Cite as: Kakkos GA, Klontzas ME, Koltsakis E, Apostolos H. Karantanas AH: US-guided high-volume injection for Achilles tendinopathy. J Ultrason 2021; 21: e127–e133. doi: 10.15557/JoU.2021.0021.

Submitted: 11.02.2021
Accepted: 16.03.2021
Published: 07.06.2021

US-guided high-volume injection for Achilles tendinopathy

George A. Kakkos[1], Michail E. Klontzas[1,2,3], Emmanouil Koltsakis[1], Apostolos H. Karantanas[1,2,3]

[1] Department of Medical Imaging, University Hospital of Heraklion, Crete, Greece
[2] Advanced Hybrid Imaging Systems, Institute of Computer Science, FORTH, Crete, Greece
[3] Department of Radiology, School of Medicine, University of Crete, Greece

Correspondence: Michail E. Klontzas, e-mail: miklontzas@gmail.com

DOI: 10.15557/JoU.2021.0021

Keywords
Achilles tendinopathy, neovascularity, ultrasound, high-volume image-guided injection

Abstract

Achilles tendinopathy is a common overuse condition affecting the adult population. The incidence is on the rise because of greater participation of people in recreational or competitive sporting activities. Chronic Achilles tendinopathy occurs most commonly in the tendon's mid-portion, and it is challenging to manage, leading to significant patient morbidity. Despite conservative management many patients still require surgical intervention. The mechanism underlying pain is not entirely understood; however, high-resolution color Doppler ultrasound has shown that neovascularisation could be involved. Minimally-invasive treatments for chronic Achilles tendinopathy may prevent the need for surgery when conservative methods have failed. Ultrasound provides an option to guide therapeutic interventions accurately, so that treatment is delivered to the desired site of pathology. High-volume image-guided injection is a relatively new technique where a high volume of liquid is injected between the anterior aspect of the Achilles tendon and the Kager's fat pad, used to strip away the neovascularity and disrupt the nerve ingrowth seen in chronic cases of Achilles tendinopathy. High-volume image-guided injection has shown promising results in terms of reducing pain and improving function in patients where conservative measures have failed. This review aims to describe the fundamental technical factors, and investigate the efficacy of high-volume image-guided injection with reference to the available literature.

Introduction

The Achilles tendon is the strongest and thickest weight-bearing tendon in the human body. Its origin is near the middle of the calf and is the conjoint tendon of the gastrocnemius and soleus muscles[(1)]. The tendon does not have a true synovial sheath; instead, it is enveloped on its dorsal, lateral, and medial aspects by a paratenon composed of connective tissue that allows for approximately 1.5 cm of tendon gliding with activity[(2)].

Along with the patellar tendon, the Achilles is the commonest lower limb tendon to rupture, but also it is most frequently impaired as a result of overuse leading to tendinopathy[(3)]. Chronic midportion Achilles tendinopathy is a common overuse injury that is often long-standing. Over the past three decades, the incidence has been rising because of greater participation in sports activities. Runners are most at risk of developing symptoms, with a lifetime risk of 52%[(4)]. However, patients with this condition do not always participate in vigorous physical activity[(5)].

Achilles tendinopathy as a clinical syndrome is characterized by a combination of pain, swelling, and impaired performance[(6)]. Conservative or physical therapies are established as first-line management, with eccentric loading exercises considered as the gold standard in the initial treatment[(7)]. Despite the initiation of therapy, a significant proportion of patients continue to have symptoms even after ten years[(8)]. About one-third of these non-responders eventually require surgery[(9)]. Therefore, effective minimally invasive treatment options are necessary to improve the outcome of patients with chronic Achilles tendinopathy who fail to respond to the initial exercise treatment. The use of injectable substances such as platelet-rich plasma,

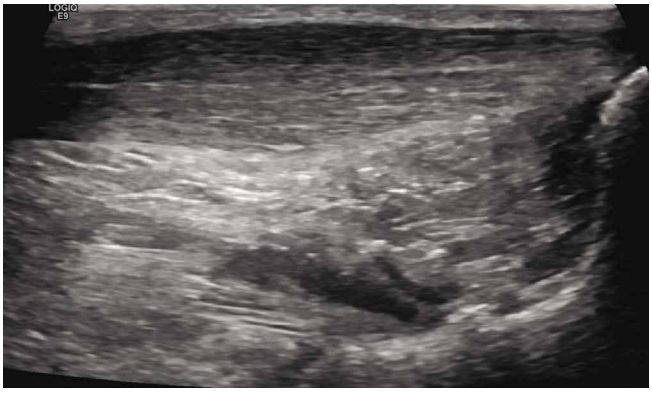

Fig. 1. *Longitudinal B-mode image of the Achilles tendon in a patient with chronic mid-portion Achilles tendinopathy. Fusiform swelling with increased anterior-posterior diameter and reduced echogenicity of the superficial part of the tendon are shown*

