DOI: https://doi.org/10.30795/jfootankle.2023.v17.1702

Special Article

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

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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

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How to cite this article: Prata SDS, Mizusaki JM, Ferreira LR. Impact of proximal medial gastrocnemius release in plantar fasciitis: a rapid review. J Foot Ankle. 2023;17(2):88-93.

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).

References

1. Neufeld SK, Cerrato R. Plantar fasciitis: evaluation and treatment. J Am Acad Orthop Surg. 2008;16(6):338-46.
2. Aronow MS, Diaz-Doran V, Sullivan RJ, Adams DJ. The effect of triceps surae contracture force on plantar foot pressure distribution. Foot Ankle Int. 2006;27(1):43-52.
3. Boyle RA, Slater GL. Endoscopic plantar fascia release: a case series. Foot Ankle Int. 2003;24(2):176-9.
4. Riddle DL, Pulisic M, Pidcoe P, Johnson RE. Risk factors for plantar fasciitis: a matched case-control study. J Bone Joint Surg Am. 2003;85(5):872-7.
5. Abbassian A, Kohls-Gatzoulis J, Solan MC. Proximal medial gastrocnemius release in the treatment of recalcitrant plantar fasciitis. Foot Ankle Int. 2012;33(1):14-9.
6. Riddle DL, Schappert SM. Volume of ambulatory care visits and patterns of care for patients diagnosed with plantar fasciitis: a national study of medical doctors. Foot Ankle Int. 2004;25(5):303-10.
7. Crawford F, Thomson C. Interventions for treating plantar heel pain. Cochrane Database Syst Rev. 2003;(3):CD000416.
8. Patel A, DiGiovanni B. Association between plantar fasciitis

