Roundtable Discussion

Minimally Invasive Surgery

The concept of minimally invasive surgery has gained considerable attention in the past 10 years or so. Once considered a radical departure from well established principles of osteosynthesis, it is practiced widely throughout the world. Historically, in the foot and ankle, minimally invasive surgery was aptly named "minimal incision surgery" dating back to the late 1970s and 1980s. Some would argue that it was not necessarily minimally invasive, but clearly had a robust following, and enabled surgeons to do routine forefoot operations through stab incisions. This symposium will contemporize this topic and highlight the utility of this surgical strategy in the foot and ankle.

What does the concept of minimally invasive surgery mean to you?

Krettek: Minimal soft tissue dissection, especially preservation of periosteum in osteotomies and fracture treatment. Length of skin incision is not the issue.

In the foot and ankle area, sometimes it is better to have a longer incision which avoids pressure of the skin with retractors and other instruments

Ford: The concept is about decreasing the insult to the associated soft tissue and bone in order to allow for an optimal healing environment. In the appropriate circumstances, less dissection and trauma to the blood supply can correlate with quicker healing and less wound complications. But the misconception of minimally invasive surgery always being superior to traditional open approaches is misguided. The arguments regarding the benefits and potential complications of a minimally invasive approach must outweigh those of a traditional open approach. Sacrificing stout fixation and precise anatomic reduction in favor of biologic healing and adequate alignment and stability is obviously advantageous in areas of the foot and ankle that are notorious for delayed union or wound complications.

DiDomenico: It allows one to perform certain surgical procedures for the appropriate patient under given circumstances to optimize the outcome with less morbidity and a quicker recovery for the patient.

Jones: Minimally invasive surgery pertains to reducing the footprint of the surgical approach, fracture reduction, and implant insertion.

What factors help you decide whether to do a particular operation in a minimally invasive manner? If it is less invasive but takes twice as long, is it worth it? Is the additional radiation exposure a significant concern?

Krettek:

- *Factors:* The more a patient is biologically compromised, the more he or she benefits from minimally invasive surgery (MIS), meaning soft tissue preservation and preservation of the periosteum.
- *Time:* No question, it takes longer. But, if it heals better, if you avoid secondary surgery, it's well invested time.

Each issue, we ask different practitioners how they treat a certain condition. This month's topic is minimal incision surgery. In this edition of "Roundtable Discussion," *Foot and Ankle Specialist* has assembled 6 foot and ankle surgeons from around the globe with tremendous experience in minimally invasive techniques. We have surgeons from Hong Kong, Great Britain, France, and the United States who have contributed to this lively exchange about the increasingly important topic of minimally invasive surgery.

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- *Radiation:* For the patient, it is not the problem. It is more a problem for the surgeon and the surgical team. Many C-arm shots are done in an "unreflected" way, not needed/superfluous (centering before you push the button, many things you can see, feel, or indirectly evaluate). And latest generation image intensifiers using digital imaging also help reducing radiation

Ford: The indications and rationale must be sound. Performing MIS in the foot and ankle for the sake of making small incisions is where poor outcomes are more likely to occur. If there is a high risk for complications associated with surgical exposure and visualization, then I would consider a minimally invasive approach. If equal reduction, fixation, and stability can be accomplished with less surgical harm to the adjacent structures through a less invasive approach, then this would also be an indication.

Although longer operating time carries its own risks, in appropriate cases I do not think it is a determining factor if the benefit to risk ratio of biological healing to surgical site complications is worth it. I would argue that a large wound with exposed metal implants in a compromised host may be a greater risk to that patient than a longer operating time.

The additional radiation exposure can be a concern with a proper C-arm, but again this factor must be weighed against the potential benefits of the approach.

DiDomenico: I usually attempt to perform a surgical procedure with a minimally invasive manner when possible as I believe it decreases the post op morbidity, allows for a quicker recovery, is more cosmetically pleasing and probably reduces the risk of complications.

