CHAPTER **29**

PLANTAR FIBROMATOSIS: Treatment Considerations

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DISEASE DEFINITION

The term fibromatosis is used to represent a wide array of locally infiltrative disorders that are characterized by abnormal hyperplasia of fibrous tissue. Plantar fibromatosis, specifically, is distinguished by replacement of the plantar aponeurosis with abnormal fibrous tissue which slowly invades the skin and the deep structures. They are characterized by slow growing, nodular, indurated lesions of variable size and shape. Although rare, contracture of the second toe may be seen if the fibroma enters the flexor tendon sheath.[1-7] The topic of plantar fibromatosis was addressed by Dr. Mahan in previous PI updates where he discussed the etiology, diagnosis, conservative and surgical management.[8] Our goal is to present an update on the pathogenesis, imaging and treatment of this lesion

HISTORICAL OVERVIEW

Baron Guillaume Dupuytren (1777-1835), a French surgeon, described an "affliction" of the palmar aponeurosis in 1831 that has a propensity to affect the ring and little fingers with a flexion contracture that is often disabling. Dupuytren's disease is the equivalent to its counterpart, the plantar fibroma, which is also referred to as Ledderhose's disease. The disease is named after Georg Ledderhose (1855-1925), a German surgeon who described the condition arising in the foot for the first time in 1897. The histological findings between Dupuytren's and Ledderhose are similar which suggests a common etiology.[4]

ETIOLOGY

The exact mechanism for the formation of plantar fibromas remains unknown. Repeated trauma, long-term alcohol consumption, chronic liver disease, diabetes, and epilepsy have been reported in association with the development of the lesion (Table 1). These factors are recognized as contributors to the pathology rather than the cause of it. Skoog, for example, hypothesized that trauma encouraged scar formation and contracture, thereby contributing to the pathology.[9] The formation of plantar fibromatosis is described in phases. Meyerding and Sheltito[10] described the initial two phases, and the third phase was later added by Luck[11] in 1959 (Table 2). The first phase, the proliferative phase, is characterized by increased fibroblastic activity and cellular proliferation. This is followed by the involutional (active) phase, whereby nodule formation occurs. De Palma et al performed a histochemical, immunohistochemical and ultrastructural study of the nodule, where they found cells with typical features of smooth-muscle cells, called myofibroblasts.[9] It is not clear whether these myofibroblasts are altered fibroblasts of the normal aponeurosis or belong to a subpopulation of

Table 1

ETIOLOGY OF PLANTAR FIBROMA

- Hereditary
- Repetitive trauma
- Long-term alcohol consumption
- Chronic liver disease
- Diabetes mellitus
- Epilepsy

Table 2

PHASES OF FIBROMA FORMATION

Phase	Process
Proliferation	Increased fibroblastic activity and cellular proliferation
Involution	Nodule formation, histological presence of fibroblasts
Residual	Reduction of myofibroblast and fibroblasts and formation of scar tissue

Figure 1. Clinical presentation of a solitary plantar fibroma.

mesenchymal cells with no relation to smooth-muscle cells. The myofibroblasts, regardless of origin, are capable of contractile activity and play a central role in the pathogenesis of the contraction of the plantar aponeurosis.[9-11] The third phase is the residual (maturation) phase where the activity of fibroblasts is reduced and there is maturation of collagen tissue and scar contracture. In the final stage where the disease is inactive, the myofibroblasts and fibroblasts recede and type III collagen, which resembles scar tissue, is more prevalent than type I collagen. There is no timeline for the progression from one phase to the next, but rather, the phases provide a histological description of existing cells and their transformation and contribution to the contraction of the plantar aponeurosis.

CLINICAL PRESENTATION

Plantar fibromatosis can present as an isolated fibroma (Figure 1), desmoplastic fibroma, juvenile aponeurotic fibroma, or generalized fibromatosis.[12] It can have a unilateral or bilateral presentation. These lesions are generally asymptomatic; however, common complaints include the feeling of a mass, difficulty with shoe gear, and pain. When pain is present, it is important to distinguish if there is a neurological basis to it. Lesions with nerve impingement can elicit dysesthesias that can be localized within a dermatomal pattern.[13] The literature varies in regards to bilateral presentation, distribution by sex, age of onset, and presentation with other associated fibrosing diseases.

