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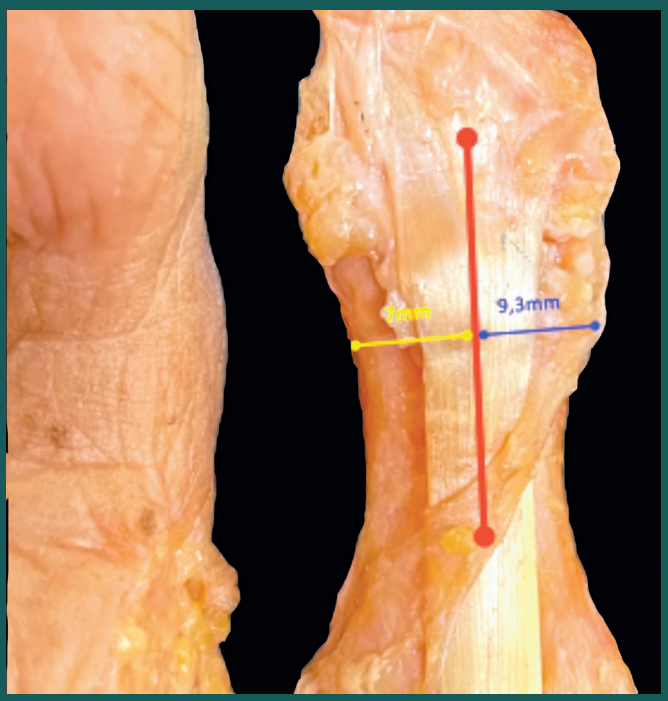

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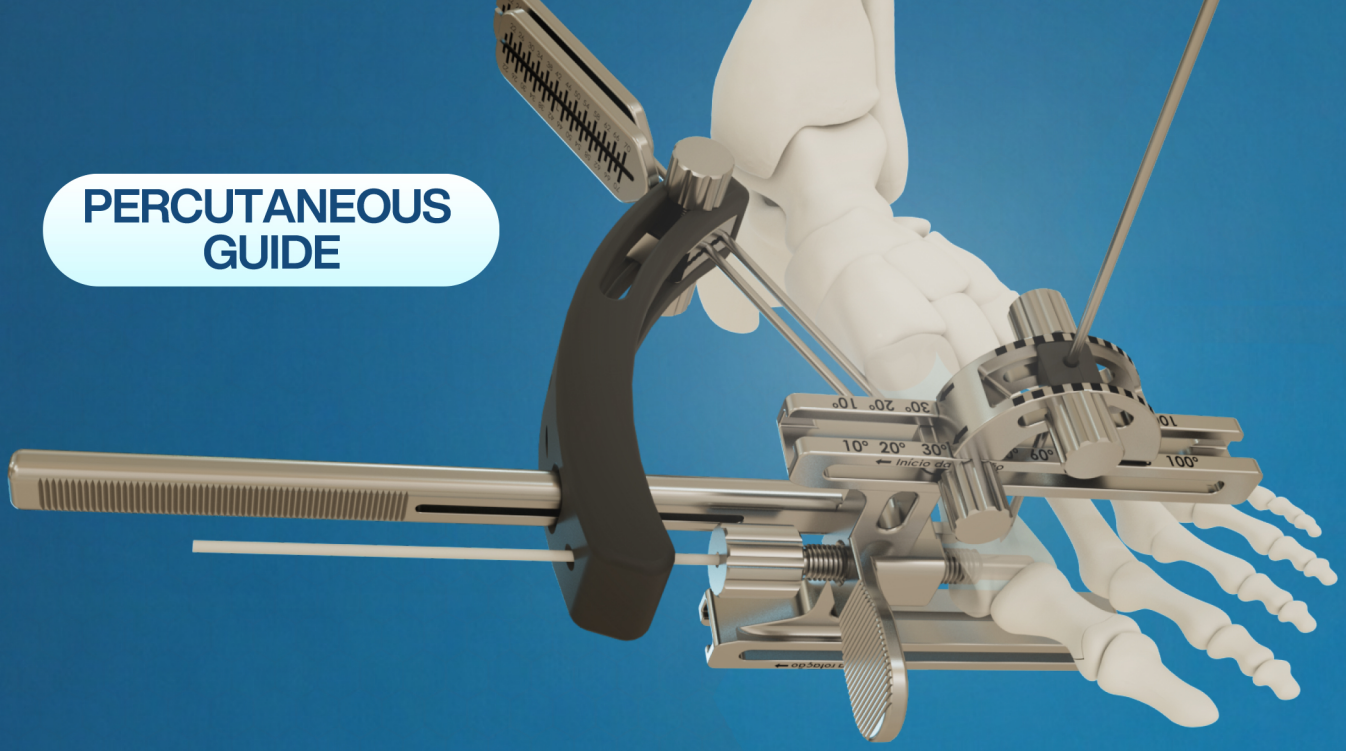

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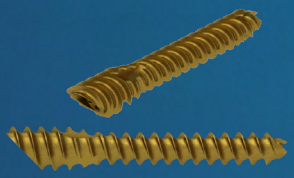

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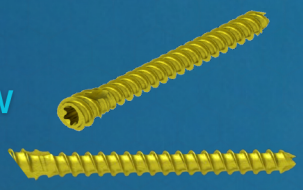

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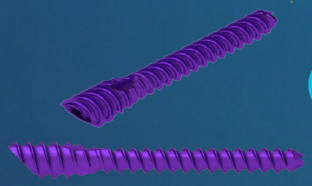

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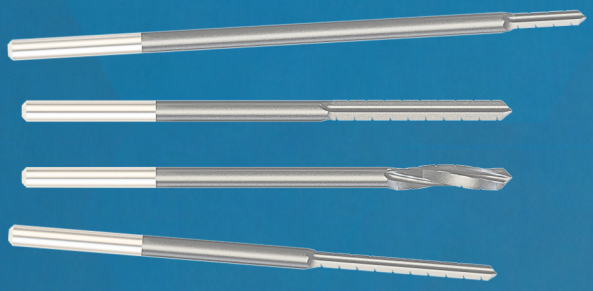

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CESAR DE CESAR NETTO, MD, PHD

PROUD BRAZILIAN AND LATIN AMERICAN

ASSOCIATE PROFESSOR, DEPARTMENT OF ORTHOPEDIC SURGERY

DUKE UNIVERSITY

The Cold Never Bothered Us Anyway

Dear colleagues,

Writing this editorial article for the Journal of Foot & Ankle is a great pleasure and honor. It is also fantastic to watch the growth of the Journal and its strength, influence, and respect among the International Orthopedic Foot and Ankle Community.

I'm a girl's dad, and after watching Disney's Frozen movie at least a million times in the last several years, I cannot avoid making a parallel of us, Latin Americans Foot and Ankle Surgeons, and the main Frozen's character, Princess Elsa.

Elsa was blessed with mighty powers that she could not understand or control initially, which kept her sad and isolated. However, she was unstoppable once she could dedicate time and effort to understanding her capabilities and started funneling her powers to achieve specific goals.

I was always very proud of my roots and origins. Still, I remember being extremely concerned regarding how I would be able to transition and blend into the North American and International Orthopedic Foot and ankle Community. I worried about not fitting in or being diminished. I quickly found out that the recognition and respect we have rightfully conquered throughout the years, thanks to the hard and excellent work performed by several of our Latin American Foot and Ankle icons and ancestors, had paved the way for any Latin American surgeon to blossom and succeed anywhere in the globe they decided to go.

A solid and indexed journal is crucial for us to fit and participate and also highlight and unleash the top-notch quality of our surgeons and researchers. The importance of our commitment to our journal is paramount at this point. The strength of a journal comes from its authors and articles. It is beautiful to see so many researchers with different levels of experience from all over Latin America participate and collaborate in publishing their high-quality articles and supporting our journal to grow strong.

Returning to Disney Frozen and Princess Elsa and the iconic "Let it Go" song that echoed inside many brains for a long time, I would now recommend that we go the other route. Let's not let it go. Do not let it go. Let's go all in. Everything that we do daily in our practices could be something interesting to be turned into a research project and a manuscript eventually. Things we all do could be teaching and guiding surgeons anywhere and everywhere in Latin America and worldwide. Small changes in planning and organization, setting up a team, and a strategy can support any and all of us to contribute to becoming researchers and strengthen our academic and scientific production. It is a lot of fun. So that "Brostrom" that you do every week in your own way with excellent results could influence other surgeons and other patients. The only thing you need is to put the information out. We need to organize, understand, and control our power and funnel it to strengthen our research and our journal. Don't let it go and start/keep doing it!

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Special Article

Impact of proximal medial gastrocnemius release in plantar fasciitis: a rapid review

Sérgio Damião Santos Prata[1], Jorge Mitsuo Mizusaki[1], Lívia dos Reis Ferreira[1]

1. Hospital Santa Marcelina, Setor de Ortopedia e Traumatologia, São Paulo, SP, Brazil.

Abstract

Objective: Evaluate the effectiveness of proximal medial gastrocnemius release in plantar fasciitis.

Methods: An electronic search was performed, and prospective, randomized, comparative, and cadaveric clinical trials from 2012 to 2022 were considered as eligibility criteria, with a minimum sample of ten patients and with a follow-up ≥ one year.

Results: Eight articles written in English were identified and analyzed.

Conclusion: Although isolated proximal medial gastrocnemius release is the preferred technique for most patients, few studies with a high level of evidence demonstrate its long-term effectiveness in plantar fasciitis.

Level of Evidence I; Therapeutic Studies; Systematic Review.

Keywords: Fasciitis, plantar; Fasciotomy; Muscle, skeletal; Heel; Pain.

Introduction

Plantar fasciitis (PF) is the most common cause of chronic heel pain, and it affects active young people and older people who are more sedentary[1]. The risk of developing this disease seems to increase in patients with reduced ankle dorsiflexion[2]. It results from chronic overload of the plantar fascia due to repetitive use in runners and military personnel or due to excess load observed in obese individuals (Body Mass Index (BMI) > 30), sedentary and those who are in an orthostatic position for a prolonged time[3-5].

It is more frequent in individuals with structural foot deformities, including flat and cavus foot, gastrocnemius contracture, severe hallux valgus, and lower limbs dysmetria, associated with the stiffness of the intrinsic muscles of the foot or plantar fascia[1,4]. It is usually unilateral, but 30% of patients have bilateral symptoms[1]. The peak incidence is between 45 and 65 years[6]. Around 90% of patients will improve in 12 months with conservative treatment[7].

Plantar fasciitis patients present limitation of ankle dorsiflexion in 83% of cases[8]. The plantar fascia tension during weight-bearing activities is caused by the gastrocnemius contraction that increases the calcaneal tendon tension and decreases ankle dorsiflexion[9]. Gastrocnemius shortening, congenital or acquired, is the most common cause of decreased ankle dorsiflexion.

It is possible to observe an antalgic gait and external leg and foot rotation in patients with gastrocnemius shortening and plantar fasciitis to compensate for the lack of ankle dorsiflexion. The plantar fascia is injured due to a subtle repetition of damaging moments of longitudinal tension.

The plantar fascia originates in the medial tubercle of the calcaneus and inserts in three locations in the forefoot, creating three distinct bands: medial, central, and lateral. The lateral band is inserted at the base of the fifth metatarsal, and the medial overlaps and has its insertion in the hallux muscles, both being little involved in the pathology. The central band (plantar aponeurosis) is the thickest, strongest, and most often involved. It splits into five bundles at the midshaft of the metatarsal level that attach to the plantar plate of one of the proximal phalanges and, combined with the bone structures

Study performed at the Hospital Santa Marcelina, Setor de Ortopedia e Traumatologia, São Paulo, SP, Brazil.

Correspondence: Sérgio Damião Santos Prata. Rua Azevedo Soares, 1826, Apto 121, Torre 4, Vila Gomes Cardim, 03322-001, São Paulo, SP, Brazil. **Email:** sergioprata@yahoo.com. **Conflito de interesses:** none. **Source of funding:** none. **Date received:** May 13, 2023. **Date accepted:** September 26, 2023. **Online:** October 31, 2023

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of the arch, create a lattice. The plantar fascia raises and stabilizes the arch during gait using the reel mechanism. The dorsiflexion of the toes that occurs during the support leads to the tightening of the central band, which, in turn, pulls the metatarsals' head closer to the calcaneus, increasing the arch height[10].

The diagnosis is clinical, characterized by acute pain in the medial plantar region of the heel in the first steps, in the morning, and after a period of rest, which is relieved when walking. The pain worsens at the end of the day and with sports and impact activities[11]. The sensitivity to palpation is located in the plantar aspect of the calcaneus medial tuberosity around the fascia insertion.

The Tinel test should be performed behind the medial malleolus to rule out tarsal tunnel syndrome. Sensitivity when squeezing the calcaneus may suggest a calcaneal stress fracture or Haglund's disease[12].

Silfverskiöld test is also used to diagnose and evaluate gastrocnemius shortening. The range of motion of ankle dorsiflexion should be evaluated, with the knee flexed and extended. The difference between the dorsiflexion in these two positions quantifies its shortening as the gastrocnemius crosses the knee, ankle, and subtalar joints. The test will be considered positive when the dorsiflexion is less than 10º with the knee extended or if there is more than 10º difference between dorsiflexion with the knee flexed and extended[13].

The treatment for this comorbidity is broad, including conservative and surgical. The surgical treatment is reserved for cases of persistent symptoms after exhausting all therapeutic possibilities for conservative treatment.

Silfverskiöld, in 1923, was the first to describe the proximal gastrocnemius lengthening in cases of cerebral palsy[13]. He sectioned their heads medially and laterally at their insertion into the femoral condyle. Since 2005, most authors have released only the aponeurosis of the medial gastrocnemius[14].

This review aims to evaluate the effectiveness of proximal medial gastrocnemius release (PMGR) in plantar fasciitis through a "rapid review" that address the topic and its impact after the procedure.

Methods

The search was conducted in the Pubmed (MEDLINE), Cochrane Library, SciSearch, Embase, Lilacs, and Scielo databases, using the search terms "plantar fasciitis", "resection of medial gastrocnemius in plantar fasciitis", "plantar fasciitis surgical treatment", "resection of medial gastrocnemius", "plantar fasciopathy", "heel pain", "release of medial gastrocnemius in plantar fasciitis" and "gastrocnemius recess".

The articles obtained through the different search strategies were evaluated and classified into: a) eligible: studies with relevance and the possibility of being included in the review; b) ineligible: studies without relevance, without the possibility of inclusion.

Relevance criteria for eligibility were defined as follows:

- **Publication date:** articles published from 2012 to 2022;
- **Accessibility:** studies that could be obtained in their entirety;
- **Language:** studies in English, Spanish, and Portuguese;
- **Content:** studies that address the PMGR, comparative studies with other surgical procedures, surgical techniques, postoperative results, and morphological changes found after release.
- **Casuistry:** studies that evaluated less than ten patients were considered without relevance due to the tendency to overestimate the accuracy of the results obtained with small samples.
- **Follow-up:** studies with follow-up ≥ 12 months;
- **Potential conflicts of interest:** the possible funding sources and their relationship with the research objective in the different selected studies were analyzed.

Results

The first search in the databases without filtering indicated 7714 articles. After applying all the eligibility criteria, eight articles were identified to be analyzed, with titles, main authors, year of publication, and level of evidence described in table 1.

The following articles were found: one cadaveric study, two comparing surgical techniques for plantar fasciitis treatment, one on the technique, indication, and results of medial gastrocnemius lengthening, one on ultrasound-guided resection, one on morphological changes after surgery, one on the surgical technique, and one on PMGR in plantar fasciitis.

The clinical heterogeneity between the studies did not allow a meta-analysis.

Discussion

The surgical procedure is performed under peripheral or regional local anesthesia, with sciatic nerve block with an ultrasound-guided lateral subgluteal approach. Mepivacaine (15mg/ml) is used for outpatients, or a mixture of mepivacaine (20mg/ml) and ropivacaine (7.5mg/ml) for hospitalized patients[15]. This blockage is, however, ineffective for cutaneous anesthesia, particularly the posterior cutaneous nerve of the thigh, being complemented with local anesthesia just above the popliteal fossa with lidocaine with adrenaline (20mg/ml) immediately before the incision[15].

The patient is positioned in a prone position, without a tourniquet, except when not indicated by anesthetic evaluation. The medial fovea of the popliteal fossa is located, and the incision is marked at 1 cm distal and lateral. The lateral incision prevents damage to the nerve or saphenous vein branches. A 3 cm incision is made through the skin and subcutaneous, then deepened through the deep fascia to expose the underlying aponeurosis of the gastrocnemius

Table 1. List of titles and main author of the studies.

No.	Study Title	Author	Year	Level of evidence
1	Proximal medial gastrocnemius release in the treatment of recalcitrant plantar fasciitis	Abbassian et al. [5]	2012	IV
2	Chronic plantar fasciitis: plantar fasciotomy versus gastrocnemius recession	Monteagudo et al. [45]	2013	III
3	Technique, indications, and results of proximal medial gastrocnemius lengthening	Barouk et al. [15]	2014	
4	Proximal ultrasound-guided gastrocnemius recession: a new ultra-minimally invasive surgical technique	Villanueva et al. [42]	2019	IV
5	Proximal medial gastrocnemius release versus open plantar fasciotomy for the surgical treatment in recalcitrant plantar fasciitis	Gamba et al. [41]	2020	I
6	Clinical and plantar fascial morphologic changes after proximal medial gastrocnemius release treatment of recalcitrant plantar fasciitis	Ginés-Cespedosa et al. [32]	2021	II
7	Ankle dorsiflexion after isolated medial versus complete proximal gastrocnemius recession: A cadaveric study	Manzi et al. [40]	2021	V
8	Proximal medial gastrocnemius release: surgical technique	Gamba et al. [47]	2022	

medial head. The aponeurosis is then split with scissors, ensuring the white fibers release. The skin is sutured with absorbable wire, and a small dressing is applied[15].

After surgery, the release of contracture is clinically confirmed by the Silvferskiöld test[5]. Patients do not use cast or orthosis and walk after the effect of anesthesia. Then physiotherapy with passive ankle dorsiflexion with the knee extended is started. The use of non-heeled footwear is recommended to maintain dorsiflexion[11].

Reduced ankle dorsiflexion was associated with a much higher risk of developing the condition than BMI or activity type[4].

Plantar fasciotomy has also been performed. Some authors associate it with the release of the first branch of the lateral plantar nerve[16]. Success rates of up to 90% have been reported in the literature[16,17] despite the risk of plantar fascia rupture, plantar nerve injury, lateral spine pain, high incidence of wound complications, and rehabilitation within four weeks to release the full load. In a study of 47 heels submitted to this procedure, only 48% were satisfied[18].

The plantar fascia is essential for effective propulsion during the gait cycle as it transmits the force from the calcaneal tendon to the forefoot at the end of the gait support phase. Therefore, surgical procedures for its release may compromise efficient propulsion[5].

There are several procedures for gastrocnemius lengthening. Baumann's procedure consists of intramuscular lengthening (resection) of the gastrocnemius muscles in the deep interval between the soleus and gastrocnemius muscles, releasing its deep aponeurosis[19]. Strayer's procedure[20] also showed a good correction[21]. It consists of release in its insertion close to the Achilles tendon and can be performed with an open or endoscopic approach, and the patient is immobilized with cast postoperatively. Open surgery may present an unsatisfactory cosmetic result with a risk of sural nerve injury and require an immobilized period and general or regional anesthesia[22].