Regarding the time it takes to perform certain procedures percutaneously, the procedures that I perform routinely actually take me much less time to perform. This is probably because I perform procedures such as endoscopic gastrocnemius recession and percutaneous calcaneal displacement osteotomies often and have become efficient with the procedures through small incisions. If it did take me longer, I still believe it would be worth it in foot and ankle surgery as most of the time there are multiple procedures being performed at one time and therefore in my experience it minimizes the complications (ie, edema, stress on the soft tissues, hematoma formation, etc) of multiple surgeries in a given small anatomic region

I typically use intraoperative fluoroscopy with or without minimal invasive techniques and I wear a lead apron, therefore the additional radiation is not a significant concern. Additionally, most of the fluoroscopy use with minimally invasive techniques is used with quick "spot checking."

Jones: Factors pertaining to MIS techniques are patient factors (local trauma, healing potential, smoking, malabsorption, immunocompromised, vascular insufficiency, insulin-dependent diabetes mellitus, compliance), fracture factors (comminuted vs simple fracture, open vs closed, diaphyseal vs metadiaphyseal), and surgeon factors (experience, patience, C-arm availability, 3-dimensional [3D] conception).

Which comorbidities are more likely to sway you toward a minimally invasive approach?

Krettek: Anything which compromises blood perfusion (smoking, vascular diseases, diabetes) or compromises cellular response (immunosuppression, kachexia)

Ford: Tobacco, peripheral vascular disease, diabetes with complications, immunocompromised hosts, chronic venous insufficiency, extensive soft tissue trauma

DiDomenico: Patients who suffer from a damaged or pathological soft tissue envelop. Patients who I believe would possibly have a difficult time healing their soft tissues. Typical patients who fall into this category are patients who suffer from diabetics, rheumatoid arthritis, peripheral vascular disease, posttrauma patients (damaged soft tissue envelop) or previously patients who have had either significant scar tissue or local infection that may have affected the local soft tissues

Jones: Insulin-dependent diabetes mellitus, vascularity, smoking, noncompliance, malabsorption, burns.

Do you think that computer-assisted navigation has a place in foot and ankle reconstructive or traumatic surgery? In what situations would you use it?

Krettek: Computer navigation based on 2D and 3D imaging has a huge potential also for foot and ankle, but we are far from where we would like to be. We use it in ankle fusion and hindfoot corrections to control alignment and support screw placement. Several problems still exist, for example, referencing, reference base placement, instrument deformation, and workflow issues. Industry is not very interested and not very active, unfortunately.

Another interesting field with great potential is the intraoperative use of load measuring platforms. This allows you to analyze intraoperatively the load distribution pattern of the foot and therefore enables the surgeon to control and achieve good functional alignment, for example, in fusions.

Ford: Yes, it is an exciting prospect. Having the ability to 3-dimensionally confirm reduction and implant placement would facilitate even less invasive incisional approaches. Hindfoot reconstruction, certain fractures of the talus and calcaneus, and reduction of the syndesmosis are areas where this could be of huge benefit.

DiDomenico: I have very little knowledge on this issue, but I would think that some day it would possibly have an application for deformity correction and total ankle replacements.

Jones: No. There are no situations in which I would use it.

Would you fix the following injuries with a minimally invasive technique (percutaneous insertion of fixation)?

Figure 1.

Lisfranc 1.

Krettek: The important target is to achieve reduction and maintain it until healing is finished. Reduction is easier in an open way, especially if the fracture is not new.

- *Situation 1:* MIS is possible and would make sense if you are able to check intraoperatively, for example with a 3D C-arm scan and 2D reconstructions, if your reduction is perfect.
- *Situation 2:* MIS would make sense if a perfect reduction is not necessary ((low demander/nonambulatory patient) or not worth the price (wound healing risks)

Ford: Yes. The goal here is to reduce the subluxation anatomically and provide stability to the Lisfranc complex, both of which can be achieved via a minimally invasive technique.

DiDomenico: Given this is in the acute setting—yes, it appears that there is minimal displacement and it would seem that this could be anatomically reduced with closed reduction and percutaneous fixation.

Jones: No.

Is this amenable to MIS?

Figure 2.

Lisfranc 2.

