Surgical and Radiologic Anatomy (2019) 41:1445–1449
https://doi.org/10.1007/s00276-019-02355-z

ORIGINAL ARTICLE

Fluid distribution in ankle tendon sheaths in healthy volunteers: MRI findings

Inneke Willekens[1] · Maryam Shahabpour[1] · Leon Lenchik[2] · Nico Buls[1] · Johan De Mey[1] · Steven Provyn[3] · Michel De Maeseneer[1]

Received: 18 February 2019 / Accepted: 27 September 2019 / Published online: 19 October 2019

Abstract

Purpose To assess normal distribution of fluid in the tendon sheaths of the ankle.

Methods 21 healthy volunteers were evaluated. Bilateral ankle MRI was performed on a 3T unit with PD-weighted images with fat saturation. The images were interpreted by two radiologists separately, and the short-axis dimension of fluid amount was measured. Bland–Altman plots and correlation plots were used to assess consistency between readers.

Results There were 13 men and 8 women. The mean age was 24.7 years. Fluid in the retromalleolar part of the peroneus longus was seen in three ankles of three volunteers and in the inframalleolar part in three ankles of three volunteers. Fluid in the retromalleolar part of the peroneus brevis was seen in four ankles of three volunteers and in the inframalleolar part in three ankles of two volunteers. Fluid in the retromalleolar part of the tibialis posterior was seen in 37 ankles of 20 volunteers and in the inframalleolar part in 38 ankles of 21 volunteers Fluid in the retromalleolar part of the flexor digitorum was seen in 14 ankles of eight volunteers and in the inframalleolar part in 11 ankles of eight volunteers Fluid in the retromalleolar part of the flexor hallucis longus was seen in 23 ankles of 16 volunteers and in the inframalleolar part in 17 ankles of 11 volunteers.

Conclusion Fluid is common in the retro- and inframalleolar parts of the medial tendons. Fluid is virtually absent in the peroneal tendons and anterior tendon sheaths in normal volunteers.

Keywords Ankle · Tendon ankle · Ankle joint

Introduction

Although some authors have reported that any visible fluid in an ankle tendon sheath as abnormal, others have suggested that a certain amount of fluid in the tendon sheath may be a normal finding [1–3, 8, 9]. However, reference values for the normal amount of fluid and the distribution of fluid on MR imaging have not been established. This is of clinical interest as MR imaging of the foot is commonly performed and it is important to determine if the presence of fluid is clinically significant.

✉ Michel De Maeseneer
Michel.demaeseneer@uzbrussel.be

[1] Department of Radiology, Universitair Ziekenhuis Brussel, Laarbeeklaan 101, 1090 Brussels, Belgium

[2] Department of Radiology, Wake Forest School of Medicine, Winston-Salem, NC, USA

[3] Department of Experimental Anatomy, Vrije Universiteit Brussel, Brussels, Belgium

The purpose of this study is to assess fluid in the tendon sheaths of the ankle on MRI imaging in healthy volunteers.

Materials and methods

The study was approved by the ethical committee of our hospital. Twenty-one healthy volunteers (42 ankles) were evaluated with MR imaging. Written informed consent was obtained. There were 13 men and 8 women. The mean age was 24.7 years, range 19–43 years. None of the participants was a professional or recreational athlete. To avoid an increase in synovial fluid due to recent activity the volunteers abstained from exercise for 3 days. MR imaging was performed on a 3T MR unit (Philips, Achieva, Best, The Netherlands) using proton density-weighted images with fat saturation (TR 2969 ms; TE 30 ms; NA 2; slice thickness 2.5 mm). Patients with a history of trauma, pain, and rheumatological conditions were excluded from the study group. Four initially selected volunteers were thus not included.

