Achilles Tendinopathy, Pathophysiology, Diagnosis, and Management with Shockwave Therapy

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Abstract

The Achilles tendon is a strong structure that is frequently injured in runners and jumpers, but it can also be present in patients who do not engage in any sports. This clinical syndrome is characterized by pain, structural changes, and impairment of physical function. Achilles tendinopathy is extensively studied because it can be devastating, with slow and prolonged recovery that can take a year or more, and a high risk of re-injury. This condition is classified into insertional and non-insertional Achilles tendinopathy, depending on the affected region of the tendon. Intrinsic and extrinsic factors contribute to the intratendinous changes in vascularization and elevated pain neurotransmitters. The diagnosis is primarily based on the patient's clinical history, and imaging techniques such as ultrasound, including sonoelastography, and magnetic resonance imaging can be useful in identifying the nature, location, and extent of the lesion. Treatment options for Achilles tendinopathy include rehabilitation, image-guided injections, shockwave therapy, ultrasound therapy, percutaneous intratissue electrolysis, orthotics, medications, and surgery. Among these options, shockwave therapy may provide the best tolerance, pain relief, and functional recovery.

Keywords: Achilles tendon, tendinopathy, insertional, non-insertional, extracorporeal shock waves

Introduction

The Achilles tendon is the largest and strongest tendon in the human body and Achilles tendinopathy is one of the most common injuries. The Achilles tendon is formed by the gastrocnemius and soleus muscles, inserting on the posterior surface of the calcaneus. Instead of a true synovial sheath, this tendon has a single layer of paratenon, which is composed of vascularized areolar fatty tissue. The paratenon is responsible for a significant portion of the blood supply to the Achilles tendon, with a hypovascular area located 2–6 cm proximal to the insertion on the calcaneus.[1]

People engaging in running or jumping activities are more likely to develop this condition, but it can also be diagnosed in the general population, with a prevalence of 65%.[2,3]

Studies have reported that Achilles tendinopathy affects 9% of recreational runners and leads to career termination in 5% of professional athletes. Among non-athletes, the prevalence of Achilles tendinopathy is around 5.6%. A study by Kvist found that 20–25% of patients with Achilles tendinopathy had an insertional disorder, 66% did not, and 23% had retrocalcaneal bursitis or insertional tendinopathy. Although most studies include more male participants than females, there is no evidence of a higher prevalence in men. The role of aging as a risk factor for tendinopathy remains controversial.[4].

In cases of rupture, Achilles tendinopathy can be devastating, with slow recovery and a high risk of re-injury. Early recognition and management of initial symptoms such as pain and stiffness can reduce the severity of the injury, minimizing the impact on athletic performance and shortening the time for full recovery.[5].

Achilles tendinopathy can be classified as insertional or non-insertional, which has distinct underlying pathophysiologies and management options.[4].

Furthermore, Achilles tendon injuries can be categorized as insertional tendinopathy (20–25%), midportion tendinopathy (55–65%), and proximal musculotendinous junction injuries (9–25%) based on the location of pain. However, patients may experience symptoms in both the insertion and midportion simultaneously, and approximately 30% of individuals have bilateral pain.

Pathophysiology

Conventionally, several terms have been used to describe tendon disorders, such as tendinitis, tendinosis, and paratenonitis. However, recent histopathological studies have found that these disorders are a result of a failed healing response, leading to degenerative changes in the tendon.[6,7].

In 1998, Maffulli et al. suggested using the term "tendinopathy" to describe these

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Table 1: Risk factors in the presentation of achilles tendinopathy

Intrinsic factors	Extrinsic factors
Valgus heel	Quinolone consumption
Cavus foot	Statins/fibrates consumption
Overweight/obesity	Infiltrations or corticosteroid use
Ankle and first metatarsophalangeal joint arthropathy	Physical overload
Haglund deformity	Inadequate footwear
Dyslipidemia	Direct traumas
Presence of accessory soleus or thin plantar muscle	Vasodilator consumption
Diabetes	Drug consumption
Hypothyroidism	Isotretinoin consumption
Previous or contralateral tendinopathy	Anti-androgenic medication consumption
Sedentary lifestyle	Tobacco
Joint instability	
Menopause	
Vitamin D deficiency	

intratendinous disorders, defining it as a clinical syndrome characterized by pain, structural changes, and impairment of the tendon's physical function.
Histological studies demonstrate collagen disorganization and fragmentation, decreased collagen fiber diameter and overall density, increased number of tenocytes, accumulation of glycosaminoglycans in the extracellular matrix, and neovascularization.[8,9].
Metalloproteinases (MMPs) play a crucial role in extracellular matrix remodeling, and their levels are altered during tendinopathy. MMP-9 and MMP-13 have been implicated in collagen degradation, while MMP-2, MMP-3, and MMP-14 participate in both degradation and remodeling processes.[10,11].

