical effectiveness after the posterior annular targeted decompression as a treatment of discogenic pain in terms of pain control and functional improvement.

Methods: A literature search was performed using MEDLINE, EMBASE, Cochrane Review, and KoreaMed databases from the studies published until December 2022. After reviewing titles, abstracts, and full texts of 65 studies during the initial database search, 12 studies were included in a qualitative synthesis, and 9 trials from 8 studies were in quantitative meta-analysis. Data, including pain and functional scores, were extracted and were analyzed using a random effects model to obtain statistical significance of mean difference. Quality assessment and evidence level were established in accordance with the Grading of Recommendations Assessment, Development and Evaluation methodology.

Results: Finally, 12 single-arm studies without the control group were included. All studies showed significant pain reduction and functional improvement from a 1-month to 1-year follow-up period. A meta-analysis showed significant reduction in pain scores at 1 month, 3 months, 6 months, and 1 year and functional scores at 1 month, 6 months, and 1 year. The level of evidence was very low because of the nonrandomized study design and inconsistency and imprecision across studies.

Limitations: Only single-arm studies comparing clinical results before and after treatment without the control group were analyzed. The statistical and clinical heterogeneity, due to different aspect of techniques across the studies and a relatively small number of patients, reduced the evidence level.

Conclusions: Comprehensive reviews of selected articles revealed posterior annular targeted decompression could be recommended as treatment option in the patients with discogenic pain who have failed in attaining clinical improvement after the conservative managements under weak evidential strength support.

Key words: Discogenic pain, minimal invasive technique, percutaneous targeted disc decompression, systematic review, meta-analysis

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Discogenic pain that attributes to the internal disc disruption without actual herniation accounts for approximately 25% to 40% of chronic axial low back pain (1,2). Internal disc disruption starts with the degradation of the extracellular matrix inside the nucleus pulposus, which subsequently ignites the posterior annular disruption (3). The posterior nucleus then dorsally creeps and consequently evolves to a granulation tissue formation between this torn posterior annulus. Moreover, the sinuvertebral nerve fibers that normally distribute over the outer posterior annulus become denser, also not only innervate into this posterior annular fissure but also penetrate deeper into the nucleus (4,5). Discogenic pain might originate from the combination of increased mechanical stress over these pathologic tissues formed inside the posterior disc portion and chemical irritation triggered from the infiltrative sinuvertebral nerves through the inflammatory mediators release (3).

Treatment of discogenic pain might be challenging. Various common conservative treatments, including medication, physical therapy, exercise, and injections, have been frequently fraught with disappointment (6-9). Surgical treatments, such as fusion or artificial disc replacement, might be considered because they can potentially eradicate the main pain source after the removal and immobilize the potentially irritating nociceptor or disc itself. But the controversies always follow in terms of the relative clinical advantages over their invasiveness or subsequent complications (7,9). In addition, the removal or immobilization of the still functioning disc might not be a physiologic solution (10).

Various percutaneous intradiscal procedures, such as intradiscal electrothermal therapy (IDET), nucleoplasty, or other central decompression techniques, have been implemented (11-18). However, probably due to the devices' inherent mechanical properties, most of these procedures practically end up manipulating the central nucleus pulposus or the inner annulus, instead of accessing the posterior outer annulus where the actual, major pain generators are located. These nonspecific disc decompressions simply manipulate and damage the normal healthy nucleus, which might consequently prompt the corresponding disc degradation without practical pain source eradication.

Thus, more accurately localizing percutaneous techniques, specifically devised to address the pathologic tissues inside the posterior disc, have been brought up to treat this discogenic pain. But their clinical effectiveness might be still skeptical and is not empowered with the relevant evidential strength.

To the best of our knowledge, there has been no systematic review with meta-analysis that validates clinical effectiveness of the posterior annular targeted decompression in the patients with lumbosacral discogenic pain. This study has investigated whether this targeted decompression is a useful method to treat lumbosacral discogenic pain in terms of pain control or functional improvement.

Methods

The acquisition of the Institutional Review Board approval or informed consents from the participating institutions or patients was not mandated due to the systematic review and meta-analysis nature of this research.

Study Selection Criteria

The authors have recruited articles described in Korean or English language that have primarily met the following criteria: patients aged ≥ 18 years, main clinical manifestation with axial back pain, and the confirmative diagnosis of lumbosacral internal disc derangement, bulging or high-intensity zone supported by magnetic resonance imaging (MRI). Exclusion criteria were a previous history of lumbosacral spinal surgery, inflammatory spinal diseases, tumors, infectious diseases, or prominent disc herniation by MRI. The final selections unanimously assumed and addressed the posterior part of the disc or annulus as the main pain source followed by the contents pertaining to its clinical effectiveness, while the articles dealing with the access to the central part of disc space were excluded.

Database Search and Study Extraction

The MEDLINE (PubMed), EMBASE, Cochrane Review, and KoreaMed databases were searched for articles published until December 2022. We established individual search terms in each database's search engine (Appendix). The search was not restricted to randomized controlled trials(RCTs) and was extended to original articles, including non-RCTs and case reports. Search terms were determined not to be restricted to the targeted decompression, but have comprehensively included the disc decompression procedures. The decision for an article selection was primarily based on the title and abstract review, followed by full-text screening. Irrelevant studies or case reports not fulfilling selection criteria were excluded. The study screening and data extraction were independently performed by the 2 reviewers (JHL, YL), and any discrepancies were resolved after the discussion between the 2 reviewers (JHL, YL) or with the entire research group. Flow chart demonstrating the process of study selection is illustrated in Fig. 1.