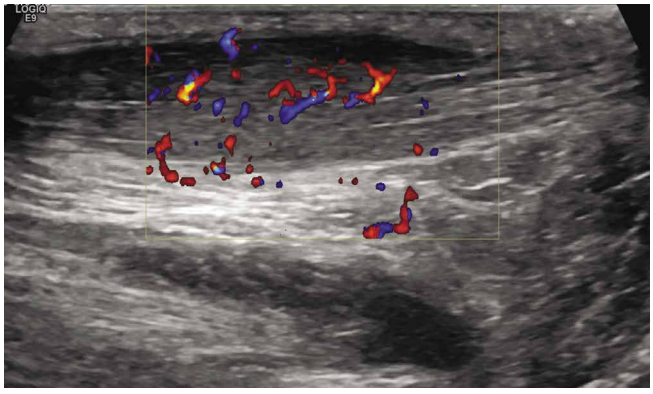

Fig. 2. *Longitudinal color Doppler image of the Achilles tendon in the same patient as in Fig. 1, demonstrating florid neovascularity with intratendinous neovessels inserting from the ventral side of the tendon*

autologous blood, polidocanol, corticosteroids, and aprotinin in and around tendons is a widespread therapeutic modality; however, there is minimal clinical evidence to support its efficacy[10]. High-volume image-guided injection (HVIGI) is a relatively new procedure that has shown good short- to medium-term relief of symptoms in the management of chronic mid-substance Achilles tendinopathy[11].

Ultrasound imaging

High-resolution ultrasound (US) is the imaging examination of choice for assessing the Achilles tendon. The superficial location and orientation of the tendon allow excellent evaluation results[12], and the current advances in probe and scanner design enable superior visualization even of the finest anatomical details[13]. On US, the normal Achilles tendon is a bright echogenic structure that typically demonstrates a compact fibrillar pattern of parallel hyperechoic lines corresponding to the collagen fiber bundles in the tendon[14]. The paratenon surrounding the tendon appears as a thin echogenic line marking the edge of the tendon[15]. In the current practice, there are several sonographic findings that may suggest a diagnosis of Achilles tendinopathy, including an increase in tendon caliber (particularly of the mid- and distal portions of the tendon), a disruption of the fibrillar pattern, and an increase in tendon vascularity (Fig. 1). Additional signs include increased Kager's fat pad echogenicity and associated peritendinous adhesions, seen as thickening of the paratenon[16]. Promising results for the diagnosis of Achilles tendinopathy have been demonstrated with US elastography (both compression and shear wave), with comparable or even superior accuracy to standard B mode ultrasound. However large well-designed studies are still needed to establish the suitability of this promising technique in the diagnosis of Achilles tendinopathy[17].

Neovascularity

It has been shown that microcirculatory blood flow is significantly elevated at the site of pain in insertional and mid-portion tendinopathy[18]. With the technological advances in color and power Doppler ultrasound, small vessel detection in musculoskeletal structures is possible with great accuracy[19]. In 2001, Öhberg *et al*.[20] first described the presence of blood flow on ultrasound in the areas of degenerative tendon changes (localized thickening with focal hypoechoic areas) in patients with chronic Achilles tendinopathy, but not in any of the normal pain-free tendons. The formation of new blood vessels, termed neovascularization, has been linked to pain[21], reduced function, and chronicity of tendinopathy[22]. When present, these neovessels predominate on the ventral side of the Achilles tendon (Fig. 2). There is evidence that nerve structures of the ventral paratendinous tissue related to the neovessels may be the source of pain in tendinopathy[23,24]. Alfredson *et al*.[23] injected a local anesthetic ventral to the tendon in a cohort of affected individuals, achieving temporary pain relief in all patients. This finding led to the hypothesis that obliterating the neovasculature may diminish refractory Achilles tendon pain. Öhberg and Alfredson[25,26] conducted a series of studies targeting neovessels in chronic tendinopathies, using polidocanol as a sclerosing agent. Polidocanol injections showed good clinical results and an absence of or a decrease in neovascularity in the treated tendons. A potential disadvantage of sclerosing therapy is that multiple treatment sessions are necessary, and the long-term effects of the method still remain unclear[27].

