# Local compression movement in tendon tissue wound healing

RENÉ DE BRUIJN[1], FRIDERIKA KRESAL[2]
*Correspondance: [1]Nederlandse Academie voor Orthopedische Geneeskunde, Gravin van Burenlaan 27 6961 ES Eerbeek, the Netherlands, [2]Institution of Higher Education for Physiotherapy,* FIZIOTERAPEVTIKA*, Slovenska c. 58, 1000 Ljubljana, Slovenia*
*e-mail: info@naog.nl, friderika.kresal@fizioterapevtika.si*
*webpage: www.fizioterapevtika.si*

***Abstract***
*Tendinopathy is a common problem in medical care, yet it is still unclear what is the best treatment to resolve the condition. Various studies showed local massage directly applied to the affected tissue to be effective with the idea that it promotes tissue repair. In this study, both Achilles tendons of the rat where artificially damaged, where one side was treated with Local Compression Movement (LCM) whereas the other side served as control to study its influence on collagen wound healing. The number of treatments varied from 3-6 in a time schedule of 10 days. After scarification, light microscopy morpho-histological study of the Achilles tendon was done, where the treated side was compared to the non-treated side. Main outcome, ordinal ranked tissue repair, showed that LCM was superior to no treatment (p = 0.01) but was dependent on the number of LCM treatments that was given. Keywords: tendinopathy, rat, local compression movement, repair.*

# Učinkovitost lokalnega kompresijskega gibanja pri tendinopatiji ahilove tetive

***Povzetek***
*Tendinopatije so ene izmed najpogostejših okvar vezivnega tkiva. Še vedno ni natančno znano, kateri način zdravljenja je najprimernejši. Študije so pokazale, da je lokalna masaža prizadetega tkiva učinkovita pri zdravljenju tendinopatij in spodbuja njihovo regeneracijo. V raziskavi smo umetno poškodovali Ahilovi tetivi podganjih primerkov. Eno stran smo obravnavali s pomočjo lokalnega kompresijskega gibanja (LKG), druga stran pa je služila kot kontrola za proučevanje naravnega poteka zdravljenja. Število obravnav je znašalo od 3 do 6 v obdobju 10 dni. Po skarifikaciji, površinskem rezu, so bile opravljene morfološke in histološke analize ter primerjava vzorcev Ahilovih tetiv. Rezultati so pokazali statistično značilno izboljšanje pri Ahilovih tetivah obravnavanih s pomočjo LKG (p = 0.01), ki pa je bilo odvisno od števila obravnav. Ključne besede: tendinopatije, podgane, lokalno kompresijsko gibanje, regeneracija.*