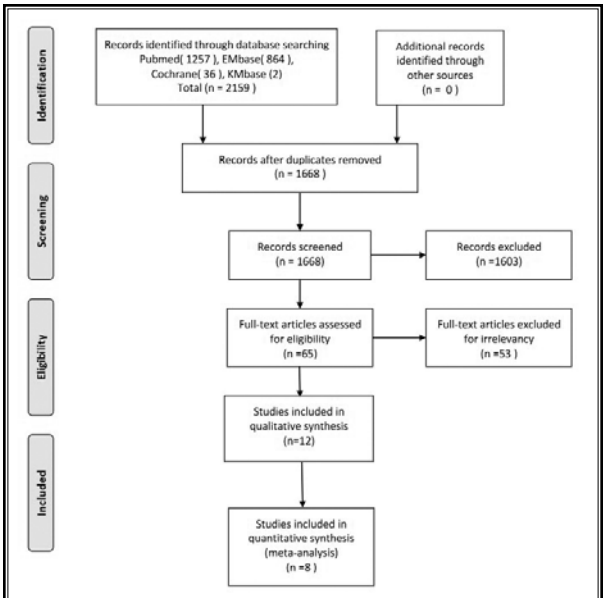

Fig. 1. *Flow diagram of study selection.*

Data Collection

Reference data, such as study design, number of patients, targeted decompression method, clinical evaluation tools, follow-up period, and clinical outcomes, were extracted from the selected articles. Continuous variables, such as mean and SD of clinical scores were extracted. Mean difference and SEs were obtained by calculation using mean, SD, and number of patients at pretreatment and follow-up period.

Quality Assessment of Selected Studies, Establishment of Level of Evidence, and Strength of Recommendation

Quality assessment of each study and level of evidence was established in accordance with the Grading of Recommendations Assessment, Development and Evaluation methodology (19,20). The bias for each non-RCT was assessed with the Risk of Bias Assessment tool for Nonrandomized Study; domains were selection of patients, confounding variables, measurement of intervention (exposure), blinding of outcome assessment, incomplete outcome data, and selective reporting (21) All the domains were evaluated as "low risk," "high risk," or "unclear." These evaluations were performed by 2 independent reviewers (JHL, YL) and disagreements were resolved after the discussion between the 2 reviewers (JHL, YL) or with the entire research group.

Based on the comprehensive evaluation of inconsistency, indirectness, imprecision, and publication bias in addition to risk of bias in all studies, the evidence level was determined as high, moderate, low, or very low grade. Besides, the strength of recommendation was determined as strong or weak by comprehensively assessing not only evidence level, but also other factors, such as benefits, risks, burdens, and possibly cost (22). The level of evidence and strength of recommendation were determined after the discussion from the entire research group participation.

Quality assessment was performed additionally using Interventional Pain Management Techniques – Quality Appraisal of Reliability and Risk of Bias Assessment for Nonrandomized Studies (IPM-QRBNR). Studies meeting the inclusion criteria with a score of 32-48 were considered as high quality, those with a score of 16-31 were considered as moderate quality, and those with a score < 16 were considered as low quality (23).

Meta-analysis

Comprehensive Meta-Analysis Version 3 (Biostat Inc., Englewood Cliffs, NJ) was used for data analysis. The analysis was performed in 2 categories of clinical outcomes, such as pain control and functional improvement in 1 month, 3 months, 6 months, and 1-year follow-up after treatment. Tests of heterogeneity were performed using I^2 statistics. The category with I^2 values of 50% or more was considered to have a high degree of heterogeneity. A random effects model was

applied to obtain effect size and its statistical significance because it was assumed that the patients and methods of the included studies performed by independent researchers could not be entirely equivalent and, therefore, could not have a common effect size. A probability of $P < 0.05$ was considered statistically significant. The results were expressed as standardized mean difference (SMD) in change from baseline and the 95% CI in the analysis.

Results

Search Results

Our database search has initially recruited 2,159 articles. After the exclusion of the 491 duplicates, 1,668 potentially eligible articles have remained. After the title and abstract screening, 65 articles were excluded due to the lack of the inclusion criteria fulfillment. Thus, the remaining 65 articles were retrieved for full-text analysis, of which 53 were subsequently excluded because of the irrelevance to the scheme of this analysis.

Finally, 12 articles were included in this study (24-35). All 12 articles were single-arm observational studies assessing the clinical improvement achieved after the treatment compared to the pretreatment in the absence of the control group. Eleven studies (24-33,35) used the Numeric Rating Scale (NRS-11) or Visual Analog Scale (VAS) for the evaluation of pain intensity, and Oswestry Disability Index (ODI) for the evaluation of functional status. For the evaluation of patients' satisfaction, modified MacNab criteria was used in 7 studies (24-26,28,29,32,34). One study (30) used the Rolando-Morris Disability Questionnaire and Bodily Pain Scales of Short Form-36 for pain score and functional assessment in addition to VAS and ODI. Another study (26) used the Japanese Orthopedic Association score in addition to ODI for functional evaluation. The follow-up period was diverse across the studies ranging from one month to one year.

Among 12 selected studies, 9 studies (24-26,28,29,31-34) performed percutaneous endoscopic discectomy and/or annuloplasty, and 3 other studies (27,30,35) conducted percutaneous navigable catheter ablation techniques without endoscopic visualization.

Clinical Outcome Analysis

All studies showed significant reduction of NRS-11/VAS and ODI during the follow-up period. Several studies (28,29,33) investigated a proportion of patients with successful NRS-11 and ODI reduction, which were defined as 50% or more reduction of NRS-11 and 40% or more reduction of ODI, respectively. Overall, 70% to 80% of patients accomplished successful NRS-11 or ODI reduction.

Satisfactory patients' responses, good or excellent results in MacNab criteria, ranged from 43% to 93.3%. Lee et al (28) applied a very strict criteria for the definition of successful results as concomitant achievements of > 50% reduction in pain, > 40% reduction of disability, good or excellent MacNab criteria, and no necessity for analgesics, and produced 49% successful outcomeachievements.

Park et al (33) conducted different types of epiduroscopic annuloplasty. One was transforaminal laser annuloplasty to remove granulation tissues from the posterior annulus and to coagulate the sinuvertebral nerve encroached into the ventral epidural space. The other was intradiscal radiofrequency annuloplasty to remove granulation tissues within the posterior part of disc without ventral epidural space involvement. There was no significant difference between the 2 groups in terms of the portion of patients with ≥ 40% reduction of ODI or ≥ 50% reduction of NRS-11 (Table 1).