Rush et al.[23], when evaluating the results of the medial gastrocnemius resection found complications in nine (6%) of 126 patients: six (4%) had healing problems; two (1.3%) wound dehiscence; two (1.3%) infection; three (2%) nerve problems, and one (0.67%) complex regional pain syndrome. None had calf weakness, claudication, gait disturbance, or persistent decrease in muscle strength. Similar results were found in Abbassian et al. study, where 16 of the 19 patients (84%) had full calf strength, assessed by the ability to complete the heel lift test consecutively 20 times, with simple support on the released side[5]. These data suggest that isolated medial gastrocnemius procedures maintain calf strength, unlike Achilles tendon stretching, resulting in weakness[5].

In PMGR, the incision is in the posterior region of the knee and is aligned with the Langer lines without risk of sural nerve injury[5]. No major complications were found, demonstrating that the method is safe and an acceptable lengthening alternative[5].

Maskill et al.[24] performed medial gastrocnemius resection for plantar fasciitis with good success rates. No sural nerve injury or wound problems were reported. Despite the short period of immobilization using pneumatic boot, 93% of patients would recommend surgery to a friend[24]. In the Abbassian et al.[5] series, 88% would recommend it to a friend, suggesting that PMGR has high satisfaction rates in treating plantar fasciitis, regardless of the lengthening level.

The gastrocnemius medial head inserts more proximal to the femur and has a much larger cross-sectional area[25]. Magnetic resonance imaging (MRI) has shown that the medial head presents more changes after exercise and may play a greater role in generating plantar flexion force[26]. It was found, intraoperatively, that the PMGR achieves a satisfactory correction of the contracture, and, therefore, the release of both heads is not necessary[5]. More than half of the patients

improved within two weeks after surgery, even presenting a mean of three years of symptoms[5].

The indications for PMGR are Silfverskiöld test positive, additional symptoms such as cramps and calf tension, and difficulty walking barefoot or with flat shoes, which will also be resolved after surgery[11].

Proximal medial gastrocnemius release was performed in 368 patients in a study where it was observed: four hematomas (two with spontaneous resolution and two were drained), two deep venous thromboses (both undergoing simultaneous correction of hallux valgus), no dysesthesia, scar with keloid and weakness. Ankle dorsiflexion with the knee extended was improved in all cases and normalized in 79%[15].

It is difficult to evaluate the influence of gastrocnemius release on the forefoot because simultaneous forefoot surgery is often performed. However, the proximal release may be sufficient to avoid foot surgery in some cases, such as correcting ankle instability, Achilles tendinopathy, plantar fasciitis, metatarsalgia, and rigid hallux[15].

Few surgeons routinely use proximal release. The most popular way for gastrocnemius lengthening is by Strayer's procedure[27].

Colombier[14] also presented similar results. A 95% improvement in ankle dorsiflexion was observed with the knee extended.

Proximal medial gastrocnemius release can be performed bilaterally. Generally, the gastrocnemius shortening occurs bilaterally, so the patient's complaints regarding low back pain, cramps, and difficulty walking without jumping should be considered if the release occurs unilaterally[15].

Reasons for medial gastrocnemius lengthening only:

- The gastrocnemius medial head is a strong tendon, while the lateral side has a thin aponeurosis[15]. Hamilton et al.[25] demonstrated that the tendinous fibers of the medial gastrocnemius are 2.4 times thicker than the lateral ones;
- Complications are rare, self-limited, and without consequences, such as lateral dysesthesia, healing, and postoperative pain;
- It is a minimally invasive surgery with a very short surgery time;
- It is as efficient as releasing both gastrocnemius heads[15]. It is technically easy and fast, with simple postoperative and immediate ambulation.
- Reasons to prefer proximal lengthening vs. distal lengthening:
- The distal section involves the gastrocnemius tendon and often the soleus aponeurosis, as the junction between these structures is wide and cannot always be found. Not being a pure gastrocnemius lengthening;
- The distal section interrupts muscle continuity and can cause weakness[21]. Allows the septum that divides the soleus to rupture secondarily. These problems justify the need for postoperative immobilization. Vulpius and Stoffel[28] recommend its section. Rabat[29] also recommends if seen endoscopically;
- The bilateral distal section is difficult[15];
- The scar in the open distal section is less aesthetic, the endoscopic section being preferred;
- Complications caused by a distal section are not negligible[23,30]. There are still indications for distal lengthening when immobilization is required due to a hindfoot osteotomy to avoid changing from prone to supine position between gastrocnemius lengthening and foot surgery and when the contracture involves both the gastrocnemius and soleus. The endoscopic section is efficient, safe, and non-invasive in these cases.

Gastrocnemius lengthening replaced multiple metatarsal osteotomies in cases of metatarsalgia favorably[15].

The plantar fascia thickness above 4 mm is considered pathological in imaging studies, such as ultrasound and MRI[31].

Ginés-Cespedosa et al.[32] evaluated plantar fascia thickness and clinical outcomes in 13 patients with PMGR, pre- and postoperatively, through MRI. The mean preoperative thickness was 6.59 mm and in the postoperative, 6.37 mm. The authors found no statistically significant differences. After one year, most patients obtained a clinical improvement in pain, quality of life, and function, with a satisfaction rate above 85%. A decrease in plantar fascia thickness measured by MRI after conservative treatment has been reported in acute case[33] and cases starting chronic symptoms[34,35].

The inflammatory changes initially present in the plantar fascia can be modified with conservative treatment, thus causing the reduction of its thickness. On the other hand, patients with chronic plantar fasciitis symptoms who do not respond to conservative treatment end up developing recalcitrant plantar fasciitis (RPF). In this, neovascularization and fibrosis cause degeneration of the fascia rather than chronic inflammation[36-38]. These changes can be considered irreversible. In these cases, the plantar fascia thickness measured by MRI cannot be modified by treatment[39].

Manzi et al. conducted a cadaveric study in 15 adults and performed PMGR followed by the additional release of the lateral gastrocnemius to assess dorsiflexion with flexed and extended knee. They concluded that PMGR effectively improved ankle dorsiflexion, while the additional lateral head release produced no significant change in ankle range of motion[40].

Gamba et al.[41] conducted a prospective randomized study in 36 patients with plantar fasciitis and compared PMGR with open plantar fasciotomy regarding pain, satisfaction, and quality of life. The analysis was performed on 21 patients submitted to fasciotomy and 16 to PMGR. Recovery was faster in the PMGR group. The authors concluded that both provide good results for plantar fasciitis. Neither was superior to the other regarding pain. They recommended PMGR as the first option in surgical management to avoid potential biomechanical complications related to open plantar fasciotomy.

Villanueva et al.[42] conducted a pilot study in 16 specimens to ensure the efficacy and safety of the ultrasound-guided

PMGR technique and subsequently performed in 12 patients (23 extremities), combined with other minimally invasive ultrasound-guided techniques, all performed under local anesthesia plus sedation. An effective release was obtained in all patients without damage to the saphenous vein, nerve, or hamstring tendons. Damage to the underlying muscle fibers was minimal. In the clinical series, ankle dorsiflexion increased by a mean of 12° without calf weakness. Pain and function improved in all patients at three months follow-up. No wound infections or complications were observed. All patients developed mild superficial bruising that resolved within 2–3 weeks. The authors concluded it was a safe technique and as effective as open procedures. The incision is smaller and more aesthetic; it is made under local anesthesia, without exsanguination, with fewer complications and morbidity, and in a shorter operative time. It can be performed bilaterally or in combination with other ultrasound-guided surgical techniques on an outpatient basis. The disadvantage is the steep learning curve[42].

Minimally invasive surgery is defined as surgery that requires a 1 mm incision, like the one left by a 16-gauge Abbocath needle (1.7 mm in diameter)[43,44].

Monteagudo et al.[45] conducted a prospective study comparing the results of partial proximal fasciotomy (PPF) with PMGR in treating plantar fasciitis. Thirty patients were evaluated for each procedure. PPF had satisfactory results in only 60% of patients; 45% would recommend the procedure, and 35% would operate on the contralateral limb, with a mean of ten weeks required to resume work and sports. In the PMGR group, satisfactory results, the recommendation of the procedure, and the operation of the other leg obtained 95%, returning to work and sports with a mean of three weeks.

Functional and pain scores were considerably better for the PMGR group with a single complication, calf hematoma, without needing treatment. No loss of calf strength was observed. In fasciotomy, complications included one case of plantar nerve neuropraxia, five painful scars, and one superficial infection with wound dehiscence. Partial proximal fasciotomy can alter the normal function of the plantar fascia, and the potential effects on foot and ankle biomechanics are unpredictable[45].

Proximal medial gastrocnemius release is a simple method, and the procedure is reliable in treating patients with fasciitis, as it presents lower morbidity and higher patient satisfaction, thus becoming the surgical procedure of choice for the authors[45]. Fasciotomy is restricted to rare cases of failure of PMGR[45].

A plantar fasciotomy (open or endoscopic) has the risk of side spine overload or a painful flat foot if > 50% of the fascia is divided[46].

Gamba et al.[47] had a satisfaction rate above 80%, with substantial pain relief in the first 2–3 months and good functional results. It has low complication rates, with more common calf hematoma and wound healing delay. The study also evaluates the PMGR as an outpatient procedure of short operative time, enabling the rapid return to recreational and work activities.

Conclusion

In recent years, isolated PMGR has been the preferred technique for most patients, according to the studies analyzed in this review.

Although it is safe, effective, low morbidity, performed under local anesthesia with sedation, and presents a rapid recovery, few studies with a high level of evidence demonstrate the procedure's applicability.

More large-scale randomized trials with prolonged follow-up are needed to verify the evidence and its long-term efficacy in plantar fasciitis.

Authors' contributions: Each author contributed individually and significantly to the development of this article: SDSP *(https://orcid.org/0000-0002-8677-3981) Interpreted the results of the study, participated in the review process; JMM *(https://orcid.org/0000-0001-6039-4599) Conceived and planned the activities that led to the study, participated in the review process; wrote this article; LRF *(https://orcid.org/0009-0004-8150-4418) Participated in the review process. All authors read and approved the final manuscript.*ORCID (Open Researcher and Contributor).

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Original Article

Are complications after repairing acute Achilles tendon ruptures related to the surgical approach or the patient's comorbidities?*

Ana Cecilia Parise[1], Nicolás Martin Molho[1], Melanie Naiman[1], Pablo Valenti[1], Virginia Maria Cafruni[1], Daniel Sebastián Villena[1], Facundo Bilbao[1], María Gala Santini Araujo[1], Leonardo Angel Conti[1], Guillermo Cardone[1], Pablo Sotelano[1], N. Marina Carrasco[1]

1. Hospital Italiano de Buenos Aires, Buenos Aires, Argentina.

Abstract

Objective: Analyze the postoperative complications after repairing acute Achilles tendon rupture and compare them according to the surgical approach (open surgery (OS) or minimally invasive surgery (MIS)) and the patient's comorbidities.

Methods: A retrospective analytical study including 154 consecutive patients with an acute Achilles tendon rupture submitted to surgery and divided into OS and MIS cohorts. The following relevant comorbidities were analyzed: obesity, diabetes mellitus, smoking, dyslipidemia, gout, chronic corticosteroid use, connective tissue pathologies, transplant history, cancer treatment patients, and postoperative complications.

Results: Seventy-eight patients (50.6%) were treated surgically with an OS technique and 76 (49.4%) with an MIS approach. Twenty patients (13%) had postoperative complications between the two cohorts (OS 11.5%; MIS 14.5%; p = 0.588). No statistically significant difference was found in the logistic regression of the risk of the surgical approaches and complications. Obesity had a significant statistical difference when complications and comorbidities were compared.

Conclusions: Patients with obesity have a higher risk of developing postoperative complications with both OS and MIS techniques. No relationship was found between the type of surgical approach and a higher percentage of postoperative complications in treating acute Achilles tendon rupture.

Levels of Evidence III; Therapeutic Studies; Retrospective Comparative Study.

Keywords: Achilles tendons; Rupture; Minimally invasive surgery; Comorbidities; Postoperative complications.

Introduction

Acute Achilles tendon ruptures are frequent in men between 35 and 60 years, especially in occasional athletes[1,2]. The surgical treatment could achieve a lower rate of re-rupture[3], better functional outcomes, and a shorter recovery time[1,2]. However, the choice of surgical approach is still controversial.

Different surgical techniques and approaches have shown efficacy in repairing the Achilles tendon. There is currently a trend in trauma surgery towards adopting minimally invasive approaches[4-6]. Some studies suggest tendon repair using minimally invasive surgery (MIS) as an advantage compared to open surgery (OS) due to the lower rate of infection[7-9]. Smaller incisions generate less damage to the soft tissues[10,11]. Sural nerve injury has been described in MIS techniques[5,11]. Among MIS, there are completely percutaneous approaches such as the one described by Ma and Griffith; this technique carries the risk of entrapment with the suture thread of the sural nerve[12]. Another MIS technique is the one described by Kupcha and Mackenzie[13], where a small incision is made at the level of the rupture and with instruments such as Foerster-type oval forceps progressed intra-peritendon, avoiding

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Correspondence: Ana Cecilia Parise. Potosí 4247, C1199ACK, Ciudad Autónoma de Buenos Aires, Argentina. **E-mail:** ana.parise@hospitalitaliano.org.ar. **Conflicts of interest:** none. **Source of funding:** none. **Date received:** May 10, 2023. **Date accepted:** June 12, 2023. **Online:** October 31, 2023.

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entrapment of the sural nerve and its consequences. Later, more sophisticated devices with nonabsorbable and locked sutures were developed, such as the ACHILLON® (Integra) and the PARS® system (Arthrex)[14]. Other MIS techniques do not address the source of rupture, such as the technique described by Dresden in the study by Joannas et al.[15]. On the other hand, authors who endorse OS maintain that directly visualizing the ends and their status usually gives the procedure more reliability and a low complication rate[5,15]. Several series compare different techniques, but there is still no consensus on the best approach[4,5,7,11].

Immunocompromise, venous insufficiency, peripheral vascular disease, diabetes mellitus (DM), tobacco use, and recent corticosteroid use can affect outcomes after surgery for acute Achilles rupture[16]. Obese patients have had more complications than non-obese patients in surgical treatment. Other studies have also described increased complications in patients with decreased albumin values, advanced patient age, chronic obstructive pulmonary disease (COPD), elevated creatinine values, alcohol and drug abuse, psychiatric illnesses (depression and psychosis), and active tobacco use[17].

The aim of the study is to analyze the postoperative complications after repairing acute Achilles tendon rupture and compare them according to the surgical approach (OS or MIS) and the patient's comorbidities.

Methods

A retrospective analytical study including consecutive patients with a complete acute Achilles tendon rupture between February 2011 and March 2020. A fellow and two advanced orthopedics resident doctors collected the electronic medical record (EMR) data after approval by the institutional ethics committee.

Adult patients presenting acute Achilles tendon rupture of total thickness at the central level (2 cm-6 cm)[18] of the insertion treated surgically within 21 days of the event were included. Patients with exposed Achilles tendon section, incomplete EMR, previous Achilles surgery and/or rupture, or who did not complete six months of follow-up were excluded from the study.

The demographic variables and all the comorbidities described in the EMR were studied and grouped as relevant comorbidities: obesity, DM, smoking, COPD, renal failure, dyslipidemia, gout, chronic corticosteroid use, connective tissue pathologies, history of transplant and patients undergoing cancer treatment.

The patients were divided into OS and MIS cohorts. The surgeons chose the surgical technique according to their preference during the pre-surgical consultation.

A postoperative complication is an eventuality that occurs in the expected course of recovery from a surgical procedure with a local or systemic response that can delay healing and put function or life at risk[8]. The local complications revealed were: wound dehiscence, superficial and deep infection, sural nerve injury, re-rupture, and hematoma. All systemic complications were relieved, including deep vein thrombosis (DVT) and pulmonary thromboembolism[4,7,19]. A superficial infection was categorized as an infection that did not extend beyond 2 cm from the outer edge of the surgical skin wound. It could be resolved with wound care and oral antibiotics. On the other hand, a deep infection was characterized by soft tissue involvement exceeding 2 cm, necessitating surgical debridement[20].

Surgical technique

All patients were operated on in ventral decubitus under regional blockade and monitored anesthetic care. The OS was performed through a longitudinal medial Achilles incision (10 cm-12 cm) with suture after tendon through direct vision.

The MIS technique was performed through a minor transverse or longitudinal incision, the ends of the tendons were visualized (2 cm-3 cm) at the level of the tendon hiatus. The proximal and distal ends were crossed inside the paratenon using three suture threads through healthy skin through a Foerster clamp (modified Kupcha technique) or with the PARS device (Arthrex®). The suture threads are extracted from both ends through the mini-approach and tied, returning tension to the injured tendon[13,14].

Both groups followed the same rehabilitation protocol: immobilization with an equinus cast for three weeks, with wound control in the first postoperative week. In the third week, the equinus cast was replaced with a removable boot with a 2 cm posterior enhancement removed 0.5 cm per week, with progressive partial weight bearing up to total weight. After three weeks, the patient progressed to athletic shoes with a heel cup. The patients underwent rehabilitation with kinesiology equipment.

Statistic analysis

Quantitative variables are presented as means with their standard deviation (SD) or median with the interquartile range (IQR) according to the distribution and categorical variables with absolute and relative frequency.

The chi-square test was used to identify differences in categorical variables. The Mann-Whitney test was used for continuous variables because it presented a non-normal distribution.

Univariate analysis was performed using logistic regression; the null odd ratios (ORs) are presented with their 95% confidence interval. The statistically significant value was set at < 0.05.

The STATA software (Stata Statistical Software: version 15, 2017. College Station, TX: StataCorp LLC) was used for statistical analysis.

Results

One hundred and seventy-nine patients were operated on during the study period, and 154 patients met the inclusion

criteria; 78 (50.6%) were treated surgically with an OS, and 76 (49.4%) with an MIS approach. The median follow-up time for the total sample was nine months (IQR: 7-19); for OS, nine months (IQR: 6-19) and for MIS, nine months (IQR: 7-19.5). Risk factors for rupture and the most relevant comorbidities were analyzed (Table 1). As an augmentation technique, a harpoon was used in 56 surgeries (36.4%), 27 (34.6%) in OS, and 29 (38.2%) in MIS.

Twenty patients (13%) had postoperative complications between the two cohorts (OS 11.5%; MIS 14.5%; p = 0.588). Nine patients (45%) required reoperation, six from OS and three from MIS (Table 2). No statistically significant difference was found in the logistic regression of the risk of the surgical approaches and complications (OS 11.5%, MIS 14.5%, p = 0.588). Previously, the different subgroups within the MIS technique (transversal Kupcha, longitudinal Kupcha, and longitudinal PARS) were compared, and no statistically significant differences were found. In the same way, the risk for harpoon placement and complications were analyzed, and no statistically significant differences were found.

When complications and comorbidities were compared, obesity was statistically significant, with a statistical trend for gout and DM (Table 3).

Table 1. Demographic data and comorbidities

	OS (78)	MIS (76)	Total (154)
Male sex, n, (%)	73 (93.59)	71 (93.4)	144 (93.5)
Age, median, (IQR), years	42.5 (37-53)	42 (33-57.5)	42 (36-56)
Comorbidities n, (%)	41 (52)	39 (51.3)	80 (51.95)
Hypothyroidism	1 (1.3)	3 (3.9)	4 (2.6)
Rheumatologic disease	0	1 (1.32)	1 (0.6)
Gout	2 (2.56)	2 (2.63)	4 (2.60)
Diabetes mellitus	3 (3.85)	2 (2.63)	5 (3.25)
Oncological	0	1 (1.33)	1 (0.6)
Transplant	1 (1.28)	0	1 (0.65)
Chronic renal insufficiency	0	0	0
Corticosteroid consumption	2 (2.56)	1 (1.32)	3 (1.95)
Smoking	7 (8.9)	18 (23.6)	25 (16.2)
Arterial hypertension	26 (33.3)	16 (21.05)	42 (27.2)
Dyslipidemia	11 (14.1)	9 (11.8)	20 (13)
Obesity	8 (10.6)	10 (13.1)	18 (11.7)
COPD	2 (2.56)	1 (1.3)	3 (1.9)

OS: Open surgery; MIS: Minimally invasive surgery; IQR: interquartile range; COPD: Chronic obstructive pulmonary disease.

