The Journal of Foot & Ankle Surgery 50 (2011) 504–506

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Tips, Quips, and Pearls

"Tips, Quips, and Pearls" is a special section in The Journal of Foot & Ankle Surgery *which is devoted to the sharing of ideas to make the practice of foot and ankle surgery easier. We invite our readers to share ideas with us in the form of special tips regarding diagnostic or surgical procedures, new devices or modifications of devices for making a surgical procedure a little bit easier, or virtually any other "pearl" that the reader believes will assist the foot and ankle surgeon in providing better care. Please address your tips to: D. Scot Malay, DPM, MSCE, FACFAS, Editor, The Journal of Foot & Ankle Surgery, PO Box 590595, San Francisco, CA 94159-0595; E-mail: editorjfas@gmail.com*

Hallux Varus as Complication of Foot Compartment Syndrome

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ARTICLE INFO

Keywords:
deformity
great toe
metatarsophalangeal joint
surgery
trauma

ABSTRACT

Hallux varus can present as a congenital deformity or it can be acquired secondary to trauma, surgery, or neuromuscular disease. In the present report, we describe the presence of hallux varus as a sequela of calcaneal fracture with entrapment of the medial plantar nerve in the calcaneal tunnel and recommend that clinicians be wary of this when they clinically, and radiographically, evaluate patients after calcaneal fracture.

Compartment syndrome occurs when the tissue pressure within a myofascial compartment becomes elevated, compromising circulation within that compartment. The increase in compartment pressure can result from an increase in the content of a compartment or from a decrease in the volume of the compartment. The detection of foot compartment syndrome must start with clinical suspicion and can be confirmed with tissue pressure measurements. With early recognition, the decrease in blood flow can be transient. The structures within the compartment might not be damaged, or they might only experience reversible damage. Left unchecked, the cycle of increased compartment pressure and tissue ischemia results in permanent tissue damage, deformity, and dysfunction. Nerves sustain irreversible functional damage at 12 to 24 hours of ischemia and muscle at 4 to 12 hours (1). In the lower extremity, unrecognized or untreated compartment syndrome has resulted in the following identified sequelae: claw toes, equinus/equinovarus, cavus, pes planus, calcaneus deformity and/or dropfoot, and abduction and/or eversion.

High-energy trauma, including crush injury, is a common cause of increased compartment pressure and compartment syndrome. The calcaneal fracture has been implicated as a cause of isolated compartment syndrome of the foot (2–4). Manoli and Weber (2) first described the existence of the calcaneal compartment and hypothesized that compartment syndrome of the calcaneal compartment would result in claw toes by contracture of the quadratus plantar muscle. Michelson (3) was the first to describe the finding in a case study. Because the calcaneal compartment is continuous with the deep posterior compartment of the leg, compartment syndrome of the deep compartment of the leg (2) or tibial fractures (5) can also lead to calcaneal compartment syndrome of the foot. However, the calcaneal compartment as a functionally separate compartment within the foot has been argued. In a dye infusion experiment, Guyton et al (6) asserted that there is not a "physiologically significant" boundary between the quadratus plantae and the flexor digitorum brevis. Ling and Kumar (7) described the septum between the flexor digitorum brevis and quadratus plantae as "thin, filmy and often incomplete" in cadaveric specimens.

The ultimate deformity and dysfunction of the foot is determined by the combination of structures involved and the type of damage sustained. Contractures, deformity, weakness, paralysis, and sensory neuropathy are all long-term complications. Contractures and deformity can result from fibrosis and/or muscle group imbalance. Weakness can be caused by nerve damage and dysfunction and/or loss of muscle through fibrosis. Paralysis and sensory loss are caused by direct ischemic nerve damage or by entrapment of the nerves within a fibrotic compartment. These findings are progressive and can worsen for months after the ischemic insult.

Technical Observations

We have observed progressive hallux varus deformity after closed calcaneal fracture in 3 patients. We believe this finding is related to compartment syndrome of the calcaneal compartment and suggest that attention be paid to the clinical and radiographic alignment of the hallux in patients who have sustained a calcaneal fracture.

Financial Disclosure: None reported.
Conflict of Interest: None reported.
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doi:10.1053/j.jfas.2011.04.033

Case Reports

Case 1

A 35-year-old man presented 6 months after closed calcaneal fracture that had been treated nonoperatively with slowly progressive hallux varus. The space between the first and second digit on the right foot was markedly increased compared with the left foot (Figure 1).

