Extracorporeal Shockwave Therapy

The Future of Chronic Tendinopathy?

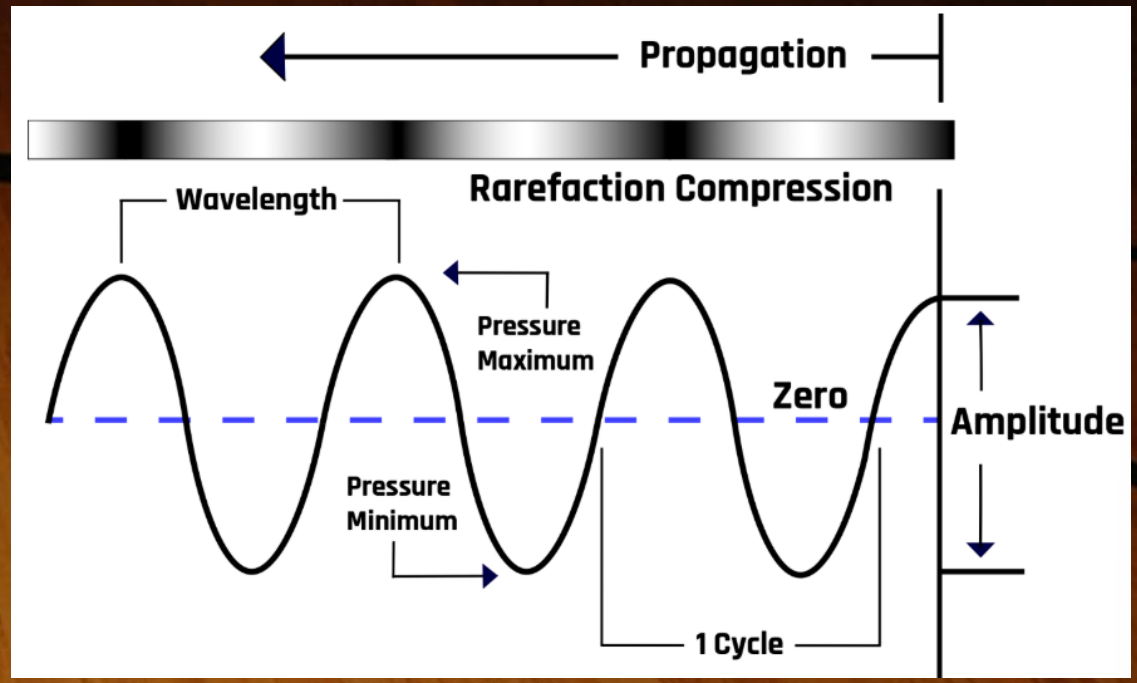
Michael Osterholt, MD, CAQSM

Outline

- What is Extracorporeal Shockwave Therapy?
- Define common indications for use
- Evidence of efficacy for common chronic tendinopathies

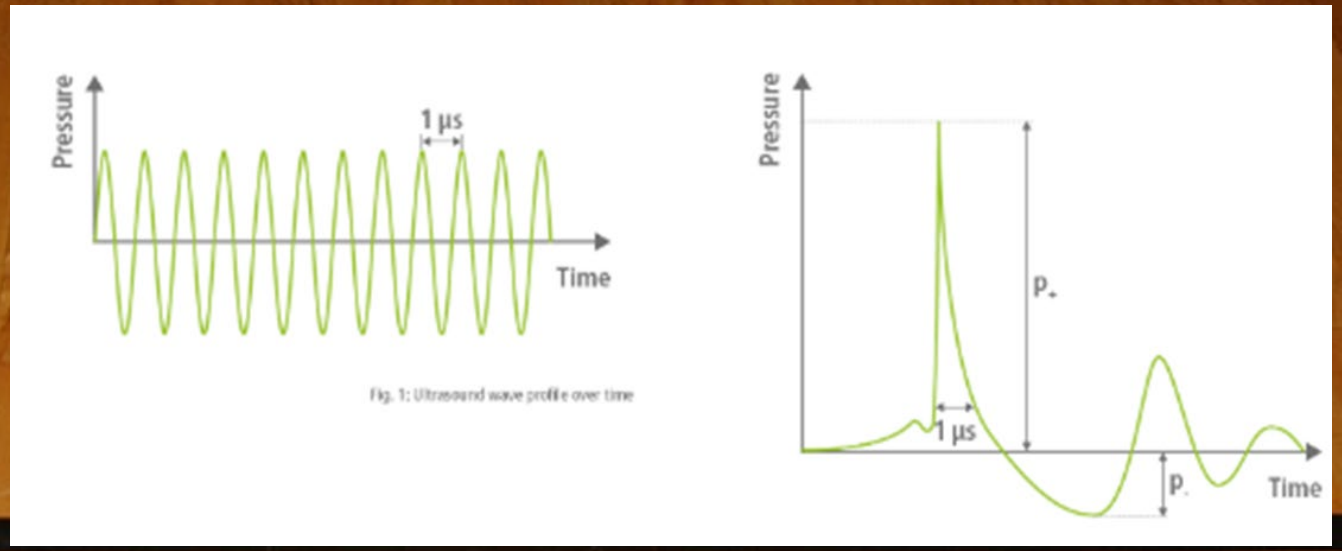
What are sound waves?