Table 2. Postoperative complications

Complications	OS (78)	MIS (76)	Total
Re-rupture, n	3	5	8
Superficial infection, n	0	2	3
Deep infection, n	0	0	0
Dehiscence, n	2	2	4
Sural lesion, n	0	2	2
DVT, n	1	0	1
PE, n	1	0	1
Harpoon intolerance, n	2	0	2
Reoperations, n, (%)	6 (7.7)	3 (3.9)	9 (5.84)

OS: Open surgery; MIS: Minimally invasive surgery; DVT: Deep venous thrombosis; PE: Pulmonary Embolism.

Discussion

Several meta-analyses and randomized case-control studies have been published, seeking an answer, and some articles compared the most appropriate OS or MIS approach to surgically treating an acute Achilles tendon rupture. The trend in orthopedic surgery favors MIS approaches. Our study presents a comparative series of patients treated with OS and MIS and found no statistically significant difference in postoperative complications. Comparing our results with other published studies, similarities were observed with Hsu et al.[8], who recorded 10% complications in OS and 5% in MIS. Cretnik et al.[21] reported 12.4% and 4.5%, respectively. Open surgery should not be a protective factor for re-ruptures, as found in our patients who suffered a re-rupture in both groups but not statistically significant. A low rate of thromboembolic events was found (OS 1; MIS 0; p = 0.5). The only patient with thromboembolic complications reported had a favorable clinical course. The reported risk of developing pulmonary thromboembolism suggests postoperative thromboprophylaxis[22,23]. In our series, OS did not have a higher prevalence of infections and problems related to the wound, as published in other series[7-9]. These results may be associated with the homogenization of postoperative care in both techniques and the strict control of the soft tissues in the first postoperative weeks.

Burrus et al.[16] reported that obese patients had more wound, infection, and systemic complications than non-obese patients; however, they do not refer to the technique or approach used for surgical resolution. A statistically significant difference was found between patients with obesity and postoperative complications; we did not analyze them separately. Another study concludes that the values of albumin and the patient's age were related to wound complications, COPD with more systemic complications, and renal failure with all complications[24]. Preoperative albumin values were not evaluated, but no differences between chronic renal failure and COPD were found. Alcohol

Table 3. Logistic regression of risk and comorbidities

	OR (CI 95%)	p-value
Gout	7.33 (0.97-55.32)	0.053
Diabetes mellitus	4.85 (0.76-31.04)	0.095
Obesity	4.36 (1.41-13.42)	0.010

OR: Odds ratio; CI: Confidence interval.

and drug abuse, psychiatric illnesses (depression and psychosis), and obesity are related to a higher incidence of surgical site complications[17]. Stavenuiter et al.[25] have concluded that the factors associated with a higher risk of postoperative complications are the patient's advanced age and active tobacco use. In our series, no relationship between postoperative complications and the approach used was found[17,25]. Also, no association between smoking and patient age was found, although we analyzed them as older and younger than 40 years. On the other hand, Pean et al.[26] have not found statistically significant differences for any comorbidity with postoperative adverse events. A positive trend for DM and gout was found, although both were not statistically significant, probably due to our low sample. An exhaustive preoperative evaluation to select surgical treatment, considering each patient's comorbidities, could be a more effective way to reduce postoperative complications in acute Achilles tendon repair, regardless of the surgical technique used.

The limitations of our study are typical of a retrospective design. The publications that have analyzed comorbidities during the repair of acute Achilles ruptures have examined a high variability of factors. Increasing the variables analyzed in a retrospective study is a limitation of these designs; prospective studies should consider them more widely.

Conclusions

Patients with obesity have a higher risk of developing postoperative complications with both OS and MIS techniques. No relationship was found between the type of surgical approach and a higher percentage of postoperative complications in treating acute Achilles tendon rupture.

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Original Article

Flexor hallucis longus. A cadaveric study of its distal insertion

Felipe Chaparro Ravazzano[1], Cristián Ortiz Marteluna[1], Giovanni Carcuro Urresti[1], Ximena Ahumada[1], Manuel Pellegrini Pucci[1], Ana Ines Butteri[1]

1. Clínica Universidad de Los Andes, Santiago, Chile.

Abstract

Objective: Describe flexor hallucis longus (FHL) distal insertion.

Methods: Ten cadaver feet were dissected to evaluate FHL distal insertion, the width of insertion, and the distance between insertion borders and medial-lateral phalangeal borders.

Results: All specimens showed a lateral tendon fascicle inserted more lateral and distal than the main insertion. The mean lateral and medial insertion distance to the phalangeal border was 3 mm and 5.2 mm. The FHL long axis was 12.36% laterally deviated at the metatarsophalangeal (MTP) joint and 14.07% at the interphalangeal (IP) joint.

Conclusion: The FHL has a closer insertion to the lateral phalanx border, and its long-axis midpoint is laterally located in relation to the IP and MTP joint. The detailed knowledge of the FHL true anatomy. The discovery of a lateral deviated axis, a lateral fascicle, and a lateral footprint.

Level of Evidence V; Cadaveric Study.

Keywords: Hallux valgus; Cadaver; Foot.

Introduction

Hallux valgus (HV) deformity prevalence in the general population reaches 23% in adults and 35.7% in older adults[1,2]. Even though its high prevalence, its etiology has not been completely elucidated[3]. The first ray is an inherently unstable structure, which relies on a fine balance between its static and dynamic stabilizers to maintain its alignment[4]. Regarding dynamic stabilizers, the abductor hallucis longus strongly resists the valgus of the proximal phalanx, but it becomes dysfunctional as its medial and plantar attachment rotates inferiorly, showing histological and electromyographic changes probably due to the hallux deformity[5]. The adductor hallucis is attached to the plantar surface laterally, so it tends to pull the phalanx into pronation and tether its base[6]. Normal variations in the attachment of the abductor hallucis have been described but without any association with HV[7]. The adductor tendon might also have a role in HV, but it has not been proven. There is no evidence of shortening[8] or overactivity of this muscle in HV, although botulinum toxin injection has successfully treated it[9].

Multiple risk factors have been associated with HV, including muscle imbalance[5]. During HV progression, with the bowstring of the flexor hallucis longus (FHL), it is reasonable to think that the change at the moment arm of this structure can help HV evolution[10]. The anatomy and function of this muscle have been described, but there is still some missing information, especially regarding its distal insertion. The FHL arises from the inferior posterior surface of the fibula and lower part of the interosseous membrane and inserts into the plantar surface of the distal phalanx of the hallux. It primarily functions as a hallux flexor but also contributes to ankle supination and is a very weak ankle plantar flexor. Anatomical

Study performed at the Clínica Universidad de Los Andes, Santiago, Chile.

Correspondence: Felipe Chaparro Ravazzano. Av. La Plaza 2501. Las Condes, Santiago, Chile. **Email:** fchaparro@clinicauandes.cl. **Conflicts of interest**: none. **Source of funding:** none. **Date received:** March 8, 2023. **Date accepted:** May 25, 2023. **Online:** October 31, 2023.

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studies involving the FHL have focused on the relationship between the FHL and flexor digitorum longus[11], but, to our knowledge, there is no literature describing the detailed anatomy of the FHL distal footprint and its relationship with hallux osseous anatomy. Therefore, the purpose of this study is to go back to the anatomy basics and describe the details of the FHL distal insertion, as it is still unknown. In addition, analyze the spatial relationship of the FHL distal portion with the hallux osseous anatomy by assessing the FHL footprint in the distal phalanx and the position of FHL traction in both interphalangeal (IP) and metatarsophalangeal (MTP) joints. Our hypothesis is that the distal footprint in cadavers without hallux valgus deformity is in the osseous midline.

Methods

This investigation was approved by our ethical committee (CEC201968). Ten adult fresh frozen cadaveric feet amputated below the knee were used. Specimens were stored at -25 degrees Celsius and thawed at room temperature for 24 hours before testing. None of the dissected feet demonstrated evidence of previous foot or ankle surgeries or deformities.

One foot and ankle surgeon dissected the feet through a plantar approach. The skin was removed, progressing through muscular and fascial layers, exposing the FHL tendon and bony structures, leaving in situ ligamentous attachments (Figure 1). Two foot and ankle surgeons identified the distal footprint at the most distal point in the distal phalanx; the morphology was analyzed after 2D on-screen digitalization of the macroscopic images. All the measurements were done with a digital ruler. The width of the tendon insertion was measured on the widest portion from medial to lateral. The distance between the insertion borders of the FHL and medial-lateral phalangeal borders was also measured on the widest portion. The force vector of the FHL was simplified as a line centered on the midline longitudinal axis (Figure 2). The spatial relationship of the FHL with IP and MTP joints was measured by the position of the FHL long axis width midpoint in relation to the phalanges and metatarsal width 1 cm proximal to each joint, IP, and MTP (Figure 2) for standardization.

Results

In all the specimens examined in this study, the FHL distal footprint was easily recognized. Its mean insertion width on the distal phalanx was 12.1 mm (range 10 to 15) standard deviation (SD ± 1.5). All specimens showed a lateral tendon fascicle inserted more lateral and distal than the main tendon

Figure 1. Exposure of the flexor hallucis longus, phalanges, and plantar ligamentous through a plantar approach.

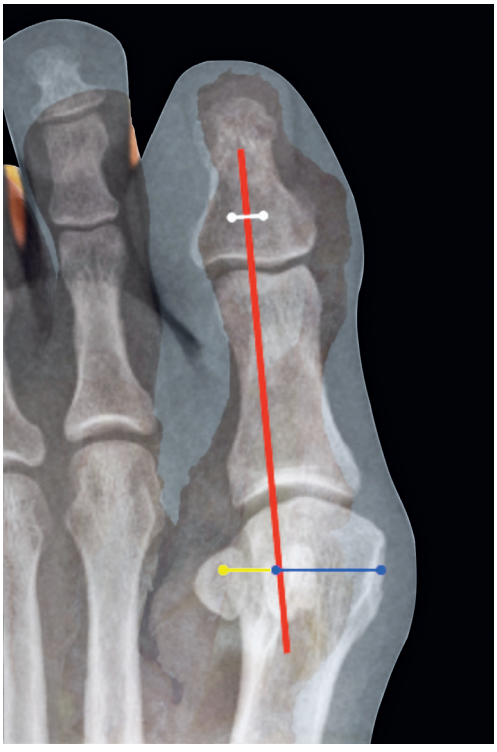

Figure 2. The force vector of the flexor hallucis longus (FHL) was simplified as a line centered on the longitudinal axis (vertical line). The spatial relationship of the FHL with interphalangeal and metatarsophalangeal joints was measured at 1 cm from the joint (horizontal lines).

insertion. The mean distance of insertion to the lateral border was 3 mm (range 3 to 4) (SD ± 0.7), while the mean distance of insertion to the medial border was 5.2 mm (range 4 to 7) (SD ± 1.1), showing a more lateral insertion on the distal phalanx (Figure 3). The FHL long axis line, 1 cm proximal to the IP joint, with a mean of 7 mm (range 6 to 9) (SD ± 1.05) away from the lateral border and 9.3 mm (range 9 to 10) (SD ± 1.2) from the medial border, showing a mean of 14.07% laterally deviation from the long osseous axis (Figure 4). The FHL long axis line, 1 cm proximal to the MTP joint, had a mean of 11.8 mm (range 10 to 13) (SD ± 0.92) away from the lateral border and 15.2 mm (range 15 to 17) (SD ± 1.6) from the medial border, showing a mean of 12.36% laterally deviation from the long osseous axis (Figure 5).

Discussion

In the HV pathogenesis, the extensor hallucis longus (EHL) tendon appears to bowstring laterally, increasing the valgus displacement and occasionally acting as a dorsiflexor of the proximal phalanx[8]. The FHL, like the EHL tendon, is known to participate by accentuating the deformity when it has already been developed due to the bowstring effect it generates on the hallux when it is in the valgus position[8]. The further the FHL is from the first metatarsal head, the weaker the moment arm of the flexor and the greater valgus of the hallux and varus of the first metatarsal head become[12]. The moment arm of the flexors moves from an inferior to a lateral direction

Figure 4. Flexor hallucis longus axis line showed a 14.07% lateral deviation on the interphalangeal joint. It was located 7 mm from the lateral border and 9.3 mm from the medial border.

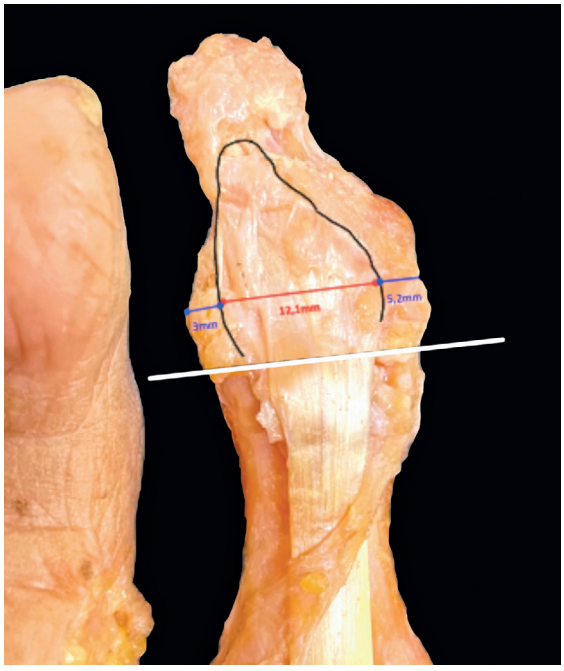

Figure 3. Boundary of the flexor hallucis longus footprint. The insertion width was 12.1 mm closer to the lateral border (3 mm) than the medial border (5.2 mm).

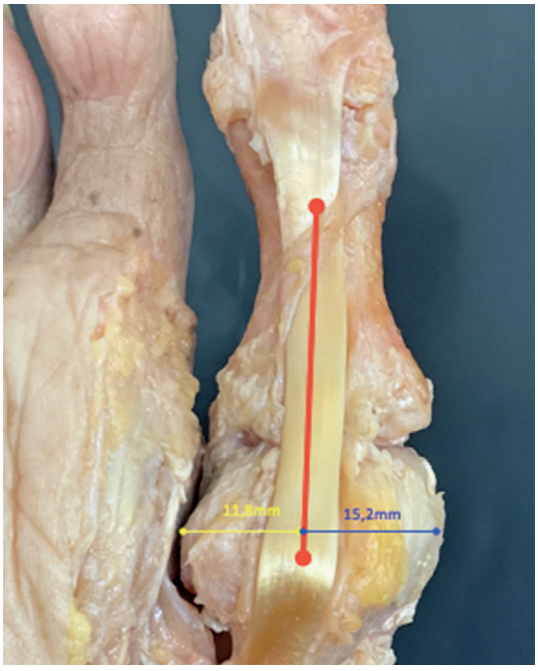

Figure 5. Flexor hallucis longus axis line showed a 12.36% lateral deviation on the metatarsophalangeal joint. It was located 11.8 mm from the lateral border and 15.2 mm from the medial border.

as the great toe pronates or moves into valgus[13]. To the authors' knowledge, this is the first study that analyzes FHL distal footprint and its axis of action related to hallux osseous anatomy. It was found a laterally deviated longitudinal axis of the tendon related to the osseous longitudinal axis that theoretically could create a laterally deviated force vector direction, which could act as a primary deforming force in some patients rather than a progressing one. Furthermore, the finding of a lateral insertion from the midline on the distal phalanx, and the discovery of this lateral FHL fascicle, present in all our specimens, could accentuate the action of a laterally deviated FHL force vector, adding more risk factors to patients that are predisposed to develop HV. Unfortunately, none of these specimens had HV deformity. It would be interesting to analyze the FHL distal insertion in cadavers with HV as a future line of research.

Conclusion

There is no current literature describing the distal anatomy of the FHL tendon. It was found that the FHL main axis slightly laterally deviates from the midline in relation to the osseous longitudinal axis. In addition, the FHL insertion footprint is also laterally deviated from the midline at the distal phalanx and has a distal fascicle inserted more distal and lateral than the FHL main footprint. All these three conditions create a laterally deviated force vector over the hallux that, in some patients, could be involved in the pathogenesis of HV.

Authors' contributions: Each author contributed individually and significantly to the development of this article: FCR *(https://orcid.org/0000-0002-3524-0624). Performed the dissections, data collection and approved the final version; COM *(https://orcid.org/0000-0003-2574-9010) and, GCU *(https://orcid.org/0000-0002-1993-6250) and, MPP *(https://orcid.org/0000-0002-2820-5337) Conceived and planned the activities that led to the study, approved the final version; XA *(https://orcid.org/0000-0002-0908-9908) Formatting of the article, bibliographic review, approved the final version; AIB *(https://orcid.org/0000-0003-4898-4259) Performed the dissections, data collection and approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

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Original Article

Patients submitted to Morton neuroma's neurectomy for plantar digital nerve through plantar approach: retrospective clinical evaluation of surgical results

Lucas Pereira de Sá[1], Lerud Frosi Nunes[1], Ricardo Borges Ramalho[1], Vinicius Andretti Zeferino[1], Bernardo Garcia Barroso[1], Jorge Luiz Kriger[1] (*In memoriam*)

1. Instituto de Ortopedia e Traumatologia, Vitória Apart Hospital – VAH, Serra, ES, Brazil.

Abstract

Objectives: Evaluate postoperative clinical outcomes of patients submitted to neurectomy to treat plantar digital nerve neuroma through plantar approach with a minimum of 12 months postoperative.

Methods: Patients submitted to neurectomy through plantar approach between 2011 and 2020 were evaluated. Twenty-eight patients were included, and 29 feet were operated on, totaling 35 resected neuromas. The medical records were evaluated, and the participants answered a form containing questions about the parameters of the Clinical Evaluation for Interdigital Neuroma and classified according to a visual analog pain scale.

Results: A predominance of females (85.71%) was observed, with a mean age of 51.55 at the surgery date. The left side was predominant (62.06%). The most affected intermetatarsal space was the third (77.14%). Clinical evolution was "excellent" (58.62%), "good" (13.79%), "fair" (20.68%), and "poor" (6.89%). A mean of 1.79 corresponding to "mild" was demonstrated.

Conclusion: The patients presented "good" clinical evolution, low pain level, and high patient satisfaction rate after a mean of 44.79 months after surgery.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Foot diseases; Metatarsalgia; Morton neuroma; Pain.

Introduction

Plantar digital nerve neuroma (Morton's neuroma) is an injury to the peripheral nervous system, representing one of the most frequent causes of metatarsalgia[1]. It was first mentioned in literature by Giannini in 1835, described by Durlacher in 1845, and disseminated by Thomas George Morton in 1876 apud Amaral Neto[2].

Morton's neuroma is a benign fibrous lesion that affects the tissue surrounding the common digital plantar nerve at the site where the branches of the medial and lateral plantar nerves anastomose. This anastomosis is believed to predispose to the neuroma development[3]. The condition is characterized by pain and burning in the corresponding interdigital space, exacerbated by constrictive walking and footwear. A mass in the intermetatarsal space can often be palpated. Lateral compression may be accompanied by a painful click, known as Mulder's sign. The etiology of this condition is still uncertain[1].

