Universitat de Barcelona

CLINICAL ANATOMY ASPECTS OF THE ARTHROSCOPY AND ENDOSCOPY IN PODIATRIC PROCEDURES (FIRST METATARSOPHALANGEAL JOINT AND PLANTAR APONEUROSIS): A REVIEW

DEGREE PROJECT - PODIATRY

BETLEM FARGUES POLO

TUTOR: DR. Mª CRISTINA MANZANARES CÉSPEDES

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ABSTRACT

Introduction and objectives

Advances in endoscopy, small joint arthroscopy, and instrumentation, have enabled surgeons to treat pathologies affecting the first metatarsophalangeal (MTPJ) and the plantar aponeurosis (PA). The aim of this paper is to study the used portals and its complications trough a systematic literature review, and evaluate the risk of nerve injury of each portal by means of cadaveric dissections.

Material and methods

A PubMed, Scopus, Scielo and ScienceDirect search was performed, between September 2014 and May 2015, using the following keywords: "first metatarsophalangeal joint arthroscopy". A refined search was carried out, using ("first metatarsophalangeal joint" AND "arthroscopy") AND NOT "hallux valgus", for first metatarsophalangeal joint arthroscopy and then, using "endoscopic" AND "plantar fasciitis", and "endoscopic" AND "plantar fascia" for PA endoscopy. An anatomical textbook research was also performed.

For the clinical anatomy experiment, ten fresh frozen feet were examined, as described by Golanó et al (2006), to evaluate the risk of nerve injury when establishing portals.

Results

A total of 43 articles were selected through the search. The portals used for first metatarsophalangeal joint arthroscopy were the dorsolateral, dorsomedial, the medial and the medial proximal portals. Portals described for managing the plantar fasciosis are the medial and lateral portals. The portal's complications cited were mainly attributed to lesion of nervous structures, being called neurapraxias. Other complications cited are: portal tenderness, infection, and persistent drainage. Arch collapse or lateral column pain are complications attributed to the plantar fascia release. On the cadaveric study no damage of the nervous structures surrounding the portals was observed, although some terminal branches on the calcaneal region can be minimally damaged.

Conclusion

The selected portals reviewed have proven to be safe because no nervous structure was injured when reviewing the anatomo-clinical procedures on the cadaveric study.

RESUMEN

Introducción y objetivos

Los avances en la endoscopia, la artroscopia de pequeñas articulaciones, y en la instrumentación, han permitido a los cirujanos tratar patologías que afectan a la primera articulación metatarsofalángica (MTF) y a la aponeurosis plantar (PA). El objetivo de este trabajo es estudiar los portales y sus complicaciones mediante una revisión bibliográfica, y evaluar el riesgo de lesión nerviosa en cada portal mediante disecciones cadavéricas.

Material y métodos

Se realizó una búsqueda en PubMed, Scopus, Scielo y ScienceDirect entre septiembre de 2014 y mayo de 2015, usando como palabras clave: "first metatarsophalangeal joint arthroscopy". Se realizó una búsqueda más refinada utilizando ("first metatarsophalangeal joint" AND "arthroscopy") AND NOT "hallux valgus", para la artroscopia de la primera articulación MTF, y luego "endoscopic" AND "plantar fasciitis", y "endoscopic" AND "plantar fascia", para la endoscopia de la PA. También se realizo una búsqueda en libros de texto sobre anatomía y artroscopia.
Para evaluar el riesgo de lesión nerviosa diez pies frescos de cadáver fueron examinados como describieron Golanó *et al* en 2006.

Resultados

Un total de 43 artículos fueron seleccionados. Los portales usados para la primera articulación MTF son el dorsolateral, el dorsomedial, el medial, y el medial proximal. Los portales que se requieren para tratar la fasciosis plantar son el medial y el lateral. Las complicaciones atribuidas a los portales son las lesiones nerviosas denominadas neuropraxias. Otras complicaciones quirúrgicas son: hipersensibilidad, infección y drenaje persistente. Un colapso del arco o dolor en la columna lateral del pie son complicaciones atribuidas a una fasciotomía plantar. En el estudio cadavérico no se observaron lesiones nerviosas, a pesar de que algunas ramas terminales en la región calcánea podrían verse dañadas.

Conclusión

Los portales revisados han probado ser seguros porque ninguna estructura nerviosa fue dañada en la realización de los procedimientos anatomo-clínicos en el estudio cadavérico.

PERSONAL MOTIVATION

In September 2011 I started my Podiatric studies in the University of Barcelona. That same year, I studied the subject Musculoskeletal Anatomy taught by Pau Golanó Álvarez. I loved the subject and the way that Pau had to explain and teach the topics.

On the next course, I asked him to join his research team. He accepted me, and at first, I started scraping bone and holding his anatomical dissections. Then, while I was seeing how he dissected, I could feel the passion that he felt doing his job. It was not difficult to transmit his passion. One day Pau gave me a foot, a scalpel and I started to dissect. While I was dissecting, I was abducted into another world where scientific questions grew.

Two years sitting beside him were enough to visualize how big was Pau in the scientific community. He was not only one of the best anatomists and scientists, he was a great person, someone who had always a space to hear me and give me the best advices that I could ever get.

His great professional carrier in the development of arthroscopy has encouraged me to do this paper on this issue. Additionally, I really believe that arthroscopy is the nowadays and future surgery. I think those are great techniques because we can see what we are treating by means of a little incision. Open surgery let surgeons see but at the expense of a biggest incision and scar. Percutaneous techniques allow surgeons to make a small incision, but not to visualize the surgical site, so it requires fluoroscopic shots to corroborate the exact place of the surgical material.

Thank you Pau for your anatomic, scientific and friendly advices, I will never forget them.

1. INTRODUCTION

Advances in small joint arthroscopy and instrumentation have enabled surgeons to treat pathologies affecting the first metatarsophalangeal joint (MTPJ) as well as the plantar aponeurosis (PA). Arthroscopic and endoscopic techniques have shown to have advantages over other surgical techniques such as minimally invasive or open surgery.[1-4] That is the reason why these techniques are more used everyday, being the first technical election for many pathologies affecting, for example, the knee, the ankle or even tendons.