DIFFERENTIAL DIAGNOSIS

Plantar fibromatosis are usually self-evident; however, presence of a soft tissue mass in the plantar foot warrants exclusion of other soft tissue lesions that can mimic a plantar fibroma.[14,15] Benign lesions included in the differential are inclusion cysts, ganglionic cysts, rheumatoid nodules, pyogenic granuloma and in some instances tophaceous gout (Table 3). Malignant differentials are fibrous histiocytoma, giant cell tumor, synovial cell sarcoma, and leiomyosarcoma.[16-18] One other disease to be aware of is neurofibromatosis, which results in multiple fibromatous nodules. Ultimately, differentiation of the lesion in regards to malignancy dictates the conservative and surgical management of the lesion.

DIAGNOSTIC IMAGING

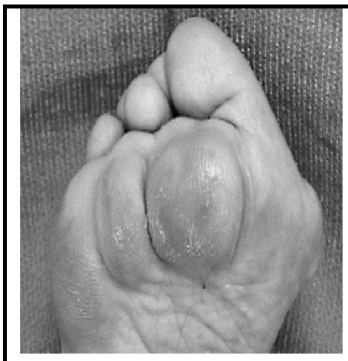
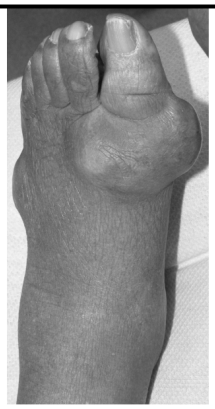
Conventional radiographs and bone scans generally are not helpful in the diagnosis and surgical planning for plantar fibromatosis. Sonography can provide the clinicians with an assessment of the depth of the lesion;[19] however, MRI is considered the gold standard in diagnostic imaging of plantar fibromatosis. This modality provides information in regard to the location and extent of involvement. Morrison et al performed MRI evaluation of sixteen patients (19 feet) to define the MRI characteristics of plantar fibromatosis.[20] They concluded in their study that with the exception of clear cell sarcoma, the location and unique signal intensity allows for the diagnosis of plantar fibromatosis with reasonable confidence by MRI alone. The high content of collagen in plantar fibromas yields low signal intensity with nodular thickening on T1-weighted images (Figure 2). On T2-weighted images, the lesion demonstrates low or medium signal intensity. It must be noted that a more aggressive lesion can demonstrate high and low-signal-intensity areas within the mass itself. Other indicators of aggressive behavior include poor margination, non-homogeneity, and invasion of bone. These characteristics make it difficult to distinguish between an aggressive fibroma and a malignant process on magnetic resonance imaging. Intravenous contrast can provide enhancement in the early phases of plantar fibromatosis, but is of limited value in the maturation phase.[19-25]

CONSERVATIVE TREATMENT

Nonoperative treatment of plantar fibromatosis is the basis of management for this disease. This lesion is frequently asymptomatic and responds well to conservative therapy including shoe gear modification, NSAIDs, intra-lesional

Table 3

Differential Diagnoses

				
Rheumatoid nodule	Gout	Pyogenic granuloma	Plantar fibroma	Inclusion cyst

injections, physical therapy, night splints, and chemotherapy. Radiotherapy is currently under study in the European medical literature for isolated treatment of plantar fibromatosis and sometimes in conjunction with surgical excision. Isolated radiotherapy treatment with a one year follow-up exhibited potential for regression of nodules, cords and symptoms, however, confirmation of these results with a 5 year follow-up and phase-III studies are pending. Utilization of this therapy along with surgical excision produced good results in terms of decreasing recurrence; however, significant functional side effects were reported.[26-28]

SURGICAL TREATMENT

The primary indication for surgical intervention is failure of conservative therapy to relieve pain. Other factors to consider in the surgical management are difficulty with shoe gear, contracture deformity, altered function, degree of aggressiveness, and obtaining a definitive diagnosis. Operative management includes local excision, wide excision, and subtotal fasciectomy with or without skin grafting. There is a high incidence of recurrence after local and wide excision, with the lowest risk associated with a subtotal fasciectomy (Table 4). Local excision carries a 57-100% recurrence rate, wide excision (Figure 3) a recurrence rate of 8% to 20% rate, and subtotal fasciectomy a 9.5% recurrence rate.