The group most affected by this pathology are middle-aged women due to the recurrent use of narrow, high-heeled shoes, while men tend to wear wider, shallower shoes. Such women's shoes compress the bone, ligament, muscle, and nerve structures of the forefoot and displace the body weight support axis to it, increasing pressure and causing pain and inflammation[4].

Study performed at the Instituto de Ortopedia e Traumatologia, Vitória Apart Hospital – VAH, Serra, ES, Brazil.

Corresponding author: Bernardo Garcia Barroso. Rodovia BR-101 Norte Km 2,38, s/n, Boa Vista II, 29161-001, Serra, ES, Brazil. **E-mail:** bernardobarroso@yahoo.com.br **Conflicts of interest**: none. **Source of funding:** none. **Date received:** August 31, 2023. **Date accepted:** October 16, 2023. **Online:** October 31, 2023.

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The diagnosis of Morton's neuroma is essentially clinical, based on detailed anamnesis and complete physical examination[2]. Several studies have shown that clinical examination is highly sensitive and specific. The four clinical signs most frequently associated with neuroma are painful intermetatarsal space on palpation, Mulder's sign with an audible click, painful plantar percussion, and sensory deficit in the tip toes[5]. Magnetic resonance imaging (MRI) and ultrasound (US) are helpful to exclude other causes of metatarsalgia and in cases of suspicion of multiple lesions or involvement of multiple interdigital spaces[2,5].

Metatarsalgia treatment due to Morton's neuroma is based on conservative and surgical treatments. As the surgical procedure of choice, neurectomy consists of resectioning the interdigital nerve approximately 3 cm proximal to the deep transverse metatarsal ligament[2].

The objective of this study is to evaluate postoperative clinical outcomes of patients submitted to neurectomy to treat plantar digital nerve neuroma through plantar approach with a minimum of 12 months postoperative.

Methods

This retrospective case series was performed at Vitória Apart Hospital in Serra, Espirito Santo, Brazil. The study was approved by the institutional review board under the number 13432519.2.0000.5071.

The information necessary for the study was obtained from the hospital's database, using as reference for patient location the procedures ID number for neurolysis of compressive syndromes and/or multiple microneurolysis between December 2011 and February 2020.

Inclusion criteria were a minimum 12 months follow-up, an attempt at conservative treatment for a minimum of 12 months, positive Mulder's sign, clinical documentation with confirmed neuroma through MRI, an informed consent form signed, and patients over 18 years on the interview.

Patients with other pathologies in the affected foot, submitted to another type of procedure, and unable to walk for other reasons or without telephone contact were excluded from the study.

Patients operated through the curvilinear transverse plantar approach in the load-free zone of the affected space (Figure 1) were evaluated, providing dissection, isolation, and resection of the neuroma (Figure 2). The neurectomy was performed with the widest possible margin by a single surgeon. The load was released on the first postoperative day using a long Baruk sandal (CINIFLEX®, Concórdia, SC, Brazil). Stitches were removed on the fifteenth postoperative day.

The objectives of the study were explained and clarified by reading the informed consent form. If the participant requested it, a copy would be emailed or mailed. Those who agreed to participate answered a form containing questions about the parameters of the Clinical Evaluation for Interdigital Neuroma[6] and were classified according to a visual analog pain scale (VAS), which classifies pain from 0 (no pain) to 10

Figure 1. A curvilinear, transverse incision in the load-free zone.

Figure 2. Isolation of Morton's neuroma in the transverse plantar approach.

(worst imaginable pain) (Figure 3), each question was read and explained by the researcher.

Table 1 and Figure 3 illustrate the questionnaires used. The results of surgical treatment were classified in the clinical evaluation score as follows: "poor" (0–49), "fair" (50–59), "good" (60–69) and "excellent" (70–80)[6].

The collected data were tabulated on Excel® software (Microsoft Corporation, Redmond, Washington, USA) and subjected to simple descriptive statistical analysis.

Results

From December 2011 to February 2020, 31 patients underwent a surgical procedure to remove Morton's neuroma. Three patients were excluded from the sample due to the exclusion criteria or because contact via telephone was not possible.

The sample consisted of 28 patients, one submitted to bilateral surgery, resulting in 29 operated feet. In addition, six patients had two neuromas on the same foot, totaling 35 resected neuromas. None of the patients had complications such as surgical wounds (infection, keloid, sensitive scar, and complex regional pain syndrome); however, some had persistent pain and paresthesias.

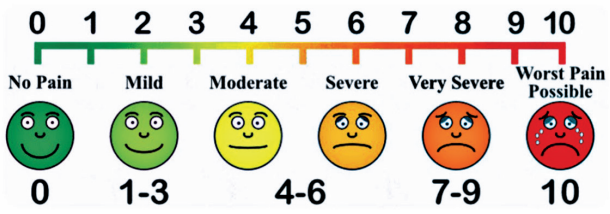

Figure 3. Visual analog scale (VAS).

Table 1. Interdigital neuroma clinical evaluation score

Parameter	Score
Pain	
None	20
Mild	10
Severe	0
Maximum walking distance	
No limitation > 6 blocks	20
Some limitation 2–6 blocks	10
Severe limitation < 2 blocks	0
Sensibility	
Normal	20
Numbness	10
Dysesthesia	0
Shoes	
Conventional	20
Comfortable	10
Difficulty with any shoes	0
"Poor" (0–49)/"Fair" (50–59)/ "Good" (60–69)/"Excellent" (70–80)	

Source: Giannini S, Bacchini P, Ceccarelli F, Vannini F. Interdigital neuroma: clinical examination and histopathologic results in 63 cases treated with excision. Foot Ankle Int. 2004;25(2):79-84

The results can be seen in Table 2. Twenty-four female and four male patients were evaluated, ranging from 32 to 64 years (mean 51.55, standard deviation (SD) 8.92) at the time of surgery. A predominance of females was observed, corresponding to 85.71% of the sample.

As for the affected side, the left side was predominant (18 feet, 62.06%) compared to the right (11 feet, 37.93%). The most affected intermetatarsal space was the third (77.14%), followed by the second (22.85%). The sizes of the resected neuromas measured by MRI are also shown in Table 2, but some records did not contain this information.

The mean follow-up was 44.79 months (SD 36.45), with a minimum of 12 months and a maximum of 100 months during research data collection.

Regarding the clinical evolution, the results showed that 17 (58.62%) feet presented an "excellent" result, 4 (13.79%) a "good" result, 6 (20.68%) a "fair" result, and 2 (6.89%) a "poor" result. The mean score was 64.13 points (SD 13.23), corresponding to a "good" classification.

Regarding the type of footwear currently used, 16 patients (55.17%) answered that they use any footwear, 13 patients (44.82%) need more comfortable footwear, and none reported difficulty with any footwear.

When asked about sensitivity, 13 patients (44.82%) reported paresthesias and 16 (55.17%) reported normal sensitivity. None had dysesthesia.

Regarding the pain, according to (VAS) scale, a mean value of 1.79 (SD 2.52) ranging from 0 to 8 was demonstrated, corresponding to "mild" pain.

Finally, regarding possible late deterioration of the clinical results obtained, the statistical analysis showed the following results: eight patients (28%) considered the results poor or fair, of these patients using our mean follow-up of the study as a cutoff point, four patients (50%) had ≥ 44 months of surgical treatment. Regarding the clinical deterioration related to pain, 13 patients (46%) evolved with some degree of postoperative pain, of these, only five patients (38%) had ≥ 44 months of surgical treatment.

Discussion

The objective of this study was to evaluate the clinical results of neurectomy and demonstrate the effectiveness through the plantar approach.

It is known that the golden standard of Morton's neuroma treatment is essentially surgical, with neurectomy being the procedure of choice[7]. Valisena et al.[8] recommend starting with conservative treatment and local infiltration, complementing with surgery only secondarily, and employing MRI to locate and measure the neuroma. According to Di

Table 2. Sample data

N	Age (Years)	Sex	Side	IMS**	Size (cm)	Postop (Months)	Score	Pain
1	32	F	L	2º	2.5	25	50	4
2	60	M	L	3º	0.7	100	80	0
3	60	F	L	3º	N***	98	80	0
4	50	F	R	3º	1	89	50	1
5	52	F	L	3º	1.3	81	60	0
6	58	F	L	3º	N***	79	70	0
7	44	F	L	2º + 3º	0.7 + 0.6	44	40	4
8	34	F	R	3º	0.7	44	70	0
9	56	F	L	3º	N***	44	80	0
10	46	F	L	3º	0.5	41	30	8
11	50	F	R	3º	N***	37	70	1
12	37	F	R	3º	0.6	32	70	0
13	53	F	R	2º + 3º	1.2 + 0.5	27	70	0
14	58	F	R	2º + 3º	0.5 + 0.7	20	60	0
15	36	M	L	3º	1.2	19	70	0
16	66	F	L	3º	0.7	20	60	7
17	54	F	R	2º + 3º	0.4 + 0.4	19	60	3
18	58	F	L	3º	1.1	17	80	0
19	56	F	R	2º + 3º	0.5 + 0.8	15	70	4
20	59	M	R	2º + 3º	0.7 + 0.6	56	70	0
21	59	F	L	3º	1.4	60	80	0
22	48	F	L	3º	N***	53	80	0
23	51	F	L	3º	1	55	70	0
24	50	F	R	3º	1.4	72	50	5
25	51	F	L	3º	2.2	65	50	5
26	40	F	L	3º	0.5	31	70	0
27	55	F	L	2º	0.8	30	70	0
28	58	F	L	3º	1.3	14	50	5
29	64	M	R	3º	0.4	12	50	5
Mean	51.55	24F/4M	11R/18L	8(2º)/27(3º)	-	44.79	64.13	1.79
SD	8.92	-	-	-	-	36.45	13.23	2.52

*Postop:Postoperative; **IMS: Intermetatarsal space; ***N: Not informed on magnetic resonance imaging; SD: Standard deviation.

Caprio et al.[9], MRI demonstrates 68% specificity and 93% sensitivity, while Mulder's test has 94%–98% sensitivity. Radiography is used to exclude other pathologies.

The mean age in our study was 51.55 years on the surgery date, and 85.71% were female, data similar to Bucknall et al.[1]. The incidence is approximately ten times higher in women than in men. The pathology typically begins between 45 and 50 years[2].

In our case series, the lesion was found in the third intermetatarsal space (77.14%) and in the second (22.85%), data compatible with Pace et al.[3], who evaluated 78 patients (82 feet), showing the lesion in the third space (53%) and in the second (25%). Higher mobility in the fourth metatarsal in relation to the third favors the microtraumas, which may be involved in the neuroma's pathogenesis[2].

The clinical evolution after a mean of 44.79 months was "excellent" in 58.62% (17/29), "good" in 13.79% (4/29), "fair" in 20.68% (6/29), and "poor" in 6.89% (2/29). Similar results were observed by Amaral et al.[2], who evaluated 25 patients, eight submitted to bilateral surgery, totaling 33 operated feet. In their study, 48.48% (n = 16) was "excellent", 24.24% (n = 8) was "good", 18.18% (n = 6) was "fair", and 9.09% (n = 3) was "poor", resulting in a mean of "good" result.

Barbosa et al.[7] included 19 patients with Morton's neuroma and, after a mean of nine months, showed that 89.5% of the patients were satisfied with the treatment.

Regarding footwear currently used, 16 patients (55.17%) answered that they use any footwear without any difficulty, while 13 patients (44.82%) need more comfortable footwear. No patient reported having difficulty even with comfortable

shoes. In the study by Amaral et al.[2], on the other hand, 16 patients (48.48%) wore any footwear, 17 patients (52.52%) wore only more comfortable footwear, and no patient reported difficulty and intolerance to any footwear, a result lower than that observed in our sample.

Di Caprio et al.[9] reported sensitivity or numbness reduction in the area innervated by the resected nerve in 72% of the feet, while only 44.82% of the feet in our sample evolved with numbness.

Finally, regarding the pain according to the (VAS) scale, a mean of 1.79 was observed, higher than the mean of 2.09 observed by Amaral et al.[2]

According to Valisena et al.[8], surgical treatment has the best results. In our study, corroborating with Nery et al.[4] and Akermark et al.[10], we believe the transverse plantar approach anterior to the loading zone is a safe access, allowing a better anatomical visualization than the dorsal approach for complete resection and making it possible to explore other intermetatarsal spaces in case of more than one neuroma.

Di Caprio et al.[9] reported in their study that postoperative complications such as surgical wound infection, hematoma, and healing problems are significantly higher in the plantar approach, but in our study, the main complaint was paresthesia (44.82%), a complaint more associated with the dorsal approach than the plantar according to Akermark et al.[10] (53% vs. 73%).

Regarding possible late deterioration of the clinical results obtained, the statistical analysis showed the following results: eight patients (28%) considered the results poor or fair, of these patients using our mean follow-up of the study as a cutoff point, four patients (50%) had ≥ 44 months of surgical treatment. Regarding the clinical deterioration related to pain, 13 patients (46%) evolved with some degree of postoperative pain, of these, only five patients (38%) had ≥ 44 months of surgical treatment. Corroborating with what is presented by Reichert et al.[11] that the result does not change in the postoperative, and still disagrees with Lee et al.[12], who state that the long-term results of Morton's neuroma neurectomy are slightly worse than the short and mid-term results.

Conclusion

Plantar neuroma neurectomy, when well indicated and technically well performed, presents "good" clinical evolution, low pain level, and high patient satisfaction rate after a mean of 44.79 months after surgery.

We believe the transverse plantar approach anterior to the loading zone is a safe access, allowing a better anatomical visualization than the dorsal approach for complete resection and making it possible to explore other intermetatarsal spaces in case of more than one neuroma.

It is extremely important that the surgeon has a good doctor-patient rapport and clearly explains that despite the good results of surgical treatment, situations such as maintenance of mild pain, a certain degree of anesthesia/dysesthesia, and difficulty in using certain shoes may remain even after surgical treatment without complications; in relevant percentages as presented in this study.

However, it is worth mentioning that 100% of the patients noticed an improvement in the clinical condition compared to the preoperative period, denoting that, with some reservations, it is still a treatment with good results remaining in the long term.

Authors' contributions: Each author contributed individually and significantly to the development of this article: LPS *(https://orcid.org/0000-0003-4274-6137), and VAZ *(https://orcid.org/0000-0001-9703-6752), and LFN *(https://orcid.org/0000-0003-2822-5976), and RBR *(https://orcid.org/0000-0002-0893-7872) Data collection, wrote the article; BGB *(https://orcid.org/0000-0002-8447-7660), and JLK *(https://orcid.org/0000-0001-7369-1525) Approved the final version. All authors read and approved the final manuscript.*ORCID (Open Researcher and Contributor).

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Case Report

Bipartite medial cuneiform: a potential cause of midfoot pain - case report

Thales Augusto de Santa Helena Ilha[1], Jose Antonio Veiga Sanhudo[1], Marina Pires Veiga Sanhudo[2], Maria Eduarda Parisotto Wisintainer[2]

1. Hospital Moinhos de Vento, Porto Alegre, RS, Brazil.
2. Medicine departament of Pontifícia Universidade Catolica do Rio Grande do Sul, Porto Alegre, RS, Brazil.

Abstract

Bipartite medial cuneiform is a rare variant of the tarsal bones. The condition can be a potential source for non-traumatic midfoot pain and a possible misdiagnosis cause of several foot disorders, such as the anterior and posterior tibialis tendon disorder. We present the case of a patient with midfoot pain with signs and symptoms suggestive of tibialis anterior tendinopathy. Imaging tests, however, elucidated a bipartite medial cuneiform. The conservative treatment using a removable boot for six weeks effectively relieved symptoms, temporarily promoting pain and limp-free gait, but symptoms relapsed were observed at the last visit.

Level of Evidence V; Case Report; Expert Opinion.

Keywords: Tarsal bones; Magnetic resonance imaging; Conservative treatment.

Introduction

Pain at the dorsomedial aspect of the foot is a common cause of medical appointments, and several diagnosis possibilities exist. Painful dorsiflexion of the ankle, swelling, and tenderness at the tendon's insertion site are characteristics of many common foot disorders, such as tibialis anterior tendinopathy[1]. On the other hand, bipartite medial cuneiform is a rare tarsal developmental variant first described in 1932 by Barclay[2]. The condition can be a potential source for non-traumatic midfoot pain and a possible misdiagnosis cause[3,4].

We present a case of a 30-year-old man with bilateral bipartite medial cuneiform, symptomatic only on the right foot. The patient complained of non-traumatic midfoot pain simulating insertional tibialis anterior tendinopathy, a much more common condition. This case report illustrates a bipartite medial cuneiform condition, a rare anatomic variant that could mimic midfoot tendinopathy, and alerts for this possibility when investigating midfoot pain.

Case description

This study was approved by the Institutional Review Board under the number 66349622.9.0000.5330, and the patient signed the informed consent form.

A 30-year-old man presented at our hospital reporting pain in the right midfoot without a history of trauma. Physical examination showed mild cavus varus feet and pain on palpation on the dorso-medial region of the midfoot along the insertion of the anterior tibial tendon and pain with resisted ankle dorsiflexion, typical findings of insertional tendinopathy. The neurovascular status of both feet was normal. (Figure 1). Due to the painful and limping gait, immobilization with a removable boot was prescribed, and radiographs and magnetic resonance imaging (MRI) were requested.

Although difficult to visualize on radiographs, the image (Figure 2) led to suspicion of medial bipartite cuneiform, later confirmed by MRI (Figure 3). The MRI revealed an important signal change in the synchondrosis area. A computed

Study performed at the Hospital Moinhos de Vento, Porto Alegre, RS, Brazil.

Correspondence: Thales Augusto de Santa Helena Ilha. Rua Riveira 520, 401, Petrópolis, 90670-160, Porto Alegre, RS, Brazil, **E-mail:** drthalesilha@gmail.com.
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Figure 1. Clinical aspect at the first evaluation. Anterior (A) and posterior (B) foot view. After two weeks, the patient returned to the hospital with the exams.

Figure 2. Foot anteroposterior (A), oblique (B), and lateral (C) radiographs. Note that the overlapping images on the medial cuneiform make radiographic analysis difficult.

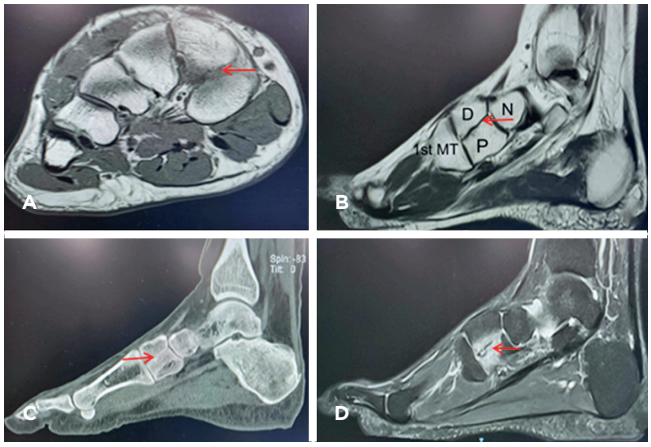

Figure 3. Axial (A) and sagittal (B) T1 MRI images and CT (C) and T2 (D) MRI images of bipartite medial cuneiform (red arrow). Sagittal T1 (B) depicting the dorsal (D) and plantar (P) components articulating with the first metatarsal (1st MT) and navicular (N).

tomography (CT) scan was requested to understand the bone structure better, showing incomplete bipartition of the medial cuneiform (Figure 3).