Despite the fact that there are no studies comparing the arthroscopic surgery versus open procedures specifically in first MTPJ, the advantages for arthroscopic techniques cited in literature include; decreased bleeding, infection rates, and scarring, along with improved cosmetics and quicker recovery, rehabilitation[1] and bone union.[2] On the other hand, endoscopic plantar fascia release has shown advantages respect to open procedures such as: precise detection of the lesion,[2,5] minimal dissection of soft tissue, less scarring of the skin over the weight-bearing area and the fat pad, immediate full weight-bearing, rapid recovery,[4,5] and prevention of potential wound complications.[5]

Although arthroscopy of the first MTPJ has been recently used for correcting the hallux valgus deformity,[6-9] its main indications are: rheumatic pathology, [10-14] septic arthritis[11] post-traumatic sequels,[11-14] osteochondritis dissecans,[11,15,16] fractures,[13,14] and hallux rígidus.[11-14,17,18]

Endoscopic plantar fascia release is indicated in recalcitrant plantar fasciosis where conservative treatments as nonsteroidal anti-inflammatory drugs (NSAIDs), rest, heel cups, splints, orthotics, corticosteroid injections, casts, physical therapy, ice, and heat, have failed.[19]

2. RATIONALE

2.1. ARTHROSCOPIC PORTALS FOR FIRST METATARSOPHALANGEAL JOINT

Watanabe et al. described this technique in 1985. The main arthroscopic portals used in first metatarsophalangeal joint are the dorsolateral, dorsomedial and medial portals.

- **The dorsolateral** and **dorsomedial portals** are located just lateral and medial to the extensor hallucis longus (EHL) tendon **(Figure 2.1.1)**.

- **The medial portal** is located midway between the dorsal and plantar aspects of the joint **(Figure 2.1.2).**

Figure 2.1.1. Dorsolateral and dorsomedial portals for first MTFJ.

Varying these portals, the whole joint can be inspected, including the articulation with the sesamoid bones.[12]

Only when a medial sesamoid has to be treated[20] or an arthrofibrosis is present,[21] an accessory portal is needed to treat the medial aspect of the joint.

- The **medial proximal portal** is located 4cm proximal to the medial portal, between the medial heat of flexor hallucis brevis (FHB) and the abductor hallucis (ABDH) muscles. It is considered as a working portal, so the arthroscope will never be placed on it **(Figure 2.1.2)**.

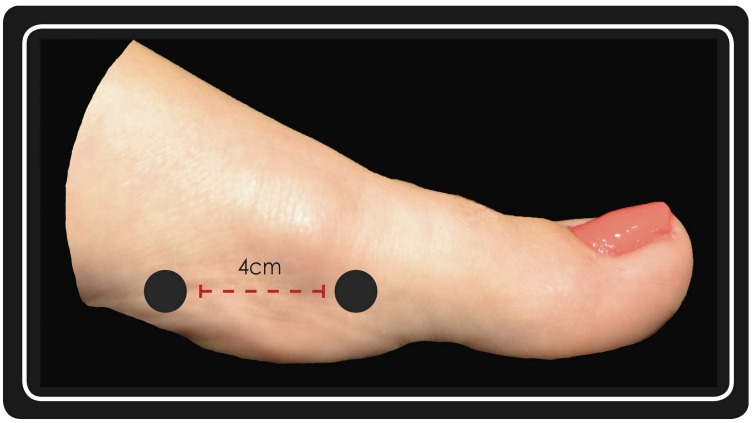

Figure 2.1.2. Medial and medial proximal portals for first MTPJ.

Even though the joint can be treated with four portals, van Dijk[11] also uses the so-called web space portal for treating lateral sesamoid bone, and Lui et al.[6-9] use the web space and the lateral portals for carrying out the lateral release to correct the hallux valgus deformity. However, these portals do not access the intraarticular space of the first MTP joint specifically.

2.2. INERVATION OF THE FIRST METATARSOPHALANGEAL JOINT

The superficial and deep peroneal nerves are responsible of the sensitive innervation of the dorsum and the medial side of the foot.[22]

- The **superficial peroneal nerve** arises the ankle and gives a branch called **medial dorsal cutaneous nerve**, which innervates the dorsomedial and medial sides of the first MTP joint by its terminal branch, the **dorsomedial digital nerve of the first toe (Figure 2.2.1).**

- The **deep peroneal nerve,** at the level of the ankle, runs between the EHL and extensor digitorum longus (EDL). It gives a lateral branch, which innervates the extensor digitorum brevis muscle (EDB) and continues distally until arrive at the base of the first metatarsal bone, where it perforates the dorsal superficial fascia, becoming superficial, and divides in two

terminal branches, the **dorsolateral digital nerve of the first toe** and the **dorsomedial digital nerve of the second toe (Figure 2.2.1)**.