Case 2

Our second patient presented 8 months after closed treatment of a nondisplaced calcaneal fracture. As in the first patient, an obvious increase was seen in the space between the first and second digit of the right foot (Figure 2).

Case 3

In our third patient, progressive hallux varus started to occur after a calcaneal fracture 10 years previously. The fracture was treated with immobilization in a cast. The radiograph (Figure 3) showed medial dislocation of the proximal phalanx of the hallux at the metatarsophalangeal joint.

Discussion

In each of the described patients, hallux varus developed over several months after a calcaneal fracture. Two muscles, the abductor hallucis and adductor hallucis, typically control the transverse plane movement of the hallux. We believe the deformity resulted from isolated, unrecognized compartment syndrome with subsequent paralysis of the adductor hallucis muscle and progressive dynamic contracture of the abductor hallucis, pulling the hallux medially. In our literature search, we found no such hallux varus deformity described as a complication of compartment syndrome. The most common cause of hallux varus was correctional surgery for hallux valgus (8).

Our proposed mechanism for this deformity involves an insult to the neurovascular bundle supplying the adductor hallucis muscle. The posterior tibial neurovascular bundle passes through the medial intermuscular septum approximately 4 cm from the posterior limit of the calcaneus (7). The lateral plantar nerve and artery, both of which supply the adductor hallucis muscle, pass through the calcaneal compartment before giving branches to the adductor compartment of the foot. The medial plantar nerve, which supplies the abductor hallucis muscle, might or might not pass through the calcaneal compartment (9). An insult to the neurovascular supply of the adductor hallucis or the adductor muscle itself could occur within the adductor compartment, although ischemic injury would likely involve

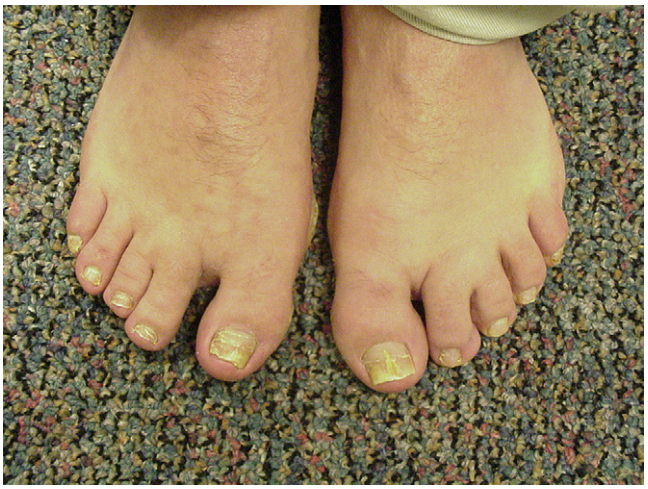

Fig. 1. Patient 1 with hallux varus 6 months after closed calcaneal fracture.

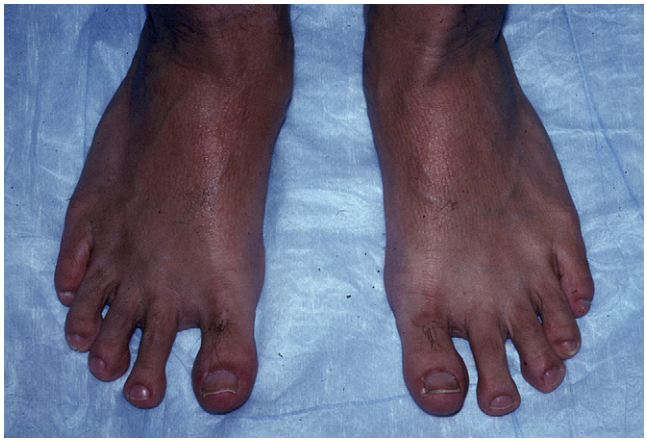

Fig. 2. Patient 2 with hallux varus 8 months after closed calcaneal fracture.