Different growth factors and cytokines, such as vascular endothelial growth factor, insulin-like growth factor, and transforming growth factor β2, have been detected with increased expression in the Achilles tendon. These factors could induce neovascularization, stimulate fibroblast and tenocyte proliferation, and enhance collagen synthesis.[10]
However, it should be noted that up to 34% of asymptomatic tendons show histopathological changes, suggesting that intratendinous degenerative changes may not be the direct cause of pain. [1].
Therefore, overuse is considered to contribute to the condition, but the etiology, pathogenesis, source of pain, and underlying pain mechanisms are still not scientifically clear.

Recently, the hypothesis has been proposed that the main source of pain in patients with symptomatic midportion Achilles tendinopathy does not arise from the tendon itself but rather from the surrounding tissues. Some studies have reported that pain is due to adhesions between the plantaris longus tendon and the Achilles tendon.[11].
Hua suggests that pain is caused by changes in the matrix, blood vessels, tenocytes, cytokines, neuropeptides, neurotransmitters, and ion channels of cells. Furthermore, pain may be triggered through non-nociceptive mechanisms through a load-sensing system, which could be disrupted by local or central dysfunction.[10].
Both intrinsic and extrinsic factors contribute to intratendinous changes, with extrinsic factors playing a significant role in acute Achilles tendon injuries, while chronic tendinopathy is associated with both extrinsic and intrinsic factors. The literature provides various intrinsic and extrinsic risk factors for Achilles tendinopathy, as shown in Table 1.[12-24].

Insertional Achilles Tendinopathy

This condition occurs at the insertion of the tendon on the middle aspect of the posterior calcaneus and is more common in middle-aged and elderly patients. The characteristic feature of insertional Achilles tendinopathy is a degenerative tendon process characterized by loss of parallel collagen structure, fiber integrity, fatty infiltration, and capillary proliferation.[25-27] These changes result from repetitive microtrauma that leads to inflammation and bone metaplasia, ultimately causing the formation of a bony spur on the posterior calcaneus [28, 29].
In patients symptomatic with this condition, calcification of the distal tendon is more common. Over time, the bony spur may continue to grow and irritate the Achilles tendon, leading to degeneration and necrosis. Intratendinous calcifications also develop, which can worsen clinical symptoms [30].

Non-insertional Achilles Tendinopathy

Athletes, both elite and recreational, are the most common group affected by non-insertional Achilles tendinopathy. This condition has been described in association with various sports activities, but it is particularly prevalent in medium and long-distance runners [31].
However, sports activity is not the sole predisposing factor for the development of Achilles tendinopathy. In one series, 18 out of 58 patients with non-insertional Achilles tendinopathy had no direct association with sports or vigorous physical activity. Another retrospective study also found several statistically significant correlations between tendinopathy and diabetes mellitus, obesity, and hypertension [32].

Diagnosis

The patient's history is essential for diagnosing Achilles tendinopathy [8, 33].
Non-insertional Achilles Tendinopathy:
• Localized symptoms 2–7 cm proximal to the insertion of the Achilles tendon.
• Pain in the middle portion of the Achilles tendon during load-bearing (sports-related).
• Local thickening of the middle portion of the Achilles tendon (this may be absent in cases with short-duration symptoms).
• Tenderness on palpation of the middle portion of the Achilles tendon.
• Pain with the painful arc sign.
• Pain with passive dorsiflexion.
• Pain with single-leg heel raise.
• Insertional Achilles Tendinopathy:
• Localized symptoms in the insertion region of the Achilles tendon (within 2 cm of the Achilles tendon insertion).
• Pain in the insertion region of the Achilles tendon during load-bearing (sports-related).
• Local thickening of the insertion region of the Achilles tendon (this may be absent in cases with short-duration symptoms).
• Tenderness on palpation of the insertion region of the Achilles tendon.