- Sound waves are mechanical waves in which vibrations propagate as acoustic waves through a medium (solid, liquid, gas)
- Amplitude – Amount of energy in a wave. In sound this refers to the magnitude of compression and expansion experienced by the medium the sound travels through
- Sound waves are made of areas of high pressure alternated by low pressure. High pressure are peaks and low pressure are troughs. Distance between the two is the wavelength
- Velocity = Frequency x wavelength
- Frequency = Cycles per second



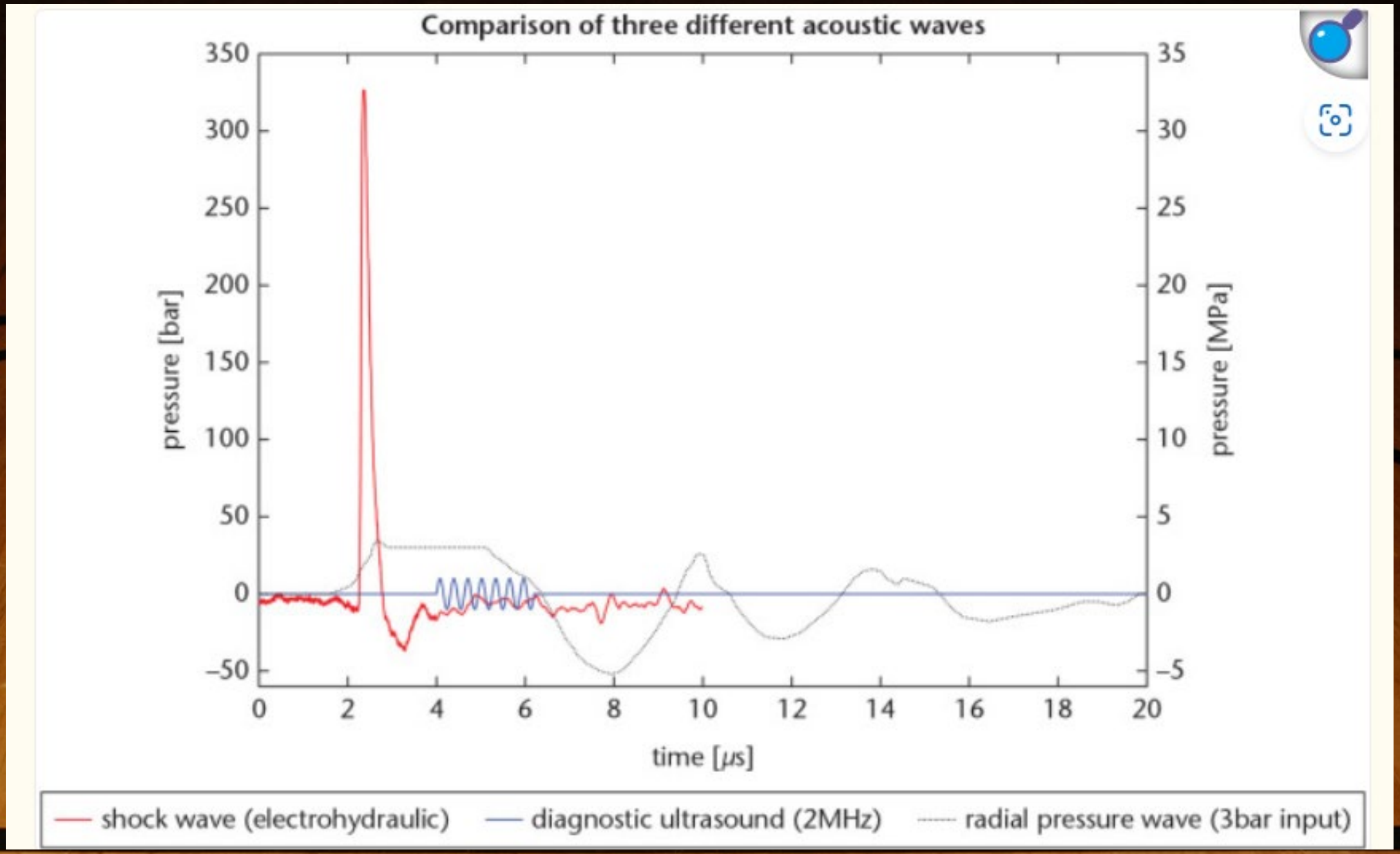
Ultrasound Waves vs. Shockwaves

- Ultrasound Waves are high frequency, low amplitude (low pressure) waves, with periodic oscillations.
- Shockwaves are characterized by a single mostly positive pressure pulse followed by a small negative pressure pulse resulting in much lower frequencies. The single pulse has a substantially higher pressure amplitude than Ultrasound resulting in nonlinear propagation through mediums.



Shockwave generation

- Two distinct forms of Shockwave therapy – The unifying principle is the conversion of energy into targeted acoustic shockwave energy.
- Focused shockwave therapy
  - Three forms of Focused used in commercial devise
  - Higher peak pressures with rise times as fast as 10ns
  - Penetration depth up to 10cm
- Radial shockwave therapy
  - Compared to F-SWT waves generated reach lower speeds and generate lower peak pressures
  - Lower peak pressures with rise times of 1-5ms
  - Generally, treat more superficial structures with penetration depth dropping significantly after 1.5cm
- In general, Focused can penetrate deeper tissues and provide more mechanical disruption
- The physical effects are related to the energy per unit area (EFD) which is commonly thought of as the “dosage”


Comparison of three different acoustic waves
pressure [bar]
pressure [MPa]
time [μs]
350
300
250
200
150
100
50
0
−50
35
30