## 1. INTRODUCTION

Lesions of the musculoskeletal system (MS) are a common condition in health care. Work-related MS disorders calculated in the Netherlands in 2018, showed an incidence of 152 per 100.000 labours (Nederlands Centrum voor Beroepsziekten, 2019). In the UK, musculoskeletal conditions account for 30% of general practitioner consultations (Margham, 2011). Hopkins et al. (2016) described a discrepancy between the clinical diagnosis of tendinopathy and MRI findings. Studies that defined tendinopathy using radiological imaging revealed a higher incidence rate compared with studies that used clinical evaluation only (Hopkins et al., 2016). Although not all sports related injuries need health care, tendinopathy can lead to agonizing pain, discontinuation of sport activities and absenteeism. However, the prognosis is relatively good. Lateral epicondylitis (e.g. tennis elbow) shows spontaneous recovery in 80% of the patients within 6 months and 90% will be cured within 12 months (Nederlands Huisartsen Genootschap, 2009; Murtagh, 1988; Hudak et al., 1996). However, shoulder pain can last for many years (Reilingh et al., 2008).
The conservative treatment of muscular pain is well documented in literature (Weir et al.,2011; Sigerist, 1977; Cyriax, 1985; de Bruijn, 1984; Le Bars, 1979). All kind of therapies are described, such as massage, stretching, warmth, cold, dry needling, taping, exercises, ultrasound and electrotherapy. A systematic review of literature on the effectiveness of conservative interventions for rotator cuff tendinopathy concluded that exercise and multimodal physiotherapy might be effective interventions although the clinical significance of this effect is unclear (Littlewood et al., 2013). Treatment of adductor related groin pain showed the best evidence for exercise therapy (strengthening hip and abdominal muscles) combined with joint mobilization in athletes (Almeida et al. 2013; Weir et al., 2011; Weir et al., 2010)
The use of massage and comparable techniques in painful musculoskeletal conditions origin in ancient times. Painful local massage, was applied by the Australian medicine man and Indian tribes such as Cheyennes, Zini's and Choctow Indians (Sigerist, 1977). The application of massage in tendinopathies was popularized by Cyriax (Cyriax, 1985). He stated that massage produces traumatic hyperemia, leading to local analgesia due to the increased speed of destruction of Lewi's P substance. Furthermore, he hypothesized that it could prevent the formation of adhesions during the process of wound healing. Other hypotheses for the perceived local analgesia are interference with supraspinal structures (Raphe nucleus) finally releasing enkephalin at a spinal cord level and muscle relaxation due to decreased motoneuron activity (de Bruijn, 1984; Le Bars et al., 1979; Dickenson et al.,1980; Lee et al., 2009). Experimental studies examining morpho-histological changes in tendon tissue evoked by augmented soft tissue mobilization, showed increased fibroblast recruitment and promotion of the collagen tissue healing process (Davidson et al., 1997; Gehlsen et al., 1999). Gregory et al. (Gregory et al., 2003) applied deep massage to untraumatized rabbit skeletal muscle. A ten-minute massage caused a cascade of ultrastructural changes that appear to be consistent with a reparative process following a sublethal injury to a skeletal muscle. In clinics, LCM is a combination of applying manual compression to the affected painful spot in the tendon and simultaneous moving in a transverse direction with respect to the alignment of the tendon fibres, for approximately 10 minutes.

## 2. METHODS

In a pilot study, scratches with an insulin injection needle were made to the Achilles tendon of three rats, observing the possibility to produce tendon tissue damage. After scarification of the pilot animals, light microscopic analysis showed the procedure was appropriate to produce tendon tissue damage. The study was approved by the NAOG Ethics Committee.
Twenty male Wistar rats (Rattus norvegicus domestica) with a weight of 250-300 gram (30 weeks old) were used. General anaesthesia was performed using chloral hydrate in a concentration of 3.92 g/100 ml (1 ml/100g body weight); 2-3 ml per rat and was injected into the abdomen/groin area using an insulin syringe. In both Achilles tendons longitudinal scratches were made with an insulin syringe avoiding skin damage as good as possible.

LCM was applied with the tip of the index finger in transverse direction with respect to the alignment of the tendon fibres for 10 minutes only to the right Achilles tendon by three experienced physiotherapists. The compression force used was average 735 Pa/1cm$^2$ controlled by a digital balance and carried out with the tip of the index finger (surface ± 1cm$^2$). The animals were housed in cages where they could freely move between the sessions. Rats were allocated in five groups: group A (6 sessions of LCM); group B (5 sessions of LCM); group C (4 sessions of LCM); group D (3 sessions of LCM) (Figure 1).

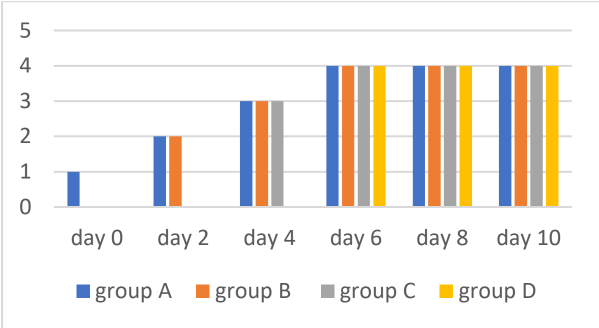


Figure 1: The number of treatments given every other day between different groups. Group A (6 sessions of LCM); group B (5 sessions of LCM); group C (4 sessions of LCM); group D (3 sessions of LCM)

