RELATION BETWEEN SIZE OF PROTRUDED SPINAL DISC AND PAIN SEVERITY LEVEL: SYSTEMATIC REVIEW

Zeinab M Abdelrehim [1], Adel ME Zedan [2*] , Sami Ahmed Zaher Basha [3 a,b], Dina Mohammed Mustafa Abdelhamid [4a,b], Yara Alburdini [5], Sabah Mohamed Elkady [6] , Gehad Mohammed[7] ·

1- Assistant Professor, Department of Physical Therapy, Faculty of Allied Medical Sciences, Aqaba University of Technology, Jordan.

2- PhD, Department of musculoskeletal disorders, Faculty of Physical Therapy, Benha University, Egypt.

3-a- Assistant Professor in Physical Therapy Department, Faculty of Allied Medical Sciences, Zarqa University, Zarqa, Jordan. Szaher@zu.edu.jo

b-Lecturer at department of cardiovascular pulmonary and geriatrics, faculty of physical therapy, Pharos university, Alexandria, Egypt.

4-a- Assistant Professor, Department of Physical Therapy, Faculty of Allied Medical Sciences, Zarqa University, Zarqa, Jordan.

5-Faculty of allied medical sciences, Aqaba University of technology, Jordan.

b-National institute of neuromotor system. Egypt. dabdelhamid@zu.edu.jo

6- Lecturer of Physiotherapy, Basic Science department. Faculty of physiotherapy, Cairo University, Egypt.

7-Lecturer, Department of Physical Therapy for Neurology and Neurosurgery, Faculty of Physical Therapy, Cairo University, Egypt.

Corresponding author: Adel ME Zedan; Department of musculoskeletal disorders, Faculty of Physical Therapy, Benha University, Egypt. Email: adel.zidan@fpt.bu.edu.eg

Orcid:0000-0002-0639-9775

Abstract

Background: Spinal disc herniation (cervical and/or lumbar) is common and can cause significant pain (localized or radicular) disability. Up to authors' knowledge, no systematic review was identified to provide the best available evidence about the relation between the size of herniated disc and pain severity level in patients.

Purpose: To pool and summarize the published research evidence examining the relationship between size of herniated spinal disc and pain severity level in patients with spinal disc herniation.

Methods: Three databases; PubMed, Cochrane, and Scopus were searched for all the studies published in English and free full text that have studied the relationship between size of herniated spinal disc and pain severity level in patients.

Results: Thirty-one studies that met the inclusion criteria were identified, with a total of 2400 participants. All studies have fair to high quality except one case report. 17 studies of 879 participants found a direct relation and 9 studies of 1041 participants found no relation, 2 studies of 228 participants found inverse relation and 3 studies of 252 participants showed inconsistent results.

Conclusions: The current evidence is inconclusive with respect to the relation of the size of herniated disc and pain severity level. This finding at least lowers the current importance of imaging and need for surgery in cases suspected to disc herniation or confirmed on MRI unless severe progressive neurological deficits and pain were present. However, further high quality studies are needed to confirm that findings.

Key words: Disc herniation, herniated disc size, back pain, radicular pain

INTRODUCTION:-

Disc bulge or herniation is the displacement of the nucleus pulposus out of the annulus fibrosus into the spinal canal due to annular tear from degeneration or trauma. It commonly causes spinal localized pain and radicular pain (affecting up to 90% of the cases) (1,2).

Protruded disc size can be determined by measuring how far a disc herniates into the spinal canal (maximal anterior-posterior length between posterior intervertebral height and most posterior located boundary of posterior disc material) on the axial view of magnetic resonance imaging (MRI) scan (3). This technique showed acceptable intra- and inter-rater agreement and reliability (4).

There was a controversy in the literature about the relation of the size of herniated disc occupying the spinal canal and spinal pain (3). In addition, no systematic review was identified in this regard.

Relation between the symptoms and MRI findings of disc herniation is important to judge the practical importance of MRI abnormalities (5). The surgical intervention and its success depend on the correlation between clinical and radiological findings (6).

So, the current study was to provide a systematic review of the available literature about the relationship between size of protruded disc and spinal pain.

METHODS:-

This review followed the PRISMA reporting guidelines.

Search Strategy

Physiotherapist (A.M.) reviewed the literature, according to the predetermined searching criteria. Literature search in the following databases were done; PubMed, Cochrane register of controlled trials, Scopus, and references of searched articles. The following search terms were used; “Cervical disc” or “Lumbar disc” or “size of protruded disc” “size of herniated disc” or “disc volume” combined with “pain,” and “relation,” or “correlation,” or “association,”. The search was limited to English studies on humans. Search strategy used on PubMed was (disc [Title/Abstract]) and (size [Title/Abstract]) or (volume [Title/Abstract]) and (spinal pain [Title/Abstract]) and (relation [Title/Abstract])) or (association [Title/Abstract]) or (correlation

[Title/Abstract]) and low back pain or lumbar disc or cervical disc Filters: Free full text. **(FIGURE 1).**