With regard to the adverse events, back pain, transient mild weakness and tingling sensation of lower extremity, and mild bleeding at needle puncture site after procedures were reported and all the incidences resolved without additional management (27-29). One study (34) reported the dysesthesia development during 4 to 6 weeks posttreatment, managed by medication or injection treatment (34). However, no serious complications, such as neurologic deficits, epidural hematoma, or infection, were reported from the selected studies.

Quality Assessment

The risk of bias of all selected studies was illustrated in Fig. 2. The most frequently biased domains were selection of patients and blinding of outcome assessment, in which 7 studies were rated as high risk or unclear, respectively. Of 48 domains across all studies, 38 domains (84.4%) were determined as low risk; thus, the overall risk of bias was considered low. A discrepancy between reviewers was found in 10 of total 48 domains (22.2%) at first. But after the full, study patients' discussion, all discrepancies were resolved.

Quality assessment results of IPM-QRBNR were presented in Table 2. Eight studies were rated as high quality and 4 studies were rated as moderate quality (25-30,32,34).

Table 1. *Summary of selected studies.*

Author (y)	Design	Intervention	Evaluation	Results
Ahn Y (2010) (24)	Prospective observational study.	n = 87 Percutaneous endoscopic discectomy and thermal annuloplasty.	Visual Analog Scale (VAS), the Oswestry Disability Index (ODI), modified MacNab criteria at 6 months & 2 years.	VAS & ODI significantly decreased. Modified MacNab excellent in 49.4% & good in 21.5%.
An G (2021) (25)	Retrospective observational study.	n = 30 Percutaneous endoscopic discectomy and thermal annuloplasty.	VAS & MacNab criteria at 1 week, 1 month, 3 months, 6 months, and 12 months.	VAS & ODI significantly decreased. Modified MacNab excellent & good in 93.3%.
Cheng J (2014) (26)	Prospective observational study.	n = 113 Percutaneous endoscopic discectomy and thermal annuloplasty.	VAS, ODI, Japanese Orthopedic Association (JOA) score, & modified MacNab criteria at 1, 2, & 3 years.	Modified MacNab criteria excellent and good in 73.8%. VAS, ODI, & JOA significantly decreased.
Kim JY (2022) (27)	Prospective observational study.	n = 106 Navigable Percutaneous Disc Decompression Device (L'DISQ).	Numeric Rating Scale (NRS-11) & ODI at 1, 2, 3, & 6 months. Success > = 50% reduction of NRS-11 or > = 40% reduction of ODI.	NRS-11 & ODI significantly decreased.
Lee JH (2016) (28)	Retrospective observational study.	n = 47 Percutaneous endoscopic lumbar annuloplasty and nucleoplasty.	NRS-11, ODI, & MacNab criteria at 2-3 weeks and 12 months.	Seventy percent showed successful NRS-11 and ODI improvement. If success is defined as simultaneously achieving > 50% reduction in pain, > 40% reduction of disability, good or excellent MacNab criteria, and no need for analgesics, 49% achieved successful outcomes
Lee JH (2017) (29)	Retrospective observational study.	n = 89 Percutaneous endoscopic lumbar annuloplasty and nucleoplasty.	NRS-11, ODI, & MacNab criteria at 3-4 weeks and 12 months.	Significant improvement in NRS-11 & ODI scores was observed at all assessment periods. Modified MacNab criteria excellent and good in 65%.
Lee SH (2015) (30)	Prospective observational study.	n = 20 Navigable Percutaneous Disc Decompression Device (L'DISQ).	VAS, ODI, Rolando-Morris Disability Questionnaire & bodily pain scales of Short Form-36 at 1, 4, 12, 24, and 48 weeks.	Signficant improvement in all scales. The success rates of procedure were 55% at 48 weeks.
Lee SH (2010) (31)	Not identified.	n = 30 Percutaneous endoscopic lumbar annuloplasty.	NRS-11, ODI, & MacNab criteria at mean follow-up of 9.7 months.	Significant improvement in NRS-11 & ODI scores. Modified MacNab criteria excellent and good in 90%.
Liu KC (2019) (32)	Prospective and retrospective observations.	n = 24 Percutaneous endoscopic discectomy and thermal annuloplasty.	NRS-11, ODI, & MacNab criteria at 1 month, 3 months, 1 year & 2 years.	All except 2 patients experienced significant symptomatic and functional improvements with a success rate of 91.7% by MacNab criteria.
Park CH (2019) (33)	Retrospective observational study.	n = 80 Transforaminal laser annuloplasty (TFLA, 37 patients) or intradiscal radiofrequency annuloplasty (IDRA, 43 patients).	NRS-11 & ODI at 1 & 6 months.	Both groups showed significant reduction in NRS-11 & ODI. But no significant difference was found in NRS-11 and ODI reduction.
Tsou PM (2004) (34)	Retrospective observational study.	n = 113 Transforaminal selective endoscopic discectomy & bipolar radiofrequency thermal annuloplasty.	Surgeon-based modified MacNab method and a patient-based questionnaire at least 2 years.	Using the surgeon assessment method, 15% had excellent & 28.3% had good results. The patient-based questionnaire yielded similar percentages in each category.
Yoo Y (2018) (35)	Retrospective observational study.	n = 80 Percutaneous navigable catheter ablation.	Fifty percent pain relief on NRS-11, no increase in analgesics, and no additional treatment during the 6-month follow-up period.	Of 80 patients, 56 experienced a successful outcome.

