Ankle Tenography: What, How, and Why

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INTRODUCTION

As I perform it, ankle tenography is primarily a therapeutic technique for treating chronic ankle pain, referable to the tendons, that has been unresponsive to more conservative measures. Because lidocaine is infused into the tendon sheath, along with iodinated contrast and steroids, tenography can be considered secondarily a diagnostic procedure by asking the patient how much immediate symptomatic relief they just received.

As a fluoroscopic procedure, ankle tenography is quick and easy to do. (I consider this the ultimate "watch one… do one… teach one" procedure.) At the present time, the biggest obstacle impeding the use of ankle tenography is that this procedure is relatively unknown by both radiologists and referring clinicians. The goal of this article is to promote the use of ankle tenography amongst the general radiology community.

TERMINOLOGY

The term "tenography" is perhaps a misnomer, as the tendon itself is not being directly imaged, and nothing is injected into the substance of the tendon. As all injections are made into the sheath surrounding the tendon, a more appropriate (albeit less pronounceable) name for this procedure would be "tenosynoviagraphy".

All of the ankle tendons, except the Achilles, are surrounded by a synovial sheath. Under normal circumstances, the synovial sheath provides an imperceptibly thin layer of lubrication allowing the tendon to slide smoothly within it, like an automobile piston in a well-oiled cylinder.

"Tenosynovitis" refers to inflammation between the tendon and the surrounding sheath. This is typically a chronic irritative process, more commonly effecting women than men, particularly in workers who are on their feet all day, such as waitresses and sales clerks. In the ankle, tenosynovitis most frequently occurs in the posterior tibial tendon and in the two peroneal tendons. These tendons in particular require lubrication as they pass around the medial and lateral malleoli respectively. The analogy I use is that of a rope passing around a rusty pulley. With lack of adequate lubrication the rope is subjected to chronic rubbing and chaffing, and will eventually fray and ultimately break. In much the same way, tenosynovitis represents a continuum of irritation between the tendon and its surrounding tissues. Some authors subdivide tenosynovitis into "peritendinitis", "chronic tenosynovitis", and "stenosing tenosynovitis" to attempt to depict this escalating spectrum of irritation. This delineation is admittedly somewhat artificial.

REFERENCES

The literature on ankle tenography is quite sparse. The technique was first describe by Palmer in 1970[1], and later refined by Gilula et al in 1984[2,3,4] who called tenography the "key to unexplained symptomatology. These articles focused upon the imaging aspects of tenography as a method for tenosynovitis. However, since the mid 1980s magnetic resonance (MR) and ultrasound have proved to be more effective non-invasive methods for imaging the tendons and the surrounding tissues. Thus tenography became a technique that seemed destined to be relegated to the annals of radiology history, much as conventional arthrograms are looked upon today.

However, Gilula and his colleagues at the Mallinckrodt of Radiology saw the therapeutic value of tenography and continued to encourage the orthopedists and podiatrists in St. Louis to refer patients with chronic ankle pain. By the time I was trained by Gilula, he had experience with over 500 tenograms, and we were performing several a month. In 2001, Jaffee, Gilula et al[5] published the first, and to date the only, outcome analysis of tenography. I will discuss the results of that paper later at the end of this article.

For my part, in 1998 I wrote a review article focusing on tenography as primarily a therapeutic modality[6]. This current "how to" article is an update of that review article.

CLINICAL INDICATIONS

In my experience, patients come to tenography after failing other conservative treatments. These patients typically have endured months if not years of ankle pain, have usually sought advice from several physicians and podiatrists, and often have already been treated with prior "blind" in-office steroid injections, with no relief. Although patients complain of diffuse ankle pain, when asked to "point to one region with one finger", most patients with tenosynovitis will trace an arc behind the malleolus in the distribution of the tendon.