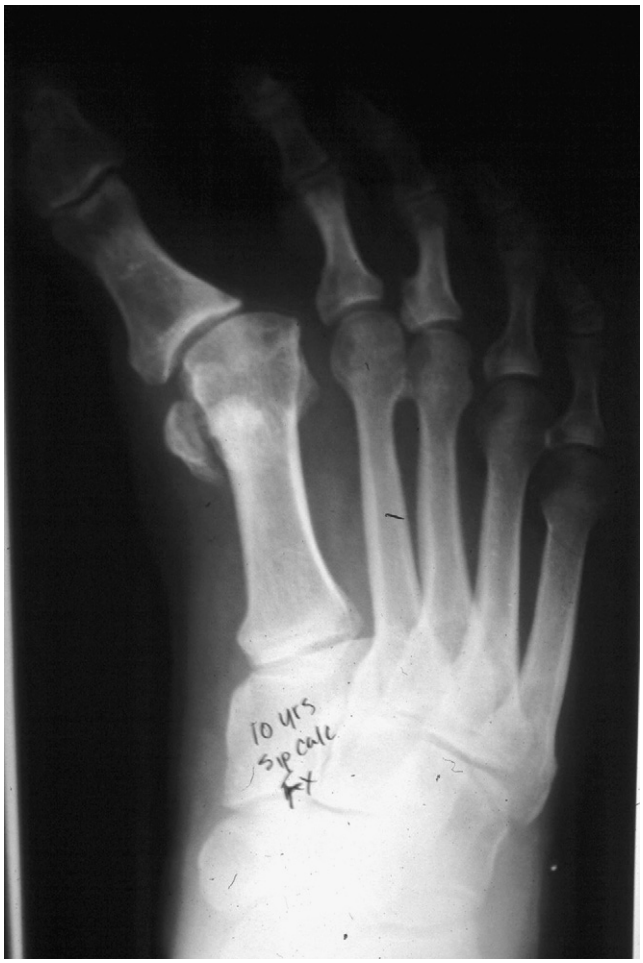

Fig. 3. Radiograph of patient 3 showing hallux varus 10 years after calcaneal fracture.

the muscle before the nerve, causing fibrosis and subsequent contracture of the adductor hallucis muscle.

An alternative mechanism would involve contracture of the abductor hallucis muscle, which lies in the medial compartment. A case of isolated medial compartment syndrome was described by Myerson and Berger (10), although it resulted in only transient paresthesia and loss of muscle function. The other muscle in the medial compartment is the flexor hallucis brevis. If this underwent ischemic contracture, it would cause plantarflexion of the hallux. This did not occur in our 3 patients, suggesting that the compartment syndrome did not involve the medial compartment.

In conclusion, we have presented 3 patients with hallux varus and associated with ischemic paralysis, secondary to unrecognized and untreated compartment syndrome of the foot. Hallux varus has not been previously described as a complication of compartment syndrome.

References

1. Matsen FA. Compartmental syndrome: A unified concept. Clin Orthop Relat Res 113:8–14, 1975.
2. Manoli A II, Weber TG. Fasciotomy of the foot: An anatomical study with special reference to release of the calcaneal compartment. Foot Ankle 10:267–275, 1990.
3. Michelson JD. Isolated compartment syndrome of the calcaneal compartment secondary to minimal incision surgery. Foot Ankle Int 16:162–163, 1995.
4. Andermahr J, Helling HJ, Tsironis K, Rehm KE, Koebke J. Compartment syndrome of the foot. Clin Anat 14:184–189, 2001.
5. Bayer JH, Davies AP, Darrah C, Shepstone L, Patel AD. Calcaneal compartment syndrome after tibial fractures. Foot Ankle Int 22:120–122, 2001.
6. Guyton GP, Shearman CM, Saltzman CL. The compartments of the foot revisited: Rethinking the validity of cadaver infusion experiments. J Bone Joint Surg Br 83:245–249, 2001.
7. Ling ZX, Kumar VP. The myofascial compartments of the foot: A cadaver study. J Bone Joint Surg Br 90:1114–1118, 2008.
8. Donley BG. Acquired hallux varus. Foot Ankle Int 18:586–592, 1997.
9. Fulkerson E, Razi A, Tejwan N. Review: Acute compartment syndrome of the foot. Foot Ankle Int 24:180–187, 2003.
10. Myerson MS, Berger BI. Isolated medial compartment syndrome of the foot: A case report. Foot Ankle Int 17:183–185, 1996.