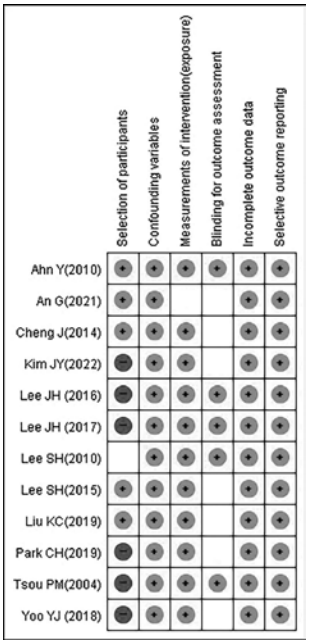

Fig. 2. *Quality assessment for extracted studies: Risk of Bias Assessment tool for Nonrandomized Study (RoBANs) for nonrandomized study (green color: low risk of bias, red color: high risk, white color: unclear risk of bias).*

Meta-analysis

Because all studies were single-arm studies comparing clinical data before and after the treatment, single-arm meta-analysis was performed as to the continuous data of VAS/NRS-11 and ODI. Sufficient data for the meta-analysis were available at 1 month, 3 months, 6 months, and 1-year follow-up periods across studies and the VAS/NRS-11s and ODIs at each corresponding period were collected and analyzed. Studies with only dichotomous data or insufficient continuous data were not included in this meta-analysis. Ultimately, 9 trials from eight studies (21,22,24,25,28-30,33) were finally included for this meta-analys since Park et al (33) have conducted 2 separate analyses from the 2 different procedures, respectively.

Pain Control at One Month

Seven trials of six studies (25,27-30,33) were used to assess the pain score at one month using VAS/NRS11. VAS/NRS-11 was significantly reduced after treatment (SMD = -19.034, 95% CI = -23.132 to -14.936, $P < 0.001$). Significant heterogeneity was observed ($I^2 = 89\%$) (Fig. 3a).

Pain Control at 3 Months

Three trials (25,27,30) were included to assess the pain score at 3 months using VAS/NRS-11. VAS/NRS-11 was significantly reduced after treatment. The SMD is -23.381 with a 95% CI of -37.279 to -9.483 ($P < 0.001$). A high degree of heterogeneity was observed ($I^2 = 97\%$) (Fig. 3b).

Pain Control at 6 Months

Six trials of five studies (24, 25, 27, 30, 33) were used to assess the pain score at 6 months using VAS/NRS-11, which was significantly decreased. The SMD is -21.421 with a 95% CI of -28.020 to -14.823 ($P< 0.001$). Significant heterogeneity was found ($I^2 = 94\%$) (Fig. 3c).

Pain Control at One Year

Five trials (25,26,28-30) were analyzed to evaluate the pain score at one year using VAS/NRS-11. VAS/NRS-11 was significantly diminished, showing that the SMD is -23.225 with a 95% CI of -31.740 to -14.709 ($P < 0.001$) (Fig. 3d). A high degree of heterogeneity was observed ($I^2 = 96\%$).

Functional Improvement at One Month

Six trials of five studies (27-30,33) were analyzed to evaluate the functional improvement at one month using ODI. ODI at one month was significantly reduced and the SMD is -15.065 with a 95% CI of -20.748 to -9.382 ($P < 0.001$). Significant heterogeneity was observed ($I^2 = 97\%$) (Fig. 4a).

Functional Improvement at 3 Months

Two trials (27,30) were used to assess functional improvement at 3 months using ODI. ODI was reduced but this was not the degree of statistical significance (SMD = -11.378, 95% CI= -23.987 to 1.23, $P = 0.077$). Heterogeneity could not be analyzed due to small number of trials (Fig. 4b).

Functional Improvement at 6 Months

Five trials of four studies (24,27,30,33) were analyzed to validate the functional improvement at 6 months using ODI, which was significantly reduced. The SMD is -17.222 with a 95% CI of -25.179 to -9.266 ($P < 0.005$). A high degree of heterogeneity was observed ($I^2 = 97\%$) (Fig. 4c).

Functional Improvement at One Year

Four trials (26,28-30) were included for analysis of functional improvement at one year using ODI, which was significantly reduced after treatment. The SMD is -14.916 with a 95% CI of -22.455 to -7.377. Significant heterogeneity was observed ($I^2 = 97\%$) (Fig. 4d).

Level of Evidence and Strength of Recommendation

The risk of bias was considered low as previously described. Directness could not be validated because

Table 2. *Methodological quality assessment utilizing IPM-QRBNR for selected studies.*

	Ahn Y (2010) (24)	An G (2021) (25)	Cheng J (2014) (26)	Kim JY (2022) (27)	Lee JH (2016) (28)	Lee JH (2017) (29)	Lee SH (2015) (30)	Lee SH (2010) (31)	Liu KC (2019) (32)	Park CH (2019) (33)	Tsou PM (2004) (34)	Yoo Y (2018) (35)
1. Study Design Guidance and Reporting	4	4	4	4	4	4	4	4	4	4	4	4
2. Study Design and Type	1	1	1	1	1	1	1	1	1	1	1	1
3. Setting/Physician	2	2	2	2	2	2	2	2	2	2	2	2
4. Imaging	3	3	3	3	3	3	3	3	3	3	3	3
5. Sample Size	0	0	1	1	0	0	0	0	0	0	1	0
6. Statistical Methodology	2	2	2	2	2	2	2	2	2	2	2	2
7. Inclusiveness of Population	4	4	4	3	4	4	4	4	4	4	4	4
8. Duration of Pain	1	1	2	1	2	2	1	2	2	0	2	1
9. Previous Treatments	2	2	2	2	2	2	2	2	2	2	2	2
10. Duration of Follow-up With Appropriate Interventions	3	2	3	1	2	2	2	1	3	1	3	1
11. Outcomes Assessment Criteria for Significant Improvement	2	2	2	4	2	2	2	2	2	2	2	2
12. Description of Drop Out Rate	1	1	1	1	1	1	1	1	1	1	1	1
13. Similarity of Groups at Baseline for Important Prognostic Indicators	0	0	0	0	0	0	0	0	0	0	0	0
14. Role of Co-Interventions	2	2	2	2	2	2	2	2	2	2	2	2
15. Method of Assignment of Patients	4	3	4	4	3	3	4	3	4	3	3	3
16. Funding and Sponsorship	2	2	2	2	2	2	3	2	2	2	2	2
Score	33	31	35	33	32	32	33	31	34	29	34	30

there was lack of study that has compared the targeted decompression to the other treatment or control. Publication bias was not assessed because fewer than 10 studies were included in each meta-analysis. The validation of the consistency was compromised due to the implementation of diverse decompressive procedures across the studies, including endoscopy. This high degree of heterogeneity residing inside this meta-analysis also reduced the level of consistency. The degree of precision was also severely compromised due to the low-numbered patients inside each study included. Thus, the level of evidence was assumed to be very low after comprehensive recollection of the negative factors; the lack of RCT, inconsistency, and imprecision.

