



Surgical Off-loading of Forefoot Ulcerations

The choice of procedure is etiology-dependent.

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Forefoot ulcerations in a patient with diabetes can be difficult to manage conservatively. While these wounds are usually multifactorial in etiology, the underlying biomechanical abnormality is often difficult to combat long-term with external off-loading. The musculoskeletal imbalance, secondary to neuropathy, causes bony prominences that can often lead to a recurrence of the wounds unless surgically addressed. This prominence, whether at the distal tuft or the interphalangeal joint of metatarsal phalangeal joint, is caused by the retrograde buckling that occurs due to a lack of the intrinsic muscles and tendons to stabilize the joints. The approach to deformity correction and wound healing in a patient with neuropathy and diabetes should be different than that of a patient with a painful forefoot deformity without wounds or neuropathy.

A focus on off-loading prominent areas while limiting morbidity should take precedence over anatomic radiographic alignment. Internal fixation should be avoided if possible. It poses infection risk and often adds rigidity back to the surgical area. Additionally, ease of post-operative weight-bearing restrictions and incision size can help reduce post-operative complications. All patients with diabetic neuropathy and a deformity should be placed in custom accommodative inserts with extra-depth shoes to prevent the ulcer from occurring in the first place.

While the focus of this article is surgical off-loading, it should be mentioned that without adequate perfusion, infection control and blood glucose regulation, it will be futile to perform any of the procedures that are going to be discussed. Additionally, amputations will often create more predictable and/or functional results for our

Apical Ulcers

Apical ulcerations are unfortunately common among patients with diabetic neuropathy. This can be caused by a static or dynamic contracture of the flexor digitorum longus at the distal interphalangeal joint. Percutaneous release of the FDL is an effective procedure to remove the excess force and

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patients. An open and honest conversation about all surgical options, including amputations, should precede any procedure in this patient population. Timing of these procedures can be difficult. Many patient-specific factors need to be taken into consideration such as the patient's hemoglobin A1C, vascular status, duration of wounds, infection, and failure of conservative modalities.

While the procedures that we are going to discuss are of relatively low morbidity, sometimes local wound care may be the more reasonable alternative if there is reason to believe that specific patients have a high risk of post-procedure complications. Additionally, osteomyelitis is often better served with resection or amputation of the affected bone.

heal the wound (Smith, et al.). The ground-reaction forces go through the distal end of the digit instead of the thicker tuft as anatomically intended. Non-weight-bearing examination can be deceiving so it is important to evaluate the patient's weight-bearing. These ulcerations often cause a firing of the flexor digitorum longus and unmask a contraction deformity which was not appreciable prior to standing. While some may argue the percutaneous release is only effective for flexible deformities it has a benefit even in the non-reducible hammertoe.

This procedure may not restore anatomical alignment of the DIPJ but it will decrease ground-reaction forces through the distal digit. This procedure is performed in the office.

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Rarely is local anesthesia needed as the patients receiving the procedure are neuropathic. After sterilization of the procedure site, an 18 gauge needle can be used to perform the tenotomy.

We recommend having the needle attached to a small syringe because it makes it easier to grip and control. Use one hand to extend the digit, creating bowstringing of the FDL, while the other hand punctures the skin just proximal to the skin fold from the PIPJ on the plantar toe. Using tactical feedback and a sweeping motion, the tendon can easily be cut with immediate release of the contracture felt. A Band-Aid can then be placed; no stitch is necessary. Wounds often heal in a few weeks. If ineffective at healing the ulcer, then arthroplasty or distal symes amputation should be considered.

Lesser Digit Interphalangeal Ulcers

Unlike apical ulcerations, dorsal interphalangeal joint ulcerations are usually caused by shear forces from the osseous prominence rubbing on the toe box of a shoe. Arthroplasty is

specific technique for the arthroplasty is not much different than that of hammertoe surgery in non-neuropathic patients.

We do not recommend any deep stitching for the tendon or the deeper tissue as this can be an environment for contamination or create a suture

heads can be gained by lengthening the Achilles tendon complex by either a percutaneous tendoAchilles (TAL) lengthening or endoscopic gastroc recession (GR).

The Silfverskiöld test gives the provider clinical data to determine if the patient would benefit from

Ulcerations under the metatarsal heads can be difficult to treat conservatively.

abscess from irritation. Also, the extensor tendon can often be exposed to the environment and could serve as a conduit for infection to track proximally into the foot. The extensor tendon is likely going to have to be removed. Often, you need to resect more bone than you would in a non-neuropathic patient due to the fear of destabilizing the digit. That risk does not decrease in the neuropathic patients; it is, however, worth the advantages of complete wound closure.

Lesser Metatarsal Head Ulcerations

Ulcerations under the metatarsal heads can be difficult to treat

either a TAL or GR. The gastroc muscle crosses the subtalar, ankle, and knee joints while the soleus only crosses the subtalar and ankle joints. By flexing the knee, tension is taken off the gastroc and can help determine which muscle is contributing to the equinus. If there is less than 10 degrees of dorsiflexion with the knee both extended and flexed, the patient would benefit from a TAL. If there is only limited dorsiflexion with the knee extended and not flexed, the patient would benefit from a gastroc recession. While the Silfverskiöld test is useful, often the presence of plantar head callus or the wound itself is enough to warrant a posterior lengthening regardless of perceived equinus on examination.