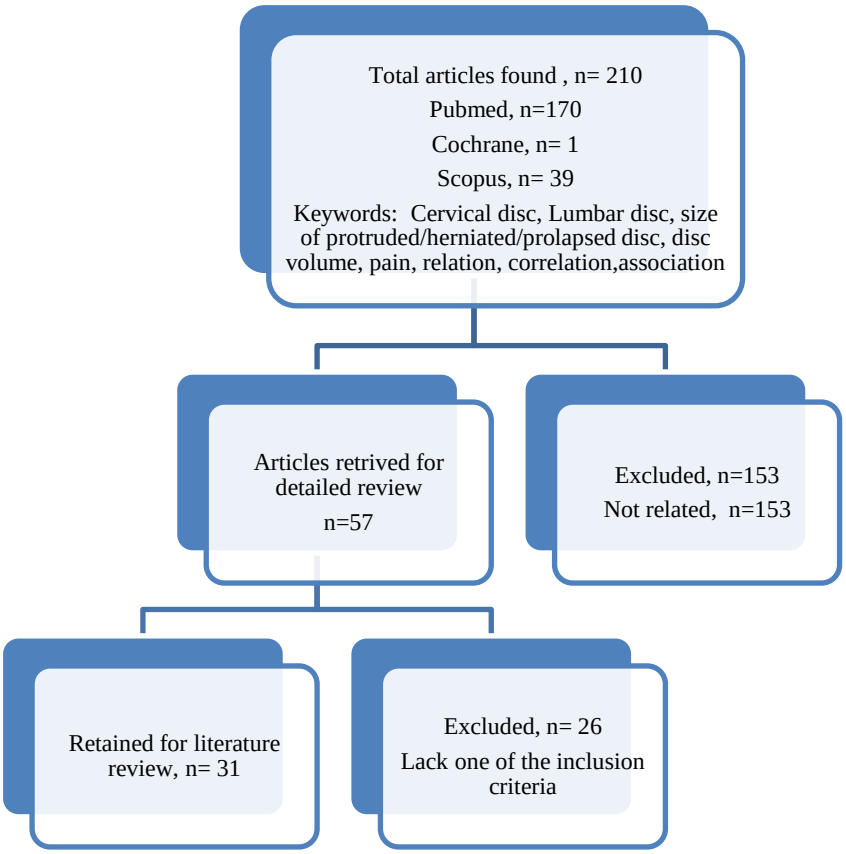

Fig. (1): PRISMA flow chart and search strategy

Inclusion and Exclusion Criteria

All English studies on human subjects that included cervical and/or lumbar disc prolapse/protrusion/herniation and assessed pain severity and disc size either observational or experimental were included. Studies that were not in English, or were not on human subjects and studies included other population as who had fractures or bony or ligamentous spinal canal stenosis, were excluded. **(TABLE 1).**

Table (1): Participants, Interventions, Comparator, Outcome, and Study design (PICOS).

PICO	**Keyword**
Participants	Patients with disc prolapse, bulge, herniation, or protrusion in cervical or lumbar spine

Interventions	No intervention, disc reduction interventions (surgical and non-surgical), or canal widening interventions
Comparator	No control or passive control
Outcome	Pain (spinal or leg) and (protruded, prolapsed, extruded, or herniated) disc size
Study design	Observational or experimental studies

Methodological Quality Evaluation

The methodological quality of the selected studies was assessed based on the design of each study; randomized controlled studies were assessed using PEDro scale, cohort and case-control studies were assessed by Newcastle-Ottawa Scale, cross-sectional studies were assessed using Agency for Healthcare Research and Quality (ARHQ) methodology checklist, non-randomized interventional studies were assessed using the Methodological Index for Non-Randomized Studies (MINORS), Diagnostic accuracy studies were assessed using the Critical Appraisal Skills Programme (CASP), case reports were assessed using the scale recommended by Murad et al. (7), and case series were assessed using the scale developed by Moga and colleagues (8). Studies got a score ≥ 50 5 of the total score of the quality assessment tool was considered high quality (or at least fair) based on the work of several previous studies (9-11). Studies that met the inclusion criteria were assessed by one author (A.M.). Any discrepancies were resolved by a second author (Z.M.).

Data Extraction

The following data was extracted from the identified studies (by A.M); sample size, age, gender of the patients, body mass index (BMI), lesion (type, level), duration of illness (DOI), intervention (if present), outcomes, and the conclusion.

RESULTS

Thirty-one studies met the inclusion criteria and were related to the purpose, thus were included in this review.

Characteristics of the included studies:

Characteristics (sample size, age, gender, BMI, lesion type and level, DOI, outcomes, interventions, and conclusion) of the included studies were presented in table (2).

Table (2): Participant characteristics by study:

Study	n	Age, Male %, BMI	Lesion type & level	DOI (m)	Outcomes	Intervention	Conclusion
Abdallah et al. (12)	45	43 (4)y, 47%, 23(0.8) kg/m^2	CDP, C5-7	NR	Disc size (MRI), pain (NDI)	Traction, TENS, IR, mobilization, stretching, ROM	Pain reduced but disc did not reduce
Chang et al. (13)	2	29&46 y, 100 %	LDH: L4,5&L5, S1	1&6	LBP, RP, disc size on MRI	EX, medications	Pain reduction coincided with disc regression
Hu et al. (14)	1	32y, 100%	LDH: L3,4, L4,5&L5, S1	0.25	LBP, RP, disc size on MRI	EX, acupuncture, massage	Reduced L4,5 disc only with reduced pain
Choi et al. (15)	60	44 (10), 50%	LDH (70% central): L4,5 (56%), L5, S1 (44%)	2(0.5)	LBP, RP (VAS), disc size (MRI)	Non-surgical decompression vs. placebo, 2m	Pain reduced with reduced disc size in both groups
Szulc et al. (16)	60	44y, NR	LDH (protrusion and bulge): Lumbosacral	>12	LBP, RP (VAS), disc size (MRI)	Mackenzie w/out MET or standard program (massage, laser, TENS, EX), 10d	Pain reduced with reduced disc size
Reddy et al. (17)	1	40y, 0%	L4,5 sequestration	24	LBP, RP	CONS	Disc regression without pain reduction
Kim & Kim (18)	1	59y, 100%	L3,4 sequestration with L4,5 stenosis		Pain	CONS	Disc regression without pain reduction
Ahn et al. (19)	22	43 (19-73y), 65%	L4,5 (12), L5, S1 (5), Extrusion (9), Sequestration 913)	1 (0.25 -2.5)	LBP, RP	Rest, NSAIDS, ex, Injection (as needed), massage, traction 3 m	More pain reduction associated with more disc regression

						then home ex	
Gezici & Ergun (20)	1	33, 0%	L4,5 herniation	24	LBP, RP	PT, drugs 1m	Pain reduced with reduced disc size not CONS
Singh & Singh (21)	1	43y, 100%	L3,4 herniation	12	LBP, RP	Rest, analgesics	Pain reduced with reduced disc size not CONS
Takada et al. (22)	42	42 (16-64y), 67%	LDH: L2,3 (8), L3,4 (6), L4,5 (15), L5S1 (13)	NR	LBP, RP	Rest, NSAIDs, traction, injection)	Pain reduced with reduced disc size, 0.25-3.5 m (1.5)
Tarukado et al. (23)	4	69y, 100%	Sequestration: L3,4 (2cases), L4,5 (2 cases)	2.5	LBP, RP	NSAIDs (3), block (1), Discectomy (1)	Pain reduced with reduced disc size (spontaneously or surgically), 3-6 m
Gupta et al. (24)	368	32 (7) y, 52%	LDH: L3,4 (4%), L4,5 (50%), L5,S1 (46%)	NR (>1.5 -24)	LBP, RP	Conservative (336), Surgery (32)	No association between disc size and improvement with CONS
Jensen et al. (25)	412	42 (11)y, 46%	Bulge, herniation (42%)	2-12	LBP, RP	-	The severe the MRI findings the higher the LBP
Vagaska et al. (26)	52	41(10)y , 50%	Bulge, protrusion, and extrusion/sequestration (87%) L1-S1	>3	LBP, RP	-	MRI findings do not correlate with the intensity of pain
Jensen et al. (27)	141	42 (11)y, 47%	Bulge (23), protrusion (55), extrusion (40), sequestration (8)	>1	LBP, RP	-	Pain was negatively associated with degenerative changes.
Jensen et al. (28)	141	42 (11)y, 47%, 27 (4.6)	Bulge (23), protrusion (55), extrusion (40), sequestration (8)	1->12	LBP, RP	-	Leg not back pain intensity was well explained by LDH causing RP
Gao et al. (29)	3	43y, 67%	C4,5 & C5,6 herniation	24	RP	Discectomy & fusion	Reduced cord compression associated with pain
Wang et	1	25y,	L5, S1	>48	LBP, RP	IV injection,	Reduced pain

al. (30)		100%	herniation			Acupuncture, massage, 7-10d	associated with reduced disc, 12m
Singh et al. (31)	75	36 (9)y, NR, 25(3) kg/m^2	Bulge and/or herniation L1-S1	>=3	LBP	-	Larger disc volume associated with LBP
Mariajoseph et al. (32)	122	50(13)y, 51 %, BMI 30 (8)	LDH: L3/4 (6), L4/5 (42), L5/S1 (52)	>6m (53.3 %)	LBP & RP	Discectomy	Disc size does not affect the severity of pain pre- or post-surgery.
Dunsmuir et al. (33)	56	41 (23-70) yr	LDH	NR	LBP & RP	-	No correlation between disc size and symptoms.
Huang et al. (34)	55	36 (9)y, 47%, BMI (19-27)(86 %)	Cervical disc degeneration including bulge	≥3	Neck pain	-	Positive correlation between cervical degeneration, and pain
Eltes et al. (35)	10	74(8)y, 40%	Advanced disc degeneration; L1,2 (3), L2,3 (2), L3,4 (4), L4,5 (4), L5, S1 (2)	NR	LBP & RP	Percutaneous cement discoplasty	Strong, significant association between pain intensity and the magnitude of the volumetric increase of the spinal canal
Negro et al. (36)	87	55 (14)y, 59%	LBP, LDH (64% L4&29% L5)	NR	LBP & RP	Intradiscal O_2-O_3 chemiodiscolysis after 3m of failed CONS	Less pain and larger disc pre-ttt associated with more disc reduction post-ttt. Larger disc may be associated with mild-moderate pain.
Kesikburun et al. (37)	40	50 (14)y, 55%, BMI 29.5 (4.5)	LDH (extrusion): L1,2 (1), L2,3 (4), L3,4 (3), L4,5 (17), L5, S1 (15)	6 (1.25)	LBP	CONS	More disc resolution associated with more pain reduction
Corniola et al. (38)	284	59y, 48%,	LDH	NR	LBP & RP	-	No association between pain