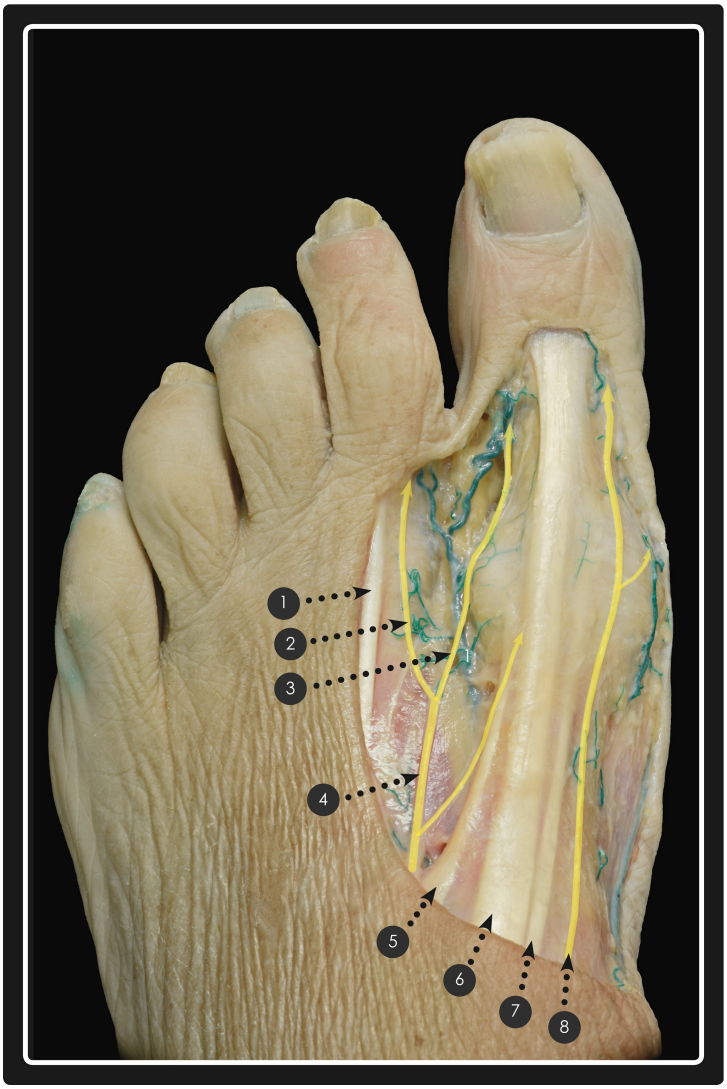

Figure 2.2.1. Innervation of the first ray**.** Extensor digitorum longus of the second toe. **2.** Dorsomedial digital nerve of the second toe. **3.** Dorsolateral digital nerve of the first toe. **4.** Deep peroneal nerve. **5.** Extensor hallucis brevis. **6.** Extensor hallucis longus. **7.** Extensor capsularis. **8.** Medial dorsal cutaneous nerve giving its terminal branch, the dorsomedial digital nerve of the first toe**.**

2.3. CLINICAL ANATOMY OF THE FIRST METATARSOPHALANGEAL JOINT

The first metatarsophalangeal joint is constituted by numerous structures that can cause signs and symptoms as pain, tenderness, and loss of mobility or inability to walk. The main pathologies affecting the first MTPJ are described as:

2.3.1. Impingement syndrome

Dorsal impingement on the first MTP joint[24] is described as the result of repetitive microtrauma on the dorsal aspect of the joint produced by repetitive forced dorsiflexion movements. This results in damage to the cartilage rim on the dorsal aspect of the distal phalanx and metatarsal head. An inflammatory reaction, synovitis, scar tissue formation, calcifications, and finally spur formation can be the result.

Clinically, there is pain on the dorsal and dorsolateral aspect of the joint, especially during or after forced dorsiflexion, which is slightly limited. On X-ray there are no degenerative changes on the anteroposterior or lateral views.

2.3.2. Hallux rigidus

This disorder can be very troubling and even disabling, because we use the first toe whenever we walk, stoop down, climb up, or even stand. Many patients confuse hallux rígidus with a bunion, which affects the same joint, but they are very different conditions requiring different treatments.

Because hallux rigidus[28] is a progressive condition, the toe's motion decreases with time. In its earlier stage, when motion of the first MTPJ is only somewhat limited, the condition is called "hallux limitus". But as the problem advances, the toe's range of motion gradually decreases until it potentially reaches the end stage of "rigidus" in which the first MTPJ becomes stiff.

In some people, hallux rigidus is a family trait as the result of inheriting a foot type, for example, those with fallen arches or excessive pronation or limitation of the ankle dorsiflexion. In other cases, it is associated with overuse, especially in professions that increase the stress on the first MTPJ, because workers often have to stoop or squat. Hallux rigidus can also result from an injury. Moreover, inflammatory diseases such as rheumatoid arthritis or gout can cause it.

Early signs and symptoms include: pain and stiffness in the first MTPJ during use (walking, standing, bending, etc.), which are aggravated by cold and damp weather, difficulty with certain activities (running, squatting) and swelling and inflammation around the joint. As the disorder gets more serious, additional symptoms may develop, including pain even during rest, difficulty on wearing shoes because bone spurs, dull pain in the hip, knee, or lower back due to changes in the way patients walk and limping in the more severe cases.

A precocious diagnosis, when first notice symptoms appear, facilitates the treatment. The development of bone spurs complicates the management of this condition. In diagnosing hallux rigidus, the surgeon will examine the range of motion of the first MTP joint. X-ray during the first stage may show no deformity. At a later stage, however, joint space narrowing and osteophytes become apparent **(Figure 2.3.2.1)**.

Figure 2.3.2.1. Dorsoplantar forefoot X-ray image. Showing with a red circle, the hallux rígidus.

2.3.3. Osteochondritis dissecans

Osteochondritis dissecans was described by Carell and Childress in 1940. It is a condition in which a fragment of bone is deprived of blood and separates from the rest of the bone causing pain.

It can lead towards a hallux rígidus deformity. The symptoms are pain, and an intermittent limitation of motion due to locking caused by a loose body.[25]

2.3.4. Sesamoiditis

The sesamoid bones are incorporated in the FHB and articulate with the plantar surface of the first metatarsal head.[22]

Suggested sesamoid functions include: elevating the first ray so the first metatarsal can plantarflex during extension of the hallux, to enhance the load-bearing capacity of the first metatarsal, and to improve the mechanical leverage for the attached intrinsic muscles.[26]

A normal sesamoid bone can consist of multiple fragments (bipartite, tripartite). Differentiation between a multifragmented sesamoid bone and a fracture (acute or chronic) is important. An acute fracture is caused by trauma, a direct blow or impact to the bone. An acute sesamoid fracture produces immediate pain and swelling at the site of the break, but usually does not affect the entire first MTP joint. A chronic fracture is a stress fracture, usually caused by repetitive stress or overuse. It produces longstanding pain in the ball of the foot, beneath the first MTP joint. The pain is variable, being generally aggravated with activity and relieved with rest.[27]

A sesamoidits is an overuse injury involving chronic inflammation of the sesamoid bones and the tendons related with them. It is caused by increased pressure to the sesamoids and often is associated with a dull and longstanding

pain beneath the first MTP joint. The pain is variable, and it is usually associated with certain shoes or activities.[27]

2.3.5. Osteochondral defects

Osteochondral lesions are usually caused by a cartilage injury followed by a defective cartilage repair, with cartilage softening and chondral fracture. A fragment of the fractured cartilage can constitute a loose body causing the locking of the articulation[28] **(Figure 2.3.5.1)**.