It is essential to use a tool to measure the degree of functional impairment using the VISA-A scale.

Imaging Diagnosis

Due to the poor correlation between abnormal tendon structure and pain, imaging plays a limited role in the diagnosis and short-term outcome measurement of tendinopathy. However, imaging can aid in differential diagnosis (identifying peritendinous pathology), confirming tendon rupture, and staging tendinopathy.

Imaging techniques such as ultrasound, including sonoelastography, and magnetic resonance imaging (MRI) can be useful in identifying the nature, location, and extent of a lesion. Ultrasound, especially when combined with power Doppler, can be particularly useful as pain in Achilles tendinopathy appears to be related to areas of neovascularization.

All imaging findings should be interpreted in conjunction with the clinical presentation. Degenerative changes in the tendon are characterized by an increase in tendon thickness. For insertional Achilles tendinopathy, a diagnostic criterion is a thickness >6 mm. Nicholson et al. developed a classification system for Achilles tendon pathology based on MRI, where severity was associated with the prognosis of conservative treatment. The classification system was based on tendon diameter and the presence of tendon degeneration:

- Grade I: Anteroposterior diameter of 6–8 mm with non-uniform degeneration.
- Grade II: Diameter >8 mm with uniform degeneration involving <50% of the tendon width.
- Grade III: Tendon diameter >8 mm with uniform degeneration involving >50% of the tendon width.

The authors found that individuals with Grade I pathology were much less likely to require surgery (13%) compared to those with Grade II or Grade III pathology (91% and 70%, respectively) [28].

MRI is indicated to evaluate concomitant tendon pathologies such as retrocalcaneal bursitis, calcaneal insertion edema, and to delineate features of the lesions, such as partial tears or calcifications. Its use is recommended when there are recurrences of Achilles tendon pain, a history of trauma, or to delineate concurrent or adjacent injuries [34].

Treatment

Treatment options for Achilles tendinopathy include rehabilitation, image-guided high-volume injections, shockwave therapy, ultrasound therapy, percutaneous intratissue electrolysis (EPI), orthoses, medication, and surgery.

New pain-transmitting nerve endings (neonerves) grow in the tendon along with the new blood vessels, and treatment modalities that reduce neovascularization or associated neurologic modulation can lead to symptom reduction.

Pharmacological Treatment

The use of medications during the clinical presentation of tendinopathies is well-known, ranging from non-steroidal anti-inflammatory drugs, opioid analgesics, to excessive use of systemic and local corticosteroids. There are many reports on the harmful effects of corticosteroids, resulting in complications such as infection, changes in collagen nature, tendon ruptures, and Kager's fat pad atrophy. Limited evidence has shown that corticosteroids may provide short-term pain relief [35, 37, 38].

There is no justified evidence for the use of drugs that can cure tendinopathy, particularly Achilles tendinopathy, and no studies support their singular use [39, 40]. The use of neuromodulatory medication may have a beneficial long-term effect on chronic tendinopathies by controlling the production and transmission of pain-generating agents in pathological tendons [41].

Nutritional support may be key to recovery and preventing tendinopathy recurrence. This includes consuming collagen, vitamin D, astaxanthin, vitamin C, and arginine, among others [42, 43].

Physical Therapy Treatment

In a systematic review and meta-analysis of 29 randomized studies, it was found that "wait and see" without intervention is not recommended. On the contrary, all possible physical treatments can help improve pain and function in the medium and long term [44].

Exercise therapy targeting the calf muscles is easy to prescribe, teach, cost-effective, widely available, and has a low risk of harm. Rehabilitation for an athlete with Achilles tendinopathy can be divided into four phases: (1) Symptom management and load reduction, (2) recovery, (3) rebuilding, and (4) return to sport.

The pre-injury activity level may play an important role in the response to treatments such as exercise therapy since it likely influences the load that can be applied to the tendon. At present, there is no tool available to distinguish sedentary patients from athletes, and individuals define this differently. When considering a patient as sedentary, the VISA-A score may be less sensitive to changes as 40% of the score can be obtained from sports activities.