		BMI 27 (4.5)					and radiological severity classifications `
Zhang et al. (39)	112	NR	LDH	NR	LBP & RP	Feng's spinal manipulation, 6 twice weekly sessions.	Pain reduction not associated with change in protruded nucleus pulposus following the therapy.
Bajpai et al. (40)	75	44.5y (19-55), 57%	Protrusion (44), extrusion (14), sequestration (2), L4 L5 and L5 S1 (94%), L4 L5 (36 %)	NR	LBP & RP	-	Degree of disc herniation was correlating well with the symptoms
Hegarty et al. (41)	16	45 (8)y, 69%	intervertebral disc herniation L1/L2 to L5/S1	>3 (8.5)	LBP &/or RP	Discectomy after failed CONS treatment for at least 12 weeks	The degree of nerve root compromise by LDH, correlated with increased pain intensity at rest.
Voorhies et al. (42)	110	NR	Disc herniation, posterior marginal osteophyte, or synovial cyst	NR	LBP & RP	Surgical decompression after failed 1.5 m CONS	RP not LBP was treatable by nerve root decompression

n: sample size; DOM: duration of illness; m: months; NR: Not reported; CONS: conservative treatment; LBP: low back pain; RP: radicular pain (sciatica, thigh pain); LDH: Lumbar disc herniation; y: year; BMI: body mass index; d: day; IV: Intravenous; NSAIDs: non-steroidal anti-inflammatory drugs; MRI: magnetic resonance imaging; VAS: visual analogue scale; MET: muscle energy technique: EX: exercises; TENS: transcutaneous electrical nerve stimulation; NDI: neck disability index; ROM: range of motion; IR: Infrared; (-): Not applicable.

This review included 2400 patients in the 32 studies, 42% of them were males (study 42 not reported gender), mean age was 44.4 years (ranged from 16-73 years) (studies 39&42 not reported age) and BMI (reported only on studies 12,27,31,32,34,37,38) was 26.4 (ranged from 19-38 kg/m2). Participants had CDH in 3 studies (10,27,32) and LDH (21% L4,5&12%L5S1) in the others. DOI was acute to sub-acute (<3m) in studies (14,15,19,23), chronic (>=3m) in studies (16,17,20,21,26,29-31,34,37), and combine in studies (13,24,25,27,25,32,41) and not reported in

the others. Participants in the interventional studies all received conservative treatment (physiotherapy and medications) except studies (23,29,32,35,36,41,42) received surgery and one study (24) received both. (**TABLE 2**). All studies reported relation between pain (e.g. using VAS, NDI...) and disc size (using MRI).

Methodological Quality

All the studies had fair to high quality except one case report had low quality (**TABLE 3**). Of the 17 studies which found positive relation; 5 were cross-sectional, 3 were case reports, 2 were RCTs, 2 case control, 2 cohorts, 2 case series, and 1 was non-RCT, all were fair-high quality. Of the 9 studies which found no relation; 4 were cross-sectional, 2 of them were non-RCTs, 1 was RCT, 1 was cohort, and 1 was case report, all were fair-high quality except the case report was low. Of the 3 studies which were inconsistent in their findings; 1 was non-RCT, 1 was cross-sectional, and 1 was case report, all were fair-high quality. Of the 2 studies which found negative relation, 1 was cross-sectional and 1 was diagnostic, both were high quality.

Table (3): Methodological quality scores

Study	Study design	Methodological quality score	Classification
Abdallah et al. (12)	RCT	7/10	High
Chang et al. (13)	Case report	4/5	High
Hu et al. (14)	Case report	4/5	High
Choi et al. (15)	RCT	8/11	High
Szulc et al. (16)	RCT	8/11	High
Reddy et al. (17)	Case report	4/5	High
Kim & Kim (18)	Case report	2/5	Low
Ahn et al. (19)	Non-RCT	20/24	High
Gezici & Ergun (20)	Case report	4/5	High
Singh & Singh (21)	Case report	4/5	High
Takada et al. (22)	Non-RCT	17/24	High
Tarukado et al. (23)	Case series	12/18	High
Gupta et al. (24)	Cohort study	8/10	High
Jensen et al. (25)	Cross-sectional study	10/11	High
Vagaska et al. (26)	Cross-sectional study	9/11	High
Jensen et al. (27)	Cross-sectional study	10/11	High
Jensen et al. (28)	Cross-sectional study	10/11	High
Gao et al. (29)	Case series	12/18	High
Wang et al. (30)	Case report	5/5	High
Singh et al. (31)	Case-control study	8/10	High
Mariajoseph et al. (32)	Cross-sectional study	8/11	High

Dunsmuir et al. (33)	Cross-sectional study	7/11	High
Huang et al. (34)	Cross-sectional study	8/11	High
Eltes et al. (35)	Cohort study	8/10	High
Negro et al. (36)	Diagnostic accuracy study	5/6	High
Kesikburun et al. (37)	Cohort study	9/10	High
Corniola et al. (38)	Cross-sectional study	9/11	High
Zhang et al. (39)	Non-RCT	20/24	High
Bajpai et al. (40)	Cross-sectional study	10/11	High
Hegarty et al. (41)	Cross-sectional study	7/11	High
Voorhies et al. (42)	Non-RCT	16/24	High

RCT: randomized controlled trial

Relation between herniated disc size and pain severity:

The evidence were inconclusive about the relation between herniated disc size and pain severity based on the findings of this review as 2 studies (27&36) with 228 participants found inverse relation between disc size and pain, 17 studies (13,15,16,19-23,25,29-31,34,35,37,40,41) with 879 participants found direct relation, 3 studies (14,28,42) with 252 participants showed inconsistent findings about the relation, and 9 studies (12,17,18,24,26,32,33,38,39) with 1041 participants revealed no relation.