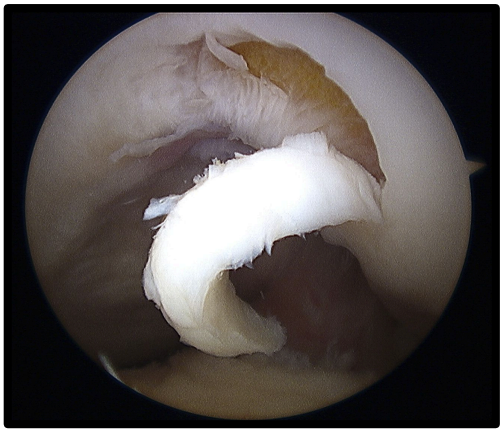

Figure 2.3.5.1. Arthroscopic image, showing a loose body on the knee. Obtained from **Gomoll AH, Farr J, Gillogly SD, Kercher J, Minas T.** Surgical management of articular cartilage defects of the knee. J Bone Joint Surg Am. 2010 Oct;92(14):2470-90.[80]

The signs and symptoms are: chronic pain deep in the joint, typically worse when bearing weight on the foot and less when resting. An occasional "clicking" or "catching" feeling when walking can appear. Joint locking and episodes of joint swelling when bearing weight, and subsiding when at rest, can come out. Unless the injury is extensive, the symptoms can be noticed very late.[28]

2.3.6. Synovitis

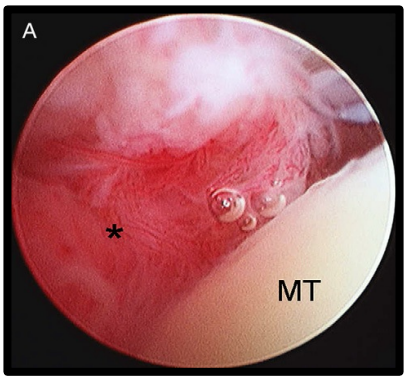

Figure 2.3.6.1. Arthroscopic image showing a synovitis marked with an asterisk. Obtained from **Lui TH.** Arthroscopic release of first metatarsophalangeal arthrofibrosis. Arthroscopy 2006 Aug;22(8):906.e1-906.e4.[21]

Synovitis is described as the inflammation of the synovial membrane **(Figure 2.3.6.1)**. It is commonly associated with specific diseases such as arthritis or gout, but may also be the result of overuse or trauma. Symptoms of synovitis may include redness, swelling, warmth, and pain with joint motion. X rays and synovial fluid analysis are the indicated explorations to diagnose the pathology.[29]

2.3.7. Arthrofibrosis

Arthrofibrosis is a complication of bunion a surgery or first toe trauma where an excessive scar tissue response leads to painful restriction of joint motion, due to a retracted capsule and intercapsular adhesions with scar tissue **(Figure 2.3.7.1)**. It is persisting despite rehabilitation exercises and stretches. Its symptoms are loss of joint mobility after a trauma, microtrauma or a surgical intervention.[30]

Figure 2.3.7.1. Arthroscopic image showing the scar tissue .

2.4. ENDOSCOPIC PORTALS FOR THE PLANTAR APONEUROSIS

The portals used for treating the plantar fasciosis and the calcaneal spur, are the **medial** and **lateral portals**.

- There exist different ways to localize the point where the **medial portal** has to be placed. Jerosch et al.[31] use the palpation method, others use fluoroscopic lateral x-ray images,[32-34] non weight-bearing lateral radiographies,[35-44] while others project a line from the posterior border of the medial malleolus distally to the plantarmedial side, making the incision at 1cm from the sole.[45-49] The last method was the used in our experimental study for establishing the medial portal on the cadaveric samples.

- The **lateral portal** is established trough the medial portal. When the medial portal is localized, the arthroscope is passed across the fat pad until contact with the lateral skin, which is sectioned by a nº15 blade to access with the arthroscope.

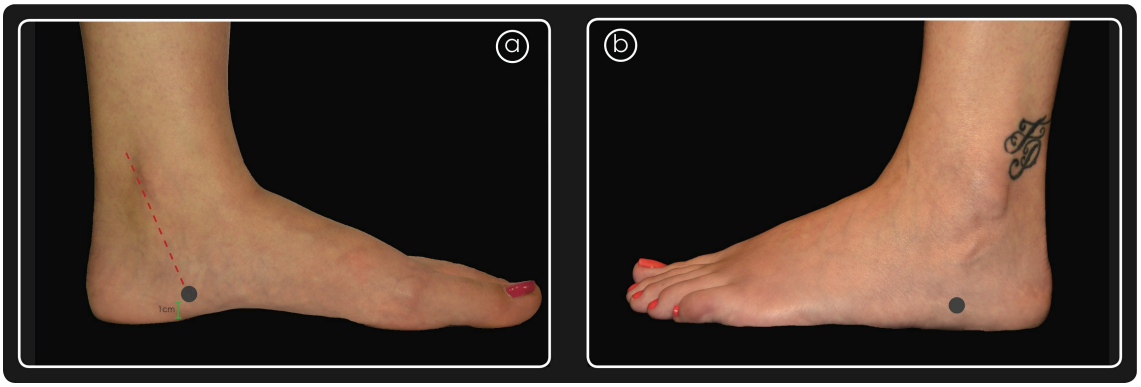

Figure 2.4.1. A) Medial view of the foot showing the medial portal in line with the posterior border of the malleolus, localized at 1cm of the foot sole. **B)** Lateral view of the foot showing the lateral portal.

2.5. INNERVATION OF THE PLANTAR APONEUROSIS

The **tibial nerve** by means of its medial calcaneal branches, the so-called **medial calcaneal nerve**, innervates the plantar aponeurosis and the heel. Furthermore, the **sural nerve** is the responsible of the sensitive innervation of the lateral aspect of the leg and the foot. It provides lateral calcaneal branches called, the **lateral calcaneal nerve**.[22]

Figure 2.5.1. Lateral innervation of the foot. **1.** Dorsolateral cutaneous nerve. **2.** Lateral calcaneal nerve. **3.** Sural nerve.