It should be noted that the gastroc recession tends to be the safer operation because there is less post-operative risk than a TAL. The TAL is a more powerful procedure that can lead to over-lengthening, rupture, and calcaneal gait which could lead to a plantar heel ulceration. However, it is well documented in the literature that the TAL is a great option to heal plantar forefoot ulcers, with healing rates as high as 93% and no ulcer recurrence at mean follow-up of 17.3 months (Lin, et al.). The gastroc recession does have a higher recurrence rate of plantar forefoot ulcerations at 16% (Nishimoto, et al.).

There are also several boney procedures that can be done for plantar metatarsal head ulcerations including a Weil osteotomy, dorsal closing wedge osteotomy, or plantar con-

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Unlike apical ulcerations, dorsal interphalangeal joint ulcerations are usually caused by shear forces from the osseous prominence rubbing on the toe box of a shoe. Arthroplasty is preferred over arthrodesis for patients with neuropathy and a history of ulceration.

preferred over arthrodesis for patients with neuropathy and a history of ulceration. It allows for ellipse of the wound at the time of surgery, does not require fusion healing or any internal fixation. While our preference is not to fixate, it should be noted that a study by Kim, et al. showed the safe use of a Kirschner wire across the arthroplasty site, with no proximal tracking of infection. This pin was not placed until all infected tissue and bone were removed. The

conservatively. If infection spreads locally, it can unfortunately subject the patients to a transmetatarsal amputation without a great plantar flap due to presence of a wound. This can then lead to the patient needing a shorter, less functional, amputation. Fortunately, there are a few procedures which can be performed to prevent these wounds from progressing and lead to healing of the ulceration. Reduction in peak plantar pressures across the metatarsal



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dylectomy. While these are excellent procedures to decrease pressure, the diabetic population is more prone to post-operative complications such as wound dehiscence or infection. We recommend utilizing the minimally invasive floating metatarsal head osteotomy. This procedure is done by making a small 3mm incision over the affected metatarsal. Next, utilize a mosquito or curved hemostat for blunt dissection down to bone. Using a Shannon burr, make a perpendicular or short oblique osteotomy in the metatarsal to dorsally displace the metatarsal head. In

had no recurrence at a mean follow up of 26 months (Tamir, et al.). If local wound care and conservative off-loading are not helping to heal a hallux wound, this option should be considered to decompress the hallux and allow for more extension of the metatarsophalangeal joint

Sub-met 1 Ulcerations

The sesamoids can sometimes be an inciting anatomical structure that increases pressure and the chance for a plantar wound in the diabetic patient. In particular, the tibial sesamoid is often larger and

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While a TAL can be beneficial for a plantar hallux wound, sometimes boney work is necessary to heal an ulcer to prevent amputation.

a study, Tamir, et al. looked at 20 cases of this osteotomy in patients with plantar metatarsal head ulcerations. In 17 of the 20 cases, the ulcer fully healed at six weeks. The remaining three showed clinical improvement but not full healing of the ulcer.

Plantar First Ray Ulcerations

Plantar Hallux Ulcerations

While a TAL can be beneficial for a plantar hallux wound, sometimes boney work is necessary to heal an ulcer to prevent amputation. The Keller arthroplasty is an option that should not be overlooked. This procedure is typically used in the elderly population with osteoporotic bone; however, this procedure can be useful in the case of a recurring plantar hallux wound. One study looked at 28 Keller arthroplasties with associated plantar hallux wounds. 78% of the ulcerations recovered in a mean of 3.1 weeks and



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bears more weight during ambulation. While not well documented in the literature, sesamoidectomy should be considered. One study had five

current neuropathic plantar metatarsal head ulcers. 11:78.

² Nishimoto GS, Attinger CE, Cooper PS. Lengthening the Achilles tendon for the treatment of diabetic plantar forefoot ulceration. *Surg Clin C Am* 83 (2003) 707-726.

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⁶ Smith SE, Miller J. The Safety and Effectiveness of Percutaneous Flexor Tenotomy in Healing Neuropathic Apical Toe Ulcers in the Outpatient setting. *Foot and Ankle Specialist* Vol 13 / No. 2 (2019).

While not well documented in the literature, sesamoidectomy should be considered.

patients with plantar tibial sesamoid ulceration and four of the five patients were fully healed at mean time of 15.6 weeks (Peng, et al.). This procedure should be considered when equinus correction, total contact casting, and diligent wound care are not enough to heal the wound. **PM**

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³ Lin SS, Lee TH, Wapner KL. Plantar forefoot ulceration with equinus deformity of the ankle in diabetic patients: the effect of tendo-Achilles lengthening and total contact casting. *Orthopaedics* 1996;19:465-75.

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⁵ Peng J, He JK, Christie M, Robin J, McKissack H, Alexander B, Naranje S, Shah A. Tibial sesamoidectomy: indica-



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