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Prevailing treatment methods for lumbar spondylolysis

A systematic review

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Abstract

Background: Aim of this study was to systematically review the prevailing treatment methods for lumbar spondylolysis.

Methods: Manuscripts published between 1951 and 2020 were searched by using PubMed, Medline, Scopus, Springer, Web of Science databases. The study protocol was registered with PROSPERO (CRD42020218651). The inclusion criteria for all articles of prevailing treatment methods for spondylolysis were:

1. English language;
2. at least 1 relevant treatment method for spondylolysis;
3. Randomized controlled trial (RCT), systematic review, comparative study, cross-sectional, cohort, and/or case control study
4. pre-diagnosed cases of spondylolysis whereas article was excluded if
5. any spinal deformity
6. any neurological condition.

Standards have been independently applied by using 2 reviewers and another author resolved disagreements.

Results: Data extraction screened 12 full-length articles. Description, treatment, outcome, and findings were individually extracted and cross-referenced.

Discussion: Current review has suggested that the noninvasive treatment method specifically low intensity pulsed ultrasound, electro acupuncture and pulsed electromagnetic filed is effective for bone union while operative treatment specifically pedicle screw fixation +/- interbody fusion depending the extent of disk degeneration and craniocaudal foraminal stenosis is effective for minimizing pain and functional disability in patients with spondylolysis. This review concluded that the noninvasive treatment method specifically low intensity pulsed ultrasound is effective for bone union.

Review Registration: PROSPERO (CRD42020218651).

Abbreviation: RCT = randomized controlled trial.

Keywords: lumbar vertebra, spondylolysis, systematic review, treatments

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This systematic review was a part of PhD Physical Therapy project. After approval from the Institutional Review Board (IRB-UOLFAHS/690/2020, Dated: 22-01-2020) of the University of Lahore, this review was registered in the PROSPERO (CRD42020218651).

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1. Introduction

Lumbar instability is the major risk factor for low back pain[1] which constitutes almost 50% of the total low back pain cases all around the globe.[2] It can be defined as increased mobility in the specific motion segment.[3] Spondylolysis is one of the common cause and risk factor of lumbar instability. It is the stress fracture of the pars inter-articularis affecting lower lumber vertebras.[4] It is prevalent in 6% to 11.5% of general population[5] while 7% to 8% in young athletes[6] out of which 27% to 37% are asymptomatic.[7] Symptomatic spondylolysis patients mostly complain of mechanical low back pain, which often worsen during activity.[8] Lumbar hyperextension with rotation is the common mechanism of spondylolysis which is commonly seen[9] in footballers, weight lifters, and gymnasts.[6] It is the precipitating factor for spondylolisthesis[10] and based on the plain radiography it can be classified as early, progressive and terminal stages. Early stage is defined as hairline fracture of the pars interarticularis, progressive stage as a significant fracture gap while terminal stage as bony sclerosis leading towards non-union.[11] Plain radiography helps in the diagnosis of spondylolysis although its guidelines are still elusive.[12]

Prevailing treatment methods include noninvasive and operative for lumbar spondylolysis. Noninvasive treatment includes activity cessation, bracing, lumbar flexion exercises, core stabilization exercises for hip flexors, hamstrings, lower abdominals and lumbar muscles, low impact-aerobic exercises that is, walking, swimming, cycling, weight reduction and low-intensity pulsed ultrasound treatment.[13]

Patient age, acuity of symptoms, presence of neurologic injury or pain, radiographic evidence of stress reaction/edema, location (unilateral vs bilateral), presence of neuroforaminal stenosis, spondylolisthesis, and dynamic instability are all important surgical considerations. The most effective operative treatment is the pedicle screw fixation +/- interbody fusion depending the extent of disk degeneration and craniocaudal foraminal stenosis.[14,15]

Previously, there was very limited literature available which systematically reviewed the prevailing treatment methods for lumbar spondylolysis. Therefore, aim of this study was to systematically review the recent prevailing treatment methods for lumbar spondylolysis.