There was no damage to other musculotendinous and bone structures or ligaments, and the tibialis anterior tendon was normal. The navicular-cuneiform and cuneo metatarsal joint of the first ray showed a preserved cartilage thickness with no joint effusion.

The conservative treatment using a removable boot for six weeks effectively relieved symptoms, temporarily promoting pain and limp-free gait, but symptoms relapsed were observed at the last visit.

Discussion

Bipartition of the medial cuneiform is a rare segmentation anomaly. Although uncommon, the prevalence ranges from 0.1% to 7% and is considered the most recognized anatomic variant of cuneiform bones[5].

The bipartite medial cuneiform is usually asymptomatic, but the disorder can become painful due to the micro-mobility and instability in the fibrocartilaginous joint between the dorsal and plantar segments. The false joint between the segments is usually bridged by a cartilaginous synchondrosis, fibrous syndesmosis, or a combination of both[5]. Due to the fibrocartilaginous union, instability may precipitate a stress reaction and/or degeneration, sometimes resulting in pain.

The pain is located in the medial cuneiform and worsens with mobilization of the first ray[5,6]. Patients with tibialis anterior tendinopathy often demonstrate pain in the same region, but the pain is usually worse with active mobilization, especially resisted ankle dorsiflexion. Once the bipartite medial cuneiform is sick, it can also present pain during resisted ankle dorsiflexion, as seen in our patient, and this similarity in the physical examination can lead to a misdiagnosis.

Several diagnostics methods can be used to diagnose bipartite medial cuneiform. However, in our study, it was not easy to observe in the radiographs. The overlapping images make radiographic analysis difficult. The best view to detect this anatomic variant is the 30° external oblique view of the foot[5]. Computed tomography and MRI show bipartite medial cuneiform.

It is important to differentiate bipartite medial cuneiform from an isolated fracture of the medial cuneiform, which represents 1.7% of all tarsal fractures[5]. There is a history of trauma and irregular bone contours in acute fractures with sharp margins. On the other hand, the bipartite medial cuneiform is well-corticated with smooth bone contours.

Given the lack of literature available, there is no consensus on the optimal treatment plan. Our patient improved with conservative treatment initially, but symptoms relapsed, and surgical treatment might be necessary. Steen et al.[7] showed a series of five cases treated successfully with conservative and surgical treatment. Four cases have been treated with arthrodesis and one with immobilization and injection therapy. Eves et al.[8] report the case of an 11-year-old soccer player boy with a bipartite medial cuneiform. The injury was

treated nonoperatively with a non-weight-bearing cast and pneumatic walker immobilization, with successful resolution of his symptoms and a return to sports activity four months after the injury.

Bipartite medial cuneiform is a rare cause of midfoot pain and presents a similarity of findings with a much more common anterior tibialis tendinopathy. This case report alerts us to this diagnosis and how challenging its treatment is.

Author' contributions: Each author contributed individually and significantly to the development of this article: TASHI *(https://orcid.org/0000-0001-6107-6808) and, JAVS *(https://orcid.org/0000-0002-6321-9566) Conceived and planned the activities that led to the study, wrote the paper, participated in the reviewing process, approved the final version; interpreted the results of the study, participated in the reviewing process; MPVS *(https://orcid.org/0000-0002-0177-8338) and MEPW *(https://orcid.org/0000-0003-3518-3719) Participated in the reviewing process, approved the final version. The author read and approved the final manuscript.*ORCID (Open Researcher and Contributor ID).

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Case Report

Chronic instability in a malformed tibiofibular syndesmosis associated with osteochondral lesion of the talus: a case report

Danilo Ryuko Cândido Nishikawa[1,2], Pedro Bragato Romanholi[1], Tânia Szejnfeld Mann[1], Guilherme Honda Saito[3], Fernando Aires Duarte[2], Marcelo Pires Prado[4]

1. Department of Orthopaedic Surgery, Hospital Alemão Oswaldo Cruz, São Paulo, SP, Brazil.
2. Department of Orthopaedic Surgery, Clínica Care Club, São Paulo, SP, Brazil.
3. Department of Orthopaedic Surgery, Hospital Sírio-Libanês, São Paulo, SP, Brazil.
4. Department of Orthopaedic Surgery, Hospital Israelita Albert Einstein, São Paulo, SP, Brazil.

Abstract

Surgical treatment of tibiofibular syndesmosis (TFS) with chronic instability aims to obtain a solid and stable joint to avoid ankle arthritis. Osteochondral lesions of the talus (OLT) may be associated in up to 24% of cases and must be treated concomitantly. We present a 27-year-old male patient with chronic ankle pain and a history of recurrent sprains since childhood. Imaging exams showed malformation of TFS associated with an OLT. He was submitted to surgical treatment with open repair, TFS fixation with suture-button, and osteochondroplasty of the OLT with collagen membrane through arthroscopy. At 13 months follow-up, he was asymptomatic and fully active.

Level of Evidence V; Case Report; Expert Opinion.

Keywords: Tibiofibular ankle syndesmosis; Joint instability; Osteochondral lesion.

Introduction

Tibiofibular syndesmosis (TFS) is often caused by a combination of external rotation and foot pronation. If left untreated, TFS can evolve into joint instability, causing pain and functional limitation[1]. The diagnosis of TFS instability is not always clear, and it is not uncommon to have a patient with chronic (> three months) injury in the first appointment[2].

Tibiofibular syndesmosis with chronic instability is better addressed with surgical treatment to avoid ankle arthritis. Surgical techniques include procedures that preserve the joint, in which the ligaments are repaired or reconstructed with tendon grafts, and fusion[2]. Arthrodesis is usually indicated in secondary osteoarthritis of the TFS[3].

Osteochondral lesions of the talus (OLT) are common in chronic TFS lesions and must be treated concomitantly[4]. The procedure is decided according to the lesion size and can be performed open or arthroscopically. Lesions smaller than 1.5 cm^2 in diameter are treated with debridement and drilling. When larger than 1.5 cm^2, the options are the osteochondral autograft transfer system (OATS) or collagen membrane with cancellous bone graft[5].

The aim of this study is to report the clinical and radiological results of a patient submitted to surgical treatment for chronic instability in a malformed TFS associated with OLT.

Case description

This study was approved by the Institutional Review Board, and the patient signed the informed consent form.

A 27-year-old male patient with a body mass index of 25 had chronic pain in the right ankle for the last two years, limiting

Study performed at the Department of Orthopaedic Surgery, Hospital Alemão Oswaldo Cruz, São Paulo, SP, Brazil.

Correspondence: Danilo Ryuko Cândido Nishikawa. Department of Orthopaedic Surgery, Hospital Alemão Oswaldo Cruz. 94, São Joaquim street, Liberdade, 01508-000, São Paulo, SP, Brazil. **E-mail:** dryuko@gmail.com. **Conflicts of interest:** none. **Source of funding:** none. **Date received:** May 16, 2023. **Date accepted:** September 26, 2023. **Online:** October 30, 2023.

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his sports practice (soccer and gym). He reported recurrent sprains since childhood. On physical examination, there was pain on palpation and stress maneuvers in the TFS (external rotation and posterior drawer) and pain in the anteromedial region of the ankle. He had a slightly asymmetrical foot shape, the right foot in mild planus valgus and the left a subtle cavus. Plain radiographs, magnetic resonance imaging (MRI), and computed tomography (CT) scans were requested. In the radiographs, we evaluated the anatomy of the feet and fibula with angular and length measurements. The right foot had a Meary angle of -8 degrees, and the left had an angle of 12 degrees. The right lateral malleolus presented altered anatomy with a different width and shape, but its length was practically equivalent to the contralateral side (Figure 1). On MRI, scar tissue in the TFS and an osteochondral lesion in the medial talar dome measuring 16 x 7 x 6 mm were evidenced (Figure 2). A bilateral comparative CT scan of the ankle was taken to evaluate TFS malformation, focusing on the morphology of the syndesmotic notch and fibular shape (Figure 3). The initial treatment consisted of physiotherapy, avoiding the impact on physical activities. No pain relief after six months was observed, and surgical treatment was indicated.

To perform the surgery, the patient received spinal anesthesia and was in a supine position with a cushion under the ipsilateral hip. A pneumatic thigh tourniquet was inflated to 300mmhg pressure. Initially, we confirmed the TFS instability by stress maneuvers under fluoroscopy visualization (Figure 4). Varus stress test was also performed to rule out lateral ligament instability. Then, the arthroscopic portals were performed. The OLT was identified and debrided until the cancellous bone was exposed, with well-defined cartilage borders (Figures 5A and 5B). We measured the lesion size with a template to mold the collagen membrane (Figure 5C).

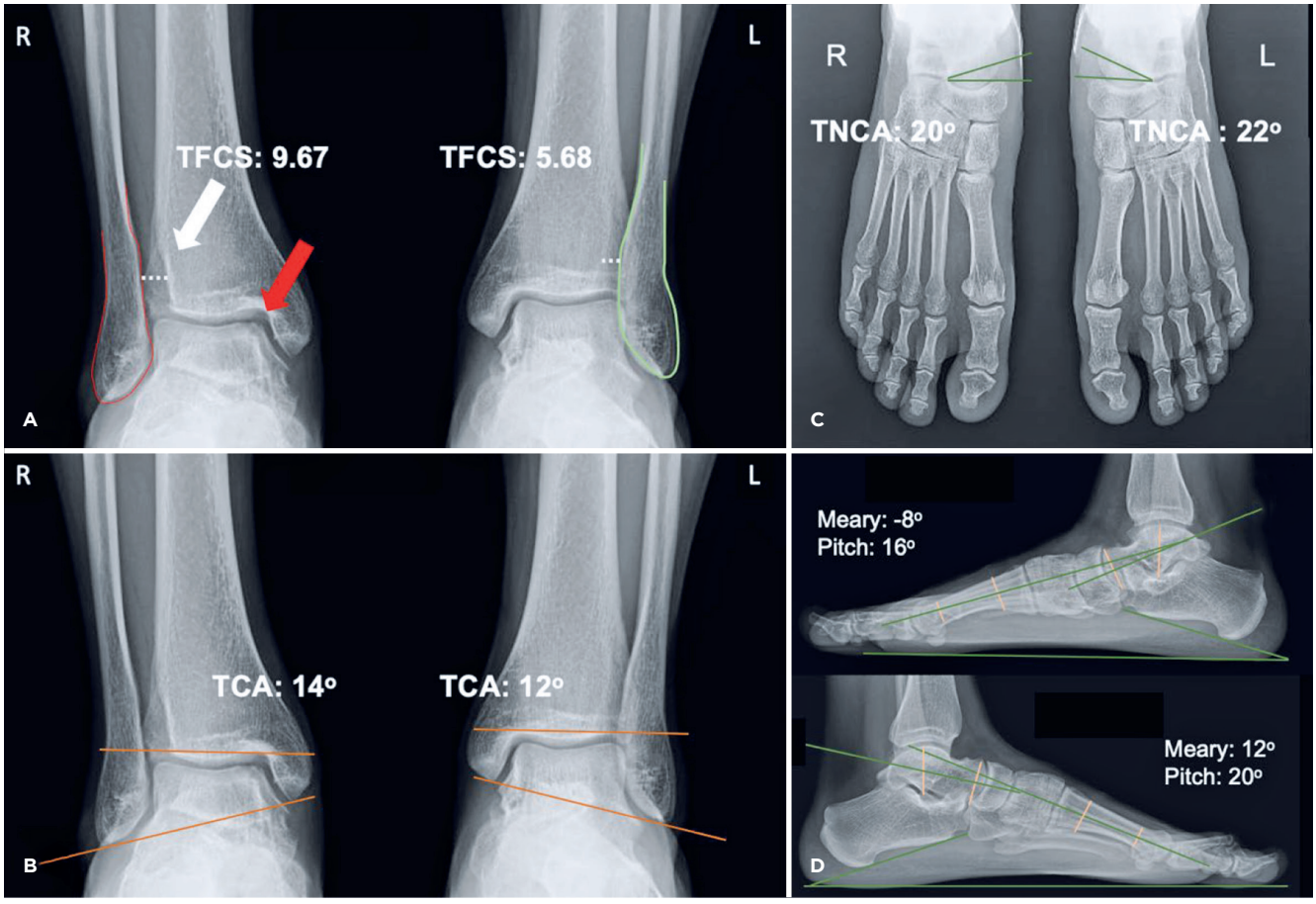

Figure 1. Ankle radiographic images to evaluate the tibiotalar and TFS joints. The anteroposterior views show (A) the right fibula with a different width and shape (*red line outline*), TFS malformation (*white arrow*) with wider TFCS (dotted white line), and the medial OLT (*red arrow*); (B) bilateral fibula length comparison. Radiographic images of the feet were taken to analyze alignment based on (C) anteroposterior and (D) lateral views.
TFS: tibiofibular syndesmosis; OLT: osteochondral lesion of the talus; TFCS: tibiofibular clear space; TCA: talocalcaneal angle.

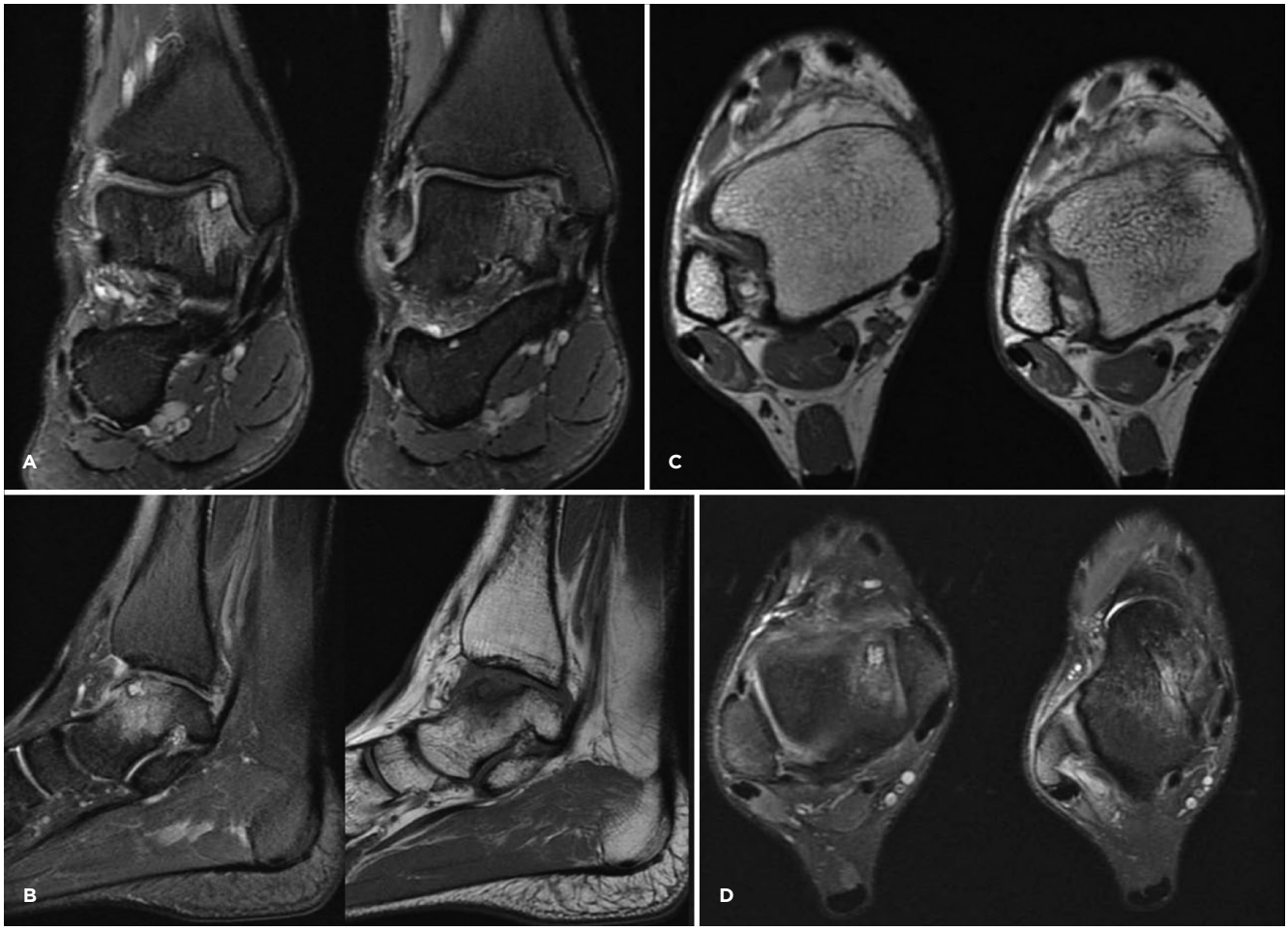

Figure 2. Magnetic resonance images of the OLT (A, B, D) measuring 16 x 7 x 6 mm and the malformed TFS with widening of the joint (C). OLT: osteochondral lesion of the talus; TFS: tibiofibular syndesmosis.

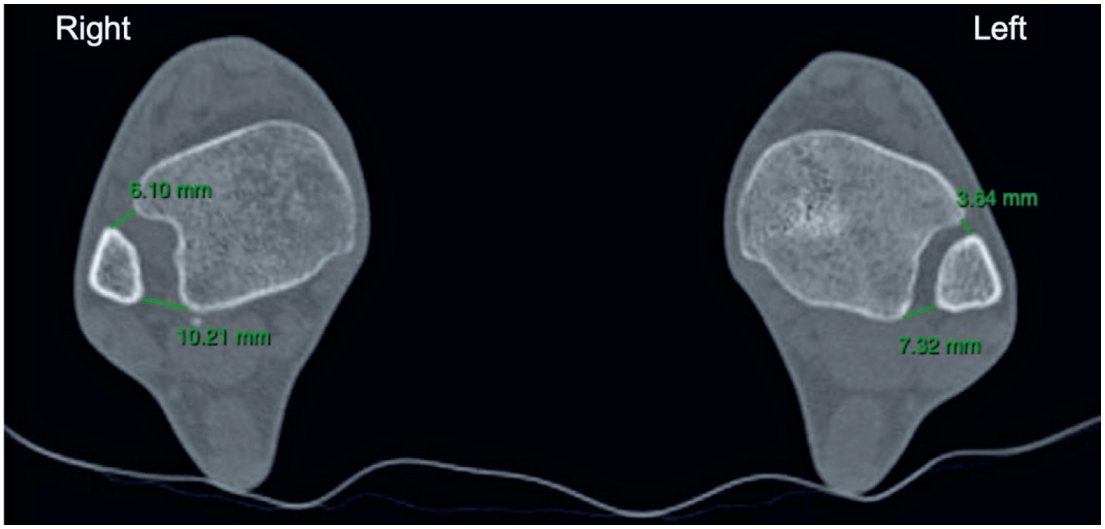

Figure 3. Bilateral CT scan images in the axial plane of the ankle showing asymmetry of the TFS anatomy and joint space. CT: computed tomography; TFS: tibiofibular syndesmosis.