Krettek: Again, the important target is to achieve reduction and maintain it until healing is finished. Reduction is easier in an open way, especially if the fracture is not new. MIS is possible and would make sense if you are able to check intraoperatively, for example, with a 3D C-arm scan and 2D reconstructions, if your reduction is perfect.

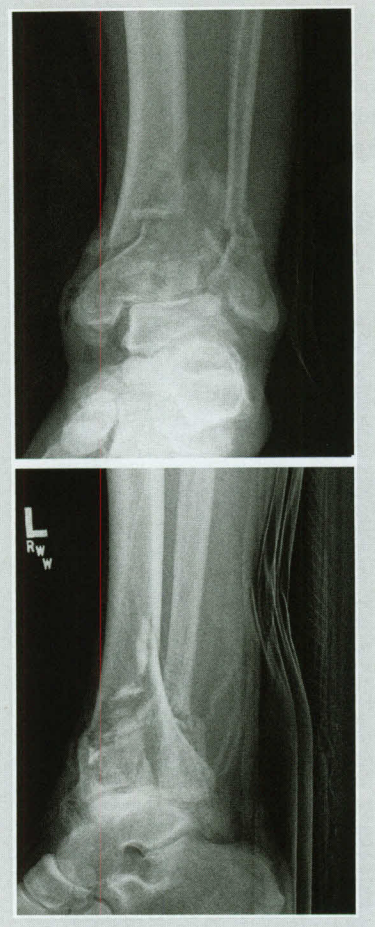
Ford: Most of us would agree that this type of ligamentous injury with frank dislocation is currently best treated with a primary fusion. The potential complications of nonunion and even malunion suggest that good exposure and preparation of the joint surfaces with robust fixation trumps the advantages gained from a minimal approach.

DiDomenico: No, it appears that this patient would need to have a traditional open procedure with debridement and relocation of the entire Lisfranc's joint in order to regain anatomical alignment followed by traditional open reduction internal fixation (ORIF) or a Lisfranc's arthrodesis.

Jones: No.

Figure 3.

Distal tibial fracture 1.



Krettek: The important target is to achieve intra-articular and extra-articular reduction and maintain it until healing is finished. But even if we achieve this, the limiting factor might be cartilage damage. The likelihood of an ankle fusion within 2 years after trauma is high.

A good MIS solution for such a case is the use of external fixation with or

without the modification as an articulated external fixator.

An important aspect for the judgment of these fractures is imaging. A good computed tomography (CT) scan with multiplanar 2D and 3D reconstructions and partial subtractions is essential for understanding and planning MIS.

DiDomenico: Given this is in the acute setting and based on the amount of comminution and patient's age, medical history, and current condition, this patient may be a candidate for external fixation with smooth and olive wire fixation to distract the ankle joint and maintain alignment while keeping the soft tissue envelop intact.

Jones: No for articular surface; yes for diaphysis.

Figure 4.

Distal tibial fracture 2.

Krettek: An important aspect for the judgment of this fractures is imaging. I assume that the fracture is extending into the ankle joint, probably undisplaced.

A good CT scan with multiplanar 2D and 3D reconstructions and partial subtractions is essential for understanding and planning surgery.

There are several ways to fix it:

- *Nail:* extreme indication but possible.

1. Distractor frame or tube-to-tube frame (prox tibia-calcaneus) helpful. Check contralateral tibia rotation before surgery.
2. Would need fibula fixation (short plate) before tibial reduction.
3. Would need to make sure that the probably undisplaced extension into the ankle joint does not get displaced during nail insertion. Therefore, secure the fracture with 2 screws according to preoperative CT scan fracture line orientation. Placement of the screws should be in a way that they do not interfere with the nail insertion.
4. Preparation of the nail corridor in the distal main fragment very close to the ankle joint with a reamer, so when the nail comes in it does not expand the fracture.
5. Nail insertion, as far distal as possible. The distal locking is performed first, using all possible locking options.
6. With slight impaction or backslapping to the nail handle, you can nicely fine tune varus-valgus position and tibia length relative to fibula with C-arm anterior–posterior control, and monitoring for rotation.
7. When you have achieved perfect position . . . proximal locking.