At day 10, all animals where scarified by an overdose of ether and the Achilles tendon was harvested by excision of the lower limb superior to the knee joint. The foot and fur were removed from the excised limb.
After harvesting, the material was fixated in formaldehyde and embedded in paraffin. Dehydration was performed by graded alcohol series: series 1-5 was done with increasing concentration of alcohol (70%-100%), 6 and 7 were done with xylene, 8-10 with paraffin. Tissue sections were cut at 4 µm, coloured with hematoxylin and eosin and mounted on microscope slides. Examination of the slides was done by a light microscope (Leitz Wetzlar, Germany) with three oculars and objectives 10 x 10/0.25, 10 x 25/0.50 and 10 x 63/0.90. All studied slides were photographed with a Wild MPS 45 Photoautomat Microscope Camera Controller with 200 ASA films. All slides where numbered, using the same number for the photograph. An independent co-operator re-numbered all photographs once again to avoid any bias to the four independent examiners. The examiners were asked to analyse the photos for histo-morphological quality and pay special attention to edema, cell activity at the wound sites, appearance of fibroblasts and fibrocytes and fibre architecture and deposition. Each photo was judged according to the abovementioned criteria and then ranked. The quality of wound repair was ranked: 0 very bad, 1 poor, 2 moderate, 3 good and 4 excellent (Figure 2).

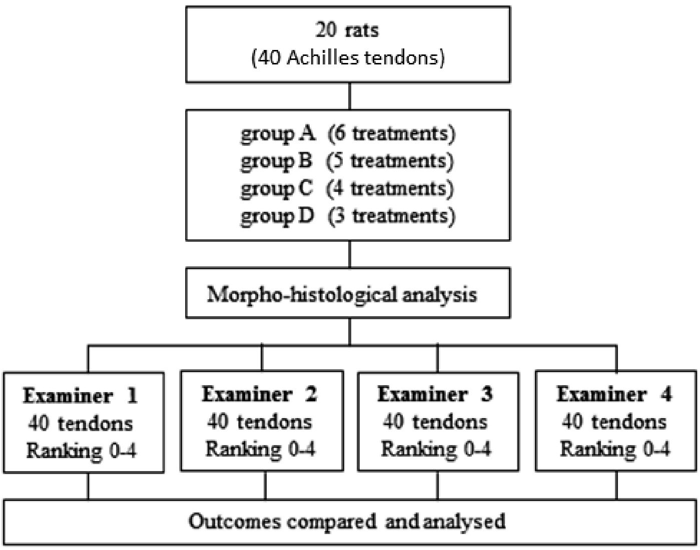


Figure 2: Study design. Four examiners ranked 40 tendons.

*Statistical analysis*

$H_0$: There is no significant difference in collagen wound repair between damaged tendons treated with LCM and non-treated damaged tendons (nt): $\eta_{LCM} = \eta_{nt}$; $H_a$: LCM influences tendon tissue repair: $\eta_{LCM} \neq \eta_{nt}$. The IBM SPSS 22.0 (Statistical Package for the Social Sciences) statistic program was used. Descriptive statistics were calculated and $H_0$ was tested by performing the Friedman's non-parametric test with an ordinal scale for testing $H_0$ at 1% significance (Conover, 1999). Comparisons were done to: *treated versus non-treated side per examiner; group A, B, C and D per examiner and all slices per examiner.* The Wilcoxon's signed rank test was used for statistical analysis at 10% level.

## 3. RESULTS

The most frequent was rank 2 (34%) followed by 3, 1, 0 (21%) and 4 (3%) (Table 2).

| Examiner | Ranking | | | | | Sum | TRS |
|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | | |
| 1 | 10 | 5 | 14 | 7 | 4 | 40 | 70 |
| 2 | 11 | 6 | 12 | 10 | 1 | 40 | 64 |
| 3 | 7 | 9 | 17 | 7 | 0 | 40 | 64 |
| 4 | 6 | 13 | 11 | 10 | 0 | 40 | 65 |
| Total (%) | 34 (21) | 33 (21) | 54 (34) | 43 (21) | 5 (3) | 160 | |

Table 2: Ordinal ranking for each examiner and total sum score (TRS) of ranks from the examiners.