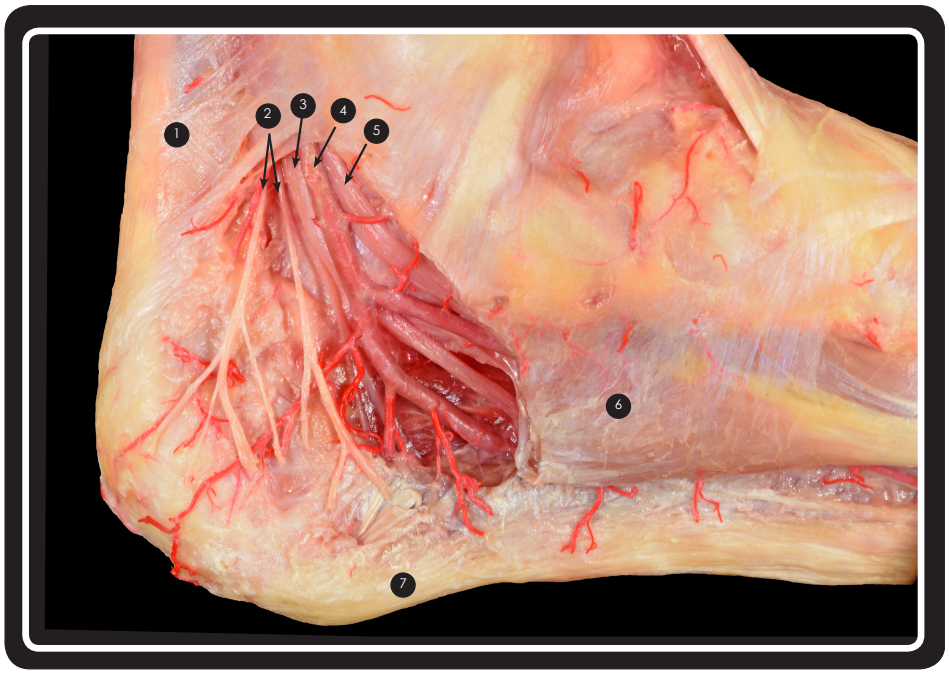

Figure 2.5.2. Innervation of the medial side of the foot, at the level of the calcaneal region. The tarsal tunnel is oppened and the abductor hallucis muscle is sectioned. **1.** Calcaneal tendon. **2.** Medial calcaneal nerve. **3.** Lateral plantar nerve. **4.** Posterior tibial artery. **5.** Medial plantar nerve. **6.** Abductor hallucis. **7.** Plantar aponeurosis insertion.

2.6. CLINICAL ANATOMY OF THE PLANTAR APONEUROSIS

"Heel pain syndrome", "Plantar heel pain", "Plantar fasciitis" and "Heel spur syndrome" are terms used interchangeably in the reviewed literature, despite the fact that they could have not the same meaning. "Heel pain syndrome" or "Plantar heel pain" are synonymous. They can be due to different diagnostic entities, such as plantar fasciosis, but also to mechanical overload, periosteal inflammation, increased calcaneal intraosseous pressure, fat pad degeneration, bursitis, nerve entrapment, local bony pathology and enthesitis caused by seronegative arthritis.[50] Some authors have found thickening of the plantar aponeurosis in the so-called "heel pain syndrome", with a mean reported thickness exceeding 4mm, with no fasciosis involved.[51]

The term "plantar fasciitis" is unclear. Some anatomical and histological studies have revealed that the "plantar fasciitis" is not an inflammatory process, but a degenerative process, because histological analysis had shown tissue changes suggestive of chronic degeneration (mixoid degeneration and fibroblast necrosis, chondroid metaplasia, angiofibroblastic proliferation, collagen

degeneration, increased numbers of abnormal fibroblasts with mitochondrial defects, etc) (Lemont). Moreover, classic signs of inflammation such as swelling, erythema, leucocytic or macrophage infiltration are conspicuously absent.[52]

Consequently, some authors[52-54] suggest that corticosteroid injections should be revised as the treatment on plantar fasciosis. According to Lemont[52] the term to describe this entity should then be plantar fasciosis instead of plantar fascitis, because the suffix –osis means "degeneration" while –itis means "inflammation".

2.6.1. Plantar fasciosis

The underlying cause of plantar fasciosis is likely to be multifactorial in origin. Degenerative changes of the heel fat pad, mechanical arch abnormalities increasing tension on the plantar aponeurosis, patient demographics, notably are commonly implicated. They increase with age, obesity and work-related weight-bearing.[55] Improperly constructed or fitting shoes can also produce a plantar fasciosis because they cause uneven distribution of weight on the feet.

Plantar fasciosis typically presents with the insidious onset of so-called “start-up pain”. This sharp, stabbing pain localized to the plantarmedial aspect of the heel occurs when arising out of bed in the morning or from a chair after sitting for a long period. Start-up pain rapidly dissipates once weight-bearing is initiated. By the end of the day, a dull, constant aching or throbbing pain typically develops and may radiate into the medial arch or the forefoot. Rest, elevation, and massage of the foot often facilitate relief of this pain. Overnight, this pain recedes and the patient awakens to a stiff, painless foot until the first step out of bed.[56]

Furthermore, patients may have multiple pathologies and presenting different clinical features. Plantar fasciosis may be combined with entrapment of Baxter’s nerve and tarsal tunnel syndrome, the so-called “heel pain triad”.[57]

2.6.2. Calcaneal spur syndrome

The association between plantar fasciosis and heel spurs remains a subject of controversy. Traction or tensile forces (such as those that occur with jumping) have been put forth as stress that induce calcaneal spur formation,[58-60] but the link between hard surfaces and jobs that require hours of standing[60] has led to claims that compressive factors induce calcaneal bony spur formation. Obesity has also been proven to be a risk factor in calcaneal spur formation.[61,62] Plantar spurs seem to arise in about 11-30% of asymptomatic population.[61,62]

Although it is tempting to speculate that heel spurs may result from traction of plantar aponeurosis, it is important to be aware that in fact heel spurs are not located in the plantar aponeurosis, but more dorsally in the flexor digitorum brevis muscle and abductor digiti minimi muscle[63] **(Figure 2.6.2.1)**. At a microscopic level, skeletal muscle tissue is described as "being attached via a fibrous to fibrocartilaginous enthesis to the apex of the spur".[63]

Figure 2.6.2.1. Lateral X-ray image showing a calcaneal spur.

3. OBJECTIVES

The main objectives of this study are:

- Describe the arthroscopic portals used in surgery of the first MTPJ and the endoscopic portals for the PA, found in the systematic literature review.
- Review the postoperative complications of the arthroscopic and endoscopic procedures as described in the literature.

Secondary objectives are:

- Examine the arthroscopic portals used in surgery of the first MTPJ and the endoscopic portals for the PA portals in cadaveric feet and their respective clinical anatomy, according to the literature.
- Review the described portal's surgical complications and their respective clinical anatomy in cadaveric feet, and explore alternative options.

4. MATERIAL AND METHODS

4.1. LITERATURE REVIEW

Databases used to collect information for the literature review were: PubMed, Scopus, Scielo and ScienceDirect. The revision includes articles in English, French, Italian, Spanish and Portuguese. All databases were consulted between September 2014 and May 2015. No limits as for the publication data were applied.