Images were obtained in three orthogonal planes. The tendons were assessed in the retro- and inframalleolar areas. All measurements were performed in the transverse plane. We found this plane to give the best representation of the amount of fluid. The other planes were also used mainly to differentiate vascular structures from real fluid. The size of the largest fluid collection was measured in the transverse plane both in the retro- and inframalleolar areas. The images were interpreted by two radiologists in separate sessions, so two measurements were obtained. With this type of data, the simplest and well-accepted way to analyze agreement between measurements is calculating the Pearson correlation coefficient and performing Bland–Altman analysis (Figs. 1 and 2). The classic kappa technique or intraclass correlation coefficients are not possible with this type of data. Statistics were performed using SPSS (IBM, version 23).

The difference between measurements of left and right tendons was assessed by Wilcoxon signed-rank test. In addition, the Pearson correlation of the TP retro, TP infra, FD retro, FD infra, FH retro and FH infra, and tendon measurements were correlated with anterior and posterior tibiotalar effusions A p value less than 0.05 was considered to represent a statistically significant result.

Results

Fluid in the retromalleolar part of the peroneus longus was seen in three ankles (three volunteers) and had a mean of 0.07 mm, range 0.01–0.16 (Fig. 3, Table 1). None of the visualized tendons had a tear or tendinosis. Fluid in the inframalleolar part of the peroneus longus was seen in three ankles (three volunteers, 7%) and had a mean size of 0.06 mm, range 0.01–0.13. Fluid in the retromalleolar part of the peroneus brevis was seen in four ankles (three volunteers, 7%) and had a mean size of 0.08, range 0.002–0.16. In the inframalleolar part of the peroneus brevis, fluid was seen in three ankles (two volunteers, 7%)

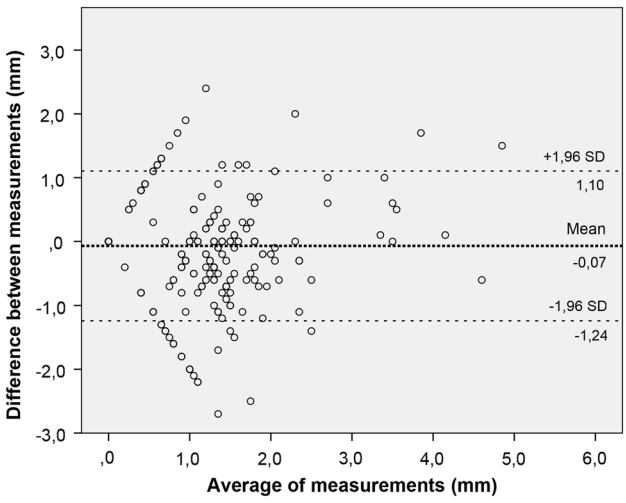

Fig. 1 Bland–Altman plot showed an average difference of 0.07 mm between both measurements and did not reveal proportional errors and systematic bias

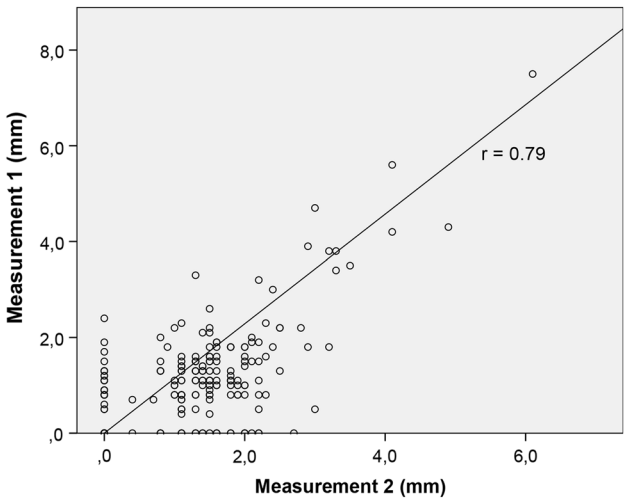

Fig. 2 Correlation between the two measurement sessions was found to be strong (Pearson correlation 0.792, $p < 0.01$)