*Comparison of treated vs. non-treated side/examiner*

Two of three examiners found a significant difference at 10% level for the treated vs non-treated Achilles tendons. This suggests that LCM treatment shows a better wound repair at the group that had the most treatments (Group A). For group B only examiner 4 found a significant difference at 10% level. This shows a tendency to regeneration but it is not statistically significant. All examiners agreed that groups C and D showed no significant difference between the treated and non-treated side.

| Examiner | Group A | Group B | Group C | Group D |
|---|---|---|---|---|
| 1 | SIGN (at 10%) | NS | NS | NS |
| 2 | NS | NS | NS | NS |
| 4 | SIGN (at 10%) | SIGN (at 10%) | NS | NS |

Table 3: Comparison of treated vs. non-treated side/examiner. SIG – significant; NS – not significant.

*Comparison of groups/examiner*

Examiners 1 and 4 found a clear difference between the treated and non-treated tendon, indicating that the treated side showed better wound healing. Only examiner 4 found significant differences for group C and D, but in favour for the non-treated side. This suggests that the treated side did not show a good wound repair.

| Examiner | Group A | Group B | Group C | Group D |
|---|---|---|---|---|
| 1 | SIG | SIG | NS | NS |
| 2 | NS | NS | NS | NS |
| 4 | SIG | SIG | SIG | SIG |

Table 4: Comparison of groups/examiner. SIG – significant; NS – not significant.

*Comparison of all photos/ examiner*

Two out of three examiners found a significant difference between the treated- and non-treated side. This indicates that LCM has a positive effect on wound healing, regardless the number of treatments (Table 6).

| Examiner | Group A+B+C+D |
|---|---|
| 1 | SIGN (at 10%) |
| 2 | NS |
| 4 | SIGN (at 10%) |

Table 5: Comparison of all photos/ examiner. SIG – significant; NS – not significant.

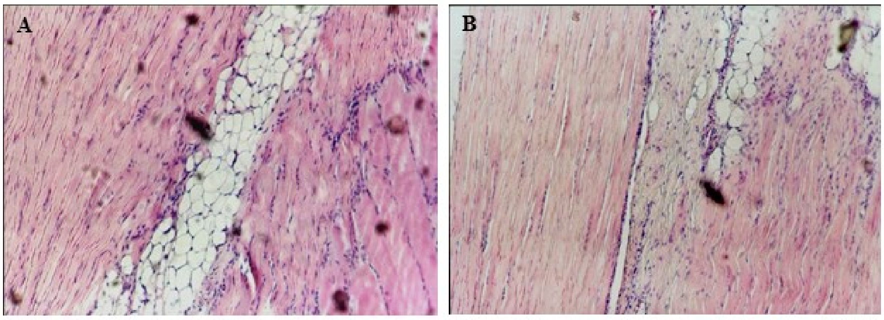


Figure 3: Histology tendon. A – group A, non-treated side. In the middle, there is a longitudinal chain of edema visible; B – group A, treated side. In the middle, fibroblasts and matrix are formed.

## 4. DISCUSSION

Tendinopathy is a medical condition commonly seen by general practitioners and physiotherapists. Since it can persist for a long period of time and lead to agonizing pain, discontinuation of sport activities and absenteeism, various kinds of treatments are described in literature to solve this problem. Eccentric exercises, heavy slow resistance exercises and stretching techniques are frequently prescribed for tendinopathy (Couppé et al., 2015; Murtaugh et al., 2013; Rees et al., 2008; Nørregaard et al., 2007; O'Neill et al., 2015; Lim et al., 2018; Beyer et al., 2015). One of the treatment possibilities often applied is massage. This study focused on the question if LCM applied directly to damaged collagen tissue of a tendon would influence tissue repair compared to no therapy. The outcome showed a beneficial effect of LCM on wound repair in experimental damaged Achilles' tendons of rats. The treated side showed better scores compared to the control side on four parameters: *edema, activity at the wound site, appearance of fibroblasts and fibrocytes and fibre architecture and deposition*. This improvement in wound repair was significant in group A, that was treated directly after scratching the tendon and had the most treatments. Although group B showed a tendency for better wound repair, this was not significant. In groups C and D with the least number of treatments, LCM showed no improvement in wound repair. Due to the small sample size of tendons (n=40), the significance level was chosen at 10% (p 0.10).

