CHAPTER **21**

AVASCULAR NECROSIS FOLLOWING HALLUX RIGIDUS SURGERY: Knowing The Risks

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A variety of surgical procedures are utilized in the treatment of symptomatic hallux rigidus. Both joint sparing and joint destructive procedures have potential risks and consequences. A healthy awareness of the potential risks specific to hallux rigidus surgery should be considered in the surgical planning phase, and tailoring the procedure to each patient based on the desired versus realistic goals should be understood by both physician and patient.

Hallux limitus is a precursor stage to hallux rigidus, which is characterized by end-stage arthritis of the great toe joint. The metatarsal-phalanx-sesamoid (MPS) complex functions as a combined unit to aid in propulsion across the first ray. Arthritis in the first MPS joint leads to pain and limits normal function. With decreasing motion in the first MPS joint, compensation occurs in adjacent joints, primarily the hallux interphalangeal joint, to accommodate the loss of motion. The body's goal is to eliminate motion in an arthritic joint and thereby eliminate pain, however, auto-ankylosis is a rare finding since the underlying subchondral bone plate remains intact, and is a barrier to fusion.

Sesamoid immobility on the plantar surface of this joint complex occurs early in the disease process, which is a response of the flexor hallucis brevis in an effort to stabilize an otherwise unstable first ray. Contracture of the FHB muscle-tendon complex leads to hallux equinus contracture and subsequent metatarsal primus elevatus. Dorsal peripheral osteophytes form as the adjacent articular cartilage is eroded due to the compressive forces on the dorsal part of the joint. Patients often complain of this "dorsal bunion," which is prone to shoe irritation.

Surgical approaches to hallux limitus and hallux rigidus have traditionally leaned toward joint salvage procedures in order to preserve and restore motion in the first MPS joint. Dorsal bone spur resection (cheilectomy) is an accepted and generally successful approach to treating this condition in the short term. Patient satisfaction at 1-year post cheilectomy remains high, however, the underlying biomechanic pathology and ensuing arthritic process continues to progress, leading to recurrent pain and progressive worsening arthritis.

The desire to salvage the first MPS joint with restorative osteotomies is sound in design and intent, however, some joints are not capable of being salvaged and go on to implant arthroplasty or arthrodesis procedures. It is this intermediate phase of deformity that every surgeon struggles to determine an appropriate procedure – the patient whose condition is more severe than a cheilectomy can help, and one whose condition is not bad enough to warrant an implant or arthrodesis.

Myriad osteotomy designs have been proposed to decompress the first MPS joint and restore motion to the joint. Some aim to shorten the first metatarsal, others plantarflex the metatarsal, while most try to do both. Osteotomy designs have been modified to afford better internal fixation so that the patient can bear weight earlier, and perform aggressive physical therapy toward increasing postoperative motion. In addition to metatarsal osteotomy, all procedures address the dorsal bone spurs through resection of the peripheral osteophytes. And herein lies the critical combination of precipitating events that can lead to disaster – avascular necrosis.

An effective cheilectomy requires significant peri-articular soft tissue dissection in order to have adequate access to remove enough bone to be an effective procedure. And some surgeons go a step further and utilize a metatarsal elevator to release the plantar proximal sesamoid-capsular contracture. A subcapitol osteotomy in the neck of the metatarsal to decompress, shorten, and plantarflex the joint now renders the metatarsal head void of soft tissue attachments and blood supply, converting the metatarsal head into an osteochondral graft. Coupled with early and aggressive physical therapy to "get the joint moving" as soon as possible aggravates swelling around the joint and increases venous congestion to the bone, thereby limiting arterial inflow to the bone. The patient is set-up for avascular necrosis.

Advances in internal fixation methods and techniques allow us to rigidly stabilize the osteotomy site, and in most cases the osteotomy will heal with little trouble, as intramedullary blood flow is sufficient to heal the osteotomy site. Distal blood flow to the metatarsal head

and subchondral bone may remain interrupted for a period of time (acute phase). In the subacute phase, blood flow is re-established to the distal portion of the metatarsal distal to the osteotomy. However, since the bone was starved for oxygenated blood, a hyperemic state occurs in the bone, and this increased flow of blood washes away bone mineral content and subsequently the bone becomes weakened and can collapse, leading to destruction of the bone (on both sides of the joint), collapse of the joint space, and end-stage arthritis. Late stage findings are seen clinically and radiographically as remodeled adaptive changes consistent with a severely arthritic joint, and significant shortening of the bony segments can be apparent.