But the patients from the included studies were refractory to the prior conservative managements, such as medication, physical therapy, or injection treatment, and the consideration to opt for the surgical management that pertains to fusion or disc replacement, which might often be fraught with subsequent complications, would have been indispensable. As featured among the selected studies, targeted decompression led to the favorable clinical results in the absence serious complications. For this reason, despite its invasiveness nature during the puncture of the annulus/disc space, as well as additional cost requirement for

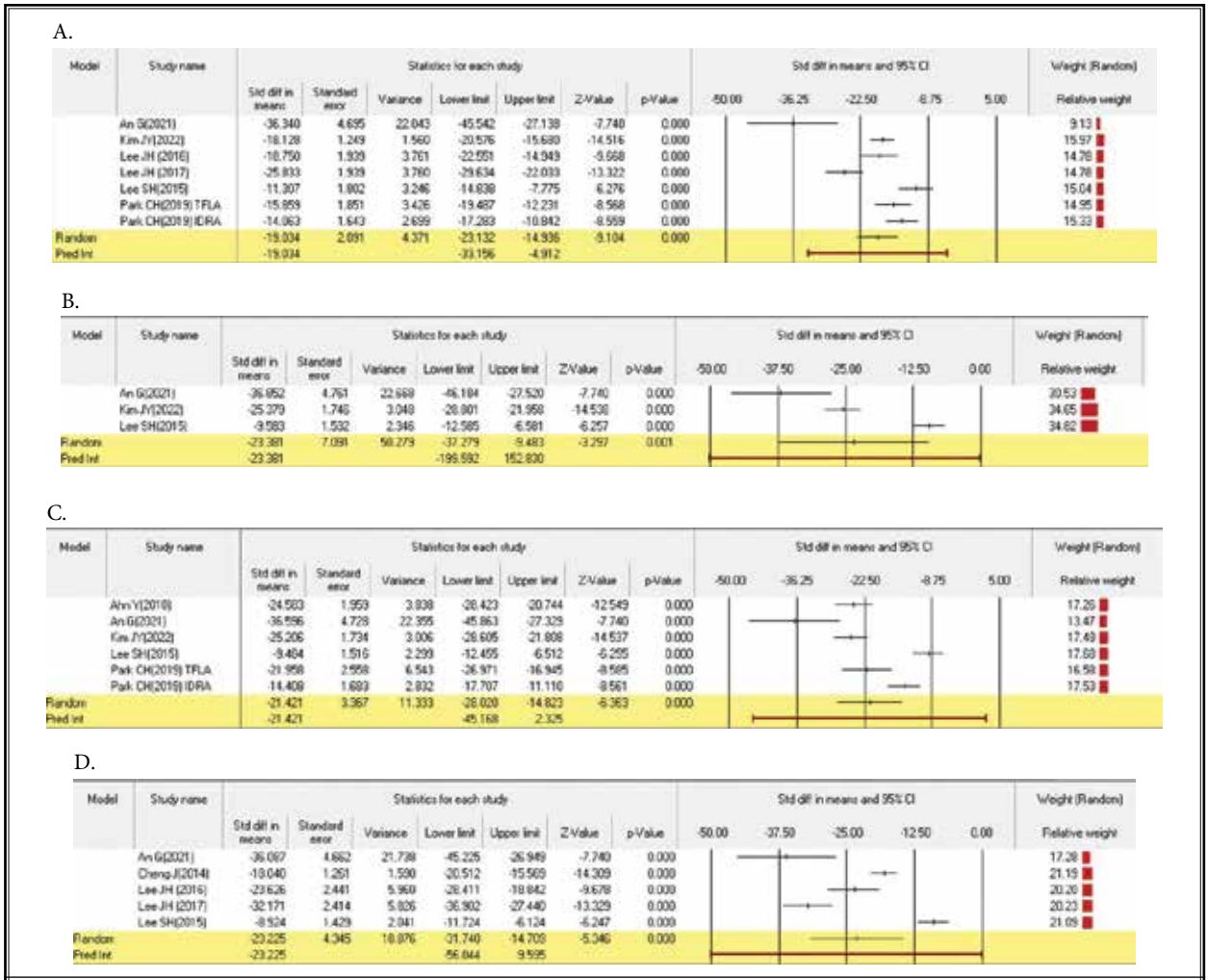

Fig. 3. *Forest plot of comparison (a) pain control at 1 month, (b) pain control at 3 months (c) pain control at 6 months, and (d) pain control at 1 year.*

the pertinent equipment preparation, this targeted posterior decompression should be considered as one of the therapeutic options for the management of the discogenic pain that is refractory to the conservative treatment.

With all these analyses and considerations taken into account, the authors have concluded that targeted posterior disc decompression could be recommended as a proper treatment option for the patients with discogenic pain who have failed in attaining clinical improvement after the conservative managements under with weak evidential strength support.

Discussion

A selection of the optimal treatment modality for the discogenic pain has been always challenging since the pursuit and prolonged maintenance of the conservative managements' efficacy might often be frustrating. The proven knowledges on the pathogenesis of discogenic pain have brought up the idea that the direct removal of pinched nucleus and granulation tissues from the annular fissure or coagulation of ingrowing sinuvertebral nerve that have encroached into the intervertebral disc could be a beneficial treatment method.