Daily practice shows that most patients with tendinopathy are not seen directly at the time point of first tissue damaging but mostly some weeks afterwards. Based on the conclusions of this study, it is therefore difficult to argue that they will benefit from LCM as well. Some studies report no significant clinical effect of local massage in chronic conditions like epicondylitis lateralis and patellar tendon tendinopathy (Stasinopoulos et al., 2004; Stasinopoulos et al., 2007). On the other hand, even if wound repair would not or hardly be influenced at this stage, the analgesic effect of LCM makes it possible to exercise with less pain and could therefore be an argument to use it. Probably, pain free exercising will contribute to a better compliance of exercise therapy.

There are limitations inherent in this study. First, this study has an *animal* experimental design. Therefore, conclusions can only be carefully implemented to human physiology. Second, the sample size was not very large. Since the pressure force seems to be relevant, the optimal pressure force must should be researched in the future. Recently, Chaves et al. (2020) described the mean pressure given by physiotherapists during deep massage is 2.3 kgf/cm$^2$ in a human population and stated that higher pressures resulted in shorter times to onset of analgesia. Furthermore, it remains unclear if the artificially made tissue damage in this study sufficiently mimics human tendinopathy. Finally, for future studies, classification of wound repair should be standardized.

## 5. CONCLUSION

The application of LCM on damaged collagen tissue improves collagen tissue repair. On the other hand, this tissue repair was only significant in the group that received most treatments, while the groups with the least treatments showed no difference compared to the non-treated side. More research must be done to find the optimal treatment regime for the application of LCM in tendinopathy.

## 6. REFERENCES


1. *Beroepsziekten in cijfers. Nederlands Centrum voor Beroepsziekten (NCvB) 2019, Amsterdam*
2. *Margham T. Musculoskeletal disorders: Time for joint action in primary care. Br J Gen Pract. 2011. doi:10.3399/bjgp11X601541*
3. *Hopkins C, Fu SC, Chua E, et al. Critical review on the socio-economic impact of tendinopathy. Asia-Pacific J Sport Med Arthrosc Rehabil Technol. 2016. doi:10.1016/j.asmart.2016.01.002*
4. *Nederlands Huisartsen Genootschap: Richtlijn Epicondylitis, 2009*
5. *Murtagh JE. Tennis elbow. Aust Fam Physician. 1988.*
6. *Hudak PL, Cole DC, Haines AT. Understanding prognosis to improve rehabilitation: The example of lateral elbow pain. Arch Phys Med Rehabil. 1996. doi:10.1016/S0003-9993(96)90300-7*
7. *Reilingh MWL, Kuijpers T, Tanja-Harfterkamp A, Van Der Windt D. Het beloop en de prognose van schouder-klachten: Verschillen tussen acute en chronische klachten. Huisarts Wet. 2008. doi:10.1007/bf03086934*
8. *Littlewood C, May S, Walters S. A review of systematic reviews of the effectiveness of conservative interventions for rotator cuff tendinopathy. Shoulder Elb. 2013;5:151-167. doi:10.1111/sae.12009*
9. *Almeida MO, Silva BNG, Andriolo RB, Atallah AN, Peccin MS. Conservative interventions for treating exercise-related musculotendinous, ligamentous and osseous groin pain. Cochrane database Syst Rev. 2013;6(6):CD009565. doi:10.1002/14651858.CD009565.pub2*
10. *Weir A, Jansen JACG, van de Port IGL, Van de Sande HBA, Tol JL, Backx FJG. Manual or exercise therapy for long-standing adductor-related groin pain: A randomised controlled clinical trial. Man Ther. 2011;16(2):148-154. doi:10.1016/j.math.2010.09.001*
11. *Weir A, Jansen J, van Keulen J, Mens J, Backx F, Stam H. Short and mid-term results of a comprehensive treatment program for longstanding adductor-related groin pain in athletes: A case series. Phys Ther Sport. 2010;11(3):99-103. doi:10.1016/j.ptsp.2010.06.006*
12. *Sigerist H. E. A History of Medicine. Vol I, Primitive and Archaic Medicine. Oxford University Press, 1977.*
13. *Cyriax, JH. Textbook of Orthopaedic Medicine, volume 2, 8th edition, Balliere Tindall, 1985.*
14. *de Bruijn R. Deep transverse friction; its analgesic effect. Int J Sports Med. 1984. doi:10.1055/s-2008-1025944*
15. *Le Bars D, Dickenson AH, Besson JM. Diffuse noxious inhibitory controls (DNIC). I. Effects on dorsal horn convergent neurones in the rat. Pain. 1979. doi:10.1016/0304-3959(79)90049-6*
16. *Dickenson AH, Le Bars D, Besson JM. Diffuse noxious inhibitory controls (DNIC). Effects on trigeminal nucleus caudalis neurones in the rat. Brain Res. 1980. doi:10.1016/0006-8993(80)90921-X*
17. *Davidson CJ, Ganion LR, Gehlsen GM, Verhoestra B, Roepke JE, Sevier TL. Rat tendon morphologic and functional changes resulting from soft tissue mobilization. Med Sci Sports Exerc. 1997. doi:10.1097/00005768-199703000-00005*
18. *Gehlsen GM, Ganion LR, Helfst R. Fibroblast responses to variation in soft tissue mobilization pressure. Med Sci Sports Exerc. 1999. doi:10.1097/00005768-199904000-00006*
19. *Lee HM, Wu SK, You JY. Quantitative application of transverse friction massage and its neurological effects on flexor carpi radialis. Man Ther. 2009. doi:10.1016/j.math.2008.09.005*
20. *Gregory MA, Deane MN, Mars M. Ultrastructural changes in untraumatised rabbit skeletal muscle treated with deep transverse friction. Physiotherapy. 2003. doi:10.1016/S0031-9406(05)60074-0*