Clinical findings will vary depending on the stage of progression of this condition. Early on, there will be profound swelling, redness, warmth, and pain. These findings may be confused with a deep infection, however, a lack of draining sinus, negative wound or bone cultures, negative bone biopsy, and absence of constitutional and clinical signs of infection (fever, malaise, lymph-adenopathy, increased WBC or ESR count) suggests that infection is not likely the cause.

Due to the concomitant bone hyperemia as is seen following any recent bony surgery, a bone scan or magnetic resonance image (MRI) will be inconclusive to rule out infection. One must be very careful when ordering special studies and requesting specific diagnoses, such as osteomyelitis. If an MRI is ordered on a patient with ongoing avascular necrosis to "rule-out osteomyelitis," the radiologist cannot discern between the 2, so they will invariably read the report as "cannot rule-out osteomyelitis," which is what you asked them to say. If on the other hand you ordered an MRI on this patient and listed "rule-out avascular necrosis" the radiologist would likely report "cannot rule-out avascular necrosis" as well. The prior report that could not conclusively determine that there is not a deep infection often leads the treating physician to unnecessarily seek more aggressive or invasive diagnostic testing such as a bone biopsy and culture (and possibly hardware removal which was not unstable), or upon the fear of a deep infection an infectious disease consult may result in a prolonged course of intravenous antibiotics against a presumptive organism that has never been confirmed via a wound, bone, or blood culture.

Pain, redness, and guarding is often out of proportion to what is normally observed following a distal metatarsal osteotomy, so a diagnosis if RSDS/CRPS may be entertained as well. Early treatment for RSDS/CRPS is important to break the sympathetically-mediated pain cycle, and this includes aggressive physical therapy to mobilize the part. To the contrary, aggressive physical therapy is counter to what early stage avascular necrosis needs. Aggressive mobilization of the surrounding joint further aggravates edema and inflammation and venous congestion, and prevents normalization of arterial flow, thus compounding the already traumatized bone and joint.

Early recognition of avascular necrosis and the lack of solid evidence against infection is critical for initiating the healing process. Immobilization, off-weighting, and gentle compression therapy are critical to allowing normalization of blood flow and preventing bone collapse. Discontinuance of physical therapy is helpful to allow the edema to abate and blood flow to normalize. The author also utilizes ultrasound bone stimulation to accelerate healing throughout this entire process through late stage bone remodeling, although this is an off-label use for these devices. Ultrasound bone stimulation has been proven effective and is Food and Drug Administration approved for the treatment of fresh fractures in addition to delayed and non-unions, so the inference that it can be helpful in treating avascular necrosis is assumed and has been effective in treating this condition by this author.

End-stage arthritis of the first MPS joint is typically treated with joint arthrodesis. Patients with late stage avascular necrosis typically present with aggravated symptoms consistent with degenerative arthritis. In these patients, arthrodesis is the treatment of choice. The decision to fuse the joint in-situ versus lengthening through the joint with bone grafting is an important decision that must be made prior to surgery. One must also assume that there will be additional loss of bone length when performing a fusion on a joint that has remodeled after avascular necrosis. The decision to bone graft and lengthen the fusion site drastically changes the surgical technique, fixation method, and postoperative course. Autograft (autogenous bone) is the desired type of bone graft for these patients, and the author prefers ipsilateral calcaneal bone graft when possible. In instances where there is not enough bone length or quality in the calcaneus, autogenous iliac crest bone graft may be necessary. If the bone can be obtained from the same foot, donor site morbidity is decreased as compared to iliac crest bone grafting, however sural neuritis or nerve entrapment remains a concern both intraoperatively as well as postoperatively.

In-situ arthrodesis of the first MPS joint is similar to fusing an arthritic joint that has not previously undergone a surgical intervention, however, there is typically retained hardware in the distal first metatarsal that may need to be removed to allow placement of new hardware. For these

patients, buried Kirschner wires, screw fixation, or plating with screws are all acceptable forms of fixation. Since these patients do not require bone grafting, postoperative management is similar to any other first MPS joint fusion, in that these patients can be partial weight bearing soon after surgery, and a 5-6 week radiograph following surgery will demonstrate whether or not adequate bony consolidation has occurred to allow normal ambulation and return to regular shoes.

In the patient requiring interpositional bone grafting, the author uses a curvilinear incision between the posterior fibula and Achilles tendon to access the posterolateral body of the calcaneus, carefully retracting the sural nerve and lesser saphenous vein anteriorly. The fusion site is prepared prior to harvesting the bone graft in order to adequately measure and procure the desired/necessary length of bone. The calcaneal donor site is typically not back-filled with allograft bone, however doing so is also acceptable. The author utilizes locking screw/plate technology, and a nonweight-bearing splint or cast is applied at the time of surgery. These patients may require 8-12 weeks of nonweight bearing to ensure bone graft incorporation and consolidation prior to initiating weight bearing, and serial radiographs are taken at any point during the recovery that a change in activity level is anticipated or proposed.