There has been percutaneous intradiscal procedures, such as IDET, nucleoplasty, and other disc decompressive techniques. But most of these techniques had considerable limitation that they practically end up manipulating the central nucleus pulposus or the inner

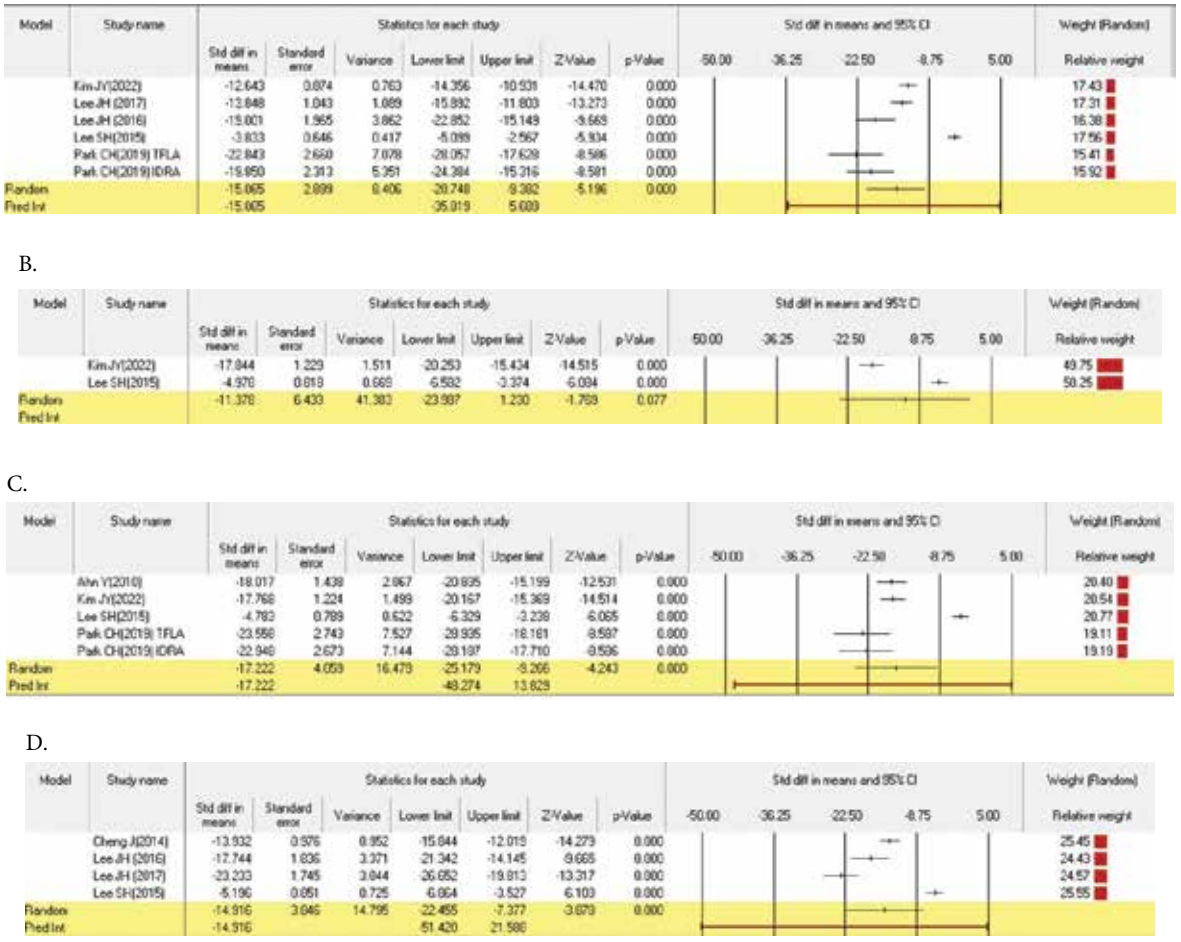

Fig. 4. *Forest plot of comparison (a) functional improvement at 1 month, (b) functional improvement at 3 months, (c) functional improvement at 6 months, and (d) functional improvement at 1 year.*

anulus, instead of accessing the posterior outer anulus where the actual, major pain generators exist. This might stipulate the disruption onto the normal healthy nucleus instead of pain source removal, and would inevitably prompt the corresponding disc degeneration (36).

The targeted posterior decompression would provide the access to the posterior disc space in full width, which property allows the direct, selective removal of the main discogenic pain source, such as pinched nucleus, granulation tissues, hyperplastic sinuvertebral nerve, or damaged annular tissue. Moreover, this removal would reduce the compressive force that is applied over the ventral epidural space, posterior longitudinal ligament, and dural sac without insulting the central normal disc tissue that would otherwise activate nociceptors (28,31). Also, this can dispense with the necessity for a extensive fusion or disc replacement surgery and its subsequent risk of complications (37,38).

Both targeted posterior decompression techniques with and without endoscopic visualization were successful in terms of the significant clinical improvement during this analysis. The procedure, including the endoscopy, could be superb to those without the expectation on the complete removal of discogenic pain source under direct visualization. But this direct visualization was not an indispensable or crucial factor for the sake of prominent discogenic pain alleviation, as requested during the radiculopathy relief from the large protruded or extruded disc material.

The main weakness exposed during this analysis starts from the fact that all included studies were single-arm studies comparing the clinical results before and after the treatment. The weakened evidential level attributes to the lack of comparative study, especially RCT. However, the proven clinical improvement achievements after the targeted posterior decompression for the included patients, who were refractory to the former 3 to 6 months of the conservative treatments, provide the clue that this procedure might offer a superb clinical effectiveness than the other conservative treatments despite lacking the direct, head-to-head comparison.