Chronic tenosynovitis represents a chronic cycle of pain (figure 1a). Chronic inflammation causes chronic local irritation, which causes chronic adhesions and scar formation (stenosing tenosynovitis). Chronic adhesive scarring further impedes normal tendon sheath lubrication, and goes on to cause chronic rubbing and inflammation, and the cycle perpetuates. I believe that tenography is effective because it breaks this cycle of pain at two points (figure 1b). Filling the tendon sheath with contrast distends the sheath, breaking up adhesions (adhesiolysis). Adhesiolysis is important to prevent further irritation and restore smooth motion between the sheath and tendon. For this reason, during the injection it is important to distend the tendon sheath as much as possible. Sometimes, when I am watching fluoroscopically, I can see the sheath partially fill initially, and with continued pressure on the syringe I can practically feel the adhesions break and observe further filling of the sheath. I tend to continue filling the sheath until I observe contrast extravasation proximately at the muscle-tendon junction. This signals to me I cannot build up any more pressure within the sheath and I stop injection contrast. It is at this point I administer a 1cc bolus of steroids within the sheath. Steroids are an important second component to therapeutic tenography, to cool down the inflammation and to prevent adhesions from reforming.

PRE-TENOGRAM IMAGING

My preference is to have the patient undergo an MR scan of the ankle in question and either bring the images with them at the time of their tenogram or, better yet, make them available for me ahead of time. I strongly feel it is important to review these images looking for: a) causes other than tenosynovitis to explain the patient's symptoms, and b) the integrity of the tendon. In particular, edema sensitive MR sequences (such as T2-weighted with fat-suppression, or Inversion Recovery) may point the way towards other diagnoses such as: tarsal stress fractures, accessory navicular syndrome, os peroneum syndrome, and tarsal tunnel syndrome[7]. If I detect other possible causes of symptoms, I will review these with the referring clinician and discuss if they feel they would still like to proceed with the tenogram. In cases where there is felt to be multiple factors contributing to the patient's symptoms, the degree of immediate relief provided by the intra-sheath injection of lidocaine can indicate the degree of symptoms referable to that sheath.

Clinically it can be difficult to distinguish between a tendon that is merely inflamed from one that contains a partial longitudinal split, from one that is frankly ruptured. In theory, bathing an already weakened tendon with steroids can impede healing and contribute to tendon rupture. And if the tendon is already ruptured, a therapeutic tenogram will be of little value. For these reason it is prudent to confirm the tendon is indeed intact before proceeding with a tenogram. My preferred method for evaluating the medial and lateral ankle tendon is with MR, in particular with Proton Density and corresponding T2-weighted images in the axial plane as they cross the ankle joint. (I find a useful secondary plane is an oblique coronal plane, perpendicular to the posterior facet of the subtalar joint. This plane is useful to following the tendons as they wrap around the malleoli.) I will concede that in the hands of an experienced ultrasonographer, an ultrasound examination performed with a high frequency probe (10 MHz) can be as accurate a modality as MR for the ankle tendons. However, with ultrasound the examination is usually limited to the tendons in question, and as such it will not detect the osseous causes of ankle pain that can be seen by MR.

MATERIALS

As I perform it, a tenogram is a two-part injection. The first injection is a mixture of contrast with lidocaine. A volume of 10cc is more than sufficient to fill any of the tendon sheaths. I use roughly a 1:2 mixture of iodinated contrast with 1% lidocaine, although the exact dilution is not important. (Individuals may want to try various contrast:lidocaine dilutions to see which yields satisfactory fluoroscopic visualization.) I use whatever contrast material is readily available; in the past we have used Conray 43, but now that we use non-ionic contrast exclusively I use Omnipaque 300. (I find the non-ionic agents are relatively viscous, and flow easier through a 25-gauge needle when diluted with lidocaine.)

I am often asked if tenography can be performed under ultrasound guidance rather than fluoroscopically. While I suspect ultrasound could be use to confirm the needle is in the tendon sheath, it would be difficult to observe the degree of distention over the length of the tendon via ultrasound. As I have already mentioned, tendon sheath distension and adhesiolysis is an important step in a therapeutic tenogram, and as I perform it, fluoroscopy is needed to confirm this.

With regard to choice of which injectable steroid to use, Jaffee & Gilula prefer a 1cc bolus of betamethasone (Celestone Soluspan 6mg/ml Schering), "because of our belief, supported by the product descriptions of these drugs, that less chance exists for a flare response after injection for skin discoloration or atrophy."[5] I find that Celestone goes into suspension easier than an equivalent dose of Kenalog (Triamcinolone 40mg/ml Bristol-Myers Squibb), and I speculate that this allows the betamethasone particles to be more evenly distributed along the sheath, but I have no outcome data to support the use of one agent over another. Ultimately, the choice of steroid may be mostly influenced by the personal experiences of the radiology and referring clinician, and to pharmacy availability.