DISCUSSION

This study provided a systematic review about the relationship between size of the protruded disc and the severity of spinal pain.

This study revealed that the correlation between pain and protruded disc size is inconclusive with fair to high evidence with and against the relation.

This study came in line with the study Gupta et al, who found that size of herniated disc occupying the spinal canal does not affect treatment effect and type (24). As well, larger disc diameters were associated with lower disability not pain after removal of any portion of the disc (3). This finding aligns with a previous research which demonstrated that the size of a herniated disc occupying the spinal canal does not influence the effectiveness or type of treatment (24). Additionally, larger disc diameters have been associated with reduced disability levels, although they do not affect pain intensity following the removal of any portion of the disc (3).

Takatalo et al. (43) reported a connection between obesity, lumbar degenerative disc disease, and sciatica. However, the findings of our review do not support this association. Among the 6 studies that examined body mass index (BMI), 3 of them, which included participants who were overweight and obese, did not report any radicular pain.

Komori et al. (44) and Henmi et al. (45) reported that the more the herniated nucleus pulposus migrated, the greater the subsequent decrease in size that could be observed. This may be due to the larger disc fragments having more water content, especially in patients younger than 40 years old. This phenomenon may be related to dehydration and/or shrinkage, retraction, and inflammation-led resorption of the herniated discs (13,46).

In a review study by Hu et al who reported that percent of L4/L5 lumbar disc herniation was the highest and was twice that of L5/S1. In addition, 65.6% of the cases had low back pain, 87.5% had radicular pain and 59.4% had both types (14). The current review found higher percentages; 91% for radicular pain, 95.7% for low back pain, and 91% for both.

Several studies (44,47-51) found that lumbar disc herniation and its associated pain decrease over time coincidently. The current study found no enough evidence to support that.

The present review agrees with Kvistad et al. (52) who demonstrated that disc degeneration and herniation rarely explain symptoms or influence treatment, so imaging is not indicated unless in cases of serious pathology and failed conservative treatment for up to 1.5 months. Moreover, radiologically-detected findings did not predict surgery success (53). Furthermore, Hong et al. (54) found that patients whose disc herniation does not improve radiologically can also show improvement of symptoms.

Due to lack of previous systematic reviews demonstrating the relation between disc size and pain, no study was found to be compared with our findings.

Blamoutier et al, showed that that outcomes of surgery depend on the relation between symptoms and radiological findings (6) which cannot be supported in this review. This review may suggest and support that treatment of disc herniation should be conservative in the first 1.5 months and imaging and surgery should be limited to those who failed conservative treatment (still had severe neurological deficits and pain) (13,46)

This review has some positive points that lead to its strength; the included studies have consistent outcomes and their measuring tools (especially disc size). It included 2400 participants, a relatively large sample size.

There are several potential limitations in the studies included in this analysis that could have affected the results. Almost all studies did not design blinding of the participants and/or outcome assessor which might increase bias. The included participants were variable among studies in age, BMI, location and type of lesion, duration of illness, interventions (in the clinical studies), and sample size. This might affect conclusion of this review as male, age, and obesity may affect disc lesion and pain (55-57).

CONCLUSION

Based on this review, we cannot conclude that size of disc affects pain severity. This may underestimate the importance of imaging and the need for surgery in majority of cases. However, additional high-quality evidence is needed to confirm that findings.

FUNDING:- This research article is partially funded by Zarqa University, Zarqa. Jordan.

REFERENCES;-

1 Dydyk AM, Ngnitewe Massa R, Mesfin FB. Disc Herniation. 2023 Jan 16. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan–. PMID: 28722852.

2 Munakomi S, Foris LA, Varacallo M. Spinal stenosis and neurogenic claudication. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021. Cited: PMID: 28613622

3 En'Wezoh DC, Leonard DA, Schoenfeld AJ, Harris MB, Zampini JM, Bono CM. Relationship between size of disc and early postoperative outcomes after lumbar discectomy. Arch Orthop Trauma Surg (2017) 137:805–811 DOI 10.1007/s00402-017-2699-6

4 Tunset A, Kjaer P, Chreiteh SS and Jensen TS. A method for quantitative measurement of lumbar intervertebral disc structures: an intra- and inter-rater agreement and reliability study. Chiropractic & Manual Therapies 2013, 21:26 http://www.chiromt.com/content/21/1/26

5 Vroomen PC, de Krom MC, Knottnerus JA. Consistency of history taking and physical examination in patients with suspected lumbar nerve root involvement. *Spine (Phila Pa 1976)* 2000;25:91–6.

6 Blamoutier A. Surgical discectomy for lumbar disc herniation: surgical techniques. Orthop Traumatol Surg Res. 2013 Feb;99(1 Suppl):S187-96. doi: 10.1016/j.otsr.2012.11.005. Epub 2013 Jan 24. PMID: 23352565.