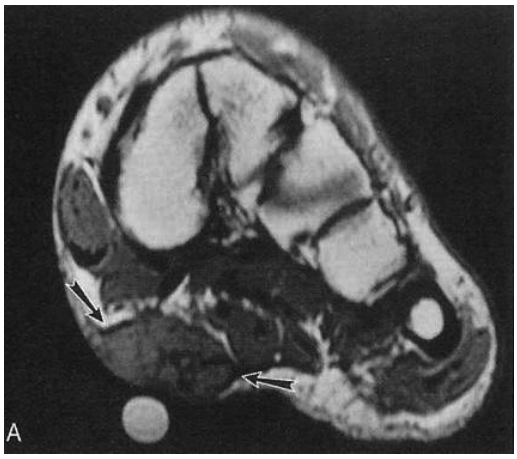


Figure 2. T1-weighted magnetic resonance image depicting a plantar fibroma.

Sammarco and Mangone performed a retrospective study with 18 patients for a total of 23 feet utilizing the subtotal plantar fasciectomy technique. An operative staging system consisting of four stages was devised to allow the surgeon to predict patients that will experience delayed wound healing and possible need for skin grafting. Stage I is a focal disease isolated to the medial and or central aspect of the plantar fascia without adhesion to the skin or deep extension to the flexor sheath. Stage II is multifocal lesions with or without proximal or distal extension without

Figure 3. Intra-operative picture of a wide-excision of a plantar fibroma.

Figure 4. Intra-operative picture that demonstrates adherence of the fibroma to the overlying skin (Stage III).

Table 4

A LITERATURE REVIEW OF SURGICAL TREATMENT FOR PLANTAR FIBROMA.

Author	Patient Population	Review	Outcomes	Conclusions
Oster & Miller 1986, JFAS	26 patients 17 females 9 males	1/17 (5.8% recurrence) w/ fasciectomy & Marlex mesh interposition	4/14 (26.6%) recurrence w/ simple local resection	Recurrence can be reduced by utilizing marlex mesh
Wapner et al 1995, FAI	10 patients; 11 feet 5 Primary / 7 Revision	1/5 (20%) Recurrence in Primary group 2/7 (28%) Recurrence in Revision group		Primary complication – Postop neuroma
Aluisio et al 1996, FAI	30 patients; 33 patients	17 Primary Excisions 4/10 (40%) Recurrence w/ Local Excision 1/3 (33%) Recurrence w/Wide Excision 2/4 (50%) Recurrent w/Subtotal Fasciectomy	16 + 5 Revision Excisions ¾ (75%) Recurrence w/ Local/Wide Excision 4/17(24%) Recurrence w/ Subtotal Fasciectomy	
Sammarco & Mangone 2000, FAI	18 patients; 23 feet	18 Primary; 5 Recurrent	2/23 (9%) Recurrence	
Griffith et al 2002, AJR	19 feet; 25 nodules 36% B/L	60% medial band; 40% central band		no correlation between sonographic findings, clinical symptoms or clinical outcome
Durr et al 1999 FAI	11 patients; 13 feet; 24 operations 13 Primary; 11 Revision	6/7 (85%) Recurrence w/ Local Excision 7/9 (78%) Recurrence w/ Wide Excision 3/8 (38%) Recurrence w/ Fasciectomy (0/2 Primary Excisions)		

adherence to the skin or deep extension to the flexor sheath. Stage III is a multifocal disease with or without proximal or distal extension and with either adherence to the skin or deep extension to the flexor sheath (Figure 4). Stage IV is a multifocal disease with or without proximal or distal extension and with adherence to the skin and deep extension to the flexor tendon. In Stage III and IV lesions, the surgeon can expect a 50% rate of significant skin necrosis, with 50% of stage IV patients requiring additional skin grafting procedures.[5,15,26,29-35] Table 4 shows a review of literature on surgical treatment.

Incisional Approach

Incisional approach is given its own section because of the complexity in deciding which approach to use. The goal of incision planning is to provide excellent exposure while leaving a more aesthetic scar, maintaining epicritic sensation, and retaining functional status. Prior to discussing the various incisions for exposure of the plantar fascia, a review of the anatomy is warranted.

The plantar skin is thick, greatly keratinized, hairless, and filled with a dense collection of sweat glands. Fibrous septae from the plantar fascia adhere to the plantar skin. Incisions along the relaxed skin tension lines, which are parallel to collagen bundles and perpendicular to muscle contraction, offer the best cosmetic result with the most narrow and strongest scar line. This concept is best utilized in facial incision planning and is difficult to perform in the plantar foot when excising large soft tissue lesions. Plantar skin incisions were fraught with complications as described in early literature. Older texts advocated high medial plantar incisions, which subsequently developed into severe postoperative wounds and led to the misconception that plantar incisions are destined for complications.