25
20
15
10
5
0
−5
0
2
4
6
8
10
12
14
16
18
20
shock wave (electrohydraulic)
diagnostic ultrasound (2MHz)
radial pressure wave (3bar input)

How does it work?

- The precise mechanism is not completely understood
- It has become increasingly clear however that the mechanical stimulus of a shockwave induces signaling pathways in treated cells. This is known as mechanotransduction.
- ESWT stimulates the release of VEGF from Extracellular matrix in turn promoting neovascularization.
- Upregulation of TGFb1 and IGF-1 which stimulate tenocyte and collagen proliferation
- Scleraxis upregulation a Transcription Factor important in tenocyte proliferation and tendon growth
- Mechanical stimulus leads to increase in intracellular RNA Which stimulates TLR3 leading to an inflammatory response.
- Numerous other proposed pathways

Common Indications

- Achilles Tendinopathy
- Patellar tendinopathy
- Lateral Epicondylopathy
- Rotator Cuff Calcific tendinopathy
- Plantar Fasciopathy
- Hamstring tendinopathy
- Trochanteric pain syndrome – Gluteal tendinopathy
- Dupuytren’s disease
- Tibial Stress Syndrome
- Myofascial pain syndromes
- Delayed or nonunion fractures

Lateral Epicondylitis

Biomed Res Int. 2020 Mar 18;2020:2064781. doi: 10.1155/2020/2064781

Efficacy of Extracorporeal Shock Wave Therapy for Lateral Epicondylitis: A Systematic Review and Meta-Analysis

Gaowen Yao [1], Jing Chen [2], Yanji Duan [1], Xiao Chen [1,✉]

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PMCID: PMC7106907 PMID: 32309425

- A meta-analysis of 13 RCT with 1035 patients
- Patients randomly assigned to ESWT or Placebo/Other intervention
- Primary outcomes were pain evaluation by VAS and Grip strength
- Pooled data analysis showed statistically significant improvement in both pain and grip strength
- A few specific studies stuck out

Clinical Trial > Am J Sports Med. 2004 Apr-May;32(3):734-43. doi: 10.1177/0363546503261697.