The materials needed for a tenogram are common and should be readily available. The tenogram is performed via a 25-gauge, 1.5-inch (3.8 cm) long needle. (I have tried using a 27-gauge needle but found the Omnipaque:lidocaine mixture too viscous to flow easily.) A connecting tube is used to attach the needle to the contrast and steroid syringes. This connecting tube should have a luer-lok connection on both ends. (Pressure within the connecting tube can be quite high during a tenogram, and if not securely tightened will fly apart, splattering the image intensifier with contrast.) A 10cc syringe holds the contrast:lidocaine mixture, and a 1cc syringe holds the 1cc steroid bolus.

Although it is arguably unnecessary, I will typically infuse the skin over my anticipated tendon puncture site with 1% lidocaine via a 29-gauge skin needle for local anesthesia. A 3 or 5cc syringe is sufficient for this, and avoids confusion with the other two syringes. (We find adding a small volume of bicarbonate as a buffering agent can mitigate the initial acidic sting of lidocaine.)

All that is otherwise needed are the appropriate materials for cleansing and draping the skin entry sight just above the malleolus, and a small Band-Aid to cover the puncture site when done.

METHOD

Although a tenogram is not difficult to perform, is does require an understanding of the anatomy of the ankle tendons and their adjacent structures. It also requires an understanding of the method for positioning a needle within the tendon sheath, but outside the tendon. Gilula has called this the "tenogram technique", and I consider it analogous to trying to get a needle inside your rubber glove but outside your finger. I will describe this technique after first reviewing the anatomy of the medial and lateral ankle tendons.

ANATOMY

With regard to tenography, the anatomy is potentially more confusing along the medial side of the ankle joint, so I will begin my review here. Figure 2 is a single image from a three-dimensional (3D) model created using a helical Computed tomography (CT) dataset and standard software provided by the CT manufacturer. Upon this I have superimposed curves and lines representing the three medial ankle tendons. (My rotating 3D color PowerPoint file is available for free download via my website.[8])

The anteriormost of the three medial tendons is the Posterior Tibial (PT) tendon, represented in figure 2 by the dashed curve. The PT muscle-tendon junction is several centimeters above the level of the medial malleolus, and the PT passes through a groove in the posteromedial tibia as it wraps around the medial malleolus. Although the PT has several minor attachment sites under the midfoot, its primary attachment is upon the medial pole of the Navicular bone (N). It is this navicular insertion we must focus on when performing therapeutic tenograms of the PT.

Directly behind the PT is the Flexor Digitorum Longus (FDL) tendon, represented in figure 2 by the white curve. The FDL runs closely behind the PT as they travel down the distal tibia and around the medial malleolus. But while the PT inserts upon the Navicular, the FDL passes under the Navicular. When it gets under the midfoot, the FDL divides into four individual tendon slips (the white lines in figure 2), that go on to insert on the distal phalanges of toes two through five.

The Flexor Hallucis Longus (FHL) tendon is represented by the black curve in figure 2. Its origin is directly behind the posterior malleolus, and its muscle-tendon junction extends nearly down to the level of the ankle joint. Rather than curving around the medial malleolus like the other two medial tendons, the FHL curves around the Sustentaculum Tali (ST). The FHL then proceeds under the midfoot, crossing deep to the FDL, and running along the plantar surface of the hallux to insert on the distal phalanx of the great toe.

(A popular mnemonic, "Tom, Dick, and Harry" reminds us of the order of the medial ankle tendons as they cross the ankle joint: PT, FDL, FHL.)

All three medial tendons pass through the Tarsal Tunnel, the roof of which is formed by the Flexor Retinaculum (figure 3).

Figure 3 is a drawing indicating the extent of the sheaths of the medial ankle tendons. Although the PT tendon inserts upon the Navicular, the sheath of the PT extends only as far anteriorly as the head of the talus (smiley face). Nonetheless, positioning of the tenogram needle properly within the PT sheath can be confirmed fluoroscopically by observing the contrast filled sheath points to the Navicular regardless of the orientation of the foot or C-arm (fig 4).