High-volume image-guided injection (HVIGI)

The assumption behind HVIGI is that with the disruption of neovessels seen in degenerated Achilles tendons, the accompanying nerve supply is also damaged, resulting in pain reduction. Chan *et al*. first[28] hypothesized that high-volume injections of normal saline would produce local mechanical effects, causing neovessels to stretch, break or occlude, with the destruction of companion sensory nerves either by trauma or ischemia. Using ultrasound guidance to place the needle between the anterior aspect of the Achilles tendon and the Kager's fat pad, a mixture of 10 ml of 0.5% bupivacaine hydrochloride and 25 mg of hydrocortisone acetate was injected, followed by 40 ml of normal injectable saline. They found that high volume injections significantly reduced pain

Tab. 1. *Summary of published evidence for the application of HIVIGI in Achilles tendinopathy*

Author (year)	Study type	Intervention	N	Change in VAS score	Change in VISA-A score	Conclusion
Chan *et al.* (2008)[28]	Case series	10 ml 0.5% Bupivacaine 25 mg Hydrocortisone 40 ml N Saline	30	N = 21 2 weeks – 50 mm 30 weeks – 47 mm	30 weeks + 31.4	HVIGI significantly reduces pain and improves function in patients with resistant Achilles tendinopathy in the short- and long-term
Humphrey *et al.* (2010)[29]	Case series	10 ml 0.5% Bupivacaine 25 mg Hydrocortisone 40 ml N Saline	11	–	3 weeks + 38	HVIGI for resistant tendinopathy of the main body of the Achilles tendon is effective to improve symptoms, reduce neovascularisation, and decrease maximal tendon thickness at short-term follow-up
Restighini and Yeoh (2012)[30]	Case series	5 ml 1% Lidocaine 25 mg Hydrocortisone up to 40 ml N Saline	32	4 weeks – 34 mm 3 months – 37 mm	4 weeks + 26 3 months + 28.7	HVIGI is safe and clinically cost-effective in the treatment of Achilles tendinopathy. Results suggest that baseline neovascularity is relevant to outcome following injection
Maffuli *et al.* (2013)[31]	Case series	10 ml 0.5% Bupivacaine 25 mg Aprotinin up to 40 ml N saline	94	–	12 months + 32.9	HVIGI with aprotinin significantly reduces pain and improves function in patients with chronic Achilles tendinopathy in the short- and long-term follow-up
Wheeler *et al.* (2014)[32]	Case series	10 ml 1% Lidocaine 40 ml N Saline No corticosteroid	16	347 days – 6.1/10	347 days + 41	HVIGI without a corticosteroid appears to be an effective procedure for patients with recalcitrant Achilles tendon symptoms. Further work is needed to formally establish benefits from HVIGI for patients with Achilles tendinopathy and to identify optimal injectate
Wheeler *et al.* (2016)[33]	Case series – 2 Groups	Group 1: 10 ml 1% Lidocaine 40 ml Saline Group 2: 10 ml 1% Lidocaine 20 ml Saline + dry needling	34	Group 1: 281 days – 4.6/10 Group 2: No data	Group 1: 281 days + 33.4 Group 2: 271 days + 6.94	HVIGI reduces VISA-A scores in both groups. A higher volume without dry needling compared with a lower volume with dry needling resulted in greater improvement in noninsertional Achilles tendinopathy
Boesen *et al.* (2017)[34]	Case series – 3 Groups	All subjects performed eccentric training Group 1: 10 ml 0.5% Bupivacaine 20 mg Depo-Medrol 40 ml N saline Group 2: 4 PRP injections each 14 days apart Group 3: Placebo (a few drops of saline under the skin)	60	Group 1: 6 weeks – 48.5 mm 12 weeks –44.9 mm 24 weeks -34.1 mm Group 2: 6 weeks – 37.3 mm 12 weeks –40.9 mm 24 weeks –37.1 mm Group 3: 6 weeks – 22.5 mm 12 weeks –29.5 mm 24 weeks –18.1 mm	Group 1: 6 weeks + 27.1 12 weeks + 28.8 24 weeks + 22.2 Group 2: 6 weeks + 13.8 12 weeks + 14.8 24 weeks + 19.6 Group 3: 6 weeks + 9.9 12 weeks + 10.6 24 weeks + 8.8	Treatment with HVIGI or PRP in combination with eccentric training in chronic AT seems more effective in reducing pain, improving activity level, and reducing tendon thickness and intratendinous vascularity than eccentric training alone. HVIGI may be more effective in improving outcomes of chronic AT than PRP in the short term
Boesen *et al.* (2019)[35]	Case series –2 Groups	All subjects performed eccentric training Group 1: 10 ml 0.5% Bupivacaine 20 mg Depo-Medrol 40 ml N saline Group 2: 10 ml 0.5% Bupivacaine 40 ml N saline	28	Group 1: 6 weeks – 55.4 mm 12 weeks –52.6 mm 24 weeks –40.1 mm Group 2: 6 weeks –16.1 mm 12 weeks – 25 mm 24 weeks –33.9 mm	Group 1: 6 weeks + 30.6 12 weeks + 31.9 24 weeks + 26.4 Group 2: 6 weeks + 13.8 12 weeks + 14.8 24 weeks + 23.7	High-volume injection with or without corticosteroid in combination with eccentric training seems effective in AT. HVIGI with corticosteroid showed a better short-term improvement than HVIGI without corticosteroid, indicating a short-term effect of corticosteroid in HVIGI treatment of AT
Nielsen *et al.* (2020)[36]	Case series	10 ml 0.5% Marcaine 0.5 mL Triamcinolonacetonid (40 mg/mL) 40 ml N saline	30	–	12 months 10 patients + 11	In this retrospective case-study, only 10 patients (33%) benefitted from a single HVIGI treatment at 12 months and an 11-point significant improvement was seen on the VISA-A score
Edwards and Sivan (2020)[37]	Case series	2 ml 0.25% Bupivacaine 0.5 ml (20 mg) Kenalog 37.5 ml N saline	18	Numeric rating scale of pain (NRS) 8 weeks – 5.3	–	Significant reduction in pain, tendon thickness and neovascularity were observed in 78% of patients. The recurrence rate was 39%. HVIGI with eccentric training is a safe and effective intervention in an outpatient clinic setting