Repetitive low-energy shock wave treatment for chronic lateral epicondylitis in tennis players

Jan D Rompe [1], Jens Decking, Carsten Schoellner, Christoph Theis

Affiliations + expand

PMID: 15090392 DOI: 10.1177/0363546503261697

- 78 patients in a placebo randomized controlled trial.
- All participants were tennis players with recalcitrant lateral epicondylitis of at least 12 months duration
- At 3 months statistically significantly higher improvement in pain and function in the ESWT group compared to sham procedure
- 65% of treatment group at least 50% reduction in pain compared to 28% in placebo

Is It all Good?

- One of the 13 randomized controlled trials found no significant difference compared to corticosteroid at 8 weeks follow up.

- Corticosteroid in chronic tendinopathy classically shows short term improvement with poor long-term outcomes.

Randomized Controlled Trial > Orthopedics. 2010 Feb;33(2):84-91.

doi: 10.3928/01477447-20100104-09.

Autologous blood and corticosteroid injection and extracoporeal shock wave therapy in the treatment of lateral epicondylitis

Kutay E Ozturan [1], Istemi Yucel, Husamettin Cakici, Melih Guven, Ibrahim Sungur

Affiliations + expand

PMID: 20192142 DOI: 10.3928/01477447-20100104-09

- Randomized control trial of 60 patients divided into 3 treatment groups; Corticosteroid injection, autologous blood injection, ESWT.
- Thomsen provocative test, upper extremity functional scores and max grip strength utilized as primary outcomes.
- While Corticosteroid showed significant improvement in all three primary outcomes at 4 weeks compared to either intervention.
- By 52 weeks success rate of corticosteroid was 50% and success rate of autologous blood product and ESWT was 83.3% and 89.9% respectively)
  - At 52 weeks ESWT most significant improvement in all three metrics.

Mid Portion Achilles Tendinopathy

Cureus. 2022 Jul 18;14(7):e26960. doi: 10.7759/cureus.26960

The Effectiveness of Extracorporeal Shockwave Therapy for Midportion Achilles Tendinopathy: A Systematic Review

Kaylem M Feeney [1,✉]

Editors: Alexander Muacevic, John R Adler

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PMCID: PMC9382436 PMID: 35989757

- A Meta Analysis of 7 RCT reviewing ESWT therapy vs. Sham ESWT, eccentric loading, or as an added intervention to eccentric loading.
- Mean sample size of 57 with a range of 43-75 participants
- Outcome measures include Pain and functional grading scales (VAS, VISA-A, AOFAS)

- Two studies looking at ESWT versus sham procedure found no statistical difference
  - Still improvement from baseline
- One found no difference between ESWT and Eccentric loading but both were better than no intervention
- Four of the seven found statistically significant benefit from ESWT compared to control
- ”Suggests that ESWT is a safe and effective modality for treating midportion Achilles tendinopathy”

Table 3. Summary of effectiveness of ESWT versus control .

ESWT - Extracorporeal shockwave therapy

Author	Intervention	Control	Statistically Significant Benefit Over Control
Costa et al. (2005) [26]	ESWT	Sham ESWT	No
Rompe et al. (2007) [29]	ESWT OR Eccentric Loading Exercises	Wait-and-see	Yes
Rasmussen et al. (2008) [30]	Stretching, Eccentric Exercises + ESWT	Stretching, Eccentric Exercises + Sham ESWT	Yes (AOFAS) No (VAS)
Rompe et al. (2009) [28]	Eccentric Loading Exercises + ESWT	Eccentric Loading Exercises	Yes
Vahdatpour et al. (2018) [24]	Conservative Care + ESWT	Conservative Care + Sham ESWT	Yes
Abdelkader et al. (2021) [33]	Stretching, Eccentric Exercises + ESWT	Stretching, Eccentric Exercises + Sham ESWT	Yes
Gatz et al. (2021) [39]	Physiotherapy + point OR line ESWT	Physiotherapy + sham ESWT	No

Insertional Achilles Tendinopathy

Randomized Controlled Trial > J Bone Joint Surg Am. 2008 Jan;90(1):52-61.

doi: 10.2106/JBJS.F.01494.