and isolated contracture of the gastrocnemius. Foot Ankle Int. 2011;32(1):5-8.
9. Pascual-Huerta J. The effect of the gastrocnemius on the plantar fascia. Foot Ankle Clin. 2014;19(4):701-18.
10. Hedrick MR. The plantar aponeurosis. Foot Ankle Int. 1996; 17(10):646-9.
11. Barouk LS, Barouk P. Gastrocnemius tightness. From anatomy to treatment. Montpellier, France: Sauramps Medical; 2012.
12. Toomey EP. Plantar heel pain. Foot Ankle Clin. 2009;14(2):229-45.
13. Silfverskiöld N. Reduction of the uncrossed two-joint muscles of the leg to one joint muscles in spastic conditions. Acta Chir Scand. 1924;56:315-30.
14. Colombier JA. Liberation proximale pure dans la prise en charge therapeutique des gastrocnemiens. Med Chir Pied. 2006;22:156-7. (Presented at Courts Symposium Brieveté des Gastrocnemiens, Journées de Printemps SFMCP-AFCP, Toulouse, 2006).
15. Barouk P. Technique, indications, and results of proximal medial gastrocnemius lengthening. Foot Ankle Clin. 2014;19(4):795-806.
16. Sinnaeve F, Vandeputte G. Clinical outcome of surgical intervention for recalcitrant infero-medial heel pain. Acta Orthop Belg. 2008;74(4):483-8.
17. Sammarco GJ, Helfrey RB. Surgical treatment of recalcitrant plantar fasciitis. Foot Ankle Int. 1996;17(9):520-6.
18. Davies MS, Weiss GA, Saxby TS. Plantar fasciitis: how successful is surgical intervention? Foot Ankle Int. 1999;20(12):803-7.
19. Herzenberg JE, Lamm BM, Corwin C, Sekel J. Isolated recession of the gastrocnemius muscle: the Baumann procedure. Foot Ankle Int. 2007;28(11):1154-9.
20. Strayer LM Jr. Recession of the gastrocnemius; an operation to relieve spastic contracture of the calf muscles. J Bone Joint Surg Am. 1950;32(3):671-6.
21. Pinney SJ, Hansen ST Jr, Sangeorzan BJ. The effect on ankle dorsiflexion of gastrocnemius recession. Foot Ankle Int. 2002;23(1):26-9.
22. Pinney SJ, Sangeorzan BJ, Hansen ST Jr. Surgical anatomy of the gastrocnemius recession (Strayer procedure). Foot Ankle Int. 2004;25(4):247-50.
23. Rush SM, Ford LA, Hamilton GA. Morbidity associated with high gastrocnemius recession: retrospective review of 126 cases. J Foot Ankle Surg. 2006;45(3):156-60.
24. Maskill JD, Bohay DR, Anderson JG. Gastrocnemius recession to treat isolated foot pain. Foot Ankle Int. 2010;31(1):19-23.
25. Hamilton PD, Brown M, Ferguson N, Adebibe M, Maggs J, Solan M. Surgical anatomy of the proximal release of the gastrocnemius: a cadaveric study. Foot Ankle Int. 2009;30(12):1202-6.
26. Segal RL, Song AW. Nonuniform activity of human calf muscles during an exercise task. Arch Phys Med Rehabil. 2005;86(10):2013-7.
27. Strayer LM Jr. Gastrocnemius recession: five year report of cases. J Bone Joint Surg Am 1958;40(5):1019–30.
28. Vulpius O, Stoffel A. Orthopädische operationslehre. Stuttgart: Verlag von Ferdinand Enke; 1924.
29. Rabat E. Allogement endoscopique du gastrocnémien. In: Baudet B, Baudet P, Bonnel F, Colombier JA, Cazeau C, Davies M, et al, editors. Brievete des gastrocnemiens: de l'anatomie au traitement. Montpellier, France: Sauramps Medical; 2012. p. 351-73.
30. Rodineau J. Stratégie therapeutique medicale dans les retractions des triceps suraux. In: Baudet B, Baudet P, Bonnel F, Colombier JA, Cazeau C, Davies M, et al, editors. Brievete des gastrocnemiens: de l'anatomie au traitement. Montpellier: Sauramps Medical; 2012. p. 329-3.
31. Karabay N, Toros T, Hurel C. Ultrasonographic evaluation in plantar fasciitis. J Foot Ankle Surg. 2007;46(6):442-6.
32. Ginés-Cespedosa A, Ugarte IW, Ares-Vidal J, Solano-Lopez A, Adames DB, Gamba C. Clinical and plantar fascial morphologic changes after proximal medial gastrocnemius release treatment of recalcitrant plantar fasciitis. Foot Ankle Orthop. 2021;6(3):24730114211027323.
33. Bicer M, Hocaoglu E, Aksoy S, Inci E, Aktas I. Assessment of the efficacy of extracorporeal shockwave therapy for plantar fasciitis with magnetic resonance imaging findings. J Am Podiatr Med Assoc. 2018;108(2):100-5.
34. Hammer DS, Adam F, Kreutz A, Rupp S, Kohn D, Seil R. Ultrasonographic evaluation at 6-month follow-up of plantar fasciitis after extracorporeal shock wave therapy. Arch Orthop Trauma Surg. 2005;125(1):6-9.
35. Ulusoy A, Cerrahoglu L, Orguc S. Magnetic resonance imaging and clinical outcomes of laser therapy, ultrasound therapy, and extracorporeal shock wave therapy for treatment of plantar fasciitis: a randomized controlled trial. J Foot Ankle Surg. 2017;56(4):762-7.
36. Gamba C, Sala-Pujals A, Perez-Prieto D, Ares-Vidal J, Solano-Lopez A, Gonzalez-Lucena G, et al. Relationship of plantar fascia thickness and preoperative pain, function, and quality of life in recalcitrant plantar fasciitis. Foot Ankle Int. 2018;39(8):930-4.
37. Lemont H, Ammirati KM, Usen N. Plantar fasciitis: a degenerative process (fasciosis) without inflammation. J Am Pod Med Assoc. 2003;93(3):234-7.
38. Miller LE, Latt DL. Chronic plantar fasciitis is mediated by local hemodynamics: implications for emerging therapies. N Am J Med Sci. 2015;7(1):1-5.
39. Maki M, Ikoma K, Kido M, Hara Y, Sawada K, Ohashi S, et al. Magnetic resonance imaging findings of chronic plantar fasciitis before and after extracorporeal shock wave therapy. Foot (Edinb). 2017;33:25-28.
40. Manzi G, Bernasconi A, Lopez J, Brilhault J. Ankle dorsiflexion after isolated medial versus complete proximal gastrocnemius recession: A cadaveric study. Foot (Edinb). 2021;49:101842.
41. Gamba C, Serrano-Chinchilla P, Ares-Vidal J, Solano-Lopez A, Gonzalez-Lucena G, Ginés-Cespedosa A. proximal medial gastrocnemius release versus open plantar fasciotomy for the surgical treatment in recalcitrant plantar fasciitis. Foot Ankle Int. 2020;41(3):267-74.
42. Villanueva M, Iborra A, Ruiz MDM, Sanz-Ruiz P. Proximal ultrasound-guided gastrocnemius recession: a new ultra-minimally invasive surgical technique. J Foot Ankle Surg. 2019;58(5):870-6.
43. Iborra A, Villanueva MJ, Barrett SL. Ultrasound-guided plantar fascia release with needle: a novel surgical technique. Open J Orthop. 2016;6(7):159-70.
44. Rojo-Manaute JM, Capa-Grasa A, Rodríguez-Maruri GE, Moran LM, Villanueva Martínez M, Vaquero Martín J. Ultra-minimally invasive sonographically guided carpal tunnel release anatomic study of a new technique. J Ultrasound Med. 2013;32(1):131-42.
45. Monteagudo M, Maceira E, Garcia-Virto V, Canosa R. Chronic plantar fasciitis: plantar fasciotomy versus gastrocnemius recession. Int Orthop. 2013;37(9):1845-50.
46. Brugh AM, Fallat LM, Savoy-Moore RT. Lateral column symptomatology following plantar fascial release: a prospective study. J Foot Ankle Surg. 2002;41(6):365-71.
47. Gamba C, Gomez CA, Zaragoza JM, Alexandre CL, Adames DB, Ginés-Cespedosa A. Proximal medial gastrocnemius release: surgical technique. JBJS Essent Surg Tech. 2022;12(1):e20.00039.