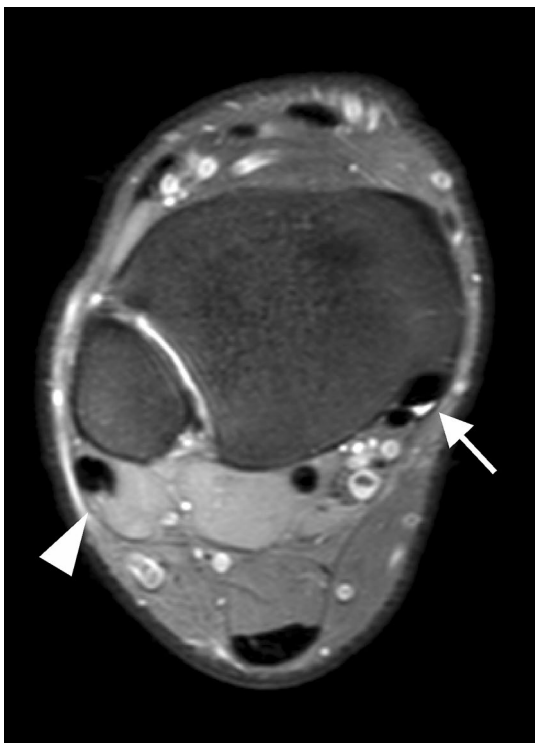

Fig. 3 Transverse proton density-weighted MR image. Note absence of fluid around peroneal tendons in retromalleolar area (arrowhead), and small sliver of fluid around tibialis posterior in retromalleolar area (arrow)

Table 1 Fluid in mm at the different tendons (right and left)

PLr	PBr		PLi		TPr		TPi		FDr		FDi		FHr		FHi		TAb	TAo	EHb	EHo	EDb	EDo
0.03	0.03	0.01	0.09	0.23	0.07	1.38	1.13	1.53	1.19	1.19	0.77	0.68	0.39	1.83	1.29	0.51	0.45	0	0	0	0	0	0

PLr peroneus longus retromalleolar, *PBr* peroneus brevis retromalleolar, *PLi* peroneus longus inframalleolar, *PBi* peroneus brevis inframalleolar, *TPr* tibialis posterior retromalleolar, *TPi* tibialis posterior inframalleolar, *FDr* flexor digitorum retromalleolar, *FDi* flexor digitorum inframalleolar, *FHr* flexor hallucis retromalleolar, *FHi* flexor hallucis inframalleolar, *Tab* tibialis anterior above joint, *Tao* tibialis anterior below joint, *EHb* extensor hallucis above joint, *EHo* extensor hallucis below joint, *EDb* extensor digitorum above joint, *Edo* extensor digitorum below joint

Fig. 4 Transverse proton density-weighted MR image. Note small amounts of fluid around all flexor tendons in the inframalleolar area (arrows)

and had a mean size of 0.05, range 0.008–0.12. Fluid in the retromalleolar part of the tibialis posterior was seen in 37 ankles (20 volunteers, 88%) and had a mean size of one, range 0.83–1.16, while in the inframalleolar part of tibialis posterior it was seen in 38 ankles (21 volunteers, 90%) and had a mean size of 1.42, range 1.18–1.66 (Fig. 4). Fluid in the retromalleolar part of the flexor digitorum was seen in 14 ankles (eight volunteers, 33%) and had a mean size of 0.43, range 0.2–0.65, whereas in the inframalleolar part of the flexor digitorum it was seen in 11 ankles (eight volunteers, 26%) with a mean size of 0.3, range 0.12–0.47. Fluid in the retromalleolar part of the flexor hallucis longus was seen in 23 ankles (16 volunteers, 54%) and had a mean size of 1.15, range 0.65–1.65. In contrast, in the inframalleolar part of the flexor hallucis longus it was seen in 17 ankles (11 volunteers, 40%) and had a mean size of 0.7, range 0.34–1.02. No fluid was seen around the anterior tendons above and below the ankle joint (Fig. 5). Correlation between the two measurement sessions was found to be strong (Pearson correlation 0.792, $p < 0.01$). Bland–Altman plot showed an average difference of 0.07 mm between both measurements and did not reveal proportional errors and systematic bias.