21. *Chaves P, Simões D, Paço M, Pinho F, Duarte JA, Ribeiro F. Pressure Applied during Deep Friction Massage: Characterization and Relationship with Time of Onset of Analgesia. Appl Sci. 2020. doi:10.3390/app10082705*
22. *Couppé C, Svensson RB, Silbernagel KG, Langberg H, Magnusson SP. Eccentric or concentric exercises for the treatment of tendinopathies? J Orthop Sports Phys Ther. 2015. doi:10.2519/jospt.2015.5910*
23. *Murtaugh B, Ihm JM. Eccentric training for the treatment of tendinopathies. Curr Sports Med Rep. 2013. doi:10.1249/JSR.0b013e3182933761*
24. *Rees JD, Lichtwark GA, Wolman RL, Wilson AM. The mechanism for efficacy of eccentric loading in Achilles tendon injury; an in vivo study in humans. Rheumatology. 2008. doi:10.1093/rheumatology/ken262*
25. *Nørregaard J, Larsen CC, Bieler T, Langberg H. Eccentric exercise in treatment of Achilles tendinopathy. Scand J Med Sci Sport. 2007. doi:10.1111/j.1600-0838.2006.00545.x*
26. *O'Neill S, Watson PJ, Barry S. Why are eccentric exercises effective for Achilles tendinopathy? Int J Sports Phys Ther. 2015.*
27. *Lim HY, Wong SH. Effects of isometric, eccentric, or heavy slow resistance exercises on pain and function in individuals with patellar tendinopathy: A systematic review. Physiother Res Int. 2018. doi:10.1002/pri.1721*
28. *Beyer R, Kongsgaard M, Hougs Kjær B, Øhlenschlæger T, Kjær M, Magnusson SP. Heavy slow resistance versus eccentric training as treatment for achilles tendinopathy: A randomized controlled trial. Am J Sports Med. 2015. doi:10.1177/0363546515584760*
29. *Stasinopoulos D, Johnson MI. It may be time to modify the Cyriax treatment of lateral epicondylitis. J Bodyw Mov Ther. 2007. doi:10.1016/j.jbmt.2006.03.005*
30. *Stasinopoulos D, Stasinopoulos I. Comparison of effects of exercise programme, pulsed ultrasound and transverse friction in the treatment of chronic patellar tendinopathy. Clin Rehabil. 2004. doi:10.1191/0269215504cr757oa*
31. *Conover, W.J., Practical nonparametric statistics, Third edition, John Wiley&Sons,1999.*