DOI: https://doi.org/10.47391/JPMA.3320

Role of low-intensity pulsed ultrasound on lumbar spondylolysis: a systematic review

Fahad Tanveer[1], Syed Asadullah Arslan[2], Haider Darain[3], Ashfaq Ahmad[4], Syed Amir Gilani[5], Asif Hanif[6]

1,2,4 University Institute of Physical Therapy, University of Lahore, Lahore, Pakistan; **3** Institute of Physical Medicine & Rehabilitation, Khyber Medical University, Peshawar, Pakistan; **5** University Institute of Radiological Sciences, University of Lahore, Lahore, Pakistan; **6** University Institute of Public Health, University of Lahore, Lahore, Pakistan.

Correspondence: Fahad Tanveer. **Email**: fahadtanveer3.pt@gmail.com

Abstract

Objective: To systematically review the role of low-intensity pulsed ultrasound on lumbar spondylolysis.

Method: Literature search was conducted on PubMed, Embase, CINAHL, Web of Science, PEDro and Scopus databases to identify relevant studies published between 2010 and 2020 by using medical subject headings and applying Booleans, such as low-intensity pulsed ultrasound OR interventional ultrasound AND lumbar spine OR lumbar region AND spondylolysis OR stress fracture. Unpublished studies were hand-searched in the journals, abstracts of conferences were reviewed, and citation index was used for searching experts in the field and then contacting them for information. Studies included were the ones that had at least one of the following outcomes: bone union rate, treatment period to bone union and time to return to previous activities.

Results: Of the 243 studies identified, 228(94%) were full text articles and only 2(0.8%) studies were critically appraised for qualitative synthesis based on bone union rate, treatment period to bone union, and time to return to previous activities.

Conclusion: Low-intensity pulsed ultrasound was found to be effective for bone union and a useful therapy for quick return to playing sports in patients with lumbar spondylolysis.

Key Words: Lumbar region, Spondylolysis, Interventional ultrasound, Systematic review.

Introduction

Low-back pain (LBP) has emerged as an expensive health problem in many countries.[1] Lumbar spondylolysis, which is the defect or abnormality of the pars interarticularis and a common LBP cause[2], mostly occurs in males bilaterally at the fifth lumbar vertebra[3]. It has a prevalence of 5% in children age <7 years and 6% in adults[4] and is classified as developmental, dysplastic, traumatic (acute and chronic) and pathologic.[5]

Chronic traumatic spondylolysis is associated with stress fracture or spondylolytic defect of the pars interarticularis which occurs as a result of repetitive movements during extension and rotation of the lumbar spine.[6] Mostly, patients present with pain, joint limitation, muscle spasm, sacral flattening and waddling gait pattern.[7] In severe cases, tightness of hamstring and iliopsos may also occur along with posterior pelvic tilt.[8] During examination, pain is reproduced on performing the single-leg hyperextension test.[9] According to the computed tomography (CT) findings, it is classified as early, progressive and terminal.[10] Early-stage spondylolysis refers to the stress fracture in which bone union can be achieved conservatively. However, in progressive and terminal stages, spondylolytic defect occurs in which bone union is delayed and cannot be obtained through conservative interventions, such as hard or soft braces.[11] If this condition remained untreated, it can progress to spondylolisthesis.[12]

Early diagnosis and treatment is the key to complete bone union through conservative interventions, such as activity restriction and usage of thoraolumbosacral brace for 3-6 months.[13] However, treatment time is very long in many cases.[14] Previous studies have reported that low-intensity pulsed ultrasound (LIPUS) is effective for reducing pain, treatment time, and promoting bone union both in animal and human trials.[15] LIPUS has been used in medicine as a treatment modality. It is a form of energy transfer for mechanical vibration. When it spreads in the organism, a certain dosage of ultrasound can cause sonoporation effect that makes the cell membrane surface temporarily disruptive, which promote extracellular molecules to enter the cell, causing changes of the organism function and structure that is the biological effect of ultrasound.[16] Collection and review of studies showing the role of LIPUS on lumbar spondylolysis can be helpful for better interventions. To our knowledge, no such systematic review has critically reviewed and appraised the role of LIPUS on lumbar spondylolysis. The current systematic review was planned to fill the gap in literature.

Materials Methods

The systematic review followed the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines, and the protocol was registered with the PROSPERO database in January 2021 (CRD42021227439).

Literature search was conducted on PubMed, Embase, CINAHL, Web of Science, PEDro and Scopus databases to identify relevant studies published between 2010 and 2020 by using medical subject headings and applying Booleans, such as low-intensity pulsed ultrasound OR interventional ultrasound AND lumbar spine OR lumbar region AND spondylolysis OR stress fracture. Unpublished studies were hand-searched in the journals, abstracts of conferences were reviewed, and citation index was used for searching experts in the field and then contacting them for information.