Through a longitudinal approach of 1 cm on the lateral side of the calcaneus body, a cancellous bone graft was harvested with a Jamshidi biopsy needle. The infusion of fluid was turned off, and the bone graft was placed in the OLT bed with the needle itself and impacted with a curette (Figures 6A, 6B, and 6C). Then, the membrane was accommodated, with its rough side facing down, and fixed with fibrin glue (Figure 6D and 6E). The smooth surface was dotted with a Codman pen to identify the membrane sides when it was intra-articular (Figure 6D). The glue limit was at the level of the intact joint

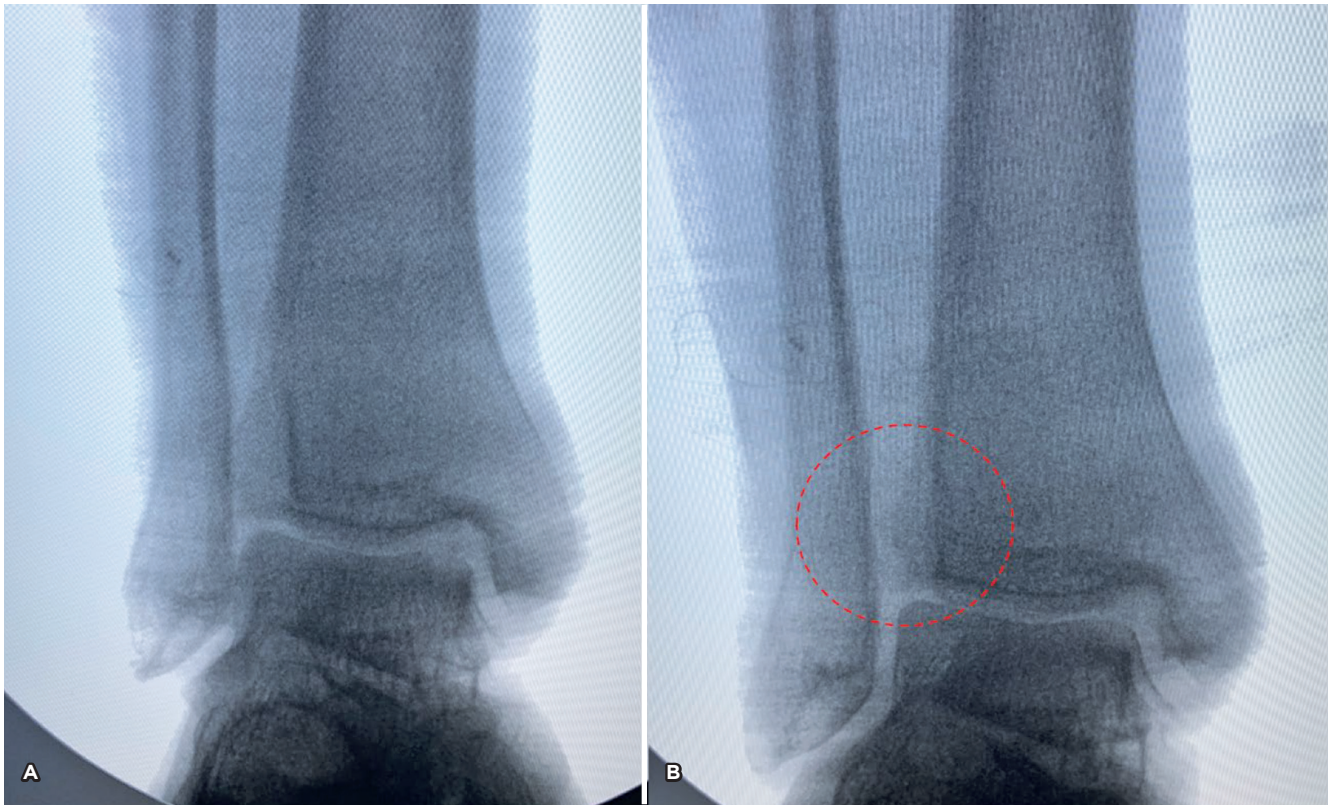

Figure 4. Intraoperative evaluation of TFS instability with stress in external rotation under fluoroscopy view (A) position of the TFS at rest and (B) its openness to stress (*red circle*).
TFS: tibiofibular syndesmosis.

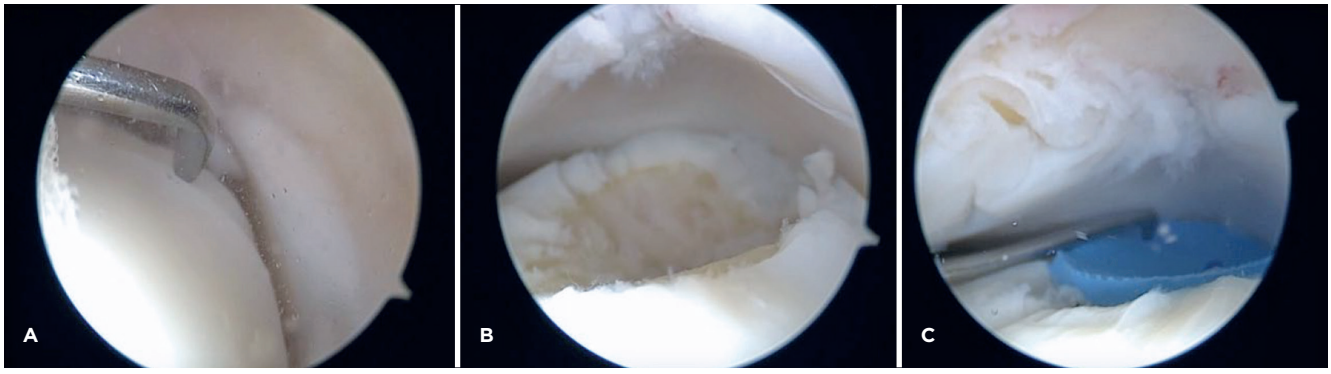

Figure 5. Arthroscopic approach of the OLT (A) identification of the lesion, (B) appearance after its debridement, and (C) measurement of the lesion diameter with a flexible template.
OLT: osteochondral lesion of the talus.

surface to prevent the loosening of the membrane with ankle movements (Figure 6E). Due to the TFS joint malformation, an open approach with a longitudinal incision of approximately 5 cm was performed on the anterolateral edge of the lateral malleolus to evaluate its anatomy better. Debridement of all scar tissue within was performed. We could not bring the fibula closer to the tibia, and they were fitted congruently. Two suture-buttons were placed divergent in the axial plane and parallel in the coronal plane to stabilize it (Figure 7).

The patient remained non-weight-bearing with a walking boot for two weeks without joint mobilization. After two weeks, the stitches were removed, and active ankle mobilization was oriented. At six weeks, progressive load on the operated limb was allowed. After eight weeks, the boot was removed, and physiotherapy started. Thirteen months after surgery, the patient was asymptomatic and has returned to his previous sports activities without pain or limitation. Control radiographic and MRI images show TFS and OLT healing (Figure 7).

Discussion

Tibiofibular syndesmosis ligaments take a longer time to heal compared to lateral ligaments. When left untreated, it fails to heal properly, leading to joint incongruency and instability[3]. We presented a patient with pain due to chronic instability in a congruent malformed TFS associated with OLT, which was successfully treated with TFS stabilization and repair of the talus cartilage.

Tibiofibular syndesmosis congruence and instability diagnosis are not always evident and are evaluated by combining different imaging exams[6]. Plain radiographs are unreliable and can miss up to 3mm of joint displacement in 50% of the cases[7]. Images under stress can be taken, but their usefulness is questionable, with a reported accuracy of 72%[8]. Ogilvie-Harris and Reed demonstrated that 7 of 19 of their patients with arthroscopically evidenced TFS instability had a negative stress radiograph[9]. Tibiofibular syndesmosis incongruency is best evaluated by a CT scan, which can detect minor displacements of up to 1mm[7]. In our patient, altered TFS anatomy was easily visible on radiographic views and non-weight-bearing CT images. Besides, intraoperative fluoroscopy demonstrated the widening of the joint with the stress test.

Normally, the fibula has no contact with the weight-bearing area of the talus, but 16% of body weight is transmitted through the strong ligaments of the TFS and the fibula[10]. Therefore, restoring congruency and stability is mandatory to prevent osteoarthritis. However, there is still no consensus on which surgical treatment method is the gold standard. Satisfactory outcomes were achieved in late syndesmosis

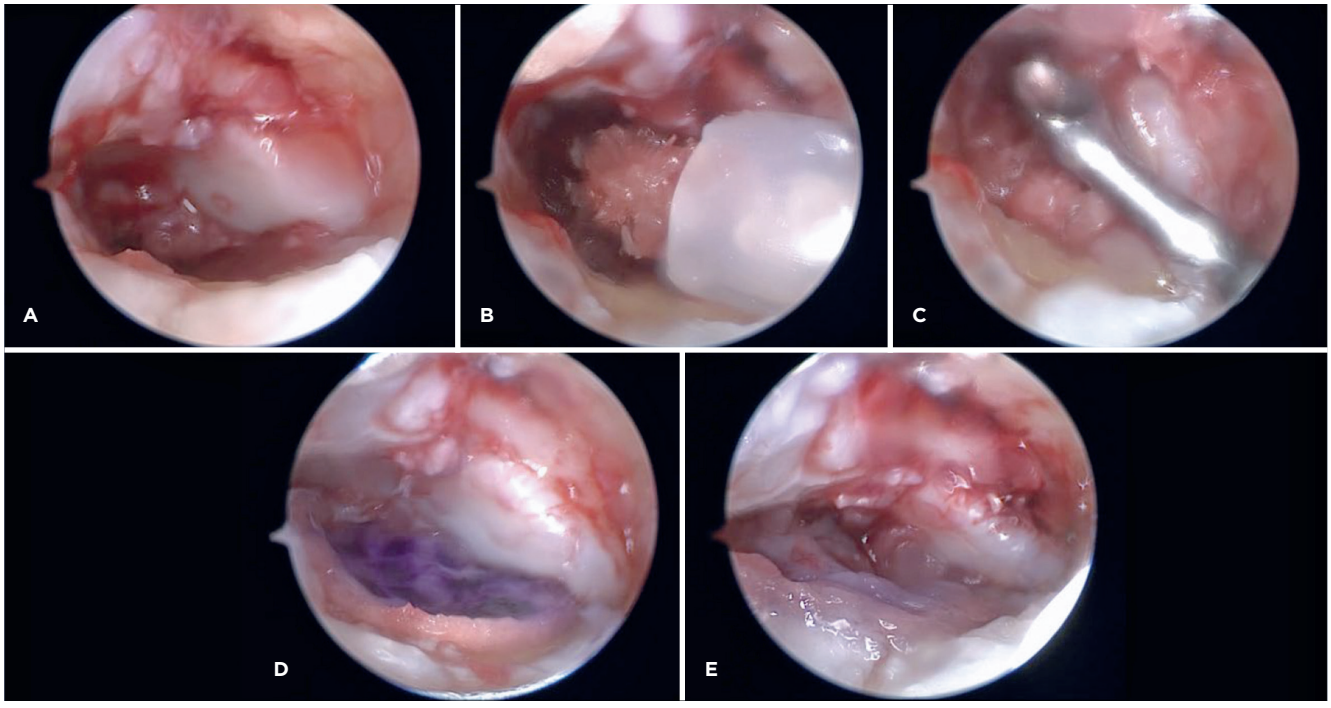

Figure 6. Membrane placement steps, without saline solution infusion (A) appearance of the debrided lesion with a clean bed, (B) placement of a cancellous graft with a small cannula, (C) impaction of the graft with the convex side of the curette, (D) accommodation of the membrane, and (E) its fixation with fibrin glue.
MRI: magnetic resonance imaging; TFS: tibiofibular syndesmosis.

Figure 7. Radiographic and MRI images at 13-month postoperatively (A and B) weight-bearing radiographic views of the ankle with postoperative fixation, (C, D, and E) MRI showing bone graft integration and bone edema resolution, and (F) TFS morphology.

disruptions in ankle fractures treated with joint debridement, anatomical reduction, and stabilization. On the other hand, some authors have recommended arthrodesis in the same fracture setting and described good outcomes[2]. In our study, we also had a case with chronic TFS disruption, but differently, it was caused by multiple episodes of ankle sprains and not by a fracture. Intraoperatively, we observed a unity in the malformed TFS, like an acetabular dysplasia, but the joint was significantly unstable. Our impression was that they were fitted together as if they had developed with this anatomy during patient growth. After stabilization, the patient was pain-free in the TFS.

In chronic TFS lesions, OLTs are present in up to 24% of the cases[4]. They are traditionally treated surgically with reparative or replacement techniques[5]. The main concern is about the longevity of fibrocartilaginous at the OLT site. It can deteriorate with bone marrow stimulation (BMS)[11]. In a systematic review, Ramponi et al.[5] demonstrated that lesions with size greater than 107.4mm^2 in area and 10.2mm diameter are significantly correlated with poorer clinical outcomes. Although the lesion size (112mm^2) may be an indication to treat with the OATS, we opted for a less aggressive approach, a collagen membrane with cancellous bone graft. Previous studies have demonstrated that it is possible to achieve satisfactory clinical results with this surgical technique[12].

The study has limitations, mainly its methodological design and short-term follow-up, such as the risk of overinterpretation and lack of reproducibility of the results.

In this rare case with chronic instability in a malformed TFS associated with OLT, a successful outcome could be achieved with surgical treatment at thirteen months of follow-up.

Authors' contributions: Each author contributed individually and significantly to the development of this article: DRCN *(https://orcid.org/0000-0003-0227-2440), and, PBR *(https://orcid.org/0000-0002-7215-8187) Conceived and planned the activities that led to the study, wrote the paper, participated in the reviewing process, approved the final version; TSM *(https://orcid.org/0000-0003-4168-0981), and, GHS *(https://orcid.org/0000-0002-1211-9258), and FAD *(https://orcid.org/0000-0001-6871-2491), and, MPP *(https://orcid.org/0000-0003-0325-8050) Interpreted the results of the study, participated in the reviewing process; All authors read and approved the final manuscript.*ORCID (Open Researcher and Contributor ID) .

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Case Report

Spontaneous open rupture of the Achilles tendon

Luiz Carlos Ribeiro Lara[1], Diego Vitor Braga Santos[1], Glaucia Bordignon[1,2], Lara Furtado Lancia[1], Gustavo Kogake Claudio[1], Matheus Neves Castanheira[1]

1. Hospital Municipal Universitário de Taubaté, Taubaté, São Paulo, Brazil.
2. Instituto Brasil de Tecnologias da Saúde (IBTS), Rio de Janeiro, RJ, Brazil.

Abstract

This case report describes a spontaneous open rupture of the Achilles tendon. This type of injury is rare and has few descriptions in the literature. What draws attention in this case report is the extent of the open injury and tendon pullout without associated trauma. This pattern may be related to the patient's overweight profile and previous history of retrocalcaneal bursitis. The treatment received for the spontaneous open rupture led the patient to a satisfactory result without sequelae.

Level of Evidence V; Case Report; Expert Opinion.

Keywords: Achilles tendon; Rupture, spontaneous; Treatment outcome.

Introduction

The Achilles tendon is the strongest in the human body. During gait, it undergoes approximately 5 to 7 times of body weight; therefore, it is the most commonly ruptured tendon structure of the lower limb, corresponding to approximately 20% of all injuries of large tendons[1,2]. Its total rupture occurs in an incidence between 18 and 31 cases per 100,000 inhabitants. It affects more male patients, with two stand-out characteristic groups, non-professional athletes between 25 and 40 years old and older patients over 60. In open injuries, the trauma mechanism usually involves lacerations caused by motorcycle accidents or injury with sharp objects[1,3-5]. Spontaneous injuries are even more rare and scarce in the literature, and the main group is the people prescribed drugs such as corticosteroids and fluoroquinolones, in addition to comorbidities such as diabetes, chronic renal failure, chronic tendinopathies, and bursitis[1,2,6]. The surgical treatment of open ruptures involves initial care, such as wound cleaning and debridement, in addition to early intravenous antibiotic therapy. In closed injuries, conservative or surgical treatment is possible, and the patient's functional demand, age, and comorbidities must be evaluated to indicate the best treatment for the individual[2,4,5,7].

The aim of this study is to report the case of a patient who suffered a spontaneous open rupture of the Achilles tendon, an extensive open injury and tendon pullout without associated trauma. The patient reported having suffered a previous injury to the same tendon 25 years ago but in a different anatomical area, which required surgical repair. The treatment received for the spontaneous open rupture led the patient to a satisfactory result without sequelae.

Case description

In December 2019, a 58-year-old male patient noticed an open rupture of the right Achilles tendon while riding on a horse doing plantar flexion force on foot supported by the ground.

Immediately, the patient contacted a medical team and presented to the hospital for an orthopedic evaluation and initial care that the injury required.

On physical examination in the emergency room, the tendon pullout from its insertion was identified through the cutaneous wound exposing the injury (Figure 1). In addition, the patient informed a history of parenchymal rupture of the same tendon approximately 6 cm from the insertion in

Study performed at the Hospital Municipal Universitário de Taubaté, Taubaté, São Paulo, Brazil.

Correspondence: Glaucia Bordignon. Av. Granadeiro Guimarães, 270, Centro, 12020-130, Taubaté, SP, Brazil. **Email:** glauciabordignon@gmail.com. **Conflicts of interest**: none. **Source of funding:** none. **Date received:** October 10, 2022. **Date accepted:** May 20, 2023. **Online:** October 31, 2023.

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1993 when the end-to-end tenorrhaphy was performed. The patient reported being overweight at that time. In this new injury, the patient was operated on urgently, and all the classic recommendations for open tendon injuries were followed. The complete tendon deinsertion was confirmed during the procedure. After regularization of the distal end of the tendon stump, it was reinserted into the posterior tuberosity of the calcaneus using two metallic anchors. The wound was closed conventionally, and the postoperative dressing consisted of a cast in 30º plantar flexion (Figure 2).

The postoperative period was four weeks without load using crutches. Then, from four to eight weeks, the patient was allowed a full load protected by rigid orthosis. After eight weeks, immobilization was removed, and a physiotherapy program began to recover the ankle's range of motion and improve the gait pattern, balance, and muscle strengthening.

The patient progressed well, without complications. At the six months postoperative return, the patient showed a complete, painless ankle movement arch, managing to stand on tiptoes (Figure 3).

Discussion

Spontaneous open rupture of the Achilles tendon described in this case report is rare. Few studies have been found in the literature involving re-rupture of the Achilles tendon, corresponding to 2%–12% of the reports found[1,4]. The first authors to describe an open injury of the Achilles tendon were Garcia-German et al. [8].

However, the cases cited by these authors were injuries that occurred within a short period after the initial approach, between 9 and 12 weeks after primary tenorrhaphy, which also involved the associated trauma mechanism. Cesar Netto et al.[4] recently described a case of open rupture after surgical repair without associated trauma.

Therefore, the uniqueness of this case is worth mentioning since this case does not involve re-rupture; the current injury occurred in a location different from the previous and no

Figure 1. A) Site of skin injury by spontaneous rupture. B) Proximal stump of the Achilles tendon.

Figure 2. Immediate postoperative radiography, showing fixation of the tendon using a metallic anchor.

Figure 3. Patient with six months postoperative. A) Scar in good condition. B) Patient staying on tiptoes without difficulty.

type of associated trauma was reported. There are some differences between an open and closed injury. A hypothesis suggested by the authors would indicate that an open injury could be related to a previous adhesion between the repaired tendon and the subcutaneous tissue, causing retraction on the skin. It is important to highlight that this report is uncommon and rare. It is an open rupture of the Achilles tendon, at its insertion, with good clinical evolution.

Close rupture of the Achilles tendon occurs most often, keeping the skin intact. However, paying attention to the possibility of tendon injury with associated skin continuity solution is important, requiring an urgent approach.

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Case Report

Septic arthritis of the ankle due to *Citrobacter koseri*: a case report

Alexandre Loureiro de Castro[1], Raquel Diana de Lima Cunha[1], Tânia Raquel Alegre Veigas[1], Eduardo Miguel de Almeida Moreira Pinto[1], Pedro Manuel Atilano Carvalho[1,2], João Pedro Lopes Teixeira[1,2]

1. Centro Hospitalar de Entre o Douro e Vouga, Departament of Orthopaedic and Traumatology, Santa Maria da Feira, Portugal.
2. Hospital da Luz Arrábida, Porto, Portugal.