2. Methods

2.1. Literature search

This study conforms to all Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and reports the required information accordingly (see Supplementary Checklist). The protocol was registered in the PROSPERO database in December 2020 (CRD42020218651). Patients or public partners were not involved in the design, conduct or interpretation of this systematic review.

Manuscripts published between 1951 and 2020 were searched by using PubMed, Medline, Scopus, Springer, Web of Science databases by using Medical Subject Heading (MeSH) terms (spondylolysis OR spondylolyses OR stress fracture OR stress fractures) AND (treatments OR disease management). A list of references was additionally checked to retrieve relevant manuscripts. Additionally, literature that is, abstracts presented at conferences, textbooks, internet records, and so on were searched. Flow diagram of study selection is shown in (Fig. 1).

2.2. Eligibility criteria

The inclusion criteria for all articles of prevailing treatment methods for spondylolysis were:

1. English language;
2. at least 1 relevant treatment method for spondylolysis;
3. RCT, systematic review, comparative, cross-sectional, cohort, and/or case control studies
4. pre-diagnosed cases of spondylolysis.

Articles was excluded if

1. any spinal deformity
2. any neurological condition.

2.3. Data extraction

Two review authors independently extracted data description, treatment, outcome, findings and then cross-referenced. Primary outcome was self-rated pain levels. Secondary outcomes were bone union rate, range of motion, self-rated recovery status, return to work.

2.4. Quality assessment

Standards have been independently applied by using 2 reviewers. Another author resolved disagreements. Two review authors independently assessed the risk of bias using the Cochrane risk of bias tool.

3. Results

Data extracted through PubMed, Medline, Scopus, Springer, Web of Science databases yielded 12 eligible articles. Out of these 12 full length articles, 4 were comparative studies,[16,17,18,19] 1 was a cohort study,[15] 1 was an RCT,[23] 1 was a systematic review[24] and 5 were case-control studies.[20,21,22,25,26] One study had compared operative treatment with physical therapy.[16] Another study had compared brace with activity restriction.[18] Exercise protocols were compared in 2 articles.[17,19] Healing modalities were compared with PT in 4 studies[20,21,23,24] whereas remaining 4 studies had compared surgery with a placebo control group.[22,25,15,26] The descriptive data has been shown in the (Table 1).

Four studies had discussed the importance of operative interventions among which 1 had also compared operative with noninvasive treatment method.[16] The results of these studies had reported that bone union rate was more significant in non-invasive as compared to operative treatment method. The remaining 8 studies had described the noninvasive treatment methods, among which 4 had shown the improvement in self-rated recovery status, return to work, self-rated pain levels and lumbar segmental range of motion[16,17,18,19] while the other 4 were about the interventional effects of low-intensity pulsed ultrasound, low level laser therapy, electro acupuncture pulsed and electromagnetic field (Table 3).[20,21,23,24] Operative treatment methods showed more improvement in pain and functional disability with fusion as compared to strength training.[22,25,15,26] The prevailing noninvasive interventions had compared flexion and extension exercises and showed significant improvement in self-rated recovery, pain and return to work in the flexion-exercise group.[17,19] Previous studies proved that low intensity pulsed ultrasound, electro acupuncture and pulsed electromagnetic filed