Therefore, a modified version of the existing VISA-A questionnaire is being developed to assess treatment response in sedentary individuals. A considerable amount of literature converges on the fact that eccentric strengthening exercises form the foundation for tendon recovery, especially when combined with nutritional supplementation, shockwave therapy, or the application of biologics [31, 45-48].

Hydrodissection with High Volume

This technique, performed with the assistance of ultrasound, involves injecting a large volume of fluid between the anterior surface of the Achilles tendon and the Kager's fat pad. This leads to elimination of neovascularization and disruption of nerve growth seen in chronic cases of Achilles tendinopathy.

EPI

EPI is a minimally invasive technique guided by ultrasound that involves non-thermal electrochemical ablation using a direct cathodic flow directed toward the degenerated tendon. It promotes phagocytosis and repair of the affected tissue, triggering a localized inflammation exclusively in the treatment area, which leads to rapid regeneration of the injured tendon.

Shockwave Therapy for Achilles Tendinopathy

Extracorporeal shockwave therapy (ESWT) has been widely used in orthopedics and is proposed as a non-surgical alternative treatment for Achilles tendinopathy when conservative treatment fails. ESWT was originally introduced in the medical field in the 1980s for the removal of kidney stones. After successful experiments with rats, ESWT started being used for bone fractures in humans in the early 1990s. In 1991, Valchanou and Michailov introduced the use of shockwaves in orthopedic surgery for delayed fracture consolidation and non-union fractures.

In 2006, John Furia published the results of a prospective randomized controlled trial. The aim of this trial was to determine whether ESWT is an effective treatment for insertional Achilles tendinopathy.

Its use in tendinopathy has been mentioned for about 20 years, and its efficacy and low morbidity are well demonstrated in the literature published so far. According to published literature, shockwave therapy appears to be the most effective option for chronic Achilles tendinopathy.

ESWT was comparable to eccentric training and superior to a wait-and-see approach at 4 months of patient follow-up. Shockwaves provide cell-to-cell contact and cell-matrix interactions, leading to conformational changes in membrane proteins and subsequent generation of intracellular signals that modify gene expression and growth factor release (also called mechanotransduction), allowing the tendon to heal.

In non-insertional tendinopathy, three randomized controlled trials, three case–control studies, and two prospective cohort studies were analyzed. These studies found an overall positive effect of ESWT, both alone and compared to the control groups.

In insertional Achilles tendinopathy, three studies (one randomized controlled trial, one case–control study, and one prospective cohort study) investigated the effect of ESWT on Achilles tendon pathology at the calcaneal insertion. These studies found a positive effect of ESWT on Achilles tendon pathology at 4-month and 1-year follow-ups.

Some protocols have been established for the application of ESWT. Focal ESWT was administered once a week for five sessions. During each session, the number of shocks was 2000, the energy intensity was 0.06–0.1 mJ/mm2, and the frequency was 6–8 Hz.

The level of sports activity is an important factor influencing long-term ESWT outcomes. In 2020, Yunxia et al. published an article stating that active sports patients had better clinical outcomes than inactive non-sports patients after 5 years of follow-up. Maffulli et al. reported that non-athletic patients experienced longer recoveries and more complications and had a higher risk of further surgeries than athletic patients with recalcitrant Achilles tendinopathy after surgical treatment.

It has also been determined that the effect of ESWT may continue after completing the treatment, with clinical outcomes continuing to improve after 5 years. Furia evaluated the effectiveness of ESWT in the symptomatic treatment of Achilles tendinopathy over time and observed satisfactory results in 47.2% of cases at 2 months of follow-up, 73.2% of cases in mid-term follow-up (6–12 months), and 76% of cases in long-term follow-up (13–24 months). These findings indicate that ESWT can effectively treat Achilles tendinopathy over a long period of time.

In reviews of over 100 articles, it has been found that regardless of the final outcome of shockwave therapy, it is a safe and well-tolerated treatment modality.

Complications, side effects, and adverse effects of shockwave therapy have been reported, including neurological injuries and tendon ruptures, usually due to poor application of shockwaves. Therefore, it is essential that qualified personnel perform the evaluation and application of shockwave therapy on patients with appropriate diagnosis and high-quality equipment [56-58].