Curtin's work with infrared photography allowed for the visualization of the superficial vascular pattern of the foot.[30] It was noted that high medial incisions disrupted the delicate arterial supply to the plantar foot and led to early complications. Further investigation by Hidalgo's cadaveric injection studies revealed that the arterial supply to the plantar foot relies on anastomosing arterial supply from the dorsalis pedis and the anterior perforating peroneal artery, not solely from the posterior tibial artery and its branches.[36] Hidalgo described four zones of plantar arterial supply (Table 5). The first zone, the plantar proximal region, is supplied by the dorsalis pedis and lateral plantar artery. The second zone is the midplantar region and is supplied by multiple sources and termed the watershed area. The third zone is the lateral plantar foot and is supplied by the dorsalis pedis and lateral plantar arteries. The fourth zone is the distal foot which is supplied by the dorsalis pedis, the lateral plantar artery, and the medial plantar artery.

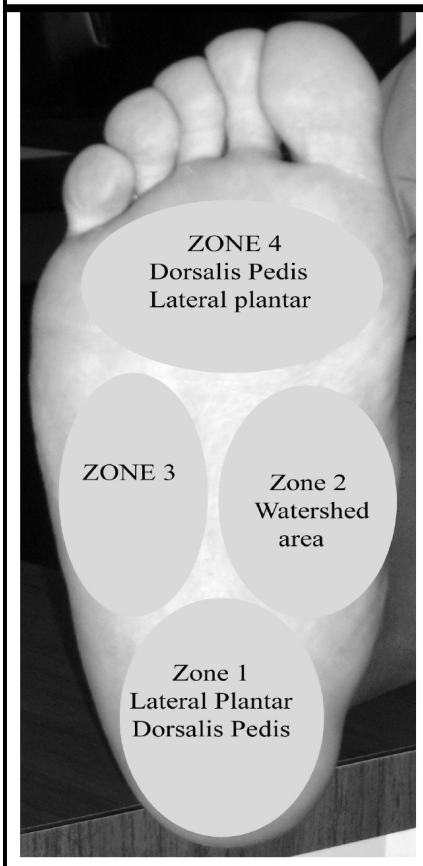
Attinger's work in plantar incision planning is based on identifying the angiosomes supplying the area.[37] Angiosomes are areas of skin that are supplied by a particular artery or arteries. The plantar foot is generally supplied by the branches of the posterior tibial artery and peroneal artery. The posterior tibial artery branches as it enters the plantar foot into medial and lateral plantar arteries. The medial plantar artery's angiosome, from medial to lateral, is the central aspect of the plantar midfoot to just dorsal to the glabrous junction. From proximal to distal it is the posterior aspect of the midfoot, plantarly, and the medial edge of the anterior heel. This area is consistent with the medial longitudinal arch. The lateral plantar artery's angiosome, from medial to lateral, is from the central aspect of the plantar midfoot to the lateral glabrous junction. From distal to proximal, the boundary is the lateral plantar heel anteriorly to the entire plantar forefoot, including the digits. The plantar hallux may not only be supplied by the angiosome of the lateral plantar artery, but in some cases, the angiosome of the medial plantar artery or the first dorsal metatarsal artery. The plantar lateral heel is supplied by the angiosomes of the lateral calcaneal artery and the medial calcaneal artery. The lateral calcaneal artery supplies the area from the medial plantar-dorsal skin junction to the lateral malleolus and extending from the posterior heel to the proximal fifth metatarsal. The angiosome of the medial calcaneal artery is from the medial heel, posteriorly to the lateral glabrous junction and extends to the distal aspect of the plantar heel. The medial and lateral calcaneal arteries have an overlapping angiosome, meaning the plantar heel is a highly vascular area.

With angiosomes in mind, there are a number of plantar incisions to consider. The most common angiosomes encountered with plantar fibroma incisions are those arising from the medial and lateral plantar arteries. The safest incision is a straight longitudinal incision at the midline of the plantar foot. This type of incision is the least likely to violate any neurovascular bundles. A Z-shaped, or a 'Lazy S' incision may be utilized and should be made from distal-medial to proximal-lateral (Table 6). With these incisions, the distal two arms follow the described boundary of the medial plantar artery angiosome. A curvilinear incision may also be made with its convexity lateral (Figure 5).