Studies included were the ones that had at least one of the following outcomes: bone union rate, treatment period to bone union and time to return to previous activities. All observational studies were sought and considered eligible for the review. However, to maintain scientific rigour, quantitative studies with only control group were included. Inclusion criteria comprised both genders, human, symptomatic, mechanical LBP, aged 0-60 years, lumbar vertebra, radiological evidence of spondylolysis, and congenital spinal abnormalities. The exclusion criteria comprised neurological deficits, other spinal pathologies, and degenerative spinal diseases.

Evaluation, critical appraisal of the retrieved studies and reporting of data was done by two investigators independently using the Grading of recommendations, assessment, development, and evaluations (GRADE) criteria.[17] These were rated as high (4 point), moderate (3 points), low (2 points) and very low (one/less). In terms of interpretations, very low means the true effect is probably markedly different from the estimated effect; low means the true effect might be markedly different from the estimated effect; moderate means the true effect is probably close to the estimated effect; and high means the authors have a lot of confidence that the true effect is similar to the estimated effect.

Results

Of the 243 studies identified, 228(94%) were full text articles and only 2(0.8%) studies were critically appraised for qualitative synthesis (Figure). As per the GRADE criteria, the included studies were appraised as moderate (Table 1). The studies were both case-control studies and showed significant improvement in outcome measures from LIPUS (Table 2).

Discussion

The systematic review had a strict study selection criteria to remove potential bias. The two studies which met the criteria were subjected to qualitative data synthesis. The experimental groups (EGs) in both studies reported significant improvement in bone union rate, treatment period to bone union, and time to return to previous sports activities compared to the control groups (CGs). [18-19]

Hideyuki Arima et al. in 2017 investigated the treatment effects of LIPUS on progressive-stage spondylolysis. The study used case-control design on patients with progressive-stage spondylolysis with magnetic resonance imaging (MRI). Nine patients were given routine physical therapy, including avoidance of any sport activity and the use of a brace during the treatment, while six patients were treated using LIPUS every day during treatment in addition to routine physical therapy. About every 1.5 months, bone healing was evaluated via CT. Cases that retained defects after 4.5 months were defined as non-union. The most important finding was that the bone union rate in LIPUS group was significantly higher than that in routine physical therapy group (66.7 vs. 10.0%, p=0.020). It is a form of mechanical energy transmitted into the tissue as sound waves creating series of biomechanical changes at cellular level. The treatment period to bone union was 3.8 months and 2.7±0.3 months in routine physical therapy and LIPUS groups. The said study revealed that LIPUS treatment is effective for bone union in patients with progressive-stage spondylolysis with MRI high-signal change.[18]

The primary concerns of these two retrieved studies were that no randomised controlled trial (RCT) for LIPUS for lumbar spondylolysis was available in literature, and the two eligible studies had limited sample sizes. The actual treatment protocol was not mentioned clearly. For example, details about frequency, intensity and duration of trunk muscle strength and flexibility exercises were not provided. The outcome measure used in the 2019 study to Masahiro et al. was time to return to previous sports activities, while Hideyuki et al. sett it as bone union rate and treatment period to bone union.[18-19]

The major limitations of the current review were sample size estimation and lack of RCTs in literature in the matter under review.

RCTs must be done to determine the role of LIPUS in the treatment of patients with LBP associated with spondylolysis. Moreover, treatment effects of these studies should be graphically represented through meta-analysis.

Conclusion

Only a few studies were found eligible for qualitative synthesis and were rated as moderate on quality assessment through evaluation and critical appraisal which concluded that LIPUS is effective for bone union and a useful therapy for quick return to playing sports in patients with lumbar spondylolysis.

Acknowledgement: The authors would like to acknowledge the assistance of librarian of the University of Lahore. His assistance in the search component of this systematic review was invaluable. The authors would also like to thank Prof Muhammad Imran for the review of this manuscript.

Disclaimer: None.

Conflict of interest: None.

Source of Funding: None.

References

1. Bernardelli G, Vigna L, Nava C. Physical Activity in Healthcare Workers with Low Back Pain: Effects of the Back-FIT Randomized Trial. J Occu Envi Med. 2020; 62:245-9. doi:10.1097/JOM.0000000000001844.
2. Sayari AJ, Harada GK, Lopez GD. Stress Fractures of the Lumbar Spine. In Stress Fractures in Athletes. 2020 (pp. 191-207). Springer, Cham.
3. Mironov SP, Cykunov MB, Burmakova GM, Andreev SV. Lumbosacral pain in athletes and ballet dancers: spondylolysis and spondylolisthesis. Conservative treatment. J Trauma Ortho. 2020; 27:11-8. doi: 10.17116/vto20190215
4. Tawfik S, Phan K, Mobbs RJ. The incidence of pars interarticularis defects in athletes. Global Spine J. 2020; 10:89-101. doi: 10.1177/2192568218823695.
5. Lin T, Zhang Z, Jiang Q, Yin J. The Joe-Lin Operative Classification System for Pediatric Lumbosacral Spondylolysis and Spondylolisthesis. World Neurosurgery. 2020. doi: 10.1016/j.wneu.2020.05.101.
6. Wong JS, Lalam R, Cassar-Pullicino VN. Stress Injuries of the Spine in Sports. In Seminars Musculo Radio. 2020; 24:262-276. doi: 10.1055/s-0040-1709484.