A very selective criteria search was carried out, employing as key words: “first metatarsophalangeal joint arthroscopy”. Because of the results of the initial search were few, a broader search was performed, filtering the information in journals and using as key words: ("first metatarsophalangeal joint" AND "arthroscopy") AND NOT "hallux valgus”, thus excluding the "hallux valgus deformity" procedures.

For the endoscopic plantar fascia release, keywords used were: “endoscopic” AND “plantar fasciitis”, and “endoscopic” AND “plantar fascia”. A selection criteria was to take into account only the so-called "two portal" procedures, due to the fact that the uniportal access is considered expensive, thus is less described and used.

An anatomical and arthroscopic textbook research was also carried out, in the automated catalog (CRAI) of the library of the University of Barcelona. Atlas books were excluded of the review. All books were consulted between September 2014 and May 2015.

4.2. ANATOMICAL DISSECTIONS

Ten lower legs from Caucasian origin, amputated approximately 15cm below the ankle, were carefully examined in the Human Anatomy and Embryology Unit and the Dissection Room of the Health University of Barcelona, campus Bellvitge in Barcelona, Spain. The fresh frozen feet were examined, dissected and photographed, following the method described by Golanó et al. in 2006[64] Specimens with hallux deformities or scars were excluded of the study.

During the first phase of the dissection, particular care of mimicking the surgical maneuvers carried out in clinical setting was taken, in order to apply the results to the improvement of surgical technique. The eventual damages to the nervous fibers were first observed during the sham operating procedure and then confirmed with the anatomical dissection of the cadaveric sample, as well as on the photographic documents. Once dissections were achieved, high-resolution anatomical images were obtained (Camera Nikon D810, Objective AF-S Nikon Micro Nikkor 85mm 1:3.5 Format: NEF+RAW).

4.2.1. Cadaveric nerve dissection of the first metatarsophalangeal joint

The foot was orientated in a supine position; portals were made through a 2,5mm K-wire, the same diameter as the arthroscope has. First metatarsophalangeal joint portals were established with traction of the hallux. The dorsomedial and dorsolateral portals were placed on the soft spots, which were just lateral and medial to the EHL tendon **(Figure 2.1.1)**. After that, the medial portal was established midway between the dorsal and plantar aspects of the joint, and the proximal medial portal was located 4cm proximal to the medial portal **(Figure 2.1.2)**.

Once portals were established, a single cutaneous incision was carried out from the first cuneiform running medially, plantarly and distally to the first interphalangeal joint. Then, the incision was continued proximally and laterally

to the extensor digitorum longus (EDL) tendon of the second toe. The incision finished on the first cuneiform where the first incision was made **(Figure 2.2.1)**. After that, skin was removed very carefully, leaving the subcutaneous tissue intact in order to not damage the superficial and deep peroneal nerves. With iris scissors nerve dissection was made, from proximal to distal, leaving the nervous fibers attached to the dorsal fascia of the foot to not modify its route. Veins were removed, as well as dissection of the first intermetatarsal dorsal artery was performed with iris scissors, from proximal to distal.

Once the area was cleaned, revision of the relationship between portals and nerve was carried out in order to detect the eventual damages of the nervous structures made when establishing the portals. This revision was repeated afterwards on the photographical documents obtained from each dissection.

4.2.2. Cadaveric nerve dissection of the plantar aponeurosis

The foot was in a supine position. The medial portal was established in line with the posterior border of the medial malleolus. The incision was established at 1cm proximal from the foot sole **(Figure 2.4.1 A)**.[24] A 4mm cannula was inserted in the medial portal, passing across the fat pad until arrive to the lateral skin, which was cut with a nº15 blade, creating the lateral portal **(Figure 2.4.1 B).**

A single cutaneous incision was carried out from the lateral malleolus, distally and laterally, to the tuberosity of the fifth toe. Then, a transversal incision to the navicular was performed and continued medially and proximally to the medial malleolus exposing the insertion of the calcaneal tendon **(Figure 2.5.1)**. Removal of the skin was carried out, leaving the subcutaneous tissue intact to not damage the sural and the lateral calcaneal nerves. The tarsal tunnel was opened **(Figure 2.5.2)** in order to visualize the medial calcaneal nerve. With iris scissors nerve dissection was performed, from proximal to distal. Fiber nerves' attachments to the superficial fascia of the foot were preserved. Veins were removed.

As previously described, once the area was cleaned, revision of the relationship between portals and nervous structures was carried out in order to detect the eventual damages of the nerves made when establishing the portals. This revision was repeated afterwards on the photographical documents obtained from each dissection.

5. RESULTS

20 studies were identified for inclusion and analysis first MTFJ arthroscopy. 23 articles were found for the PA endoscopy. 5 anatomical and arthroscopic textbooks were consulted for the knowledge of the anatomy and the clinical anatomy.

According with the literature, the main portals used for treating pathologies affecting the first MTPJ specifically are the dorsolateral, dorsomedial and medial proximal portals. The medial proximal portal is used only when the medial aspect of the joint has to be managed, such as in medial sesamoiditis[11] or arthrofibrosis.[21] For performing the endoscopic plantar fasciotomy two portals are involved, the medial and the lateral. The medial portal is the first established in line with the posterior border of the medial malleolus, 1cm proximal to the foot sole.

The more relevant complication related to the portals described are reviewed in **Table 5.1.** for first MTPJ arthroscopic procedures, and in **Table 5.2** for the PA endoscopy. The complications mentioned are neither related to a particular nerve lesion, nor its diagnosis, prevalence or duration, are described. Moreover, there is considerable confusion in the descriptive terms for nerve and vascular injuries. On the other hand, some of the complications reported, such as infection, wound dehiscence, sinus tract formation, are also related to other surgical treatments thus not to be uniquely attributed to a singular arthroscopic or endoscopic procedure.

Cadaveric dissections made using the same surgical maneuvers as the treatments were submitted to study. Neither, evidence of nerve damage was found while carrying out the sham-surgical interventions or the post-hoc direct and photographic observations.

However, we have observed that, in all our samples, the feeding artery of the first metatarsal head goes through the proximal plantar insertion of the capsule

to the fist metatarsal head, before entering the head of the first metatarsal bone **(Figure 5.1)**.