Other incision types include a 'V' incision with the apex laterally (Figure 6), and multiple 'Z' incisions (Figure 7). All these incisions include both medial and lateral plantar artery angiosomes and have a high vascular supply. With the longitudinal and curvilinear incisions there is a limitation in exposure, although, the curvilinear allows

Table 5

Zones of Plantar Subcutaneous Blood Supply[32]



Zone 1: is the proximal plantar area extending from the proximal calcaneus to the middle distance from the proximal metatarsal heads. This area contains an extensive subcutaneous plexus in a medial to lateral orientation supplied primarily by the dorsalis pedis and lateral plantar artery with small contributions from the medial plantar, posterior tibial, and peroneal arteries.

Zone 2: distal 2/3 of the plantar fascia, described as the watershed area secondary to the blood supply from multiple areas. Contribution of blood supply from the muscle and fascia are minor and not essential for survival of the skin.

Zone 3: Middle 1/3 lateral to plantar fascia supplied by dorsalis pedis and lateral plantar arteries.

Zone 4: Distal to the plantar fascia supplied by the deep plantar artery and lateral plantar artery and a small branch of the medial plantar artery.

more than the longitudinal. With the lazy 'S' or Z-shaped incision, there would be plenty of exposure to assess the extent of the fibroma(s) and adequate blood supply (Table 7).

Surgical Pearls

It is paramount that a proper preoperative workup be performed. While the patient is in the holding area, a skin marker may be used to draw out the margins for excision (Figure 8). This gives insight into which incision to use. Also, a hand-held Doppler may be utilized to evaluate the course of the medial plantar artery (Figure 9). This is important in aiding the identification of the neurovascular bundle when performing wide excision.

Once an incision type is chosen, a #15 blade is used to make the incision. After the incision is made, blunt dissection is performed in order to preserve and raise the subcutaneous tissue with the flap. This may prove to be challenging because the majority of these fibromas are partially adhered to the skin, however, this is necessary in order to maintain adequate vascular supply to the flap. Once the flap is raised, the plantar fascia and the fibroma are readily identifiable. At this point dissection may be carried out medially with care so as not to violate the medial plantar neurovascular bundle (Figure 10). When dissecting medially, you will see perineural fat indicating the neurovascular bundle is in close proximity (Figure 11). Medial dissection is carried out to the medial extent of the plantar fascia, and then dissection is carried out laterally until a 2 cm margin is obtained. A 2 cm margin is also recommended distally and proximally.

Careful dissection of the fascia from the underlying muscle belly should be performed in order to prevent excessive bleeding and possible hematoma formation (Figure 12). The fascia and fibroma are removed from the field (Figure 13) and sent for pathologic examination. At this point, if a tourniquet is used, it should be deflated to ensure hemostasis. If a large lesion is excised then a drain may be inserted to aid in the prevention of hematoma

Table 6

			
Relaxed skin tension lines	Central incision	Lazy S incision	Z incision
Incision made parallel to RSTL	Safest incision Least likely to violate neurovascular structures	Convex of the incision is lateral	Raises a medial flap in Zone 2 with excellent blood supply that does not relay on muscle for blood supply.
RSTL on plantar foot are transverse, the exposure needed for excision of lesion is longitudinal	Limited exposure	Provides better exposure	Care must be taken to reapproximate the apex

formation. Copious amounts of saline are then used to flush the wound and a few retention sutures may be placed in the subcutaneous tissue. The skin is then closed in horizontal mattress fashion. The area is covered with a well padded dry sterile dressing.

Postoperative Care

Post surgical care consists of the application of a Jones compression dressing to control postoperative edema. The patient is then nonweightbearing for the initial 3 to 4 weeks. Suture removal commences at the 3 week period and the patient is encouraged to wear compression stockings for a period of one year. We recommend fitting the patient with custom shock absorbing orthotics. Periodic monitoring for recurrence is suggested considering the documented recurrence rate with this lesion.

Complications

Postoperative complications are similar to other lower extremity complications such as; infection, hypertrophic scarring, nerve damage, RSD, DVT and PE. One complication reported frequently with plantar fibroma excision is the high rate of recurrence. As described before, utilizing a subtotal fasciectomy will decrease the recurrence rate. If the subtotal fasciectomy technique is utilized, the Windlass mechanism is disrupted and therefore, the structural integrity of the foot is changed radiographically, however, this is usually asymptomatic. Another common complication is necrosis of the incision flap (Figure 14). This complication is secondary to either inadequate blood supply or stripping of the subcutaneous tissue from the plantar skin.

Figure 5. A Curvilinear incision.

Figure 6. A 'V' incision, note the apex is lateral.

Figure 7. Multiple 'Z' incision.

Figure 8. Preoperative demarcation of margins to be excised. Please note there are no marks for the medial and lateral extents as these margins are to be excised at each respective border.