7 Murad MH, Sultan S, Haffar S, Bazerbachi F. Methodological quality and synthesis of case series and case reports. BMJ Evid Based Med. 2018 Apr;23(2):60-63. doi: 10.1136/bmjebm-2017-110853. Epub 2018 Feb 2. PMID: 29420178; PMCID: PMC6234235.

8 Zeng X, Zhang Y, Kwong JS, Zhang C, Li S, Sun F, Niu Y, Du L. The methodological quality assessment tools for preclinical and clinical studies, systematic review and meta-analysis, and clinical practice guideline: a systematic review. J Evid Based Med. 2015 Feb;8(1):2-10. doi: 10.1111/jebm.12141. PMID: 25594108.

9 Ferreira, G. F., Stefani, K. C., Haje, D. D. P., & Nogueira, M. P. (2018). The Ponseti method in children with clubfoot after walking age–Systematic review and metanalysis of observational studies. *PloS one*, *13*(11), e0207153.

10 Sobeeh, M. G., Hassan, K. A., da Silva, A. G., Youssef, E. F., Fayaz, N. A., & Mohammed, M. M. (2023). Pain mechanisms in complex regional pain syndrome: a systematic review and meta-analysis of quantitative sensory testing outcomes. *Journal of Orthopaedic Surgery and Research*, *18*(1), 2.

11 Hefny, A., Ahmed, G., Mansour, W., Ibrahim, A., & Elsherif, A. (2023). Effect of Virtual Reality on Neural Recovery in Patients with Stroke: A Systematic Review. *NILES journal for Geriatric and Gerontology*, *6*(2), 477-486. doi: 10.21608/niles.2023.212022.1076

12 Abdallah, A.A.E., Abdelkader, W.H., Karkousha, R.N., El Azizi, H.M. Prone versus supine traction in treatment of cervical disc bulge: A randomized controlled trial | Naciąganie podczas leżenia na brzuchu a na plecach w leczeniu wypukliny krążka szyjnego: Randomizowane badanie kontrolowane. Fizjoterapia Polska, 20(3): 158–163.

13 Chang CW et al. Spontaneous regression of lumbar herniated disc. J Chin Med Assoc. 2009; 72(12): 650-3.

14 Hu C, Lin B, Li Z, Chen X, Gao K. Spontaneous regression of a large sequestered lumbar disc herniation: a case report and literature review. J Int Med Res. 2021 Nov;49(11):3000605211058987. doi: 10.1177/03000605211058987. PMID: 34812080; PMCID: PMC8649452.

15 Choi E, Gil HY, Ju J, Han WK, Nahm FS, Lee PB. Effect of Nonsurgical Spinal Decompression on Intensity of Pain and Herniated Disc Volume in Subacute Lumbar Herniated Disc. Int J Clin Pract. 2022 Sep 19;2022:6343837. doi: 10.1155/2022/6343837. PMID: 36263240; PMCID: PMC9553669.

16 Szulc P, Wendt M, Waszak M, Tomczak M, Cieślik K, Trzaska T. Impact of McKenzie Method Therapy Enriched by Muscular Energy Techniques on Subjective and Objective Parameters Related to Spine Function in Patients with Chronic Low Back Pain. Med Sci Monit. 2015 Sep 29;21:2918-32. doi: 10.12659/MSM.894261. PMID: 26418868; PMCID: PMC4596425.

17 Reddy U, Agrawal A, Hegde K, et al. Spontaneously disappearing large herniated lumbar disc fragment. J Orthop Allied Sci 2014; 2: 26–28.

18 Kim KD and Kim ES. Unknown case: part 2. Spontaneous regression of herniated disc. Spine (Phila Pa 1976) 2013; 38: 368.

19 Ahn SH, Park HW, ByunWM, Ahn MW, Bae JH, Jang SH, et al. Comparison of clinical outcomes and natural morphologic changes between sequestered and large central extruded disc herniations. Yonsei Medical Journal 2002;43:283–90.

20 Gezici AR, Ergun R. Spontaneous regression of a huge subligamentous extruded disc herniation: short report of an illustrative case. Acta Neurochirurgica 2009;151:1299–300.

21 Singh P, Singh AP. Spontaneous resorption of extruded lumber disc fragment. Neurology India 1999;47:338–9.

22 Takada E, Takahashi M, Shimada K. Natural history of lumbar disc hernia with radicular leg pain: spontaneous MRI changes of the herniated mass and correlation with clinical outcome. Journal of Orthopaedic Surgery (Hong Kong) 2001;9:1–7.

23 Tarukado K, Ikuta K, Fukutoku Y, et al., Spontaneous regression of posterior epidural migrated lumbar disc fragments: case series, Spine J. 15 (6) (2015) e57–e62

24 Gupta A, Upadhyaya S, Yeung CM, Ostergaard PJ, Fogel HA, Cha T , Schwab J, Bono C, and Hershman S. Does Size Matter? An Analysis of the Effect of Lumbar Disc Herniation Size on the Success of Nonoperative Treatment. Global Spine Journal 2020, Vol. 10(7) 881-887 DOI: 10.1177/219256821988082.