When attempting to position a needle into the PT sheath, it is not uncommon to inadvertently access the FDL sheath instead. It is important to recognize this, because otherwise you are performing your therapeutic tenogram on the FDL, rather than on the PT as intended. As illustrated in figure 3, the FDL sheath passes under the Navicular (frowney face). An example of a tenogram opacifying the FDL sheath is shown in figure 5a (frowney face). Once I realize contrast is not flowing towards the Navicular, and thus not in the PT sheath, I can fluoroscopically reposition my needle anterior to the FDL (arrowhead in figure 5), and into the PT sheath (smiley face).

Inadvertently injecting the FDL sheath is not necessarily a bad thing, as long as it is recognized. Indeed, pre-procedural clinical and/or imaging findings may have indicated that the FDL, as well as the PT, contributed to the patient's symptoms. In these instances I may elect to make use of this serendipitous injection to perform a complete FDL therapeutic tenogram (with maximum tendon sheath distension and 1cc steroid bolus) before repositioning my needle into PT. If maximum FDL sheath distension is desired, it should be recognized there is a natural communication between the sheaths of the FDL and FHL at the point where they cross under the midfoot. This point is known as the Master Knot of Henry, and is indicated by the star in figure 3. With antegrade filling of the FDL sheath (from proximal to distal as indicated by the direction of the solid arrow in figure 3), contrast can pass into the FHL via the Master Knot of Henry, and retrograde filling of the FHL sheath (as indicated by the dashed arrow) can be observed fluoroscopically. An example of this can be seen in figure 6.

Compared to the medial ankle tendons, the lateral tendons are easy (figure 7). Above the level of the lateral malleolus, the two peroneal tendons share a common sheath. As they curve around they lateral side of the ankle the peroneal tendons pass under the Superior and Inferior Peroneal Retinacula. It is between these two fibrous bands that the peroneal common sheath divides into separate sheaths, enveloping the Peroneus Brevis (PB) and Peroneus Longus (PL) tendons individually. The PB tendon then extends anteriorly to insert on the tuberosity at the base of the fifth metatarsal, while the PL tendon passes under the foot to insert at the plantar base of the first tarsal-metatarsal joint. Like the medial sheaths, the PB and PL sheaths do not extend the entire length of the tendons, and in most cases do not extend anterior to the calcaneal-cuboid joint (figure 8). (Figure 9 is an atypical case in which the PL sheath extends under the foot along the entire length of the tendon.) One way to help identify which tendon is the PB and which is the PL is to think of the lateral malleolus as a racetrack. Brevis, being the shorter tendon, will hug the inside track while Longus can sweep around the outer curve. Thus Brevis is the tendon anterior and superior to Longus.

TENOGRAM TECHNIQUE

A tenogram is performed as much by feel as by fluoroscopic guidance.

The patient is instructed to lie on the fluoroscopy table in a decubitus position with the symptomatic side of the ankle facing up (e.g. left-side down if treating the left posterior tibial tendon, as in figure 10a, or the right peroneal tendons). If the table has a narrow headrest at one end, the symptomatic ankle could be placed on the headrest, and the knee of the contralateral leg flexed to keep the other ankle out of the way (figure 10b).

The ankle should be examined before creating the sterile field. This is also a good opportunity to explain to the patient how they must actively twist their foot so that the tendon becomes palpable: inversion to create tension on the posterior tibial tendon; eversion to palpate the peroneals. This motion does not come naturally to some patients, and it may help to tell them to "try to turn the sole of your foot towards the ceiling without lifting your leg off the table". While the palpating the tendon with one hand, the other hand can provide a firm counter-force against the patient's heel; this creates isometric tension on the tendon while stabilizing the patient's foot and ankle (figure 11a). By having the patient repeatedly tense and relax their ankle, the course of the tendon can be determined. If desired, an indelible skin marker could be used to draw the path of the tendon, as well as mark the point of maximal tenderness (fig 11b). The skin site is then sterilized and draped, and locale anesthesia provided.