CONCLUSION

Plantar fibromatosis is a benign infiltrative lesion of the plantar fascia that is often asymptomatic. The etiology remains uncertain but advances in histochemical studies provide insight into the role of myofibroblasts and nodular formation of the plantar fascia. When surgical excision is required, detailed surgical planning is critical. Proper presurgical evaluation of the patient including history and type of lesion utilizing MR imaging will help predict the potential postoperative complications. Meticulous dissection and delicate tissue handling is critical to the successful outcome. The clinician must be aware that recurrence is common without aggressive resection.

Table 7

	**Incision Planning:** Majority of lesions are located in the medial and central bands of the plantar fascia. This flap design allows complete access to the lesion while preserving adequate blood supply and sensation to the flap with minimal risk to the surrounding plantar skin. The arrows demonstrate the medial to lateral subcutaneous blood flow in Zone 2. One may start with the 'V' incision and, if exposure is inadequate, move on to complete the 'Z'.

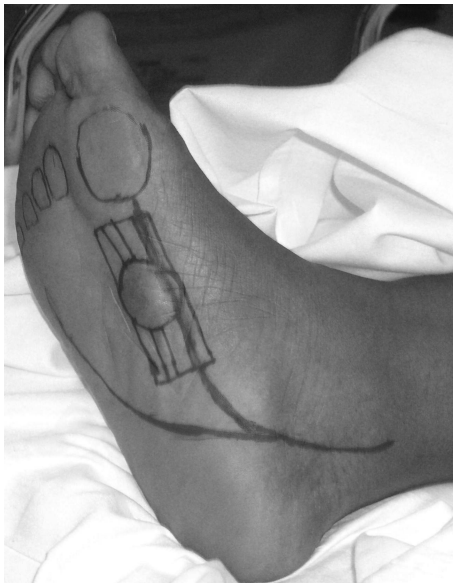


Figure 9. Preoperative evaluation with the medial and lateral plantar arteries marked out. These can be found with a Doppler.

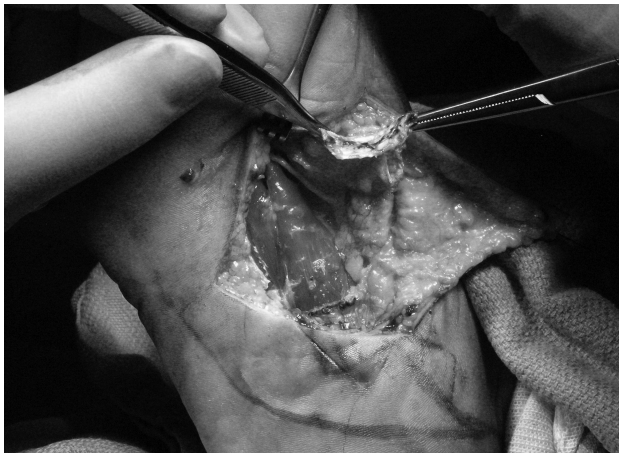


Figure 10. Identification of the medial plantar artery and nerve. This neurovascular bundle can be seen directly medial to the Flexor Digitorum Brevis muscle belly.

Figure 11. The perineural fat can be identified just medial to the Flexor Digitorum Brevis muscle belly. This is an indication of where neurovascular bundle is.

Figure 13. After excision of the fascia and fibroma.

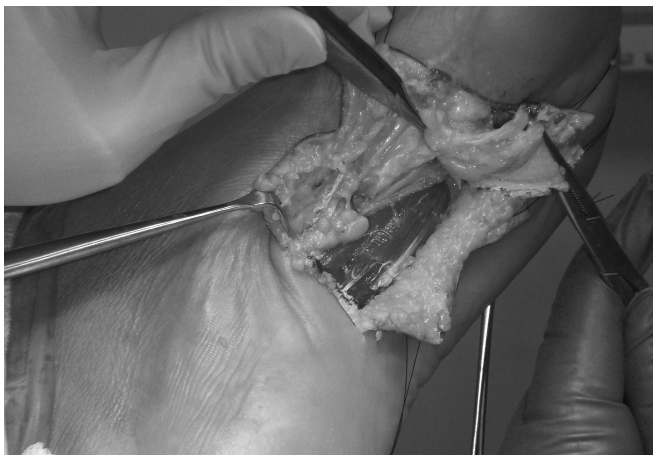


Figure 12. Excision of the plantar fibroma and plantar fascia. Care is taken not to violate the muscle belly.

Figure 14. Necrosis of the incision flap.

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