Apart from TP infra ($p < 0.01$) and FH infra ($p = 0.02$), there was no difference between measurements of the left and right tendons (average $p = 0.53$, 95% CI 0.31–0.75).

There was no correlation (average $p = 0.41$, 95% CI 0.29–0.52) between the measurements of the tendons and tibiotalar joint fluid.

Fig. 5 Transverse proton density-weighted MR image. Note the absence of fluid around anterior tendon group (arrowheads), and moderate amounts of fluid around tibialis posterior and flexor digitorum (arrows)

Discussion

On MRI and ultrasound studies of the ankle, fluid in the tendon sheaths is a common observation [6]. When interpreting MR images, it is important to determine if the fluid in the tendon sheath is abnormal, indicating a tendon injury or if it is normal, and should be considered physiologic. Although tendon sheaths are expected to contain some fluid for lubrication of tendons, without having a pathological significance, there is insufficient literature concerning the normal amount of physiological fluid.

Rosenberg et al. reported that only occasionally, a minimal amount (without further specifying the amount and tendons) of fluid is noted within a tendon sheath, and that this finding was clinically insignificant [1].

Schweitzer et al. studied [6] fluid in normal ankles; however, their study used MR systems with low resolution and thick slices. In our study, we found that 3T images can differentiate well between peritendinous vessels and synovial fluid. This may have led to misinterpretations in the study of Schweitzer. Our study assessed more tendon sheaths in more locations than these authors. Their study also included patients with symptomatic ankle problems, creating a potential bias.

As reported previously tenosynovial fluid is more common in flexor than extensor tendon sheaths. At the extensor tendons, fluid was absent in asymptomatic individuals.

Fluid in the tendon sheaths of normal volunteers was most common medially, around the posterior tibial tendon; it was present in most ankles both in the retromalleolar as well as inframalleolar area and could reach 1.6 mm in thickness. Schweitzer et al. [6] reported that 22% of the normal volunteers had fluid around the posterior tibial tendon. In our study, it was much more common, seen in most volunteers. This may be attributed to better image quality or a difference in the study population.

Fluid around the flexor digitorum was less common, about in a third of patients both in our and Schweitzer's study [6]. It could reach 0.6 mm, so less than in the tibialis posterior tendon sheath.

In Schweitzer's study, 31% had fluid around the flexor hallucis longus [7]. In our study, it was seen in about a third of patients both in the retro- and inframalleolar areas. It could reach a size of 1.6 mm similar to the tibialis posterior. Of note, in a quarter of patients, communications may exist between the tibiotalar joint and or posterior subtalar joint rendering interpretation of collections in this area somewhat difficult, and potentially causing bias.

In our study, both the peroneus brevis and longus had a small amount of fluid in three patients (retro- and inframalleolar parts). Our findings confirm that fluid around the peroneal tendons should be regarded with suspicion as it is not expected in normal volunteers. Importantly, small blood vessels curving around the peroneal tendons are common and may be confused with fluid in the tendon sheath. We suspect such misinterpretations were made with lower resolution MR systems. On a 3T system, the difference is clearly demonstrated.

In an ultrasound study of ankle tendons in healthy volunteers, Schmidt et al. [6] reported fluid around the following tendons: the peroneus longus tendon in 68%, the peroneus brevis in 76%, the tibialis anterior in 46%, and the tibialis posterior in 45%. These observations differ from Schweitzer's and our findings. Retinacula around these tendons actually present as multiple-millimeter-thick hypoechoic bands on ultrasound, and this likely explains this misinterpretation. Our findings clearly demonstrate, that as a general rule, there is no tenosynovial fluid around the peroneal tendons in the retro- and inframalleolar areas.

