Controversial Matters of Minimally Invasive Bunion Repair

Gustavo Araujo Nunes, MD, PhD(c)[a,*],
Francisco Sánchez Villanueva, MD[b],
Felipe Chaparro Ravazzano, MD[c], Tiago Baumfeld, MD, PhD[d]

KEYWORDS

• Minimally invasive bunion surgery • Percutaneous surgery • Hallux valgus • Bunion

KEY POINTS

- Despite recent advances in minimally invasive surgery (MIS) for treating hallux valgus (HV), there are controversial matters that should be discussed and studied.
- First-ray hypermobility and rotational correction of HV are controversial issues in MIS bunion surgery, similar to those in open surgery.
- The controversies linked to the MIS technique are related to the shape of the osteotomy and the use, configuration, and quantity of screws used to stabilize the osteotomies.

INTRODUCTION

In the last decade there has been a significant push for biomechanical studies and refinement of surgical techniques related to new minimally invasive bunion surgery (MIBS). The adoption of minimally invasive (MI) techniques as a mainstay treatment in hallux valgus (HV) surgery is supported by growing and robust literature.[1,2] MIBS has evolved through a better understanding of the anatomy, improvements in MI instruments, implant (MI screw) advancements and the technique refinements. The development of the MI screw fixated osteotomies has made this approach more reproducible and predictable.[3,4]

The first version (or generation) of MIBS was the unfixated Reverdin-Isham osteotomy. The second-generation MIBS involved the percutaneous K-wire fixation of a subcapital osteotomy. The next and current MIBS generation involves percutaneous MI

[a] Foot and Ankle Unit, COTE Brasília Clinic, Federal District, Brazil; [b] Department of Orthopedic Surgery, Foot and Ankle Center, Clínica Puerto Varas y Puerto Montt, Chile; [c] Department of Orthopedic Surgery, Foot and Ankle Center, Clínica Universidad de los Andes, Chile; [d] Foot and Ankle Unit, Hospital Felício Rocho, Belo Horizonte, Minas Gerais, Brazil
* Corresponding author. SGAS 915 Lote 68a Salas 16/17 Centro Clínico Advance 2 - Asa Sul, Brasília - DF 70390-150, Brazil.
E-mail address: gustavoanunes@hotmail.com

Clin Podiatr Med Surg ■ (2025) ■–■
https://doi.org/10.1016/j.cpm.2024.07.001 podiatric.theclinics.com

screw fixation subcapital osteotomy developed by Redfern and Vernois, known as the minimally invasive Chevron Akin (MICA—made commercially available by Stryker Corp, Kalamazoo, MI). This third-generation MIBS is one that involves a Chevron osteotomy. A slight variation in the osteotomy configuration to a transverse osteotomy has led some to call this a fourth-generation MIBS.[5,6] Practically speaking “new” MIBS refers to a third or fourth generation percutaneous subcapital osteotomy fixated with MI screws. Several global studies have supported the use new MIBS in treating a wide variety of bunion severities making this current iteration the most accepted method/construct.[1,4,5]

HV is a complex deformity with over a hundred different surgical operations described. With new MIBS emerging as the dominant surgical treatment for bunions, there are many controversial aspects that have emerged as topic of worldwide debate.[7,8] Newer publications are aimed at dispelling myths or providing supportive evidence that further positions MIBS as the gold standard for bunion surgery.[6,9–13] Traditionalists remain vocal that MI may not be better than open surgery as it relates to long-term results.[1,14]

Some of the pivotal controversial matters of MIBS are similar to those of open bunion surgery. The most polemic ones are how to address first-ray hypermobility and pronation.[7,9,10] Both subjects demand further assessment, preoperative planning, and intraoperative control to better correct the deformity. Another important controversy surrounds the technical aspect of the osteotomy configuration and what is the optimal fixation construct/type.[3,15,16] While the chevron-subcapital osteotomy was the first described, it has some rotational constraints questioning its “superiority.”.[6,9] And, despite MI bunion surgery classically being performed worldwide sans fixation, controversy and disagreement exists surrounding the optimal MI screw fixation type/construct.[17,18]

CONTROVERSY 1: IS OPEN SURGERY SUPERIOR TO MINIMALLY INVASIVE BUNION SURGERY?