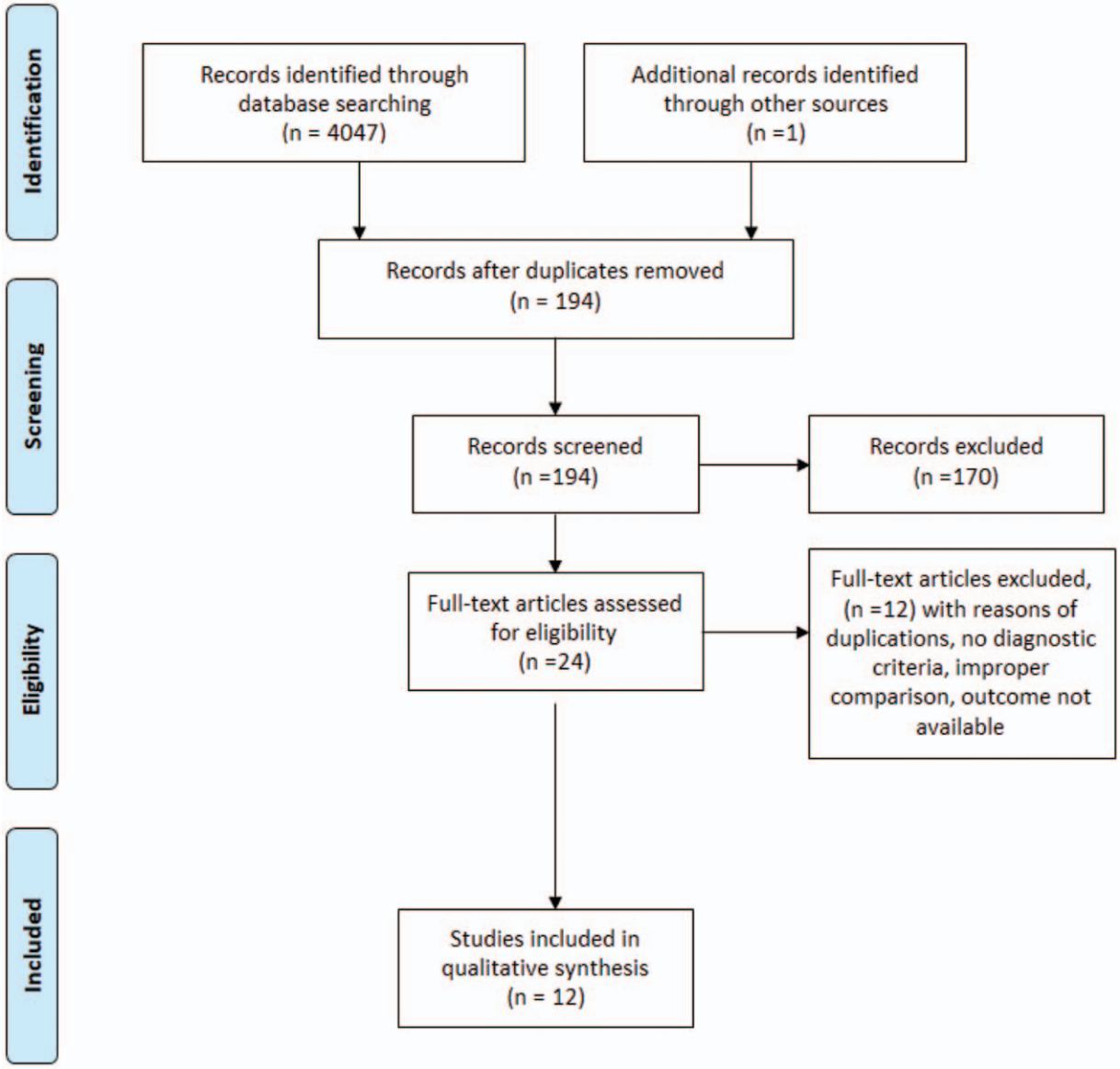

Figure 1. PRISMA Flow Diagram.

method was effective in bone union.[20,21,23,24] Operative and non-invasive prevailing treatment methods are shown in (Table 2) and (Table 3) respectively.

4. Discussion

Previous studies had reviewed only the selective treatment aspects of lumbar spondylolysis but present study has discussed all the possible available treatment methods. Current review has suggested that the noninvasive treatment method specifically low intensity pulsed ultrasound is effective for bone union while operative treatment specifically pedicle screw fixation +/- interbody fusion depending the extent of disk degeneration and craniocaudal foraminal stenosis is effective for minimizing pain and functional disability in patients with spondylolysis. Few studies have shown different effects of flexion and extension exercises in self-rated recovery status, return to work, self-rated pain levels and lumbar segmental range of motion but showed no significant difference between them.[17,19]