Several other authors have also studied fluid in ankle synovial sheaths without making measurements and differentiating the retro- and inframalleolar areas. Nazarain et al. [6] disclosed fluid in the tibialis posterior tendon sheath in 77% of tendons. This is in accordance with our findings.

Although several authors have described any visible fluid in the tendon sheath as synovitis and abnormal, our results indicate that radiologists should be careful attributing pathological significance to fluid in some tendon sheaths. The amount of physiological fluid is also relevant and as

indicated by our results it should not be more than 1.6 mm as the largest dimension, especially in the medial tendons [4, 5].

Our study has several limitations. First, our number of volunteers was limited, although we still included 42 ankles, which represents a reasonable sample. Part of our study was performed by Schweitzer decades ago but at that time, quality of MR systems was insufficient to depict these small amounts of fluid and differentiate this from vessels. We also made more detailed infra- and retromalleolar measurements. We also did not include a symptomatic population as Schweitzer. Also on the day of the study, they avoided strenuous long walks to the MR suite. We cannot exclude that any of our volunteers may have had an undiagnosed rheumatological condition, although follow-up 2 years after the actual study has not revealed any evidence of this. Schweitzer in their study attempted to use volume calculations, but we believe this is too cumbersome. We acknowledge measurements could have been performed in other planes, but we choose for a simple clinically applicable method. Our study population is relatively young, and findings may be different in elderly subjects. In the inframalleolar area, tendons are somewhat oblique and this may have led to a measurement error.

Conclusion

In asymptomatic volunteers, fluid is typically seen in the medial ankle tendon sheaths, both in the retro- and inframalleolar areas. This is most pronounced for the tibialis posterior tendon and flexor hallucis tendon. Fluid in the anterior tendons and peroneal tendon sheaths is rarely seen. We suggest this is likely to indicate a tendon or synovial pathology.

Author contribution IW: data collection, analysis, writing. MS writing and final editing. LL: writing, editing. NB: data analysis. JM: analysis and final editing. SP: data collection and analysis. MM: data collection, analysis, writing and final editing

Compliance with ethical standards

Conflict of interest The authors declare that they have no financial/personal conflicts of interest.

References

1. Bencardino J, Rosenberg ZS, Delfaut E (1999) MR imaging of sports injuries of the foot and ankle. Magn Reson Imaging Clin N Am 7:131–149
2. Cheung Y, Rosenberg Z, Magee T, Chinitz L (1992) Normal anatomy and pathologic conditions of ankle tendons: current imaging techniques. Radiographics 12:429–444
3. Nazarian LN, Rawool NM, Martin CE, Schweitzer ME (1995) Synovial fluid in the hindfoot and ankle: detection of amount and distribution with US. Radiology 197:275–278
4. O'Neill J, Pedowitz D, Kerbel Y, Codding J, Zoga A, Raikin S (2016) Peroneal tendon abnormalities on routine magnetic resonance imaging of the foot and ankle. Foot Ankle Int 37(7):743–747
5. Saxena A, Luhafiya A, Ewen B et al (2011) Magnetic resonance imaging and incidental findings of lateral ankle pathologic features with asymptomatic ankles. J Foot Ankle Surg 50(4):413–4156
6. Schmidt WA, Schmidt H, Schicke B, Gromma-Ihle E (2004) Standard reference values for musculoskeletal ultrasonography. Ann Rheum Diss 63:988–994
7. Schweitzer ME, van Leersum M, Ehrlich SS, Wapner K (1994) Fluid in normal and abnormal ankle joints: amount and distribution as seen on MR images. AJR Am J Roentgenol 162:111–114
8. Teitz CC, Garret WE, Miniaci A, Lee MH, Mann RA (1997) Tendon problems in athletic individuals. J Bone Jt Surg Ann 79:138–152
9. Trevino S, Baumhauer JF (1992) Tendon injuries of the foot and ankle. Clin Sports Med 11:727–739