The trick for positioning a needle within tendon sheath is to first stab the needle into the tendon itself. This is best accomplished with the patient holding their tendon tight, while the radiologist palpates the tendon with one hand and jabs the 25-gauge needle into the tendon with the other hand (figure 12a). The radiologist then takes hands off the needle (figure 12b), and the patient is told to relax the tendon. If the needle is indeed in the tendon, the hub of the needle will visibly move as the tendon moves (figure 12c). (While it is reassuring to see the needle move, the radiologist should avoid the temptation of asking the patient to repeatedly wiggle their foot as this may cause a properly placed needle to become dislodged from the tendon.)

Prior to attaching it to the 25-gauge needle, the connecting tube should be firmly stretched. This will greatly reduce the stiffness of the connecting tube and minimize the chance that excess torque on the tube will cause the needle to inadvertently twist out of place. To help achieve a good "wet connection" between the 25-gauge needle and the connecting tube, a second needle is temporarily attached to the end of the connecting tube. The tip of this second needle is gently placed within the hub of the 25-gauge needle, and the hub is filled with the dilute contrast mixture (figure 13a). A gauze sponge is placed beneath the needle hub to catch any contrast that might drip onto the imaging field. The second needle may now be removed, and the connecting tube attached to the 25-gauge needle which is being stabilized with the other hand (figure 13b). Once the connecting tube is firmly attached to the needle, both can be stabilized by resting the side of the hand on the patient's leg while holding the tubing several centimeters from the needle hub (figure 13c). This allows the hand to remain out of the fluoroscopic field.

The tenogram technique is illustrated in figure 14. While fluoroscopically monitoring the tip of the 25-gauge needle, gentle pressure is applied to the 10 ml contrast syringe. As long as the tip of the needle is within the substance of the tendon, contrast will be unable to flow (figure 14a). With the utmost patience, the needle is slowly withdrawn by sub-millimeter amounts, while with the other hand constant pressure is applied to the syringe. Once the needle has been withdrawn sufficiently such that its tip is no longer within the substance of the tendon but is still within the tendon sheath, contrast will be seen to flow away from the needle tip (figure 14b). When the contrast begins to flow within the tendon sheath, the resistance on the syringe will abruptly subside. (While the use of a glass syringe may make this change in resistance easier to feel, the tactile feedback from a conventional disposable plastic syringe, combined with the visual feedback from the fluoroscope, should allow any radiologist to rapidly master the "tenogram technique".) As contrast distends the sheath, the tendon within the sheath becomes outlined and is thus visible indirectly (figure 14c). Care should be taken not to move the hand stabilizing the connecting tube, lest the needle become displaced out of the sheath.

As with any arthrographic procedure, if the first drop of contrast does not rapidly flow away from the tip of the needle, then the needle tip is not within a synovial space, and the needle should be repositioned before additional contrast is infused. Contrast which does not flow away from the needle tip represents extravasation into a non-synovial space. Contrast within a sheath should be well defined on its outer edge and become hazier towards the inner edge. Extravasated contrast has the opposite appearance with haziness on the outer margin of the contrast pool. The amount of extravasated contrast should be kept to a minimum, as excess extravasation tends to obscure the fluoroscopic field and makes it increasingly difficult to properly reposition the needle. Figure 15a is the first image obtained during an attempted peroneal tenogram, prior to contrast infusion. Figure 15b demonstrates contrast extravasating within the soft tissues around the tip of the needle, indicating the needle is not within the synovial sheath. The needle is repositioned in figure 15c, and in figure 15d contrast is seen to flow away from the tip of needle, confirming it is now within the peroneal sheath.

Once the contrast begins flowing within the sheath, its progress should be checked fluoroscopically every few seconds. It does not take long to fill a tendon sheath. Contrast flow may be impeded by a relatively tight overlying retinaculum, or by adhesions within the sheath. However, in order to achieve adhesiolysis and to help insure the distribution of steroids throughout the length of the sheath, it is important to try to infuse contrast the entire length of the sheath. Or in the case of the peroneals, to the ends of the individual sheaths for the PB and PL (figure 16). I typically focus my fluoroscopic field of view on the distal end of the contrast column. When I feel I can achieve no further forward flow, I enlarge the field of view to include the proximal contrast column and look for extravasated contrast proximal to the needle (figure 17a). If further pressure on the contrast syringe yields no further forward progress of the contrast column, but instead only further proximal contrast extravasation (figure 17b), this indicates that the maximum sheath distension for this tenogram has been reached.