Eccentric loading compared with shock wave treatment for chronic insertional achilles tendinopathy. A randomized, controlled trial

Jan D Rompe [1], John Furia, Nicola Maffulli

Affiliations + expand

PMID: 18171957 DOI: 10.2106/JBJS.F.01494

- 50 patients with chronic (>6 months) of recalcitrant insertional achilles tendinopathy
- All had received prior treatment for 3 months without success
  - Local injections with anesthetic or corticosteroid,
  - NSAIDs
  - Physiotherapy
- Patients randomized to eccentric loading or Radial Shockwave
- At four months post intervention VISA-A and pain scores improved in both groups however shockwave showed statistically significant more favorable results
  - VISA-A improved from 53 to 80 and pain reduced from 7 to 3. These results were stable at a year

Patellar Tendinopathy

Randomized Controlled Trial > Am J Sports Med. 2007 Jun;35(6):972-8.
doi: 10.1177/0363546506298109. Epub 2007 Feb 16.

Extracorporeal shockwave for chronic patellar tendinopathy

Ching-Jen Wang [1], Jih-Yang Ko, Yi-Sheng Chan, Lin-Hsiu Weng, Shan-Lin Hsu

Affiliations + expand

PMID: 17307892 DOI: 10.1177/0363546506298109

- RCT with 50 patients randomized to ESWT group or Conservative group (NSAIDs, Physiotherapy, exercise program, and knee strap)
- Primary outcomes include VISA-P assessment score and Pain score
- At 2 and 3 year follow 90% of the ESWT group reported excellent or good overall results with an increase in the VISA-P score from 42.57 to 92.0
- The control group of conservative therapy at 2 and 3 year follow up reported no excellent results and 50% good results. VISA-P scores went from 39.25 to 41.04.

Randomized Controlled Trial > Am J Sports Med. 2013 Apr;41(4):795-803.
doi: 10.1177/0363546513475345. Epub 2013 Feb 13.

Platelet-rich plasma versus focused shock waves in the treatment of jumper's knee in athletes

Mario Vetrano [1], Anna Castorina, Maria Chiara Vulpiani, Rossella Baldini, Antonio Pavan, Andrea Ferretti

Affiliations + expand

PMID: 23408591 DOI: 10.1177/0363546513475345

- RCT consisting of 46 patients with history of patellar tendinopathy. Groups randomly assigned to 2 treatment groups
  - 2 autologous PRP Injections over 2 weeks
  - 3 sessions of focused ESWT
- Primary outcomes based on VISA-P and VAS pain scale. Outcomes assessed at 2, 6, and 12 months
- Patients in both groups showed statistically significant improvement of symptoms at all follow up assessments. PRP showed better improvement than ESWT at 6/12 month follow ups.

One more on Calcific Rotator Cuff Tendinopathy

J Orthop Traumatol. 2008 Aug 8;9(4):179–185. doi: 10.1007/s10195-008-0024-4

Arthroscopy surgery versus shock wave therapy for chronic calcifying tendinitis of the shoulder

Enrico Rebuzzi [1,2,✉], Nicolò Coletti [1], Stefano Schiavetti [1], Fernando Giusto [1]

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PMCID: PMC2657331 PMID: 19384483

- Retrospective study consisting of 46 patients with homogenous calcific deposit of the supraspinatus tendon who failed 6 months of conservative therapy.
- 22 underwent arthroscopic debridement 24 underwent Radial ESWT
- Follow up 24 months after treatment demonstrated 82% of patients in the surgical treatment arm report good or excellent results with no calcific deposit in 87% of patients. This was compared to 71% of patients in the ESWT arm reporting good or excellent results with 58% having resolution of calcific deposit.
- Conclusion was ESWT was similar to arthroscopic debridement