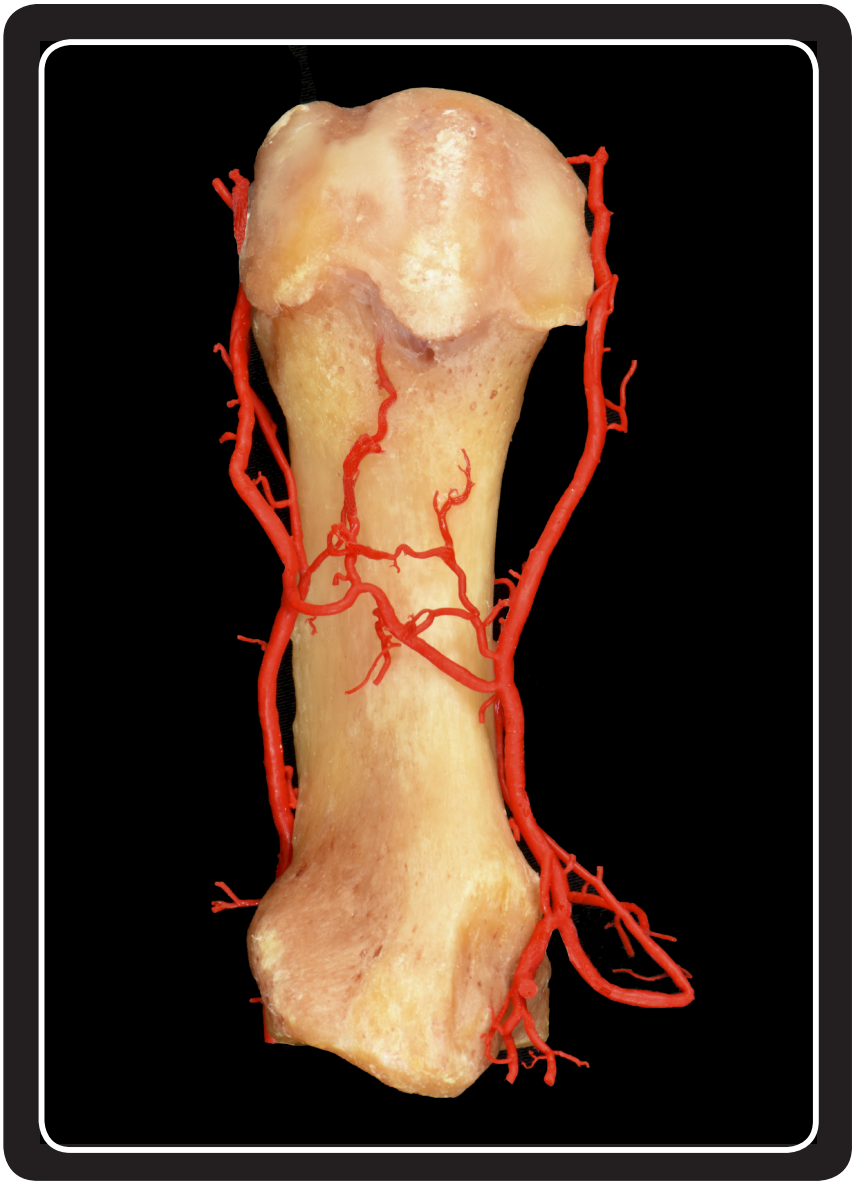

Figure 5.1. Plantar view of the first metatarsal bone showing the feeding artery penetrating the bone at the level of the first metatarsal head.

	Nik van Dijk (1998)	Debnath (2006)	Ahn (2012)	Carreira (2009)
Neuropraxias	Yes	Yes	Yes	No
Articular cartilage injury	No	No	No	Yes
Arthroscope and instrument breakage	No	No	No	Yes
Infection	No	No	No	Yes
Wound dehiscence	No	No	No	Yes
Sinus tract formation	No	No	No	Yes
Under or over boney resection in Hallux rígidus treatment	No	No	No	Yes

Table 5.1. Postoperative complications of first MTPJ arthroscopy.

	Yamakado (2013)	Bazaz (2007)	Barret (1995)	O'Malley (2000)	Boyle (2003)	Gentille (1997)	Oglivie-Harris (2000)
Incomplete fascia release	Yes	No	No	No	No	No	No
Cutaneous nerve injury	Yes	Yes	No	No	No	No	Yes
Deep venous thrombosis	No	Yes	No	No	No	No	No
Neurovascular injuries	No	Yes	No	No	No	No	No
Perioperative medical complications	No	Yes	Yes	No	No	No	No
Arch collapse	No	Yes	Yes	Yes	No	No	No
Lateral column pain	No	Yes	Yes	Yes	Yes	No	No
Portal tenderness	No	No	No	Yes	No	No	Yes
Calcaneal stress fracture	No	No	No	Yes	No	No	No
Postoperative reflex sympathetic dystrophy	No	Yes	Yes	No	No	No	Yes
Pseudo aneurysm of the lateral plantar artery	No	No	No	No	No	Yes	No
Persistent drainage leading to a compartment syndrome	Yes	No	No	No	No	No	No

Tabla 5.2. Postoperative complications of PA endoscopy.

6. DISCUSSION

Advances in visualization technology and instrumentation, and the latest clinical experience of surgeons have improved small joint arthroscopy to new approaches. Proper selection of patients and good mastery of the arthroscopic[65] and endoscopic techniques are the clue to have good results.

According to some authors,[14,46,66] the dorsomedial and dorsolateral portals for the first MTPJ should be located proximally to the EHL tendon to avoid any neural damage to the dorsolateral and dorsomedial digital nerves. When a debridement is performed, surgeons must take care to not disrupt the lateral attachment of the capsule to the metatarsal head, because of its potential risk of developing a hallux varus.[21] It is also important being aware to not damage any fiber of the FHB when treating the medial aspect of the joint.[20] On the other hand, the osteonecrosis of the metatarsal head mentioned[67-70] as a complication of first MTPJ surgical procedures, in arthroscopic techniques could be due to the disruption of the proximal plantar insertion of the capsule to the fist metatarsal head, due to the presence of the feeding artery, as has been described in literature.[22,67]

Acording to Vasenoon and Phisitkul,[71] the medial portal is saver because the dorsomedial and plantarmedial digital nerves of the first toe, are more far from the portal.