Surgical Treatment of Achilles Tendinopathy

In the study by Stenson et al., four factors were found to correlate with the failure of conservative treatment: High visual analog scale, limited ankle range of motion, previous corticosteroid injection, and presence of enthesophyte in the Achilles tendon. The indications for surgical treatment are determined by the symptoms, pain, and structural alteration present in the tendon. If there is an increase in symptoms with significant functional limitation and correlating with tears or loss of structural viability of the tendon, several treatments can be proposed, ranging from arthroscopy with debridement to transferring the Hallux tendon to the Achilles tendon, accompanied by prolonged recovery periods and appropriate physiotherapy.

Conclusions and Recommendations

Achilles tendinopathy is possibly the most common tendinopathy. It can be caused by numerous intrinsic and extrinsic factors, with common ones being statin use, quinolone use, overweight, and changes in tendon load-bearing. Timely diagnosis provides the possibility of a solution and helps prevent potential ruptures.

Imaging examinations serve to observe special characteristics such as vascularity, tendon ruptures, tenosynovitis, and even degree of stiffness, but they do not provide an immediate prognosis. The primary diagnostic tool of choice is ultrasound and elastography.

The foundation of treatment is the proper redistribution of loads through physiotherapy and eccentric exercises.

Other therapeutic methods such as orthoses, medication, physical modalities, and expectant management without therapeutic support have shown a higher risk of complete rupture of pathological tendons.

The use of supplements such as arginine, astaxanthin, vitamin D, vitamin C, and certain types of collagens is recommended to improve tendon metabolism.

The application of shockwaves and radial pressure waves is an efficient, tolerable, and safe method for tendinopathies, but it should be carried out by qualified medical personnel for both diagnosis and to avoid potential complications.

Clinical Relevance

Based on the literature review on the optimal

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has/her given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

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outcomes of ESWT-F as a treatment, further research in this field is needed to increase the evidence, and it can be established as a preferred treatment option for chronic cases.

References

1. Weinfeld SB. Achilles tendon disorders. Med Clin North Am 2014;98:331-8.

2. Silbernagel KG, Hanlon S, Sprague A. Current clinical concepts: Conservative management of Achilles tendinopathy. J Athl Train 2020;55:438-47.

3. Li HY, Hua YH. Achilles tendinopathy: Current concepts about the basic science and clinical treatments. Biomed Res Int 2016;2016:6492597.

4. Maffulli N, Longo UG, Kadakia A, Spiezia F. Achilles tendinopathy. Foot Ankle Surg 2020;26:240-9.

5. Silbernagel KG, Malliaras P, de Vos RJ, Hanlon S, Molenaar M, Alfredson H, et al. ICON 2020-international scientific tendinopathy symposium consensus: A systematic review of outcome measures reported in clinical trials of Achilles tendinopathy. Sports Med 2022;52:613-41.

6. Färnqvist K, Pearson S, Malliaras P. Adaptation of tendon structure and function in tendinopathy with exercise and its relationship to clinical outcome. J Sport Rehabil 2020;29:107-15.

7. Del Buono A, Chan O, Maffulli N. Achilles tendon: Functional anatomy and novel emerging models of imaging classification. Int Orthop 2013;37:715-21.

8. Thomopoulos S, Parks WC, Rifkin DB, Derwin KA. Mechanisms of tendon injury and repair. J Orthop Res 2015;33:832-9.

9. Li HY, Yasui Y, Han SH, Miyamoto W, Hua YH. Achilles tendinopathy: From the basic science to the clinic. Biomed Res Int 2017;2017:9534125.

10. Magnan B, Bondi M, Pierantoni S, Samaila E. The pathogenesis of Achilles tendinopathy: A systematic review. Foot Ankle Surg 2014;20:154-9.

11. Van der Vlist AC, Breda SJ, Oei EH, Verhaar JA, de Vos RJ. Clinical risk factors for Achilles tendinopathy: A systematic review. Br J Sports Med 2019;53:1352-61.

12. Ackermann PW, Renström P. Tendinopathy in sport. Sports Health 2012;4:193-201.

13. Rai V, Dietz NE, Dilisio MF, Radwan MM, Agrawal DK. Vitamin D attenuates inflammation, fatty infiltration, and cartilage loss in the knee of hyperlipidemic microswine. Arthritis Res Ther 2016;18:203.

14. Klein EE, Weil L Jr., Weil LS, Fleischer AE. Body mass index and Achilles tendonitis: A 10-year retrospective analysis. Foot Ankle Spec 2013;6:276-82.