25 Jensen, R.K., Kent, P., Jensen, T.S. *et al.* The association between subgroups of MRI findings identified with latent class analysis and low back pain in 40-year-old Danes. *BMC Musculoskelet Disord* **19**, 62 (2018). https://doi.org/10.1186/s12891-018-1978-x

26 Vagaska E, Litavcova A, Srotova I, Vlckova E, Kerkovsky M, Jarkovsky J, Bednarik J, Adamova B. Do lumbar magnetic resonance imaging changes predict neuropathic pain in patients with chronic non-specific low back pain? Medicine (Baltimore). 2019 Apr;98(17):e15377. doi: 10.1097/MD.0000000000015377. PMID: 31027128; PMCID: PMC6831323.

27 Jensen OK, Nielsen CV, Stengaard-Pedersen K. Diffuse central sensitization in low back patients: A secondary analysis of cross-sectional data including tender point examination and magnetic resonance imaging of the lumbar spine. Medicine (Baltimore). 2020 Sep 18;99(38):e22198. doi: 10.1097/MD.0000000000022198. PMID: 32957350; PMCID: PMC7505388.

28 Jensen, O. K., Nielsen, C. V., Sørensen, J. S., & Stengaard-Pedersen, K. (2015). Back pain was less explained than leg pain: a cross-sectional study using magnetic resonance imaging in low back pain patients with and without radiculopathy. *BMC musculoskeletal disorders*, *16*, 1-15.

29 Gao K, Cao Y, Wu Y, Yu W, Liu W, Sun S. Cervical cord compression with lower limb sensory disturbance: three case reports and a literature review. J Int Med Res. 2023 Jun;51(6):3000605231178414. doi: 10.1177/03000605231178414. PMID: 37350249; PMCID: PMC10291409.

30 Wang CA, Zhao HF, Ju J, Kong L, Sun CJ, Zheng YK, Zhang F, Hou GJ, Guo CC, Cao SN, Wang DD, Shi B. Reabsorption of intervertebral disc prolapse after conservative treatment with traditional Chinese medicine: A case report. World J Clin Cases. 2023 Apr 6;11(10):2308-2314. doi: 10.12998/wjcc.v11.i10.2308. PMID: 37122521; PMCID: PMC10131025.

31 Singh R, Kumar P, Wadhwani J, Yadav RK, Kaur S, Singh HD. Do lumbar intervertebral disc parameters in patients with chronic low back pain differ quantitatively from healthy individuals? A comparative study. Journal of Orthopaedics, Trauma and Rehabilitation. 2023;0(0). doi:10.1177/22104917231161835.

32 Mariajoseph FP, Castle-Kirszbaum M, Kam J, Rogers M, Sher R, Daly C, Roadley J, Risbey P, Fryer K, Goldschlager T. Relationship between herniated intervertebral disc fragment weight and pain in lumbar microdiscectomy patients. Journal of Clinical Neuroscience, 102, 2022: 75-79. ISSN 0967-5868, https://doi.org/10.1016/j.jocn.2022.06.012

33 Dunsmuir RA, Nisar S, Cruickshank JA, Loughenbury PR. No correlation identified between the proportional size of a prolapsed intravertebral disc with disability or leg pain. Bone Joint J. 2022 Jun;104-B(6):715-720. doi: 10.1302/0301-620X.104B6.BJJ-2021-1725.R2. PMID: 35638217.

34 Huang, Z., Bai, Z., Yan, J., Zhang, Y., Li, S., Yuan, L., ... & Ye, W. (2022). Association between muscle morphology changes, cervical spine degeneration, and clinical features in patients with chronic nonspecific neck pain: a magnetic resonance imaging analysis. *World Neurosurgery*, *159*, e273-e284.

35 Eltes, P. E., Kiss, L., Bereczki, F., Szoverfi, Z., Techens, C., Jakab, G., ... & Lazary, A. (2021). A novel three-dimensional volumetric method to measure indirect decompression after percutaneous cement discoplasty. *Journal of orthopaedic translation*, *28*, 131-139.

36 Negro, A., Paolucci, A., Russo, C., Di Stasi, M., Guerriero, P., Arrigoni, F., ... & Caranci, F. (2020). Predictive factors of volumetric reduction in lumbar disc herniation treated by O2-O3 chemiodiscolysis. *Acta Bio Medica: Atenei Parmensis*, *91*(Suppl 8), 89.

37 Kesikburun, B., Eksioglu, E., Turan, A., Adiguzel, E., Kesikburun, S., & Cakci, A. (2019). Spontaneous regression of extruded lumbar disc herniation: Correlation with clinical outcome. *Pakistan journal of medical sciences*, *35*(4), 974.

38 Corniola, M. V., Stienen, M. N., Joswig, H., Smoll, N. R., Schaller, K., Hildebrandt, G., & Gautschi, O. P. (2016). Correlation of pain, functional impairment, and health-related quality of life with radiological grading scales of lumbar degenerative disc disease. *Acta neurochirurgica*, *158*, 499-505.

39 Zhang, W., Guo, W., Zhao, P., Zhou, W., Wei, J., Li, X. D., & Liu, L. (2013). Therapeutic effects of Chinese osteopathy in patients with lumbar disc herniation. *The American Journal of Chinese Medicine*, *41*(05), 983-994.