My Thoughts and Conclusions

- ESWT is a safe minimally invasive intervention
- Data suggests benefit in chronic tendinopathy even recalcitrant cases
- Likely best as an addition to high quality rehabilitation
- Should be considered an addition to the treatment toolbox for chronic tendinopathy

Resources

- Auersperg V, Trieb K. Extracorporeal shock wave therapy: an update. EFORT Open Rev. 2020 Oct 26;5(10):584-592. doi: 10.1302/2058-5241.5.190067. PMID: 33204500; PMCID: PMC7608508.
- *ESWT guidelines - Updated from the ISMST managing board*. 2023 July 20. Available at: https://shockwavetherapy.org/wp-content/uploads/2024/01/ISMST-Guidelines-for-ESWT-_-engl-20240103.pdf
- Feeney KM. The Effectiveness of Extracorporeal Shockwave Therapy for Midportion Achilles Tendinopathy: A Systematic Review. Cureus. 2022 Jul 18;14(7):e26960. doi: 10.7759/cureus.26960. PMID: 35989757; PMCID: PMC9382436.
- Notarnicola A, Moretti B. The biological effects of extracorporeal shock wave therapy (eswt) on tendon tissue. Muscles Ligaments Tendons J. 2012 Jun 17;2(1):33-7. PMID: 23738271; PMCID: PMC3666498.
- Ozturan KE, Yucel I, Cakici H, Guven M, Sungur I. Autologous blood and corticosteroid injection and extracoporeal shock wave therapy in the treatment of lateral epicondylitis. Orthopedics. 2010 Feb;33(2):84-91. doi: 10.3928/01477447-20100104-09. PMID: 20192142.
- Rebuzzi E, Coletti N, Schiavetti S, Giusto F. Arthroscopy surgery versus shock wave therapy for chronic calcifying tendinitis of the shoulder. J Orthop Traumatol. 2008 Dec;9(4):179-85. doi: 10.1007/s10195-008-0024-4. Epub 2008 Aug 8. PMID: 19384483; PMCID: PMC2657331.
- Rompe JD, Decking J, Schoellner C, Theis C. Repetitive low-energy shock wave treatment for chronic lateral epicondylitis in tennis players. Am J Sports Med. 2004 Apr-May;32(3):734-43. doi: 10.1177/0363546503261697. PMID: 15090392.
- Rompe JD, Furia J, Maffulli N. Eccentric loading compared with shock wave treatment for chronic insertional achilles tendinopathy. A randomized, controlled trial. J Bone Joint Surg Am. 2008 Jan;90(1):52-61. doi: 10.2106/JBJS.F.01494. PMID: 18171957.
- Tenforde AS, Borgstrom HE, DeLuca S, McCormack M, Singh M, Hoo JS, Yun PH. Best practices for extracorporeal shockwave therapy in musculoskeletal medicine: Clinical application and training consideration. PM R. 2022 May;14(5):611-619. doi: 10.1002/pmrj.12790. Epub 2022 Apr 14. PMID: 35187851; PMCID: PMC9321712.
- Vetrano M, Castorina A, Vulpiani MC, Baldini R, Pavan A, Ferretti A. Platelet-rich plasma versus focused shock waves in the treatment of jumper's knee in athletes. Am J Sports Med. 2013 Apr;41(4):795-803. doi: 10.1177/0363546513475345. Epub 2013 Feb 13. PMID: 23408591.
- Wang CJ, Ko JY, Chan YS, Weng LH, Hsu SL. Extracorporeal shockwave for chronic patellar tendinopathy. Am J Sports Med. 2007 Jun;35(6):972-8. doi: 10.1177/0363546506298109. Epub 2007 Feb 16. PMID: 17307892.
- Yao G, Chen J, Duan Y, Chen X. Efficacy of Extracorporeal Shock Wave Therapy for Lateral Epicondylitis: A Systematic Review and Meta-Analysis. Biomed Res Int. 2020 Mar 18;2020:2064781. doi: 10.1155/2020/2064781. PMID: 32309425; PMCID: PMC7106907.