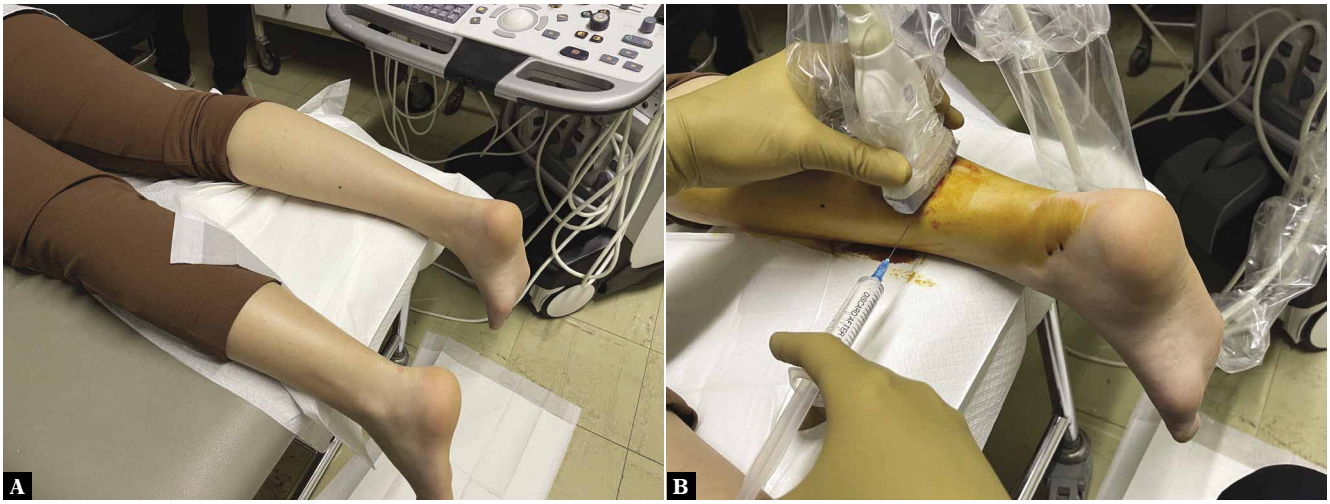

Fig. 3. *The Achilles tendon is best scanned with the patient prone. The foot overhangs the end of the examination bed to allow tendon movement (***A***). Medial approach using a freehand in-plane technique. The ultrasound probe is held transversely relative to the Achilles tendon (***B***)*

and improved function in 30 patients with chronic Achilles tendinopathy who had failed to improve after a three-month program of eccentric loading of the gastro-soleus complex both in the short- and long-term. No complications were reported. No patient experienced a rupture or tear of the Achilles tendon at follow-up, and no patient progressed to surgery. Since then, several other studies have emerged using therapeutic HVIGI to treat chronic mid-substance Achilles tendinopathy. Table 1 outlines the HVIGI studies to date[29–37]. Most of them showed significant changes in Visual Analog Scale (VAS) and the Victorian Institute of Sports Assessment-Achilles questionnaire (VISA-A) scores. The VAS for pain and the VISA-A are validated and reliable tools for measuring Achilles tendinopathy pain and function, allowing a comparison of treatment results[38,39]. At present, HVIGI is only used in patients with insertional and non-insertional Achilles tendinopathy, and avoided in patients with large tears. The application of HVIGI has not been established in other types of Achilles pathology.

HVIGI procedure

Informed consent

Through the consent process, it is a standard procedure to discuss with the patient the (low) likelihood of bleeding, infection and injury to adjacent neurovascular structures in addition to the possible adverse effects associated with corticosteroid use: post-injection flare, local tissue atrophy, tendon rupture, flushing, and transient increased blood glucose level[40,41]. Coagulation laboratory tests are not usually necessary prior to the injection due to the low risk of bleeding[42].