Hallux limitus/rigidus surgery is a complex undertaking with often opposing desires and management principles. Aggressive cheilectomy in combination with periarticular stripping and a distal decompression metatarsal osteotomy can result in vascular compromise.Early range of motion is desirable from a recovery standpoint, however, this can aggravate edema, venous congestion, and arterial bloodflow, resulting in transient avascular necrosis to the distal metatarsal head. Solitary aggressive cheilectomy and early joint mobilization appears to be a safer approach to the less arthritic joint (hallux limitus), while primary arthrodesis should be considered in a joint with immobile sesamoids (hallux rigidus), as both of these options avoids the potential for avascular necrosis. Patients undergoing a cheilectomy should be advised that they will likely need future surgery, such as a fusion, knowing that this is a stop-gap measure to intervene in an ongoing process of arthritis. Implant arthroplasty of the first MPS joint will fail given enough time, so judicious use of these devices should be undertaken knowing the potential need for implant removal and bone graft fusion in the future.

Figure 1. Hallux limitus patient - preoperative, post cheilectomy & osteotomy, and post avascular necrosis with loss of joint space and periarticular bony resorption and cyst formation.

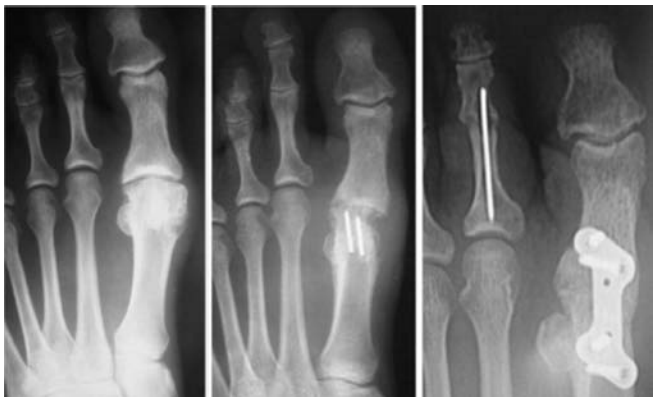

Figure 2. Fifty-two-year-old woman prior to surgery, following decompression osteotomy and cheilectomy demonstrating consolidated and arthritic changes from avascular necrosis, and following first MPS joint arthrodesis.

Figure 3. Sixty-one-year-old man prior to surgery, after decompression osteotomy and cheilectomy showing further degeneration of the joint, and following arthrodesis.

Figure 4. Fifty-seven-year-old woman prior to surgery, after decompression osteotomy and cheilectomy, 8 weeks postoperative with continued pain and swelling, 12 weeks postoperative following hardware removal and negative bone culture & biopsy, 16 weeks postoperative and after 2 rounds of IV antibiotics for presumptive osteomyelitis, and 6 months following surgery having used ultrasound bone stimulation and discontinuance of physical therapy.

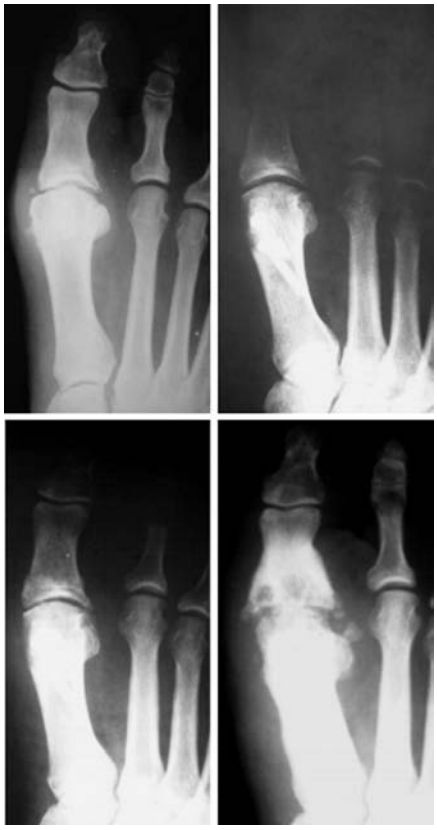

Figure 5. Sixty-three-year-old male patient prior to surgery, 6 weeks following successful osteotomy and cheilectomy healing, 3 months following surgery with continued pain and swelling and further loss of joint space, and 11 months after surgery with avascular necrosis and aggressive joint destruction.

Figure 6. Hallux valgus and arthritis in a 53-year-old diabetic woman prior to surgery, 1 year following implant arthroplasty and bony subsidence with apparent Charcot changes, and 9 months following bone autografting with locking screw/plate fixation.