15. Masci L, Spang C, Van Schie HT, Alfredson H. How to diagnose plantaris tendon involvement in midportion Achilles tendinopathy-clinical and imaging findings. BMC Musculoskelet Disord 2016;17:97.

16. Geyer M. Achillodynia. Orthopade 2005;34:677-81.

17. Yasmin Khaliq , George G. Zhanel, Fluoroquinolone-Associated Tendinopathy: A Critical Review of the Literature, Clinical Infectious Diseases, Volume 36, Issue 11, 1 June 2003, Pages 1404–1410, https://doi.org/10.1086/375078

18. Singh D. Cholesterol level in non-insertional Achilles tendonopathy. Foot (Edinb) 2015;25:228-31.

19. Luck MD, Gordon AG, Blebea JS, Dalinka MK. High association between accessory soleus muscle and Achilles tendonopathy. Skeletal Radiol 2008;37:1129-33.

20. Vallone G, Vittorio T. Complete Achilles tendon rupture after local infiltration of corticosteroids in the treatment of deep retrocalcaneal bursitis. J Ultrasound 2014;17:165-7.

21. Abate M, Salini V, Schiavone C. Achilles tendinopathy in elderly subjects with Type II diabetes: The role of sport activities. Aging Clin Exp Res 2016;28:355-8.

22. Marques PP, Vieira CP, de Oliveira LP, Pimentel ER, Da Re Guerra F. Chronical treatment with sildenafil causes Achilles tendinopathy in rats. Life Sci 2018;212:87-92.

23. Docking SI, Rosengarten SD, Daffy J, Cook J. Structural integrity is decreased in both Achilles tendons in people with unilateral Achilles tendinopathy. J Sci Med Sport 2015;18:383-7.

24. Chimenti RL, Cychosz CC, Hall MM, Phisitkul P. Current concepts review update: Insertional Achilles tendinopathy. Foot Ankle Int 2017;38:1160-9.

25. Gaston TE, Daniel JN. Achilles insertional tendinopathy-is there a gold standard? Arch Bone Jt Surg 2021;9:5-8.

26. Grambart ST, Lechner J, Wentz J. Differentiating Achilles insertional calcific tendinosis and Haglund's deformity. Clin Podiatr Med Surg 2021;38:165-81.

27. Jarin I, Bäcker HC, Vosseller JT. Meta-analysis of noninsertional Achilles tendinopathy. Foot Ankle Int 2020;41:744-54.

28. Pearce CJ, Tan A. Non-insertional Achilles tendinopathy. EFORT Open Rev 2016;1:383-90.

29. De Vos RJ, van der Vlist AC, Winters M, van der Giesen F, Weir A. Diagnosing Achilles tendinopathy is like delicious spaghetti carbonara: It is all about key ingredients, but not all chefs use the same recipe. Br J Sports Med 2021;55:247-8.

30. Pierre-Jerome C, Moncayo V, Terk MR. MRI of the Achilles tendon: A comprehensive review of the anatomy, biomechanics, and imaging of overuse tendinopathies. Acta Radiol 2010;51:438-54.

31. Lopez RG, Jung HG. Achilles tendinosis: Treatment options. Clin Orthop Surg 2015;7:1-7.

32. Knobloch K. Drug-induced tendon disorders. Adv Exp Med Biol 2016;920:229-38.

33. Bolon B. Mini-review: Toxic tendinopathy. Toxicol Pathol 2017;45:834-7.

34. Taneja AK, Santos DC. Steroid-induced Kager's fat pad atrophy. Skeletal Radiol 2014;43:1161-4.

35. Aicale R, Oliviero A, Maffulli N. Management of Achilles and patellar tendinopathy: What we know, what we can do. J Foot Ankle Res 2020;13:59.

36. Duchman KR, Lemmex DB, Patel SH, Ledbetter L, Garrigues GE, Riboh JC. The effect of non-steroidal anti-inflammatory drugs on tendon-to-bone healing: A systematic review with subgroup meta-analysis. Iowa Orthop J 2019;39:107-19.

