Minimally Invasive Foot & Ankle Surgery: A Review and a Novel Technique

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Introduction/Purpose: There has been a growing interest in the utility of minimally invasive surgery (MIS) to correct foot and ankle deformities. MIS is performed using small, targeted incisions rather than large incisions required of open procedures. Proposed benefits of MIS include preservation of blood supply, limited injury to adjacent soft tissue, and fewer wound complications amongst many others. (Neufeld et al, Lu et al). To date, a large number of minimally invasive techniques have been developed to treat common deformities such as hallux valgus, hammertoe, and bunionette. However, there is no brief review that summarizes the literature comparing open surgery with its minimally invasive counterpart. Additionally the options available for MIS treatment of Flexible Adult Acquired Flat Foot/Progressive Collapsing Foot Deformity have failed to keep pace.

Methods: We will begin by synthesizing data on MIS in the foot and ankle through analysis of those three aforementioned deformities, summarizing both technique and associated research. Then, we will introduce a novel technique for stage II (flexible) flat foot correction, the Mini-BEAR (bone extra articular reconstruction). Historically treated with the now largely insufficient FDL transfer, we believe this new technique will not only prove biomechanically efficacious but also lead to improved patient safety and lower complication rates. The rapid pace at which novel MIS procedures are developed requires surgeons to be disciplined in conducting and analyzing studies; this synopsis will aim to aid in that process.

Results: A novel surgical technique that involves a minimally invasive, all bone extra-articular reconstruction (Mini-BEAR) system. We believe that this technique can potentially replace the multiple long surgical incisions that accompany the traditional medial displacement calcaneal osteotomy, lateral column lengthening, and Cotton procedures with minimal ones, reduce post-operative recovery time, reduce operating room procedure time, and produce a better cosmetic result. Additionally, we believe it will reduce narcotic use secondary to less pain by virtue of less surgical work on the patient. We have also performed a cadaveric anatomic study that qualitatively and quantitatively observed the tendinous and neurovascular structures at risk with the Mini-BEAR procedure.

Conclusion: The majority of the publications on the use of MIS to address deformities in the foot and ankle are small cohort studies or retrospective case reviews; many of which lack a control group. Due to this, data showing improvements in MIS vs open techniques is rare. However this is to be expected in a newer, developing field and as larger studies are performed there is optimism that this trend may change. (attached file is example of chart, we have similar format for all 4 deformities discussed in this paper)

Table 1. Hallux Valgus

Technique: Description	**Procedure Steps**	**Research outcomes: Benefits of MIS**	**Research outcomes: Complications of MIS**
Reverdin-Isham: intra-articular oblique and incomplete osteotomy of the head of the first metatarsal head with no internal fixation	• Isham (1991)	• Prospective multicenter study of 189 feet (Bauer) ○ 87% patients satisfied with outcome ○ Median AOFAS score improved from 52 to 93 ○ Median HVA improved 28° to 14° ○ Median IMA improved 13° to 10° • Excellent results with no differences in AOFAS score, HVA and IMA compared to MIS Endolog technique in comparison study of 40 patients (Di Giorgio)	• Prospective multicenter study of 189 feet ○ Patients averaged loss of 17% of first MTP joint motion ○ Complications reported: Regional pain syndrome (3%), deep vein thrombosis (2%), severe pos-top first MTP joint stiffness necessitating arthrolysis (2%), • Technique does not allow reliable correction of the distal metatarsal articular angle
Bosch: a percutaneous distal transverse osteotomy on the neck of the first MT with temporary K-wire fixation for 5-6 weeks	• Bosch (2000)	• Shorter operation time and better satisfaction with cosmetic results compared to open chevron technique reported in RCT (Radwan and Mansour)	• Risk of damaging dorsal cutaneous nerve: Cadaver study reported significant difference in risk of nerve damage when procedure performed by experienced surgeons (1 of 20 cases) vs untrained residents (6 of 20 cases) (Kaipel)
Minimally invasive chevron-akin (MICA): combines percutaneous osteotomy with the rigid internal fixation - performed at the neck of first metatarsal (extra-articular)	• Redfern (2016)	• Retrospective case series showed (Neufeld): ○ 94% good or excellent patient satisfaction ○ low re-operation rate (5.3%) ○ IMA improved 12.6° to 5.7° ○ HVA improved 26.8° to 10.3° ○ Bony foot width improved 92.4mm to 87.2mm • 70% patient reported outcome as excellent and 30% as good in prospective study of 40 patients (holme) • Cadaver study reported no damage to dorsal medial cutaneous nerve, arterial plexus or EHL tendon (but medial prominence was not shaved)	• 50% of cadavers showed damage to dorsomedial cutaneous nerve in cadaver study in which medial eminence resection was performed (McGann)
Endolog device: a curved titanium endomedullary nail, which is used to laterally translate the metatarsal head, does not require device removal	• Di Giorgio (2013)	• Prospective study of 30 patients: ○ Mean AOFAS score rose from 28.7 pre-op to 93.98 at 48-month post op ○ Mean corrections for: IMA 5.95°; HVA 16.81°; DMAA 10.70°; and tibial sesamoid 1.36° ○ Average surgical time of procedure, from skin incision to taping application, was 39 min ○ no cases of superficial wound infection, cellulitis, osteomyelitis, post-op lesser transfer metatarsalgia avascular necrosis, recurrence of deformity, hallux varus due to overcorrection, malunion, nonunion, residual pain, or irritation from device ○ No devices needed to be removed during 4 yr followup • Lower risk of infection compared to other fixation techniques since the fixation is completely internal	• Prospective study of 30 patients: ○ Alignment was discrete in 7 (23.4%) cases and poor in 2 cases (6.6 %)

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