- *Plate:* Preferable locking plate. Due to rigid fixation of the distal tibia, no fibula fixation is required. Insertion of the plate from proximal to distal, not vice versa. Most people go from distal to proximal. Skin over the medial malleoulus is directly over the bone, often compromised from the initial trauma, and additionally iatrogenically compromised during implant insertion, placement, and reduction. Therefore, I insert the plate from a proximal incision of adequate length, in a proximal to distal fashion.

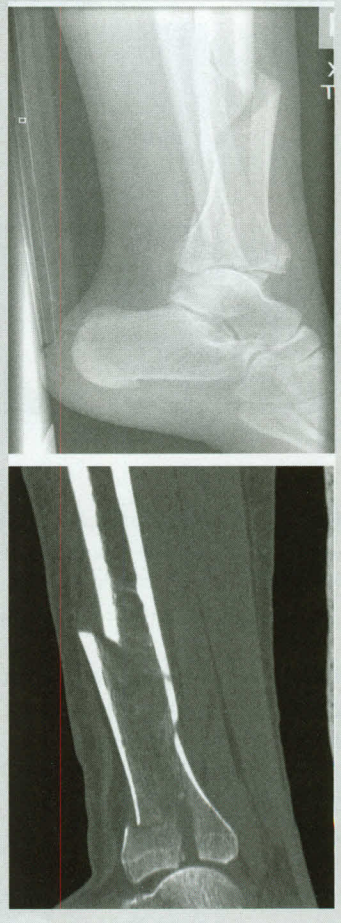
Manipulation of the proximally inserted plate is more difficult. I use 2 drill sleeves that are secured to the plate. This makes manipulation much easier. First screws are lag screws in the distal main fragment that pull the plate to the bone and shift the proximal main fragment in line.

DiDomenico: Given this is in the acute setting—yes, this patient could be done through small incision with either minimally invasive internal fixation along with plate and screws (most traditional) or it could be performed with smooth and olive wire fixation too.

Jones: Yes, with either a submuscular plating or intramedullary nailing.

Figure 5.

Distal tibia fracture 3.



Krettek: The anterior–posterior view is missing. A good CT scan with multiplanar 2D and 3D reconstructions and partial subtractions is essential for understanding and planning surgery. Direct visualization of articular surface is the key here using a median arthrotomy, extending proximally. Then perform direct reduction of shaft fragment, keep periosteum attached, lag screw fixation. Articular reconstruction is done from lateral to medial followed by neutralization with locking plate placed medially.

DiDomenico: Given this is in the acute setting—yes, this can initially be treated with minimally invasive external fixation and then followed by small incisions for ORIF with screws and plates.

Jones: No for articular surface, but yes for diaphyseal extension.

Figure 6.

Distal tibial fracture 4.

Krettek: Also here a good CT scan with multiplanar 2D and 3D reconstructions is essential for understanding and planning the reduction. One should rule out a proximal fibula fracture. The collinear reduction clamp is very helpful here, inserted/clamping from posterolateral to anteromedial while the foot is dorsiflexed. Temporary K-wire fixation and two 3.5-mm lag screws close to articular surface (harder bone, longer screws). Even if it looks good in 2D C-arm views, there can be step-offs on the postoperative CT scan. Therefore, we do these cases with intraoperative 3D C-arm imaging.

Ford: Yes. Although a posterior antiglide plate is mechanically superior, percutaneous anterior to posterior fixation with arthroscopic assist may provide for a better functional outcome.

DiDomenico: Given this is in the acute setting—yes, this can be performed through a small incision technique with ORIF of percutaneous reduction and screw fixation.

Jones: Yes.

Figure 7.

Calcaneal fracture 1.

Krettek: Depending on patient personality, health status, etc, for me this would be a case for open surgery.

Ford: Yes.

DiDomenico: Given this is in the acute setting—yes, the joint space is intact and the fractures around the joint can me mobilized and fixated percutaneously.

Jones: No if OK host, yes if compromised host.

Figure 8.

Calcaneal fracture 2.

Krettek: Depending on patient personality and health status but for me this would be a case for open surgery.