37. Scott A, Bahr R. Neuropeptides in tendinopathy. Front Biosci (Landmark Ed) 2009;14:2203-11.

38. Hijlkema A, Roozenboom C, Mensink M, Zwerver J. The impact of nutrition on tendon health and tendinopathy: A systematic review. J Int Soc Sports Nutr 2022;19:474-504.

39. Fusini F, Bisicchia S, Bottegoni C, Gigante A, Zanchini F, Busilacchi A. Nutraceutical supplement in the management of tendinopathies: A systematic review. Muscles Ligaments Tendons J 2016;6:48-57.

40. Van der Vlist AC, Winters M, Weir A, Ardern CL, Welton NJ, Caldwell DM, et al. Which treatment is most effective for patients with Achilles tendinopathy? A living systematic review with network meta-analysis of 29 randomised controlled trials. Br J Sports Med 2021;55:249-55.

41. Balius R, Álvarez G, Baró F, Jiménez F, Pedret C, Costa E, et al. A 3-arm Randomized trial for Achilles tendinopathy: Eccentric training, eccentric training plus a dietary supplement containing mucopolysaccharides, or passive stretching plus a dietary supplement containing mucopolysaccharides. Curr Ther Res Clin Exp 2016;78:1-7.

42. Gatz M, Betsch M, Dirrichs T, Schrading S, Tingart M, Michalik R, et al. Eccentric and isometric exercises in Achilles tendinopathy evaluated by the visa-a score and shear wave elastography. Sports Health 2020;12:373-81.

43. Tumilty S, Mani R, Baxter GD. Photobiomodulation and eccentric exercise for Achilles tendinopathy: A randomized controlled trial. Lasers Med Sci 2016;31:127-35.

44. Abat F, Diesel WJ, Gelber PE, Polidori F, Monllau JC, Sanchez-Ibañez JM. Effectiveness of the Intratissue Percutaneous Electrolysis (EPI®) technique and isoinertial eccentric exercise in the treatment of patellar tendinopathy at two years follow-up. Muscles Ligaments Tendons J 2014;4:188-93.

45. Fan Y, Feng Z, Cao J, Fu W. Efficacy of extracorporeal shock wave therapy for Achilles tendinopathy: A meta-analysis. Orthop J Sports Med 2020;8:2325967120903430.

46. Gerdesmeyer L, Mittermayr R, Fuerst M, Al Muderis M, Thiele R, Saxena A, et al. Current evidence of extracorporeal shock wave therapy in chronic

Achilles tendinopathy. Int J Surg 2015;24:154-9.

47. Benli MD, Tatari H, Balcı A, Peker A, Şimşek K, Yüksel O, et al. A comparison between the efficacy of eccentric exercise and extracorporeal shock wave therapy on tendon thickness, vascularity, and elasticity in Achilles tendinopathy: A randomized controlled trial. Turk J Phys Med Rehabil 2022;68:372-80.

48. Zhang S, Li H, Yao W, Hua Y, Li Y. Therapeutic response of extracorporeal shock wave therapy for insertional Achilles tendinopathy between sports-active and nonsports-active patients with 5-year follow-up. Orthop J Sports Med 2020;8(1):2325967119898118.

49. Stania M, Juras G, Chmielewska D, Polak A, Kucio C, Król P. Extracorporeal shock wave therapy for Achilles tendinopathy. Biomed Res Int 2019;2019:3086910.

50. Abarca WI, Delgado SL, Vela PT, Portillo TP, Asnalema DM, García LA. Patellar tendon rupture after radial pressure wave therapy-also known as radial shock wave therapy-for patellar tendinopathy: Report of two cases. Rev Fac Med Hum 2021;21:449-58.

51. Vela PT, Abarca WI, Asnalema DM, Platero-Portillo T, Rosas SR, Delgado SL, et al. Ulnar nerve injury secondary to radial extracorporeal shock wave therapy identified with high-resolution ultrasonography: Case report.Rev Fac Med Hum 2020;20:156-61.

52. Moya D, Ramón S, Guiloff L, Terán P, Eid J, Serrano E. Poor results and complications in the use of focused shockwaves and radial pressure waves in musculoskeletal pathology. Rehabilitacion (Madr) 2022;56:64-73.

53. Stenson JF, Reb CW, Daniel JN, Saini SS, Albana MF. Predicting failure of nonoperative treatment for insertional Achilles tendinosis. Foot Ankle Spec 2018;11:252-5.

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