40 Bajpai, J., Saini, S., Singh, R. Clinical correlation of magnetic resonance imaging with symptom complex in prolapsed intervertebral disc disease: A cross-sectional double blind analysis. Journal of Craniovertebral Junction and Spine, 4(1), pp. 16–20, 2013

41 Hegarty, D., O'Connor, O.J., Moore, M., O'Regan, K.N., Shorten, G. and Maher, M.M. (2011), Association between preoperative magnetic resonance imaging, pain intensity and quantitative sensory testing in patients awaiting lumbar diskectomy. Journal of Medical Imaging and Radiation Oncology, 55: 4-10. https://doi.org/10.1111/j.1754-9485.2010.02222.x

42 Voorhies, R. M., Jiang, X., & Thomas, N. (2007). Predicting outcome in the surgical treatment of lumbar radiculopathy using the Pain Drawing Score, McGill Short Form Pain Questionnaire, and risk factors including psychosocial issues and axial joint pain. *The Spine Journal*, *7*(5), 516-524.

43 Takatalo, J.; Karppinen, J.; Taimela, S.; Niinimaki, J.; Laitinen, J.; Sequeiros, R.B.; Samartzis, D.; Korpelainen, R.; Nayha, S.; Remes, J.; et al. Association of abdominal obesity with lumbar disc degeneration—A magnetic resonance imaging study. PLoS ONE **2013**, 8, e56244

44 Komori H, Shinomiya K, Nakai O, et al. The natural history of herniated nucleus pulposus with radiculopathy. Spine (Phila Pa 1976) 1996; 21: 225–229.

45 Henmi T, Sairyo K, Nakano S, Kanematsu Y, Kajikawa T, Katoh S, et al. Natural history of extruded lumbar intervertebral disc herniation. Journal of Medical Investigation: JMI 2002;49:40–3. [29] Teplick JG, Haskin ME. Spontaneous regression of herniated nucleus pulposus. AJR American Journal of Roentgenology 1985;145:371–5

46 Weinstein JN, Lurie JD, Tosteson TD, Skinner JS, Hanscom B, Tosteson AN, et al. Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT) observational cohort. JAMA: The Journal of the American Medical Association 2006;296:2451–9.

47 Autio RA, Karppinen J, Kurunlahti M, Kyllönen E, Vanharanta H, Tervonen O. Gadolinium diethylenetriaminepentaacetic acid enhancement in magnetic resonance imaging in relation to

symptoms and signs among sciatic patients: a cross-sectional study. Spine (Phila Pa 1976). 2002 Jul 1;27(13):1433-7. doi: 10.1097/00007632-200207010-00012. PMID: 12131742.

48 Macki M, Hernandez-Hermann M, Bydon M, et al. Spontaneous regression of sequestrated lumbar disc herniations: Literature review. Clin Neurol Neurosurg 2014; 120: 136–141.

49 Cunha C, Silva AJ, Pereira P, Vaz R, Goncalves RM, and Barbosa MA, "The inflammatory response in the regression of lumbar disc herniation," *Arthritis Research & 5erapy*, vol. 20, no. 1, p. 251, 2018.

50 Wang YAO, Dai G, Jiang L, and Liao S, "The incidence of regression after the non-surgical treatment of symptomatic lumbar disc herniation: a systematic review and meta-analysis," *BMC Musculoskeletal Disorders*, vol. 21, 2020.

51 Sucuo˘glu H and Barut AY, "Clinical and radiological follow- up results of patients with sequestered lumbar disc herniation: a prospective cohort study," *Medical Principles and Practice*, vol. 30, 2021.

52 Kvistad KA, Espeland A. Bildediagnostikk ved nakke- og ryggsmerter [Diagnostic imaging in neck and low back pain]. Tidsskr Nor Laegeforen. 2010 Nov 18;130(22):2256-9. Norwegian. doi: 10.4045/tidsskr.09.1032. PMID: 21109849.

53 Peolsson A, Peolsson M. Predictive factors for long-term outcome of anterior cervical decompression and fusion: a multivariate data analysis. Eur Spine J. 2008 Mar;17(3):406-414. doi: 10.1007/s00586-007-0560-2. Epub 2007 Dec 13. PMID: 18084782; PMCID: PMC2270379.

54 Hong, S. J., Kim, D. Y., Kim, H., Kim, S., Shin, K. M., & Kang, S. S. (2016). Resorption of massive lumbar disc herniation on MRI treated with epidural steroid injection: a retrospective study of 28 cases. *Pain Physician*, *19*(6), 381-388.

55 Teraguchi, M.; Yoshimura, N.; Hashizume, H.; Muraki, S.; Yamada, H.; Minamide, A.; Oka, H.; Ishimoto, Y.; Nagata, K.; Kagotani, R.; et al. Prevalence and distribution of intervertebral disc degeneration over the entire spine in a population-based cohort: The Wakayama Spine Study. Osteoarthr. Cartil. **2014**, 22, 104–110. [CrossRef] [PubMed]

56 Onyemaechi, N.O.; Anyanwu, G.E.; Obikili, E.N.; Onwuasoigwe, O.; Nwankwo, O.E. Impact of overweight and obesity on the musculoskeletal system using lumbosacral angles. Patient Preference Adher. **2016**, 10, 291–296. [CrossRef] [PubMed]

57 Sheng B, Feng C, Zhang D, Spitler H and Shi L. Associations between Obesity and Spinal Diseases: A Medical Expenditure Panel Study Analysis. Int. J. Environ. Res. Public Health 2017, 14, 183; doi:10.3390/ijerph14020183 www.mdpi.com/journal/ijerph