Patient positioning and preprocedural scan

To ensure patient comfort and optimal visualization of the anatomy, the patient is prone, with the foot hanging over the edge of the table (Fig. 3A). Gentle dorsiflexion of the ankle and the use of sterile transmission gel help optimize imaging[43]. A preliminary diagnostic scan using a linear high frequency (7–12 MHz) ultrasound probe should be performed before the procedure to document the baseline appearance of the abnormality, detect areas of increased neovascularity as target areas, locate any adjacent neurovascular structures to be avoided, and plan the optimal needle entry point and route to the target site[44]. The ideal injection site is at the level of the thickest portion of the tendon with the most significant degree of neovascularity. Using a skin marker, a dot for the ideal needle entry point may be drawn.

Skin and transducer preparation

The injection area is sterilized using an iodine-based solution. The transducer is also immersed in an iodine-based solution and surrounded by a sterile cover. A sterile gel must be used, if necessary.

Injectable substances, syringes and needles

The following injectables and dosages are the author's preferred choice, based on published evidence and experience. A 10 ml syringe is typically used with a 25 G needle (blue), filled with 1% lidocaine for regional anesthesia, a 10 ml syringe with a 21 G needle (green) filled with 1 mL of 40 mg/mL methylprednisolone or an equivalent corticosteroid and 9 ml of a long-acting anesthetic, typically 0.5% bupivacaine, and two 20 ml syringes with an extension tube filled with normal saline 0.9%.

Injection procedure

At our institution, the injection is routinely performed using a freehand in-plane technique[45]. The ultrasound probe is held transversely relative to the Achilles tendon.

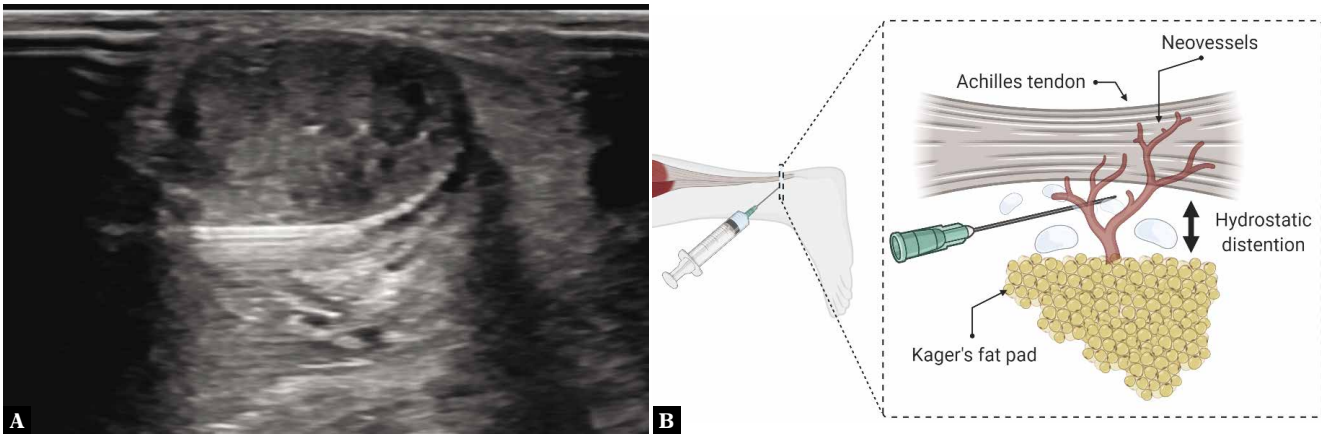

Fig. 4. *Transverse image during a high-volume image-guided injection showing needle placement ventral to the tendon between the tendon and the Kager's fat pad (***A***). Drawing demonstrating the target area between the tendon and the Kager's fat pad, aiming at stripping the tendon from neovessels originating from its ventral side (created with biorender.com) (***B***)*

A medial approach is used to minimize the risk of injuring the sural nerve[46] (Fig. 3B). First, lidocaine is injected into the skin, and subcutaneous and deep tissues. After local anesthesia is achieved, the 21 G needle with the syringe containing the mixture of methylprednisolone and bupivacaine is inserted parallel to the long axis of the ultrasound probe and – under continuous observation – is guided deep to the tendon between the tendon and the Kager's fat pad (Fig. 4), targeting the area of maximal neovascularization. Once the first syringe is injected and removed, the extension tube is connected to the needle, and the syringes containing 40 ml of normal saline are injected at the same location. Constant visualization of needle position confirms proper placement, providing continuous monitoring of the distribution of the administered agents, and ensuring that no unwanted structures are injured or injected[47].

Postprocedural care and rehabilitation

After the needle is removed, a post-injection scan is performed (Fig. 5). Pressure is applied at the puncture site, and the area is covered with a small bandage. The patient is advised to rest and avoid movements for two days. Paracetamol and ice packs are recommended, if necessary.