On heel pain syndrome a good differential diagnosis is crucial.[72,73] When a recalcitrant plantar fasciosis is present, an endoscopic plantar fascia release is required. According to Oglivie-Harris and Lobo,[45] the use of medial portal in line with the posterior border of the medial malleolus provides a safe zone and devoid of critical structures. When performing an endoscopic plantar fasciotomy, only one-third of the medial compartment of the PA or one half of the entire PA has to be released, to minimize the amount of destabilization of the longitudinal arch.[74] Furthermore, patients could develop lateral arch collapse[35,36,41,46] lateral column destabilization.[35,36,41,43,46,] Otherwise it is crucial

not damaging the flexor digitorum brevis (FDB) belly because the Baxter's nerve **(Figure 6.1)** is just above it.[41] Some studies,[41,75,76] have revealed it to be situated approximately 10mm dorsal to the plantar aponeurosis, thus, if the surgeon's instruments are plantar to the PA and the muscle belly of the FDB, the nerve will be protected from lesions. The American Orthopaedic Foot and Ankle Society (AOFAS) recommends that in case of suspected nerve compression endoscopic release should not be performed because of its complications (pseudoaneurysm of the lateral plantar artery and nerve injury).[77]

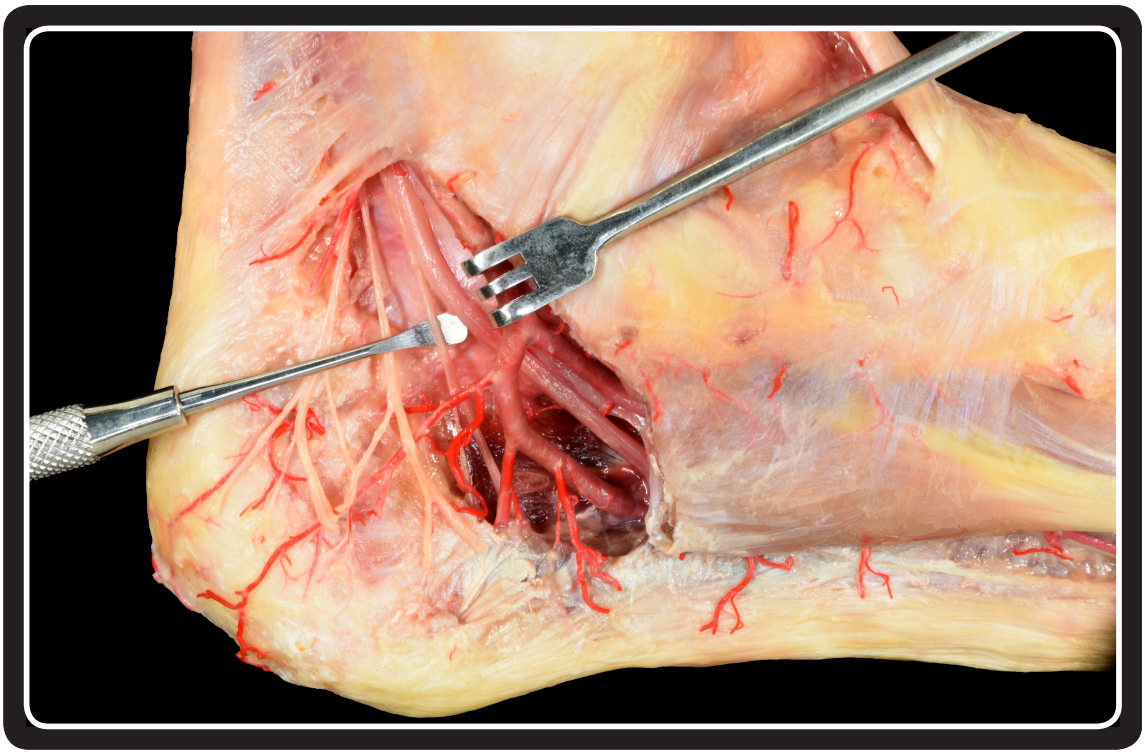

Figure 6.1. Innervation of the medial side of the foot at the level of the calcaneal region. The tarsal tunnel is oppened and the abductor hallucis muscle is sectioned. Posterior tibial artery and medial plantar nerve are retracted by a Senn-Miller retractor. The periosteotome is showing the Baxter's nerve.

The proposed treatments for calcaneal spur are controversial. Some surgeons remove the spur and carry out the plantar fascia release, and others do not remove the spur and do not perform the plantar aponeurosis release, but make a recession on the proximal medial gastrocnemius.[78] More comparative studies would be needed to assess the differences between the procedures involving or not the fascitomy and the calcaneal spur removal, and for knowing if recession

on the proximal medial gastrocnemius has better results than these procedures.[78]

According to Carreira et al. (2009),[65] the use of cannulas to avoid repetitive trauma to the soft tissues on re-entry and limited resection of the soft tissues about the portals, may help to prevent a number of the reported complications.

7. CONCLUSIONS

The appearance of neuropraxias has been the only complication unanimously attributed both to the management of arthroscopic portals for first MTPJ[11,13,14] and to PA endoscopic portals.[33,46] The other complication cited in the literature for PA is postoperative reflex sympathetic dystrophy.[35,45,46]

The complications cited as due to the first MTPJ arthroscopy are under or over-boney resection in treatment of the hallux rigidus, as well as articular cartilage injury and arthroscope or instrument breakage.[79] However, no information about the pathogenesis, prevalence, clinics or diagnosis of these complications is reported. In a similar manner, specific complications of PA endoscopy, such as incomplete fascia release, arch collapse and lateral column pain[35,41,43,46] are reported. Other complications, common to any surgical procedure are also mentioned as perioperative medical complications including infection[35,46,79] or tenderness[41,45,]calcaneal stress fracture,[41] and persistent portal drainage which can lead to a compartment syndrome.[33]

The nervous structures that could be affected by the surgical procedures of the management of the portals used for first MTP joint arthroscopy and PA endoscopy, are the dorsolateral and dorsomedial digital nerves in the case of first MTPJ arthroscopy and the Baxter's nerve, and the medial and lateral calcaneal nerves in PA endoscopy. No evidence of damage of these nervous structures was found during or after the cadaveric study. Consequently, our conclusion is that the portals employed are reasonably safe, although anatomical variations in the discourse of the vasculonervous structures can be the final cause of the sparse complications reported in the literature.

Moreover, our study has lead us to suggest that osteonecrosis of the first metatarsal head, a complication already reported for surgical procedures of first MTPJ, can also be caused by arthroscopic procedures on this area, due to the eventual lesion of the feeding artery, although this complication has never been reported in arthroscopic procedures so far.

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