Once maximum sheath distension is obtained, a 1cc steroid bolus is infused into the sheath. The 25-gauge needle should be stabilized with one hand while the connecting tube is detached with the other hand. Prior to attaching the 1cc steroid-filled syringe directly to the needle it should be gently agitated a few times to assure the steroid crystals are evenly distributed throughout the suspension. Prior to injecting the steroid I set the image intensifier to the smallest field of view, and focus on the needle tip and the surrounding contrast. I like to fluoroscopically observe contrast dilution during the steroid administration to confirm the steroid is indeed within the sheath (figure 18).

OUTCOMES

All of us who do tenography have anecdotal cases touting its efficacy. Figures 19 and 20 are two patients who had somewhat atypical clinical presentations and had good outcomes despite what I thought at the time was less than optimal tendon sheath distention.

Certainly, anecdotes are no replacement for true outcome studies. In their 2001 study[5], Jaffee, Gilula et al reported on the results of telephone interviews conducted with patients at least six months after therapeutic tenography. Of the 144 patients who had undergone tenography during the two-year study period, they were able to contact 111. Of these 111 tenogram patients, 65 (59%) were of the PT, 39 (35%) were of the peroneals, and the remaining 7 were atypical tenograms directed to the Anterior Tibial, FDL or FHL tendon sheaths. The surveys represented a follow-up period of 6 to 28 months, with an average of 19 months. The patients were asked if their symptoms were completely or nearly completely resolved verses not improved. The results for the PT and peroneal tenograms were similar: 48% (31/65) of the PT patients and 46% (18/39) of the peroneal patients reported complete or near complete symptom resolution. I think these numbers are impressive, considering 100% of these patients had failed conservative measures prior to tenography. Of the 60 patients who underwent tenography but did not have prolonged relief, 17 (28%) went on to surgical treatment.

The authors reviewed the spot fluoroscopic images from all 111 tenograms and classified the degree of tenosynovitis into mild, moderate, or severe depending upon the number of "sacculations" they could count along the length of the sheath. They reported finding no correlation between the degree of tenosynovitis shown radiographically and the symptomatic improvement following the tenogram. No correlations were made regarding the degree of immediate relief related to the lidocaine injection into the sheath verses long-term relief.

COMPLICATIONS

The dreaded complication of tenography is tendon rupture. In their recent study of 111 patients[5], Jaffee, Gilula, et al found "only one patient had a tendon rupture that could be considered caused or enhanced by tenography; that rupture occurred 1 day after tenography while the patient was playing tennis." The authors go on to write, "Our main recommendation to decrease the chance of tendon rupture is to protect the patient's ankle by refraining from sports or other strenuous activities for 6 weeks after steroid injection… To prevent the spontaneous rupture of the posterior tibial tendon and the subsequent development of a flatfoot deformity, the use of a short left cast or walking boot should be considered after posterior tibial sheath injections."

Minor complications included loss of pigmentation in 10 dark skinned patients. (The authors did not specify if these incidents occurred before or after they switched to betamethasone.) Four patients reported transient bruising at the injection site. There were no post-procedural infections.

CONCLUSIONS

Ankle tenography should not be thought of a primary imaging modality. In their recent study of 111 patients[5], Jaffee, Gilula, et al found no correlation between the fluoroscopic appearance at the time of tenography and therapeutic outcome.

However, of all patients who underwent this primarily therapeutic procedure consisting of tendon sheath distention with a contrast-anesthetic-steroid mixture, nearly half reported complete or near complete long-term symptomatic relief (range 6-28 months). Not bad, considering that all of these patients had already failed to gain relief from more conservative therapies such as immobilization, bracing, physical therapy, orthoses and sometimes even "blind" steroid injections. Of the patients who did not clinically improve after tenography, roughly one-quarter ultimately required surgery.

When performed properly as described in the above article the complication rate of tenography is quite low, with a reported post-procedure rupture rate of <1%.

On the whole, ankle tenography is a safe and effective therapeutic modality that is quick to perform and not difficult to master. If you are a radiologist with access to fluoroscopy, you should consider adding tenography to the list of minimally invasive procedures you will perform. Because you will be comparing the patient's prior imaging studies (most often an MR scan) with your fluoroscopic and physical examination of the patient's ankle tendons, your familiarity with this anatomy will quickly increase.

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