Ford: This is a bit more challenging, but yes, I would consider fixing this with a small incision approach. There is minimal lateral wall blowout. The posterior facet can be reduced and fixed through a sinus tarsi incision. Fully threaded large diameter screws can be delivered percutaneously from the posterior tuber into the sustentaculum and the anterior process to maintain length. Alternatively, a small low-profile plate can be delivered through the sinus tarsi incision to span the angle of Gissane.

DiDomenico: No, I believe this fracture would be best treated with the traditional open technique to realign the articular surfaces.

Jones: No if OK host but yes if compromised host.

Please discuss the surgical approach for this patient who requires correction of the varus heel.

Figure 9.

Calcaneal osteotomy for varus deformity

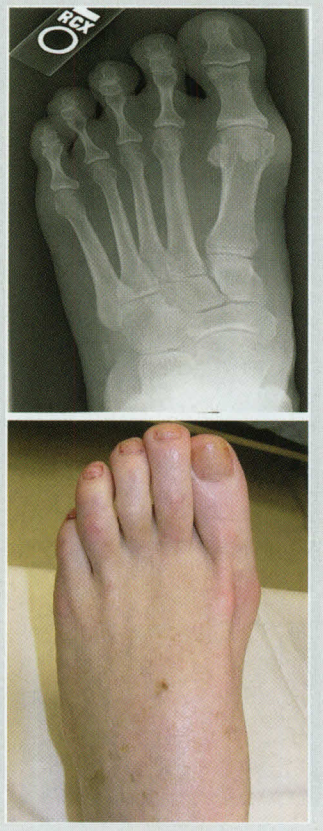
Ford: I would approach this through a standard open lateral incision with a Dwyer osteotomy that could be modified to allow lateral translation if more correction is needed.

DiDomenico: Yes; in my opinion this is a very straightforward case. I typically perform this with four stab incisions: one, inferior medial, one inferior lateral, one superior medial, and another superior lateral. This technique has been published and the reader is referred for further detail.[1]

Jones: It depends on remainder of foot. I would perform a medial or lateral tuberosity approach with an oblique osteotomy and percutaneous 7.0 screw fixation.

Do you think there is any place for minimally "incision" surgery to perform routine forefoot surgery? Can the patient pictured here be treated with a minimally invasive bunionectomy?

Figure 10.



Ford: Currently, the guidelines have not been established, but if the goal is to perform a simple bunionectomy, then MIS could be incorporated here. Given the small intermetatarsal angle, medially deviated second toe, and alignment of Choparts joint, I would caution against it here as the function of the first ray and the contribution of the hindfoot may be underappreciated.

DiDomenico: I do believe there is limited opportunity to perform minimally "incision" surgery for the appropriate patient for certain conditions in the forefoot. An example would be resecting a hypertrophic condyle at the distal interphalangeal joint.

Regarding minimally invasive bunion, I do not believe there is a place for "minimally invasive surgery" for bunions unless there are very unusual circumstances. It is impossible to treat the underlying pathology through "minimally invasive surgery," therefore, I do not believe it should be a regular practice.

Jones: No, especially if tight heal cord (Silverskold test) or hypermobile first ray.

What are the limitations of minimally invasive surgery in the patient with hallux valgus deformity such as this example?

Figure 11.

Hallux valgus deformity.

Ford: The limitations are adequate exposure needed to appropriately rebalance the soft tissues and deliver substantial fixation. The rationale for MIS in this example is limited as the advantages of this approach are few. A small incision over the first tarsometatarsal joint or proximal metatarsal combined with a small incision distally is not much different with respect to angiosomes and soft tissue insult than one larger incision.

DiDomenico: I do not believe there is a good predictable way to perform MIS in the patient with hallux valgus deformities. If it would be performed, I do not believe there could be a good long-term outcome, because the underlying pathology would not be addressed.

Jones: The limitations are incomplete correction, neutralization of deformity, and reduction of recurrence. FAS

Reference

Dull JM, DiDomenico LA. Percutaneous displacement calcaneal osteotomy. *J Foot Ankle Surg*. 2004;43:336-337.