The traditional approach to HV correction involves medium-to-large incisions on the dorsum or side of the bunion and/or the entire first ray. Open surgery has the obvious benefit of direct visualization of the osseous anatomy for the reduction of deformity and the delivery of surgical hardware/implants. Traditional chevron osteotomies were performed open and located within the metaphyseal section of the metatarsal head. The popular scarf osteotomy was also performed via a direct visualization approach through expansile linear incisions. Numerous studies have reported satisfactory outcomes with open surgery, demonstrating significant improvements in pain, function, and alignment. One particular study by Molloy and Widnall[19] showed a mean American Orthopaedic Foot & Ankle Society hallux metatarsophalangeal–interphalangeal scale score improvement from 53.5 to 91.1 following open correction procedures. Open surgery is associated with several drawbacks that include wound complications (due to the larger incisions and soft tissue trauma) and delayed healing. Extensive dissection may lead to postoperative scar development, stiffness, and prolonged recovery times.[20]

MIBS aims to achieve correction through small incisions using specialized instrumentation and implants (MI screws) with precise fluoroscopic guidance. Several studies have demonstrated favorable outcomes with MI techniques, highlighting reduced postoperative pain, quicker recovery, and improved cosmesis compared to open surgery. A meta analysis by Song and colleagues[21] reported significantly lower visual analog scale pain scores and shorter time to return to regular shoes in patients undergoing MI surgery compared to open surgery. A more recent meta-analyses made by Ji and colleagues[1] involved 22 MI surgery clinical and radiographic studies with over 1500 feet, concluded that MI procedures were more effective (better outcomes) than open surgeries in treating HV. A MIBS become more widely adopted additional studies that will add to the body of evidence on the efficacy of MIBS, and likely the new gold standard for bunion surgery.

CONTROVERSY 2: CAN MINIMALLY INVASIVE BUNION SURGERY CORRECT FRONTAL PLANE ROTATION?

HV is a multi-planar deformity and therefore the pronation (frontal plane) must be considered when correcting the deformity. Many authors opine that frontal plane deformity must be specifically corrected otherwise postoperative bunion recurrence may ensue.[22–24] Frontal plane rotation has been specifically targeted with various open surgery techniques that include the proximal oblique sliding closing wedge osteotomy, proximal metatarsal dome osteotomy, Lapidus arthrodesis, and proximal rotational metatarsal osteotomy.[25–27]

New MIBS can also adequately address frontal plane rotation. While the chevron-subcapital osteotomy frontal plane correction is locked into the osteotomy configuration, the transverse-subcapital osteotomy allows for full rotatory adjustments of the capital fragment, allowing surgeons to subjectively dial in the final frontal plane position. The exact amount of frontal plane correction is determined by the surgeons and studies are lacking as to whether frontal plane correction is associated with improved MIBS results.[6,10]

In attempt to reproducibly "dial in or control" frontal plane rotational correction, the authors (G.N. and T.G.) developed an external fixation device to assist in the correction[9] (Fig. 1). The first modification of MIBS to directly address pronation was published by Nunes and Baumfeld.[9] Assesing the preoperative pronation/frontal plane to be corrected may be performed through weightbearing computed tomography or with a weightbearing sesamoidal axial radiopgraph view. The goal is to know the pronation to be corrected preoperativelly and to have a quantitative control intraoperativelly (Fig. 2).[28,29]

CONTROVERSY 3: IS FIXATION NECESSARY FOR MINIMALLY INVASIVE BUNION SURGERY?

MI has revolutionized the surgical management of HV, offering reduced soft tissue trauma, faster recovery, and improved cosmetic outcomes compared to traditional

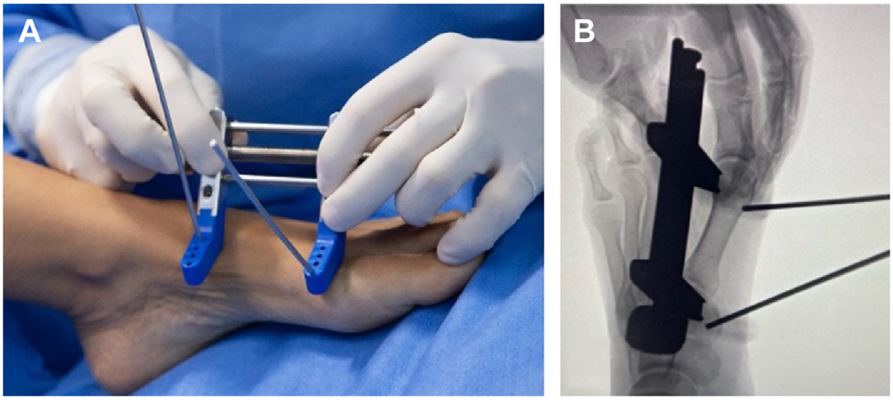

Fig. 1. (*A*) Clinical and (*B*) fluoroscopic image of the rotational correction guide.