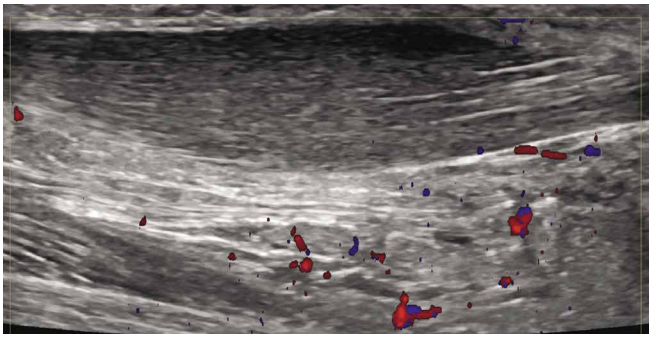

Fig. 5. *Longitudinal color Doppler image of the Achilles tendon in the same patient as in Fig. 2 after the HVIGI procedure, showing no remaining intratendinous neovessels*

An eccentric loading exercise program is recommended after three days following the procedure with gradually increasing intensity as pain allows[48].

Discussion

The management of Achilles tendinopathy remains a major challenge. Based on the relative limited published data in conjunction with our department's experience, HVIGI seems to be a safe, fast, relatively inexpensive, minimally invasive technique with a great potential for the treatment of chronic mid-substance Achilles tendinopathy. This treatment approach has been shown to significantly reduce pain and improve short- and long-term function in patients regardless of the severity of their symptoms[28,34]. It works well in combination with conservative treatments, especially eccentric loading exercises[48]. It has a very low complication rate and any serious complication has yet to be reported. HVIGI should be considered as an option before surgery when other conservative or minimally invasive methods have failed. Surgery, in addition to an increased rate of complications, is more expensive and requires an extended period of rehabilitation prior to the patient being able to return to sports or routine physical activities. With HVIGI, we can document the abnormality and perform the procedure within one patient visit.

The majority of published studies report positive results, but almost all lack control groups and are limited by the small number of included patients. There are also differences in the duration of follow-up between studies, discrepancies in outcome measurements, and variations in the injectable drugs and doses, making the results of this group of studies challenging to interpret (a detailed presentation of the available literature and the outcomes of existing studies is presented in Tab. 1). Discrepances in study design have led to a great variability in reported treatment efficacy, ranging from 18.1 mm to 61 mm of VAS score reduction[32,34]. Nonetheless, irrespective of quantitative

data, the majority of published studies report a significant benefit in treated patients.

Work is still needed to optimize the technique and systematically compare to outcomes of conservative and surgical treatments over a long follow-up course. There is still no consensus as to the optimal content and volume of the solution used to achieve desired effects. Therefore, more good-quality randomized controlled trials including a larger number of patients with a non-injected control group matched for age, sex and physical activity with longer-term follow-up are still required to further determine the value of HVIGI in the treatment of Achilles tendinopathy. Other US-guided treatment options for Achilles tendinopathy include sclerotherapy for obliterating the neovessels, corticosteroid injections, and intratendinous hyperosmolar dextrose injections (prolotherapy). However, the need for multiple treatment repeats with sclerotherapy and corticosteroids, the association of corticosteroid intratendinous injections with Achilles ruptures, and the lack of evidence for the efficacy of prolotherapy have significantly limited their clinical use[49,50].

Conclusion

In conclusion, HVIGI presents an effective treatment option for patients with Achilles tendinopathy, potentially offering a significant pain improvement when traditional conservative measures have failed. Work is still required to further optimize the technique and acquire long-term follow-up treatment outcome data. However, existing data already indicate that HVIGI might be the treatment of choice in patients with persistent Achilles tendinopathy as a safe and effective way of delaying or even avoiding surgery.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