Limitations

This study has several limitations. First, as mentioned above, only single-arm studies comparing the clinical results before and after treatment without the control group were included in this analysis. Second, the 12 studies included had relatively low evidential quality from the differential methodologies as well as inherent heterogeneity in terms fo the selected treatment modalities and follow-up periods. This might produce clinical heterogeneity as well as limit the ultimate importance of generalization. Third, the number of studies included in the analysis was small. Fourth, CIs of risk ratio in some studies were too widely ranged for achieving precision. All these aspects lowered the evidence level to very low, consequently weakening the strength of this meta-analysis. Further study with a larger number of relevant article inclusions in the future would be needed to provide the meta-analysis that would be more statistically powerful.

Conclusions

Comprehensive reviews of selected articles revealed posterior annular targeted decompression could be recommended as treatment option in the patients with discogenic pain who have failed in attaining clinical improvement after the conservative managements under the weak evidential strength support.

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Appendix

DB	No		
PubMed	#1	"Lumbar Vertebrae"[Mesh] OR "Lumbosacral Region"[Mesh]	70,807
	#2	"Vertebrae, Lumbar"[TW] OR “Region, Lumbosacral” [TW] OR “Lumbar Region” [TW] OR “Region, Lumbar” [TW]	2,831
	#3	"lumbar"[TW] OR "lumbosacral"[TW]	153,761
	#4	#1 OR #2 OR #3	153,761
	#5	"Intervertebral Disc Displacement"[Mesh] OR "Intervertebral Disc Degeneration"[Mesh]	25,424
	#6	"Intervertebral Disc Herniation"[TW] OR "Disc Protrusion"[TW] OR "Herniated Disc"[TW] OR "Disc Herniation"[TW] OR "Disc Degeneration"[TW] OR "Degenerative Disc Disease"[TW] OR "Degenerative Intervertebral Disc"[TW]	19,898
	#7	"disc bulging"[TW] OR "bulging disc"[TW] OR "discogenic pain"[TW] OR "annular tear"[TW] OR "intervertebral disc derangement"[TW]	804
	#8	#5 OR #6 OR #7	32,543
	#9	#4 AND #8	18,523
	#10	"low back pain"[Mesh]	25,709
	#11	“Low Back Pain”[TW]“Back Pain, Low”[TW] OR “Pain, Low Back”[TW] OR "Lower Back Pain"[TW] OR “Back Pain, Lower”[TW] OR “Pain, Lower Back”[TW] OR “Low Back Pain, Mechanical”[TW] OR “Mechanical Low Back Pain”[TW]	4,048
	#12	#10 OR #11	28,442
	#13	#9 OR #12	44,410
	#14	"Discectomy, Percutaneous"[Mesh] OR "Radiofrequency Ablation"[Mesh] OR "Laser Coagulation"[Mesh]	48,794
	#15	“Percutaneous Discectomy”[TW] OR “Discectomy, Percutaneous”[TW] OR “Percutaneous Discectomy”[TW] OR “Nucleotomy, Percutaneous”[TW] OR “Percutaneous Nucleotomy” OR "Ablation, Radiofrequency"[TW] OR “Thermocoagulation, Laser”[TW] OR “Coagulation, Laser” [TW] OR “Laser Thermocoagulation”	531
	#16	"Intradiscal electrothermal therapy"[TW] OR "nucleoplasty"[TW] OR "annuloplasty"[TW] OR "discoplasty"[TW] OR "percutaneous endoscopic lumbar annuloplasty and nucleoplasty"[TW] OR "percutaneous lumbar discectomy"[TW] OR "L-DISQ"[TW]	6,317
	#17	#14 OR #15 OR #16	55,218
	#18	#13 AND #17	1,257
Embase	#1	"lumbar vertebra"/exp OR "lumbar spine"/exp	94,709
	#2	"lumbal vertebra”:ti,ab,kw OR “lumbar vertebrae”:ti,ab,kw OR “vertebra lumbalis”:ti,ab,kw OR “vertebra, lumbar”:ti,ab,kw OR “lumbar spinal segment”:ti,ab,kw OR “lumbar vertebral column”:ti,ab,kw OR “spina lumbalis”:ti,ab,kw OR “spine, lumbar”:ti,ab,kw	7,527
	#3	"lumbar":ti,ab,kw OR "lumbosacral":ti,ab,kw	186,483
	#4	#1 OR #2 OR #3	202,563
	#5	"intervertebral dischernia"/exp OR "ntervertebral disc degeneration"/exp OR "discogenic pain"/exp	29,912
	#6	"disc herniation":ti,ab,kw OR "disc prolapse":ti,ab,kw OR "disc protrusion":ti,ab,kw OR "herniated disc":ti,ab,kw OR "herniated intervertebral disc":ti,ab,kw OR "herniated nucleus pulposus":ti,ab,kw OR "herniated vertebral disc":ti,ab,kw OR "intervertebral disc displacement":ti,ab,kw OR "intervertebral disc prolapse":ti,ab,kw OR "intervertebral disc protrusion":ti,ab,kw OR "intervertebral disc degeneration":ti,ab,kw OR "intervertebral disc, degeneration":ti,ab,kw OR "vertebral disc degeneration":ti,ab,kw	17,771
	#7	"disc bulging":ti,ab,kw OR "bulging disc":ti,ab,kw OR "discogenic pain":ti,ab,kw OR "annular tear":ti,ab,kw OR "intervertebral disc derangement":ti,ab,kw	1,187
	#8	#5 OR #6 OR #7	36,039
	#9	#4 AND #8	19,083
	#10	"Low Back Pain"/exp	68,346
	#11	“acute low back pain”:ti,ab,kw OR “back pain, low”:ti,ab,kw OR “chronic low back pain”:ti,ab,kw OR “lower back pain”:ti,ab,kw OR “lumbosacral pain”:ti,ab,kw OR “pain, low back”:ti,ab,kw OR “pain, lumbosacral”:ti,ab,kw	17,428
	#12	#10 OR #11	70,826
	#13	#9 OR #12	85,451
	#14	"percutaneous discectomy"/exp OR "radiofrequency catheter ablation"/exp OR "intradiscal electrothermal therapy"/exp	2,434

Appendix cont.