Previous studies used bracing along with exercise in adolescents. Blanda et al used LSO brace along with routine physical therapy and activity restriction and had high percentage (84%) in return to function.[27] Lumbar hyperextension with rotation is the common risk factor[28] for developing and aggravating spondylolysis.[29] It has been reported in some cases that extension exercise along with bracing is effective in minimizing pain and functional disability.[30] The deep extensor muscles provide compression and ultimately protection to the motion segment.[31] Thus, strengthening of lumbar muscles is important in providing stability to the lumbar spine in patients with spondylolysis and could be achieved through functional training programs.[32]

Previous reviews reported interventional effects of low-intensity pulsed ultrasound on rate of bone union[33] and showed no significant effect of low-intensity pulsed ultrasound while our review showed 82.9% and 66.7% respectively.[20,21]

Table 1

Description of included studies.

Eligible studies	Study design	Patients/demographics age in years (Mean ± SD or Range)	Training type
Seitsalo et al[16]	Comparative study	227 adolescents, age 14–19 (113 F, 114 M)	PT versus surgery
Sinaki et al[17]	Comparative study	44 adults, age 44.5 ± 14.5 (flexion only), 44.3 ± 15.7 (flexion + extension) (26 F, 18 M)	Flexion exercises versus flexion and extension exercises
Anderson et al[18]	Comparative study	34 adolescent, age 15–17 (10 F, 24 M)	Brace versus placebo
Gramse et al[19]	Comparative study	47 adults (age and gender not reported)	Flexion exercises versus flexion and extension exercises
Tsukada et al[20]	Case–control study	82 adolescents, age 14–18 (2 F, 80 M)	N/A
Arima et al[21]	Case–control study	13 adolescents, age 15–19	N/A
Tian et al[22]	Case–control study	23 adolescents (students, manual workers, athletes, office workers), age 14–35 (5 F, 18 M)	N/A
Zhang et al[25]	Case–control study	33 adolescents (army officers)	N/A
Linhares et al[15]	Cohort study	22 adolescents, age 14–47, (11 F, 11 M)	N/A
Negm et al[26]	Case–control study	9 adolescents, age 16–32	N/A
Awad et al[23]	RCT	50 adolescents, age 25–35	Electro acupuncture versus LLLT
Peng et al[24]	Systematic review	N/A	PT versus PEMF

LLLT = low level laser therapy, N/A = not applicable, PEMF = pulsed electromagnetic field, PT = physical therapy.

Table 2

Noninvasive treatments.

Article	Treatment	Outcome	Findings	Standardized mean difference
Seitsalo et al[16]	PT versus surgery	Segmental range of lumbar motion	Significant increase in segmental range of lumbar motion ($P < .05$) pre- versus post intervention	Flexion Group: 5.1 ± 6.3 (initial); 10.4 ± 1.8 (final) Extension Group: 8.4 ± 5.1 (initial); 11.1 ± 4.4 (final)
Sinaki et al[17]	Flexion exercises versus Extension exercises	Self-rated recovery status, return to work, Self-rated pain levels,	Significant increase self-rated recovery status, return to work and decrease in self-rated pain levels ($P < .05$) flexion- versus extension exercise	Flexion group: Moderate/severe pain rating: 19% at 3 yr Limited/unable to work: 24% at 3 yr Recovery: 58% at 3 mo, 62% at 3 yr Extension group: Moderate/severe pain rating: 67% at 3 yr Limited/unable to work: 61% at 3 yr Recovery: 0% at 3 yr
Anderson et al[18]	Bracing: Thoracolumbosacral brace (immediate bracing) Restricted: Activity restriction for 3 or more months, then braced (delayed bracing)	SPECT imaging	Patients treated with activity restrictions and having symptoms >3 mo before bracing had less improvement in defect healing as seen in SPECT imaging versus those braced before 3 mo ($P < .05$)	Bracing: SPECT ratio decrease of 16% Restricted: SPECT ratio decrease of 8%
Gramse et al[19]	Flexion exercises versus Extension: Extension exercises	Self-rated recovery status, return to work, self-rated pain levels,	Significant increase self-rated recovery status, return to work and decrease in self-rated pain levels ($P < .05$) flexion- versus extension exercise	Flexion group: Moderate/severe pain rating: 27% at 3-month follow-up Limited/unable to work: 32% at 3-mo follow-up Self-rated recovery: 61% "recovered" at 3-mo follow-up Extension group: Moderate/severe pain rating: 67% at 3-mo follow-up Limited/unable to work: 61% at 3-mo follow-up Self-rated recovery: 6% "recovered" at 3-mo follow-up
Tsukada et al[20]	Low-intensity pulsed ultrasound	Bone union rate	Significant improvement ($P < .05$) in bone union rate LIPUS versus Control	LIPUS Group: 82.9% CG: 25.5%
Arima et al[21]	Low-intensity pulsed ultrasound	Bone union rate	Significant improvement ($P < .05$) in bone union rate LIPUS versus Control	LIPUS Group: 66.7% CG: 10.0%
Awad et al[23]	Electro acupuncture versus low level laser therapy	Visual analogue scale Oswestry disability index	Significant decrease ($P = .001$) in low back pain intensity and functional disability in both groups.	Electro acupuncture Group: Pain intensity 8.0 ± 1.4 (initial); 3.8 ± 1.7 (final) ODI: 50.4 ± 6.3 (initial); 27.3 ± 6.8 (final) Low level laser therapy Group: Pain intensity 7.9 ± 1.2 (initial); 5.7 ± 1.0 (final) ODI: 50.1 ± 8.6 (initial); 36.3 ± 6.7 (final)
Peng et al[24]	PT versus PEMF	Bone union rate	Significant improvement ($P < .05$) in bone union rate PEMF versus Control	PEMF Group: 79.9% CG: 64.3%