References

1. Doral MN, Alam M, Bozkurt M, Turhan E, Atay OA, Dönmez G *et al.*: Functional anatomy of the Achilles tendon. Knee Surg Sport Traumatol Arthrosc 2010; 18: 638–643.
2. Uquillas CA, Guss MS, Ryan DJ, Jazrawi LM, Strauss EJ: Everything Achilles: knowledge update and current concepts in management. J Bone Joint Surg Am 2015; 97: 1187–1195.
3. Magnan B, Bondi M, Pierantoni S, Samaila E: The pathogenesis of Achilles tendinopathy: A systematic review. Foot Ankle Surg 2014; 20: 154–159.
4. Kujala UM, Sarna S, Kaprio J: Cumulative incidence of achilles tendon rupture and tendinopathy in male former elite athletes. Clin J Sport Med 2005; 15: 133–135.
5. Rolf C, Movin T: Etiology, histopathology, and outcome of surgery in achillodynia. Foot Ankle Int 1997; 18: 565–569.
6. van Dijk CN, van Sterkenburg MN, Wiegerinck JI, Karlsson J, Maffulli N: Terminology for Achilles tendon related disorders. Knee Surg Sport Traumatol Arthrosc 2011; 19: 835–841.
7. Sussmilch-Leitch SP, Collins NJ, Bialocerkowski AE, Warden SJ, Crossley KM: Physical therapies for Achilles tendinopathy: Systematic review and meta-analysis. J Foot Ankle Res 2012; 5: 15.
8. Johannsen F, Jensen S, Wetke E: 10-year follow-up after standardised treatment for Achilles tendinopathy. BMJ Open Sport Exerc Med 2018; 4: e000415.
9. Alfredson H: Chronic midportion Achilles tendinopathy: an update on research and treatment. Clin Sport Med 2003; 22: 727–741.
10. Maffulli N, Longo UG, Denaro V: Novel approaches for the management of tendinopathy. J Bone Joint Surg Am 2010; 92: 2604–2613.
11. Chaudhry FA: Effectiveness of dry needling and high-volume image-guided injection in the management of chronic mid-portion Achilles tendinopathy in adult population: a literature review. Eur J Orthop Surg Traumatol 2017; 27: 441–448.
12. Daftary A, Adler RS: Sonographic evaluation and ultrasound-guided therapy of the achilles tendon. Ultrasound Quart 2009; 25: 103–110.
13. Klauser AS, Peetrons P: Developments in musculoskeletal ultrasound and clinical applications. Skeletal Radiol 2010; 39: 1061–1071.
14. Finlay K, Friedman L: Ultrasonography of the lower extremity. Orthop Clin North Am 2006; 37: 245–275.
15. Fessell DP, Vanderschueren GM, Jacobson JA, Ceulemans RY, Prasad A, Craig JG *et al.*: US of the ankle: technique, anatomy, and diagnosis of pathologic conditions. Radiographics 1998; 18: 325–340.
16. Leung JLY, Griffith JF: Sonography of chronic Achilles tendinopathy: a case-control study. J Clin Ultrasound 2007; 36: 27–32.
17. Prado-Costa R, Rebelo J, Monteiro-Barroso J, Preto AS: Ultrasound elastography: compression elastography and shear-wave elastography in the assessment of tendon injury. Insights Imaging 2018; 9: 791–814
18. Knobloch K, Kraemer R, Lichtenberg A, Jagodzinski M, Gossling T, Richter M *et al.*: Achilles tendon and paratendon microcirculation in midportion and insertional tendinopathy in athletes. Am J Sport Med 2006; 34: 92–97.
19. Newman JS, Adler RS, Bude RO, Rubin JM: Detection of soft-tissue hyperemia: value of power Doppler sonography. AJR Am J Roentgenol 1994; 163: 385–389.
20. Ohberg L, Lorentzon R, Alfredson H: Neovascularisation in Achilles tendons with painful tendinosis but not in normal tendons: an ultrasonographic investigation. Knee Surg Sport Traumatol Arthrosc 2001; 9: 233–238.
21. Zanetti M, Metzdorf A, Kundert HP, Zollinger H, Vienne P, Seifert B *et al.*: Achilles tendons: clinical relevance of neovascularization diagnosed with power Doppler US. Radiology 2003; 227: 556–560.
22. Peers KHE, Brys PPM, Lysens RJJ: Correlation between power Doppler ultrasonography and clinical severity in Achilles tendinopathy. Int Orthop 2003; 27: 180–183.
23. Alfredson H, Ohberg L, Forsgren S: Is vasculo-neural ingrowth the cause of pain in chronic Achilles tendinosis? An investigation using ultrasonography and colour Doppler, immunohistochemistry, and diagnostic injections. Knee Surg Sport Traumatol Arthrosc 2003; 11: 334–338.
24. Andersson G, Danielson P, Alfredson H, Forsgren S: Nerve-related characteristics of ventral paratendinous tissue in chronic Achilles tendinosis. Knee Surg Sport Traumatol Arthrosc 2007; 15: 1272–1279.
25. Ohberg L, Alfredson H: Ultrasound guided sclerosis of neovessels in painful chronic Achilles tendinosis: pilot study of a new treatment. Br J Sport Med 2002; 36: 173–175.
26. Alfredson H, Ohberg L: Sclerosing injections to areas of neo-vascularisation reduce pain in chronic Achilles tendinopathy: a double-blind randomised controlled trial. Knee Surg Sport Traumatol Arthrosc 2005; 13: 338–344.
27. Wijesekera NT, Chew NS, Lee JC, Mitchell AW, Calder JD, Healy JC: Ultrasound-guided treatments for chronic Achilles tendinopathy: an update and current status. Skelet Radiol 2010; 39: 425–434.

