US-guided high-volume injection for Achilles tendinopathy

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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,
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.\(^{(25)}\) 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 neovascularature 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.\(^{(28)}\) 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...
US-guided high-volume injection for Achilles tendinopathy

| Author (year) | Study type | Intervention | N  | Change in VAS score | Change in VISA-A score | Conclusion |
|---------------|------------|--------------|----|---------------------|------------------------|------------|
| Chan et al. (2008) | 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) | 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) | 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) | Case series | 10 ml 0.5% Bupivacaine 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) | 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) | Case series – 2 Groups | Group 1: 10 ml 1% Lidocaine 40 ml N 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 resulted in greater improvement in noninsertional Achilles tendinopathy |
| Boesen et al. (2017) | 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 – 48.3 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) | 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) | Case series | 10 ml 0.5% Marcaine 0.5 ml Triamcinolone-acetonid (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) | 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 |
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.
A medial approach is used to minimize the risk of injuring the sural nerve\(^\text{46}\) (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\(^\text{47}\).

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.

An eccentric loading exercise program is recommended after three days following the procedure with gradually increasing intensity as pain allows\(^\text{48}\).

**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\(^\text{28,34}\). It works well in combination with conservative treatments, especially eccentric loading exercises\(^\text{48}\). 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). Discrepancies 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\(^\text{32,34}\). Nonetheless, irrespective of quantitative

**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)

**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
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.

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US-guided high-volume injection for Achilles tendinopathy

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