LIPUS = low-intensity pulsed ultrasound, N/A = not applicable, PEMF = pulsed electromagnetic field, PT = physical therapy, SPECT = single-photon emission computerized tomography.

Table 3

Operative treatments.

Article	Treatment	Outcome	Findings	Standardized mean difference
Tian et al[22]	Computer-assisted minimally invasive spine surgery (CAMISS) technique-buck technique	Oswestry disability index visual analogue scale scores	Significant improvement in pain and functional disability ($P < .05$), pre versus post	Pain intensity 5.5 ± 1.3 (initial); 0.7 ± 1.2 (final) ODI: 55.5 ± 16.3 (initial); 10.6 ± 6.9 (final)
Zhang et al[25]	Wiltse approach pedicle screw-laminar hook internal fixation combined with autologous ilium transplantation	Visual analogue scale (VAS) Oswestry dysfunction index (ODI)	Significant improvement in pain and functional disability ($P < .05$), pre versus post	Pain intensity 5.8 ± 0.7 (initial); 0.4 ± 0.5 (final) ODI: 41.2 ± 5.8 (initial); 9.5 ± 2.6 (final)
Linhares et al[15]	V-rod technique	Oswestry disability index visual analogue scale scores	Significant improvement in pain and functional disability ($P < .05$), pre versus post	Pain intensity 8.0 ± 1.0 (initial); 3.1 ± 2.9 (final) ODI: 43.5 ± 21.0 (initial); 20.9 ± 22.1 (final)
Negm et al[26]	Pedicle screw hook system	Oswestry disability index visual analogue scale scores	Significant improvement in pain and functional disability ($P < .05$), pre versus post	Pain intensity 7.2.0 ± 1.0 (initial); 4.2 ± 3.9 (final) ODI: 41.5 ± 6.7 (initial); 21.9 ± 2.1 (final)

ODI = oswestry disability index.

A 2013 systematic review reported that 4 RCTs found surgical intervention to be more successful than noninvasive treatment for managing pain and functional disability, while 1 RCT found no difference in future low back pain outcomes.[34,35,36] while our review also showed improvement in pain and functional disability.

5. Conclusion

This review concluded that the non-invasive treatment method specifically low intensity pulsed ultrasound, electro acupuncture and pulsed electromagnetic filed is effective for bone union. Small sample size and the lack of blinding are potential confounders while heterogeneity of studies and poorly defined study outcomes are the limitations of this review. Moreover, bilateral lytic defects would be very important to document in further studies.

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