28. Chan O, O'Dowd D, Padhiar N, Morrissey D, King J, Jalan R *et al.*: High volume image guided injections in chronic Achilles tendinopathy. Disabil Rehabil 2008; 30: 1697–1708.
29. Humphrey J, Chan O, Crisp T, Padhiar N, Morrissey D, Twycross-Lewis R *et al.*: The short-term effects of high volume image guided injections in resistant non-insertional Achilles tendinopathy. J Sci Med Sport 2010; 13: 295–298.
30. Resteghini P, Yeoh J: High-volume injection in the management of recalcitrant mid-body Achilles tendinopathy: a prospective case series assessing the influence of neovascularity and outcome. Int Musculoskelet Med 2012; 34: 92–100.
31. Maffulli N, Spiezia F, Longo UG, Denaro V, Maffulli GD: High volume image guided injections for the management of chronic tendinopathy of the main body of the Achilles tendon. Phys Ther Sport 2013; 14: 163–167.
32. Wheeler PC: The use of high-volume image-guided injections (HVIGI) for Achilles tendinopathy – a case series and pilot study. Int Musculoskelet Med 2014; 36: 96–103.
33. Wheeler PC, Mahadevan D, Bhatt R, Bhatia M: A comparison of two different high-volume image-guided injection procedures for patients with chronic noninsertional Achilles tendinopathy: a pragmatic retrospective cohort study. J Foot Ankle Surg 2016; 55: 976–979.
34. Boesen AP, Hansen R, Boesen MI, Malliaras P, Langberg H.: Effect of high-volume injection, platelet-rich plasma, and sham treatment in chronic midportion Achilles tendinopathy: a randomized double-blinded prospective study. Am J Sport Med 2017; 45: 2034–2043.
35. Boesen AP, Langberg H, Hansen R, Malliaras P, Boesen MI: High volume injection with and without corticosteroid in chronic midportion achilles tendinopathy. Scand J Med Sci Sports 2019; 29: 1223–1231.
36. Nielsen TG, Miller LL, Mygind-Klavsen B, Lind M: High-volume image-guided injection in the chronic recalcitrant non-insertional patellar tendinopathy: a retrospective case series. J Exp Orthop 2020; 7: 80.
37. Edwards S, Sivan M: High volume distension injection (HVDI) for chronic mid-portion Achilles tendinopathy: A service evaluation of clinical outcomes. J Orthop Trauma Rehab 2020: 221049172097932.
38. Haefeli M, Elfering A: Pain assessment. Eur Spine J 2006; 15 (Suppl 1): S17–24.
39. Iversen JV, Bartels EM, Langberg H: The victorian institute of sports assessment – achilles questionnaire (visa-a) – a reliable tool for measuring achilles tendinopathy. Int J Sport Phys Ther 2012; 7: 76–84.
40. MacMahon PJ, Eustace SJ, Kavanagh EC: Injectable corticosteroid and local anesthetic preparations: a review for radiologists. Radiology 2009; 252: 647–661.
41. Shah A, Mak D, Davies AM, James SL, Botchu R: Musculoskeletal corticosteroid administration: current concepts. Can Assoc Radiol J 2019; 70: 29–36.
42. Thumboo J, O'Duffy JD: A prospective study of the safety of joint and soft tissue aspirations and injections in patients taking warfarin sodium. Arthritis Rheum 1998; 41: 736–739.
43. Dong Q, Fessell DP: Achilles tendon ultrasound technique. AJR Am J Roentgenol 2009; 193: W173.
44. Yablon CM: Ultrasound-guided interventions of the foot and ankle. Semin Musculoskelet Radiol 2013; 17: 60–68.
45. Lento PH, Strakowski JA: The use of ultrasound in guiding musculoskeletal interventional procedures. Phys Med Rehabil Clin North Am 2010; 21: 559–583.
46. Kammar H, Carmont MR, Kots E, Laver L, Mann G, Nyska M *et al.*: Anatomy of the sural nerve and its relation to the achilles tendon by ultrasound examination. Orthopedics 2014; 37: 298–301.
47. Adler RS, Sofka CM: Percutaneous ultrasound-guided injections in the musculoskeletal system. Ultrasound Quart 2003; 19: 3–12.
48. O'Neill S, Watson PJ, Barry S: Why are eccentric exercises effective for Achilles tendinopathy? Int J Sport Phys Ther 2015; 10: 552–562.
49. Wijesekera NT, Chew NS, Lee JC, Mitchell AW, Calder JD, Healy JC: Ultrasound-guided treatments for chronic Achilles tendinopathy: an update and current status. Skeletal Radiol 2010; 39: 425–434.
50. Maxwell NJ, Ryan MB, Taunton JE, Gillies JH, Wong AD: Sonographically guided intratendinous injection of hyperosmolar dextrose to treat chronic tendinosis of the Achilles tendon: a pilot study. AJR Am J Roentgenol 2007; 189: W215–220.