

Substantial Biomechanical Improvement by Extracorporeal Shockwave Therapy After Surgical Repair of Rodent Chronic Rotator Cuff Tears

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Background: Characteristics of chronic rotator cuff tears include continuous loss of tendon structure as well as tendon elasticity, followed by a high failure rate after surgical reconstruction. Several studies have already shown the beneficial effect of extracorporeal shockwave therapy (ESWT) on tissue regeneration in tendon pathologies.

Hypothesis: ESWT improves biomechanical tendon properties as well as functional shoulder outcomes in chronic rotator cuff reconstruction in rodents.

Study Design: Controlled laboratory study.

Methods: After tendon detachment and 3 weeks of degeneration, a subsequent transosseous reattachment of the supraspinatus tendon was performed in 48 adult male Sprague-Dawley rats (n = 16 per group). Rodents were randomly assigned to 3 study groups: no ESWT/control group, intraoperative ESWT (IntraESWT), and intra- and postoperative ESWT (IntraPostESWT). Shoulder joint function, as determined by gait analysis, was assessed repeatedly during the observation period. Eight weeks after tendon reconstruction, the rats were euthanized, and biomechanical and gene expression analyses were performed.

Results: Macroscopically, all repairs were intact at the time of euthanasia, with no ruptures detectable. Biomechanical analyses showed significantly improved load-to-failure testing results in both ESWT groups in comparison with the control group (control, 0.629; IntraESWT, 1.102; IntraPostESWT, 0.924; IntraESWT vs control, $P \leq .001$; IntraPostESWT vs control, $P \leq .05$). Furthermore, functional gait analyses showed a significant enhancement in intensity measurements for the IntraPostESWT group in comparison with the control group ($P \leq .05$). Gene expression analysis revealed no significant differences among the 3 groups.

Conclusion: Clearly improved biomechanical results were shown in the single-application and repetitive ESWT groups. Furthermore, functional evaluation showed significantly improved intensity measurements for the repetitive ESWT group.

Clinical Relevance: This study underpins a new additional treatment possibility to prevent healing failure. Improved biomechanical stability and functionality may enable faster remobilization as well as an accelerated return to work and sports activities. Furthermore, as shockwave therapy is a noninvasive, easy-to-perform, cost-effective treatment tool with no undesired side effects, this study is of high clinical relevance in orthopaedic surgery. Based on these study results, a clinical study has already been initiated to clinically confirm the improved functionality by ESWT.

Keywords: chronic rotator cuff tear; ESWT; shockwave; biomechanical analysis

Rotator cuff tears are frequent orthopaedic disorders with challenging treatment circumstances.^{29,44} Recurrent postoperative defects are seen consistently and can reach up

to 94.4% in massive rotator cuff tears.^{6,12,36} Limiting factors for rotator cuff healing after surgical repair are size of the original tear, tear chronicity, and patient age.^{6,12,13} Fatty infiltration of the muscles, muscle atrophy, muscle and tendon retraction, fibrosis, and low bone quality, including bone microstructure and bone mineral density, are characteristics of degenerative chronic tears.^{8,20,27} Pre-clinical studies are focused particularly on acute tears and healing outcomes. In contrast to traumatic rotator cuff