Abstract

Septic arthritis of the ankle after arthroscopy is a rare but serious condition. Specifically, to the best of our knowledge, there have been no reports of septic arthritis of the ankle caused by *Citrobacter koseri*. An otherwise healthy 42-year-old male patient presented to our outpatient clinic with ankle pain, and magnetic resonance imaging (MRI) revealed intra-articular bodies compatible with osteochondromatosis. Patient underwent anterior and posterior ankle arthroscopy and, four weeks after surgery, presented with wound dehiscence of the previously healed anterolateral portal. Following the diagnostic work-up, patient was submitted to arthroscopic irrigation and debridement. *Citrobacter koseri* was isolated. After surgical intervention and antibiotic administration, patient's symptoms gradually improved. Six months later, no ankle pain or motion restriction was reported. Clinical symptoms of septic arthritis after ankle arthroscopy can be very mild and, for this reason, a low diagnosis threshold is necessary.

Level of Evidence IV; Therapeutic Studies; Case Report.

Keywords: Ankle; Arthritis, infectious; *Citrobacter koseri*; Arthroscopy; Postoperative complications.

Introduction

Citrobacter koseri (*C. koseri*) is a facultative anaerobic gram-negative bacillus belonging to the *Enterobacteriaceae* family. Members of this family are part of the normal flora of human and animal digestive tracts[1].

C. koseri is a well-known cause of central nervous system infection in pediatric patients but a rare cause of musculoskeletal infection. To our knowledge, there are only six reports of septic arthritis caused by *C. koseri*, none of the ankle[2].

Septic arthritis of the ankle is a rare but serious condition that may lead to major cartilage damage. Infection may arise from other infection sites via hematogenous spread or from direct inoculation of microorganisms into the joint, either after traumatic wounds or surgical procedures.

Septic arthritis after arthroscopy has been reported in 0.13% to 1.8% of cases, rising to 3.9% in patients submitted to intraoperative intra-articular corticosteroid injection[3]. Association between these two entities is not yet described in the literature, representing a challenging orthopedic condition.

The aim of this article is to describe the first case report of *C. koseri* septic arthritis of the ankle. Informed consent was filled.

Case description

An otherwise healthy 42-year-old male patient presented to our outpatient clinic with an indolent history of ankle pain and edema. There was no recent history of trauma. Patient had a mild dorsiflexion limitation. Magnetic resonance imaging (MRI) revealed flexor hallucis longus (FHL) and posterior tibial tenosynovitis, as well as three nodular lesions in the anterior recess of the ankle compatible with osteochondromatosis (Figure 1).

Study performed at the Centro Hospitalar de Entre o Douro e Vouga, Departament of Orthopaedic and Traumatology, Santa Maria da Feira, Portugal.

Correspondence: Alexandre Loureiro de Castro. R. Dr. Cândido Pinho 5, 4520-211, Santa Maria da Feira, Portugal. **E-mail:** alexandredecastro.06@gmail.com
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Patient underwent anterior and posterior ankle arthroscopy (Figure 2), where synovectomy was performed with further removal of intra-articular loose bodies and FHL release from its fibro-osseus tunnel. At the end of the procedure, an intra-articular corticosteroid injection was administered. Patient was discharged the following day and weight-bearing was allowed as tolerated.

Four weeks after surgery, patient presented to our outpatient clinic with wound dehiscence of the previously healed anterolateral portal and a posterior ankle hematoma.

Fever, chills, night sweats, or any other sign of systemic illness were not reported. On examination, patient ankle presented moderate swelling and erythema, but painless range of motion.

Laboratory tests showed 7.61 x 10^9/L leukocytosis with neutrophilia associated with mild elevation of c-reactive protein levels (12.1 mg/L). An ankle ultrasound was performed, showing an hypoechogenic heterogeneous collection of about 2 cm, compatible with hematoma.

With no clear sings of infection at the time, an initial course of anti-inflammatory treatment and cryotherapy was prescribed, with close surveillance of wound healing development.

Because there was no improvement, at five weeks posto-peratively, an MRI was ordered and revealed a collection

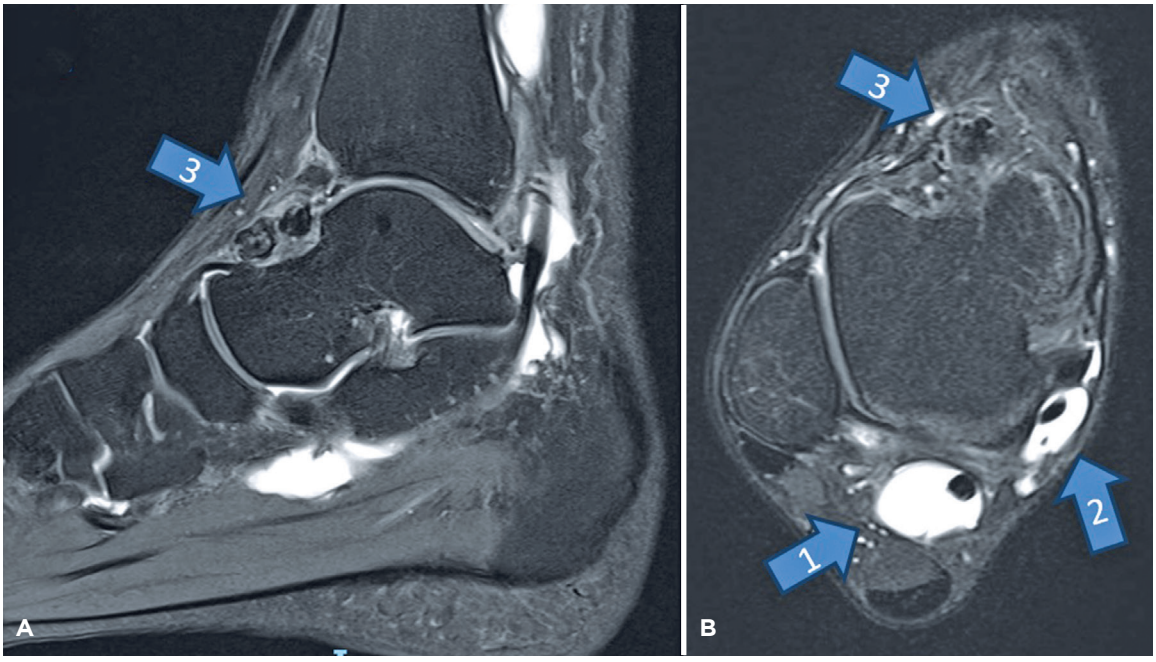

Figure 1. Ankle T2-weighted sagittal (A) and axial (B) magnetic resonance imaging showing flexor hallucis longus (arrow n. 1) and posterior tibial tenosynovitis (arrow n. 2), as well as three nodular lesions in the anterior recess of the ankle, compatible with osteo-chondromatosis (arrow n. 3).

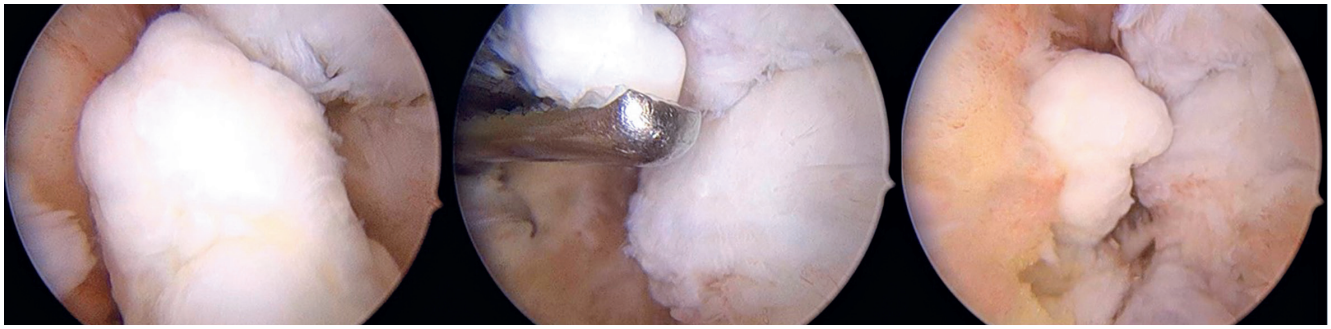

Figure 2. Intraoperative arthroscopic findings included flexor hallucis longus tenosynovitis and nodular lesions in the anterior recess of the ankle, compatible with osteochondromatosis.

of about 2 cm with high signal intensity, compatible with infection. Improvement of FHL and posterior tibial tenosynovitis was also noticed (Figure 3).

Patient was submitted to anterior and posterior arthroscopic irrigation and debridement. Main arthroscopic findings included tissue hyperemia and clots, without purulent collections. Tissue samples were sent for culture and classified as stage I infection according to Gächter classification[4]. Empiric broad-spectrum intravenous antibiotic therapy with vancomycin 1000 mg every 12 hours was initiated.

Postoperative period was uneventful, with progressive improvement of pain and edema, as well as a decrease in inflammatory parameters.

Microbiology cultures identified *C. koseri* as the causative agent of infection. It was sensitive to amoxicillin, ciprofloxacin, gentamicin, and trimethoprim/sulfamethoxazole. At this time, vancomycin was discontinued, and patient received targeted intravenous antibiotic therapy for two weeks – amoxicillin and clavulanic acid –, at which time he was discharged from the hospital. Then, patient received oral antibiotics treatment for four weeks.

During postoperative care, ankle motion was allowed, and progressive weight-bearing was encouraged after wound healing.

At six months of follow-up, no sequelae of septic arthritis were identified, and patient had a good clinical recovery.

Discussion

Native septic arthritis is a relatively uncommon condition either by arthrocentesis at the bedside, open or arthroscopic drainage in the operating room, or imaging-guided drainage in the radiology suite, is mandatory. Methicillin-resistant Staphylococcus aureus (MRSAthat requires urgent treatment to avoid cartilage damage and patient clinical deterioration[5].

As far as we know, septic arthritis of native adult ankle secondary to *C. koseri* has not been previously described in published reports.

C. koseri is considered an opportunistic agent, as it rarely causes infection in healthy individuals. It is commonly found in water, soil, and food, being also found as occasional colonizers of the gastrointestinal tract[6]. Citrobacter strains can cause several forms of infections, such as urinary tract, respiratory, intra-abdominal, skin and soft tissue, eye, bone, bloodstream, and central nervous system infections[6].

In the present case, patient was not immunocompromised and still developed ankle infection caused by *C. koseri*. Corticosteroids exert their anti-inflammatory action by interrupting the inflammatory and immune cascade at several levels, and this could possibly explain why such infection occurred. The association between intra-articular corticosteroid injection and development of infection has been extensively studied, and presence of opportunistic agents as a cause of this infection has also been reported[3].

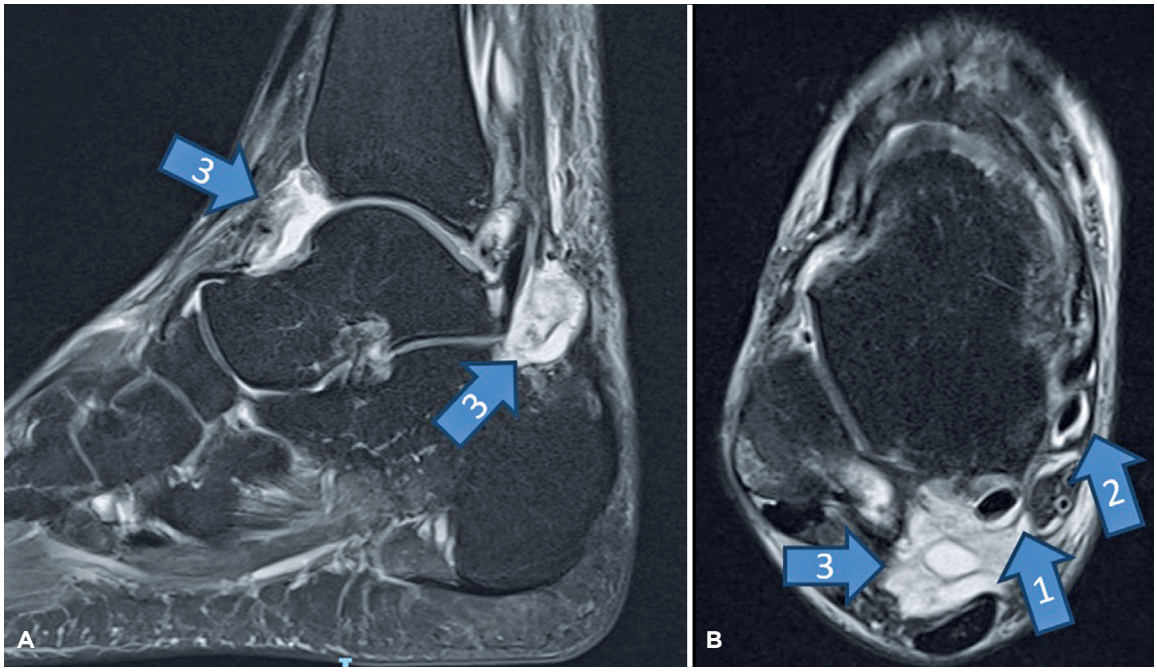

Figure 3. Ankle T2-weighted sagittal (A) and axial (B) magnetic resonance imaging showing improvement of flexor hallucis longus (arrow n. 1) and posterior tibial tenosynovitis (arrow n. 2). No nodules were present but a collection of about 2 cm, with high signal intensity, compatible with infection (arrow n. 3).

Although rare, septic arthritis is a major complication after arthroscopy[7]. Distinguishing postoperative inflammation and postoperative septic arthritis may be difficult, especially in patients with an indolent joint infection[8]. Setting a low threshold for suspicion and diagnostic work-out is important.

The presence of wound dehiscence and joint fluid demanded arthroscopic irrigation and debridement, with positive microbiology cultures for *C. koseri*.

Empiric antibiotic therapy prior to obtaining definitive cultures is based on patient age and/or risk factors, but transition to organism-specific antibiotic therapy should be made after culture sensitivities are obtained[5]. *C. koseri* is reported to be resistant to aminopenicillins and carboxypenicillins and, throughout time, gained resistance to other antibiotics. Therefore, quinolones and carbapenems have been suggested to be used as treatment options[6]. In our sample, *C. koseri* was sensitive to amoxicillin and clavulanic acid, and we choose this therapy taking into consideration that quinolones are prone to resistance mechanisms.

In conclusion, the unique features of this case re-emphasizes the importance of obtaining a joint aspirate before initiating any antibiotic therapy.

Authors' contributions: Each author contributed individually and significantly to the development of this article: ALDC *(https://orcid.org/0000-0001-7672-4265), and JPLT *(https://orcid.org/0000-0003-4857-1585) Conceived and planned the activities that led to the study, wrote the paper, participated in the reviewing process, approved the final version; RDDLC *(https://orcid.org/0000-0002-1834-6857), and EMDAMP *(https://orcid.org/0000-0002-4036-7478) Interpreted the results achieved, approved the final version; TRAV *(https://orcid.org/0000-0002-7631-9849) Wrote the paper, approved the final version; PMAC *(https://orcid.org/0000-0003-1459-6872) Participated in the reviewing process, approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID)

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Technical Tips

Percutaneous subtalar arthrodesis – configuration of portals using a guidewire

Paulo Feliciano Sarquis Dias[1], Bruno Maciel Braga[2], Gabriel Ferraz Ferreira[3,4], Eli Schmidt[5], Kepler Alencar Mendes de Carvalho[5], Gustavo Araujo Nunes[3,6]

1. Hospital Francisco José Neves - Unimed BH, Belo Horizonte, MG, Brazil.
2. Fundação Ouro Branco Hospital São José, Conselheiro Lafaete, MG, Brazil.
3. MIFAS by Grecmip (Minimally Invasive Foot and Ankle Society), Merignac, France.
4. Foot and Ankle Surgery Group, Orthopaedics and Traumatology Unit, Prevent Senior, São Paulo, Brazil.
5. Department of Orthopedics and Rehabilitation, University of Iowa Hospitals & Clinics, Iowa City, EUA.
6. COTE Brasília Clinic, Brasília, DF, Brazil.

Abstract

Subtalar arthrodesis is indicated to treat many hindfoot disorders, and different approaches are described, including percutaneous, which has grown recently. In this modified percutaneous technique, using a guidewire, two portals are ideally made for access to the subtalar joint, regardless of the deformity found in this joint. The technique intents to be faster and decrease morbidity and complication rates. Therefore, the objective of the study was to present a technical variation of the percutaneous technique.

Level of Evidence V; Therapeutic Studies; Expert Opinion.

Keywords: Arthrodesis; Foot deformities/complications; Minimally invasive surgery; Subtalar joint; Treatment outcome.

Introduction

The subtalar joint has an important biomechanical role during gait[1]. Post-traumatic osteoarthrosis is the primary pathology affecting the subtalar joint[2,3]. In cases without improvement with conservative approaches, surgical treatment is recommended. The primary procedure used for advanced stages of subtalar degenerative conditions is arthrodesis which can be performed by: open, percutaneous, or arthroscopic approach. Each one of these approaches has its indications, advantages, and disadvantages[4,5].

The open approach is the most traditional technique used for subtalar arthrodesis. The inconvenience is the complication rate related to soft tissue healing, which ranges from 20% to 38%[2,4]. When properly indicated, the subtalar joint arthrodesis performed percutaneously is another option that minimizes complications related to the soft tissue[2,3,5]. The main indication is subtalar arthritis with mild or moderate hindfoot malalignment, specifically in patients with soft tissue problems[2].

Percutaneous subtalar arthrodesis is traditionally performed through a sinus tarsus and classic posterolateral portals[6]. There are few studies evaluating the results of this technique and the best way to access the subtalar joint, especially in cases with degeneration and alteration in the height of the posterior facet[2,3,5]. In cases with post-traumatic arthrosis, the inclination of the posterior subtalar facet can be changed, making the percutaneous access for decortication through the classic posterolateral portal and the sinus tarsal portal more difficult[6]. In these cases, making the portals according to the height and inclination of the posterior subtalar facet can improve decortication and decrease soft tissue complications, potentially providing better surgical results.

The aim of this study is to describe a modification in portals.

Surgical technique

The patient was in a supine position on a radiolucent table. An ipsilateral pad was used on the hip to keep the limb in

Study performed at the COTE Brasilia Clinic, Brasília, DF, Brazil.

Correspondence: Gustavo Araújo Nunes. SGAS 915 Lote 68a Salas 16/17 Centro Clínico Advance 2, Asa Sul, 70390-150, Brasília, DF, Brazil. **E-mail:** gustavoanunes@hotmail.com **Conflicts of interest:** none. **Source of funding:** none. **Date received:** April 26, 2023. **Date accepted:** July 18, 2023. **Online:** October 30, 2023.

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60° internal rotation. The procedure was performed using a fluoroscopy (mini c-arm), allowing a lateral and axial view of the calcaneus.

The first step was the preparation of the portals. They were made according to the inclination and height of each patient's posterior subtalar joint facet. For this, a Kirschner wire was used as a guide. The wire was positioned over the skin parallel to the same slope as the posterior subtalar joint facet. According to the inclination of this wire, a 05 mm posterolateral and sinus tarsal portals were made (Figures 1A and 1B), providing an ideal angle to introduce the burr into the joint (Figure 2). The first portal was the sinus tarsus. After making the skin incision, the subcutaneous layer was split using a mosquito clamp.