DB	No		
	#15	“discectomy, percutaneous”:ti,ab,kw OR “percutaneous disc decompression procedure”:ti,ab,kw OR “percutaneous discectomy”:ti,ab,kw OR “radio frequency ablation”’:ti,ab,kw OR “rfa (radiofrequency ablation)”:ti,ab,kw OR “rfa therapy”:ti,ab,kw OR “intradiscal electrothermal annuloplasty”:ti,ab,kw	2,205
	#16	"Intradiscal electrothermal therapy":ti,ab,kw OR "nucleoplasty":ti,ab,kw OR "annuloplasty":ti,ab,kw OR "discoplasty":ti,ab,kw OR "percutaneous endoscopic lumbar annuloplasty and nuclesoplasty":ti,ab,kw OR "percutaneous lumbar discectomy":ti,ab,kw OR "L-DISQ"	6,858
	#17	#14 OR #15 OR #16	11,341
	#18	#13 AND #17	864
Cochrane Library	#1	MeSH descriptor: [Lumbar Vertebrae] explode all trees	530
	#2	MeSH descriptor: [Lumbosacral Region] explode all trees	2,845
	#3	"Vertebrae, Lumbar":ti,ab,kw OR “Region, Lumbosacral”:ti,ab,kw OR “Lumbar Region”:ti,ab,kw OR “Region, Lumbar”:ti,ab,kw	808
	#4	"lumbar":ti,ab,kw OR "lumbosacral":ti,ab,kw	19,259
	#5	#1 OR #2 OR #3 OR #4	19,259
	#6	MeSH descriptor: [Intervertebral Disc Displacement] explode all trees	960
	#7	MeSH descriptor: [Intervertebral Disc Degeneration] explode all trees	439
	#8	"Protrusions, Intervertebral Disc":ti,ab,kw OR "Herniated Discs":ti,ab,kw OR "Discs, Protruded":ti,ab,kw OR "Intervertebral Disc Herniations":ti,ab,kw OR "Disc Protrusions Intervertebral":ti,ab,kw OR "Intervertebral Disc Herniation":ti,ab,kw OR "Disc Herniation":ti,ab,kw OR "Disc Protrusion":ti,ab,kw OR "Disc, Protruded":ti,ab,kw OR "Disc Protrusion, Intervertebral":ti,ab,kw OR "Herniated Disc":ti,ab,kw OR "Herniation, Intervertebral Disc":ti,ab,kw OR "Intervertebral Disc Protrusions":ti,ab,kw OR "Disc Protrusions":ti,ab,kw OR "Intervertebral Disc Protrusion":ti,ab,kw OR "Disc, Herniated":ti,ab,kw OR "Protrusion, Intervertebral Disc":ti,ab,kw OR "Protruded Disc":ti,ab,kw OR "Herniation, Disc":ti,ab,kw OR "Protrusion, Disc":ti,ab,kw OR "Degenerative Disc Diseases":ti,ab,kw OR "Degeneration, Disc":ti,ab,kw OR "Disc Degradation":ti,ab,kw OR "Disc Degenerations":ti,ab,kw OR "Degenerative Disc Disease":ti,ab,kw OR "Disc Disease, Degenerative":ti,ab,kw OR "Disc Degeneration, Intervertebral":ti,ab,kw OR "Disc Degeneration":ti,ab,kw OR "Degeneration, Intervertebral Disc":ti,ab,kw OR "Intervertebral Disc Degenerations":ti,ab,kw OR "Intervertebral Disc, Degenerative":ti,ab,kw OR "Degenerative Intervertebral Disc":ti,ab,kw OR "Disc, Degenerative Intervertebral":ti,ab,kw OR "Degenerative Intervertebral Discs":ti,ab,kw	2,989
	#9	"disc bulging":ti,ab,kw OR "bulging disc":ti,ab,kw OR "discogenic pain":ti,ab,kw OR "annular tear":ti,ab,kw OR "intervertebral disc derangement":ti,ab,kw	143
	#10	#6 OR #7 OR #8 OR #9	3,408
	#11	#5 AND #10	2,456
	#12	MeSH descriptor: [low back pain] explode all trees	4,600
	#13	“Low Back Pain”:ti,ab,kw OR “Back Pain, Low”:ti,ab,kw OR “Pain, Low Back”:ti,ab,kw OR "Lower Back Pain":ti,ab,kw OR “Back Pain, Lower”:ti,ab,kw OR “Pain, Lower Bac”:ti,ab,kw OR “Low Back Pain, Mechanical”:ti,ab,kw OR “Mechanical Low Back Pain”:ti,ab,kw	12,525
	#14	#12 OR #13	12,525
	#15	#11 OR #14	14,179
	#16	MeSH descriptor: [Discectomy, Percutaneous] explode all trees	52
	#17	MeSH descriptor: [Radiofrequency Ablation] explode all trees	1,730
	#18	MeSH descriptor: [Laser Coagulation] explode all trees	600
	#19	“Percutaneous Discectomy”:ti,ab,kw OR “Discectomy, Percutaneous”:ti,ab,kw OR “Percutaneous Discectomy”:ti,ab,kw OR “Nucleotomy, Percutaneous”:ti,ab,kw OR “Percutaneous Nucleotomy”:ti,ab,kw OR "Ablation, Radiofrequency":ti,ab,kw OR “Thermocoagulation, Laser”:ti,ab,kw OR “Coagulation, Laser”:ti,ab,kw OR “Laser Thermocoagulation”:ti,ab,kw	157
	#20	#12 OR #13 OR #14 OR #15	14,179
	#21	#11 AND #16	36
KMBASE	#1	(lumbar OR lumbosacral OR low back pain) AND (disc disease OR discogenic pain OR disc bulging OR disc herniation OR disc derangement OR annular tear) AND (percutaneous discectomy OR nucleoplasty OR annuloplasty OR intradiscal electrotherapy OR L-DISQ)	2