7. Koslosky E, Gendelberg D. Classification in Brief: The Meyerding Classification System of Spondylolisthesis. A Publication of The Association of Bone and Joint Surgeons®| CORR®. 2020; 478:1125-30. doi: 10.1097/CORR.0000000000001153.
8. Cambridge ED. Hip & Spine Mechanics-Understanding the linkage from several perspectives of injury mechanisms to rehabilitation. Biomech Model. 2020; 21: 28-29.
9. Yokoe T, Tajima T, Sugimura H. Comparison of symptomatic spondylolysis in young soccer and baseball players. J Ortho Surg Research. 2020; 15:1-6. doi: 10.1186/s13018-020-01910-4.
10. Tsukagoshi Y, Kamegaya M, Tatsumura M. Characteristics and diagnostic factors associated with fresh lumbar spondylolysis in elementary school-aged children. Euro Spine J. 2020; 29:2465-9. doi: 10.1007/s00586-020-06553-x.
11. Sairyo K, Sakai T, Takata Y. Spondylolysis and Spondylolisthesis in Athletes. InSpinal Conditions in the Athlete. 2020 (pp. 235-247). Springer, Cham.
12. van den Heuvel MM, Oei EH, Bierma-Zeinstra SM, van Middelkoop M. The prevalence of abnormalities in the pediatric spine on MRI: a systematic review and meta-analysis. Spine. 2020; 45:1185-96. doi: 10.1097/BRS.0000000000003527.
13. Mistiaen W, Vanhecke B, Linden P. Case report: successful conservative treatment of a soccer player with multiple-level spondylolysis. Current Ortho Practice. 2020; 31:315-7. doi: 10.1097/BCO.0000000000000857.
14. Achar S, Yamanaka J. Back Pain in Children and Adolescents. Ameri Family Phys. 2020; 102:19-28.
15. Berber R, Aziz S, Simkins J. Low Intensity Pulsed Ultrasound Therapy (LIPUS): A review of evidence and potential applications in diabetics. J Clinic Ortho Trauma. 2020; 11:500-505. doi: 10.1016/j.jcot.2020.03.009.

16. Chen Y, Cai Q, Pan J, Zhang D. Role and mechanism of micro-energy treatment in regenerative medicine. Trans And Urol. 2020; 9:690-701. doi: 10.21037/tau.2020.02.25.
17. Bull FC, Al-Ansari SS, Biddle S. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. British J Sports Med. 2020; 54:1451-62. doi: 10.1136/bjsports-2020-102955.
18. Arima H, Suzuki Y, Togawa D. Low-intensity pulsed ultrasound is effective for progressive-stage lumbar spondylolysis with MRI high-signal change. Euro Spine J. 2017; 26:3122-8. doi: 10.1007/s00586-017-5081-z.
19. Tsukada M, Takiuchi T, Watanabe K. Low-intensity pulsed ultrasound for early-stage lumbar spondylolysis in young athletes. Clinic J Sport Med. 2019; 29:262-6. doi: 10.1097/JSM.0000000000000531.

Table 1: Quality assessment based on GRADE criteria.

	Quality assessment					**Summary of findings**			
No of studies (No of participants)	Study limitations*	Consistency	Directness	Precision	Publication bias	Relative effect (95% CI)	Best estimate of whipple group risk	Absolute effect (95% CI)	Quality
2(95)	Serious limitations (-1)	No important inconsistency	Direct	No important imprecision	unlikely	2.7 (2.4 to 3)	66.7 %	61 days; 167 days	+++, moderate

GRADE: Grading of recommendations, assessment, development, and evaluations. CI: Confidence interval.

Table 2: Qualitative data synthesis of the studies reviewed.

Study	Study Design	Groups	Outcomes	Findings	Authors conclusion
(Hideyuki, Arima et al. 2017)	Case-Control Study 13 subjects EG: 6 CG: 7	EG: low intensity pulsed ultrasound CG: cease any sport activity, wear a brace during treatment to immobilize the trunk, trunk muscle exercises and trunk flexibility exercises	Bone union rate Treatment period to bone union	EG: 66.7% CG: 10% p = 0.020 EG: 3.8 CG: 2.7±0.3	LIPUS treatment might be effective for bone union in patients with progressive-stage spondylolysis with MRI high-signal change.
(Masahiro Tsukada, PT et al. 2019)	Case-Control Study 82 subjects EG: 35 CG: 47	EG: low intensity pulsed ultrasound CG: Thoracolumbosacral brace, sports modification, and therapeutic Exercise, activity restriction, hip stretching and strengthening of the trunk muscles.	Time to return to previous sports activities	EG: 61(58-69) days CG: 167 (135-263) days P<0.01	LIPUS combined with conservative treatment for early-stage lumbar spondylolysis in young athletes could be a useful therapy for quick return to playing sports.

EC: Experimental group; CG: Control group; LIPUS: Low-intensity pulsed ultrasound.

Figure: Study flow-chart.