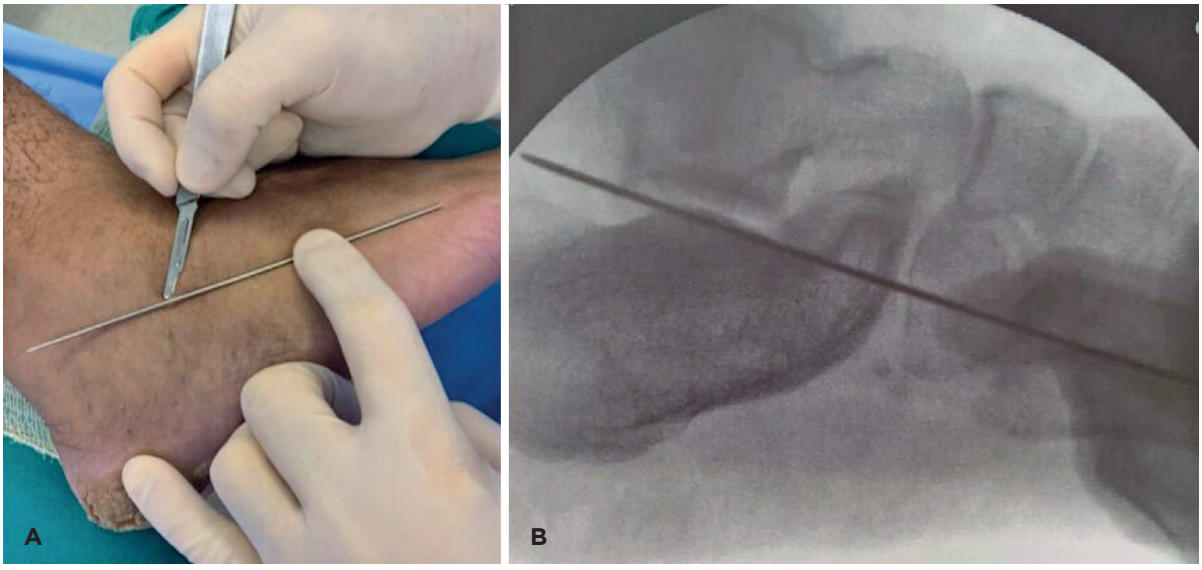

Figure 1. (A) Guidewire over the skin to guide the configuration of portals (B) Fluoroscopy with the guidewire parallel to the slope of the posterior subtalar tilt.

Figure 2. Burr introduction according to the posterior subtalar facet inclination.

Caution is essential because the dorsal intermediate cutaneous branch of the superficial peroneal nerve is superior, and the peroneal tendons are inferior. Then, the posterolateral portal was made at the level of the Kirschner wire, according to the subtalar inclination, just lateral to the Achilles tendon. The posterolateral portal varies in height according to the inclination of the posterior facet and is not limited to the classic posterolateral portal level, as described by Van Dijk[6]. Caution with the sural nerve is important in performing this portal; therefore, a blunt dissection was made with a hemostatic clamp, and the decortication is initiated just when the burr is inside the articular space (Figures 3 and 4).

After the portals were configured, a periosteal elevator was used to create a suitable working area in the joint. Decortication was started with a 2x10 mm Shanon burr (NOVASTEP®, Rennes, France) through the tarsal sinus portal. Then the same burr was introduced through the posterolateral portal (Figure 5). The decortication was finished with more robust roughing cutters such as the 3.1 mm wedge burr (NOVASTEP®, Rennes, France). During the procedure, constant irrigation separately of the burr was performed to avoid complications with the soft tissues. The last step was the fixation performed with two partial thread-cannulated 4.5 mm compression screws (Figure 6).

Postoperatively, the patient wears a plaster splint for two weeks and two more weeks with an immobilizing boot, both with non-weight bearing. Finally, weight-bearing was allowed with an orthopedic boot by the fourth week. Physical therapy started with the boot in the sixth week and was progressively removed until the eighth week (Figure 7).

Discussion

The percutaneous subtalar arthrodesis method has several advantages, including lower morbidity, soft tissue

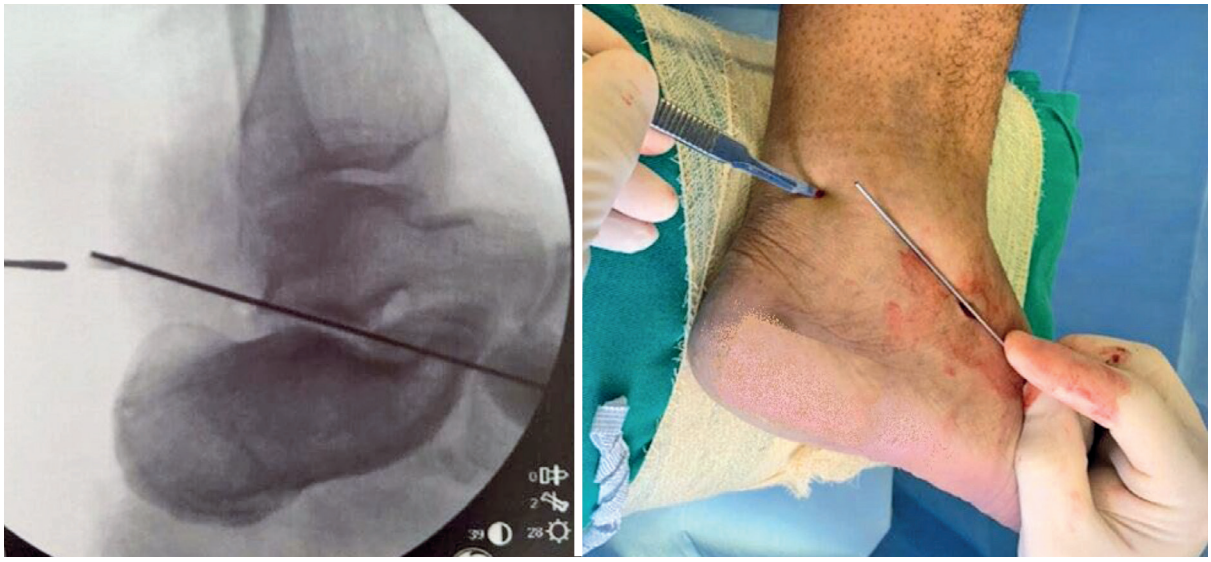

Figure 3. Making the posterolateral portal according to the posterior subtalar facet inclination. Caution with the sural nerve is important to perform this portal.

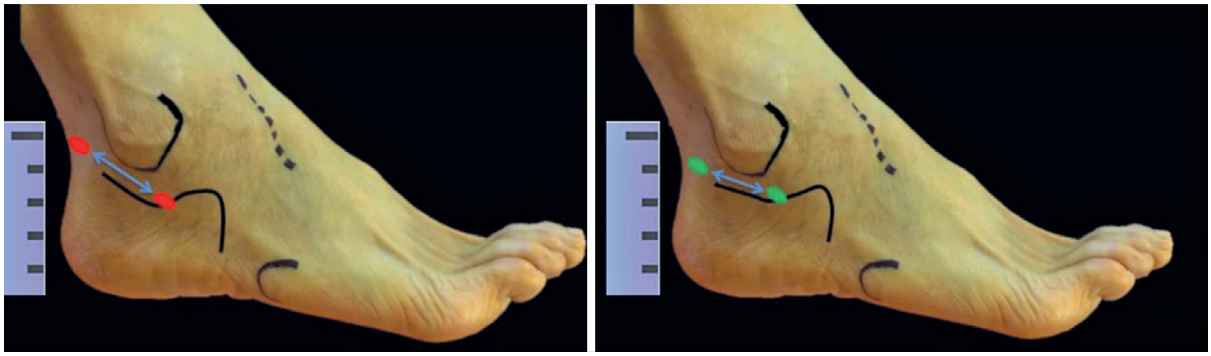

Figure 4. Height difference of the portals according to the slope of the subtalar joint.

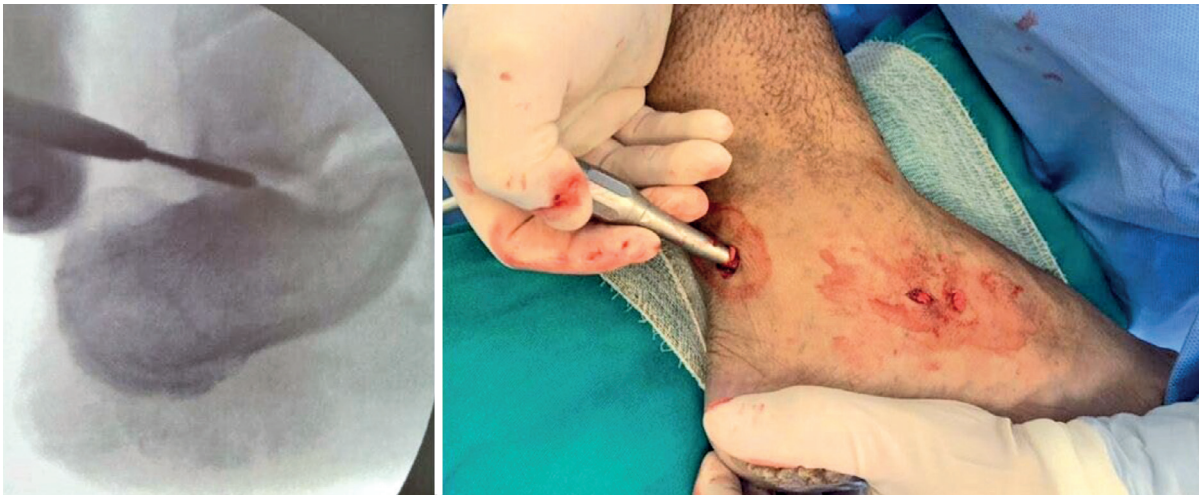

Figure 5. Burr introduction according to the posterior subtalar facet inclination.

Figure 6. Immediate postoperative clinical appearance.

complications, risk of neurovascular injury, and similar consolidation rates compared to open surgery[2,4]. Arthrodesis performed arthroscopically is also minimally invasive and includes the benefits related to soft tissue healing. However, it is a technically more complex procedure with a longer surgical time and a more challenging learning curve[2,3].

In arthrodesis, some parameters are essential to evaluate the performance of the surgery, such as consolidation, complication, pseudarthrosis (nonunion) rates, and time of consolidation. The literature shows a 6.5% pseudarthrosis rate in arthrodesis performed percutaneously without soft tissue complications[3]. In contrast, open surgery has a pseudarthrosis rate of up to 16%, with 20%–38% of soft tissue complications[2,4]. As described in arthroscopic arthrodesis, a shorter time for consolidation is expected in the percutaneous procedure compared to the open[7].

The percutaneous subtalar arthrodesis can be performed either through a posterolateral portal or associated with an anterolateral sinus tarsal portal[2,3]. The greater decortication with two portals provides a 92.2% consolidation rate and corrects mild and moderate deformities[3,8]. Since it is a percutaneous procedure, a well-directed portal is critical to achieve good subtalar decortication. The typical angulation of the posterior subtalar joint facet is 28.6° (ranging from 20° to 40°). It is possible to decorticate 65% of the posterior facet through the classic posterolateral portal[1,4]. However, several deformities are found in the arthritic subtalar joint, with pathological inclinations of the posterior facet, hindering access to adequate decortication through the classic portals. Due to this, we proposed a configuration of portals according to the inclination of the posterior subtalar facet. Using a Kirschner wire, it is possible to guide the portals providing an ideal angle to introduce the burr into the joint. The authors believe that the correct orientation of the burr predisposes to a more effective procedure, thereby improving the subtalar joint decortication and reducing surgical time and complication rate.

Percutaneous arthrodesis has limitations and contraindications such as severe hindfoot malalignment, significant bone loss, need for grafting, and a challenging learning curve[2,3,5]. Besides, the technique has some drawbacks, like higher radiation during the procedure and the use of more expensive equipment (burrs). In addition, very sclerotic areas can make

Figure 7. Clinical and radiographic results at six weeks postoperatively.

the homogeneous decortication procedure and the proper positioning of the hindfoot difficult[2]. Severe hindfoot malalignment is a contraindication because to correct the deformity, a huge graft is needed; thus, we do not recommend it.

The discomfort caused by screws was reported as the main complication in 15.5% of the percutaneous cases, similar to other techniques in 17%[3].

Conclusion

The authors presented a perioperative method to guide the configuration of sinus tarsal and posterolateral portals. It provides an ideal angle to introduce the burr into the joint and probably increase its decortication rate. Despite that, further research is needed to compare and understand its applicability in surgical practice.

Authors Contribuition: Each author contributed individually and significantly to the development of this article: conception and design. Material preparation, data collection and analysis were performed by; GAN *(https://orcid.org/0000-0003-4431-5576), and GFF *(https://orcid.org/0000-0001-8032-3077), and ES *(https://orcid.org/0000-0002-6922-5238), and BM *(https://orcid.org/0009-0006-1594-361X), and KAMC *(https://orcid.org/0000-0003-1082-6490), and PFSD *(https://orcid.org/0000-0001-7584-8290) The first draft of the manuscript was written by and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.*ORCID (Open Researcher and Contributor ID).

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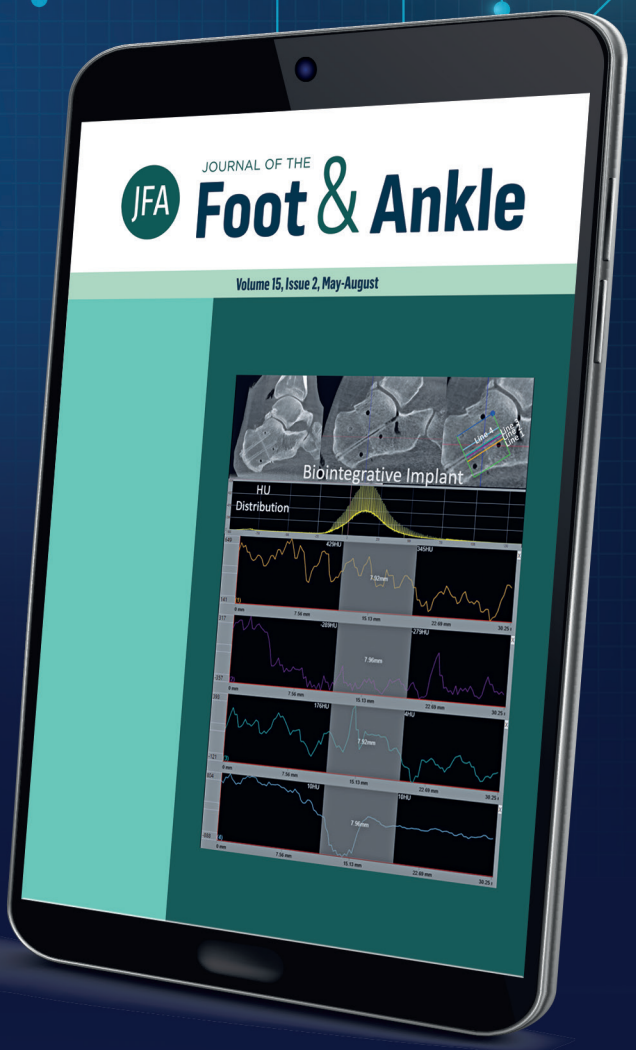

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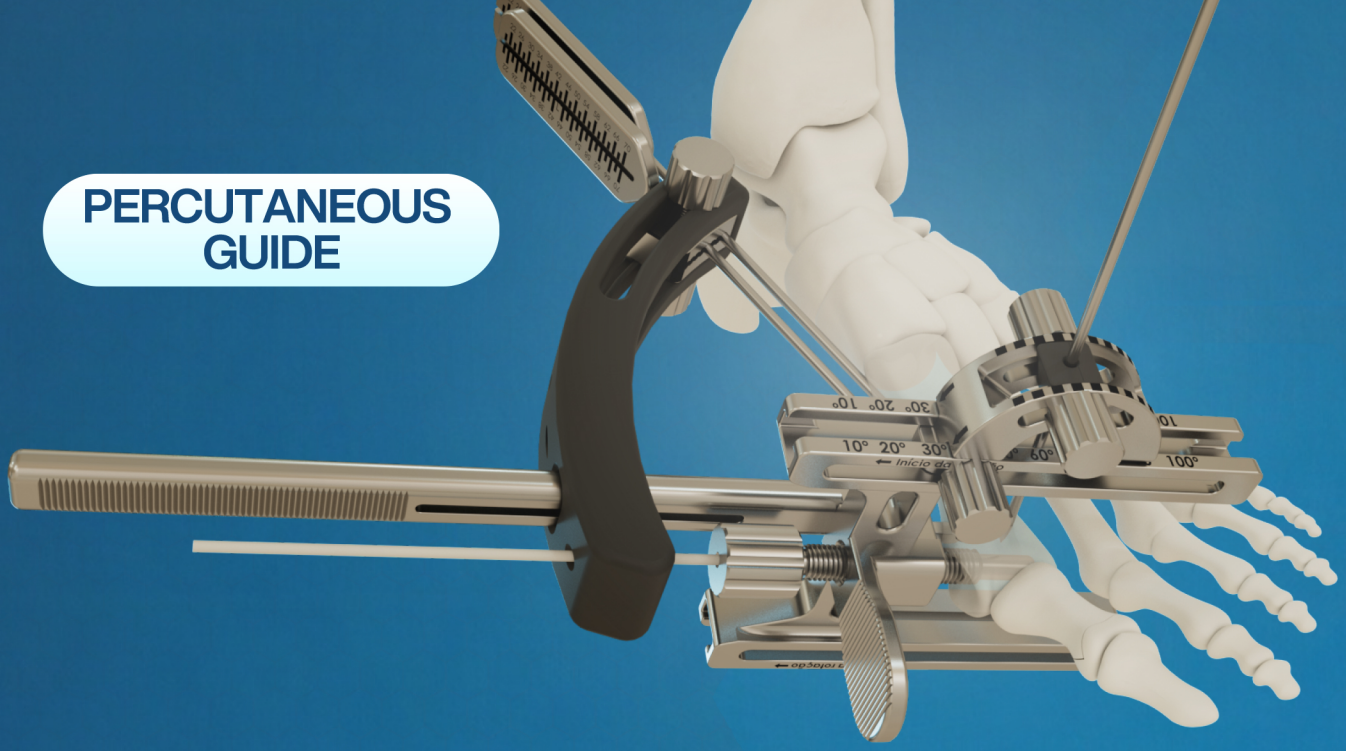

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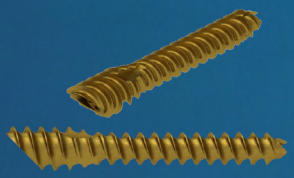

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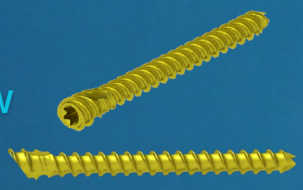

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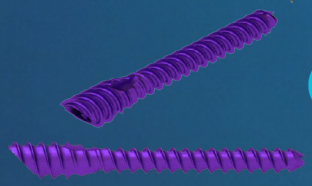

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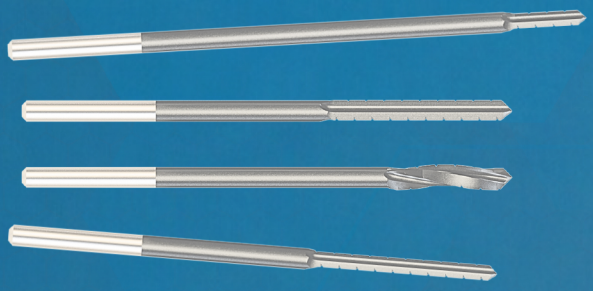

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