Fig. 2. Radiographic series of a 34 years old female who inderwent a transverse MIBS with rotational correction. Preoperative anteroposterior (*A*) and weightbearing sesamoid axial view (*B*) showing a moderate hallux valgus with 13 degrees of metatarsal pronation angle. 06 weeks postoperative anteroposterior (*A*) and weightbearing sesamoid axial view (*B*) showing a tridimensional deformity correction.

open techniques.[1] However, MIBS can be performed with or without fixation (hardware). The unfixated version of MIBS (first generation-type) involves the Reverdin-Isham that gains its stability from soft tissue tension, osteotomy configuration and extrinsic bandaging.[17] As for fixated MBIS, the current "most popular" version involves the use implanted screw(s) that are designed specifically for this type of bunion correction, where long scaffolding screws hold together bones that are in near discontinuity.[30] Although fixation may favor osteotomy consolidation, some surgeons opt for unfixed percutaneous osteotomy bunion corrections, prompting questions about the necessity of screw fixation in osteotomy healing.Although fixation may favor osteotomy consolidation, some surgeons opt for unfixed percutaneous osteotomy bunion corrections, prompting questions about the necessity of screw fixation in osteotomy healing. The main reason for internal fixation is to stabilize (or maintain correction/position) the bones for bone healing (first metatarsal regeneration, FMR) during the postoperative period.[12]

Fixation with Minimally Invasive Bunion Surgery: Advantages and Disadvantages

Advantages

1. Enhanced stability: Fixation devices provide immediate stability, reducing the risk of postoperative displacement or loss of correction.
2. Improved precision: Fixation facilitates precise control over the correction achieved during surgery.
3. Early mobilization: With stable fixation, patients may be allowed to bear weight earlier, potentially accelerating rehabilitation.
4. Reduced risk of recurrence: Secure fixation reduces the likelihood of deformity recurrence by maintaining proper alignment during healing.

Disadvantages

1. Soft tissue irritation: Fixation devices may cause soft tissue irritation, leading to discomfort or the need for hardware removal in some cases.
2. Risk of hardware complications: There is a potential risk of hardware-related complications such as loosening, migration, or breakage.
3. Additional surgical steps: The placement of fixation devices adds complexity to the surgical procedure and may prolong operative time.
4. Cost: The use of fixation devices may increase the overall cost of surgery.

Unfixated Minimally Invasive Bunion Surgery: Advantages and Disadvantages

Advantages

1. Minimized soft tissue trauma: Avoidance of fixation reduces the risk of soft tissue irritation and the potential need for hardware removal.
2. Simplified procedure: Elimination of fixation devices streamlines the surgical technique, potentially reducing operative time.
3. Lower risk of hardware complications: Without fixation, hardware-related complications such as loosening or breakage is not risky.
4. Potentially lower cost: The absence of fixation devices may result in lower overall surgical costs.

Disadvantages

1. Less immediate stability: Without fixation, there may be less immediate stability, increasing the risk of displacement or loss of correction.
2. Limited correction: Complex deformities or significant instability may be challenging to correct adequately without fixation.
3. Delayed recovery: patients usually start mobilizing the hallux later since osteotomies must be stabilized by dressings. This can affect mainly younger patients who need to return to sports earlier.
4. Higher risk of recurrence: The absence of fixation may increase the risk of deformity recurrence during the healing process.

Both MI approaches with and without fixation offer unique advantages and limitations in the surgical management of HV. Fixation provides immediate stability and precise control over correction but entails risks such as hardware complications (ie, failure, infected hardware). On the other hand, approaches without fixation minimize soft tissue trauma and simplify the procedure but may have limitations in achieving and maintaining adequate stability. The choice between these approaches should be individualized based on the patient's specific deformity, surgeon expertise, and preferences, aiming to optimize outcomes while minimizing potential risks.[31] The authors prefer fixated MIBS techniques to achieve an intraoperative corrective osseous position and stability allowing for quick/early mobilization for potentially improved functional result. The literature, however, still lacks direct comparative studies and it is not currently possible to affirm the superiority of fixated MIBS versus unfixated MIBS.

CONTROVERSY 4: DOES MINIMALLY INVASIVE BUNION SURGERY TREAT FIRST-RAY HYPERMOBILITY?

First-ray hypermobility was described as a pathologic increased first-ray mobility that occurs as a consequence of midfoot joint instability, mainly the first tarsometatarsal joint and intercuneiform joints.[32] Controversy surrounds first-ray hypermobility from its mere presence, to how it relates to HV formation and recurrence after bunionectomy. Pathologic first ray hypermobility is subjective, difficult to evaluate, measure, and even quantify.[33] Radiographically first-ray hypermobility is suggested with increased intermetatarsal angle. For the past decade or so, arthrodesis of the first tarsometatarsal joint has been considered the "best" approach to eliminate bunion-related hypermobility. However, non-fusion-based hypermobility treatment exists, and has been an area for investigation. Rush and colleagues[34] in a cadaveric study suggested that hypermobility is quelled through a traditional distal metaphyseal chevron osteotomy by reengaging the windlass mechanism. In contrast, other authors believe that stabilizing first tarsometatarsal joint can be accomplished by realigning distal soft tissues through distal osteotomies.[7,33]

MIBS can also treat hypermobility. The mechanism of first-ray stabilization (aka locking of the first ray) with MIBS was proposed by the senior author (G.N.).[7] In this landmark MIBS study using a subcapital chevron osteotomy, the authors proposed that the increased varus displacement of the proximal fragment (metatarsal) in maximum medial position stabilized the transverse plane and reducing the rate of recurrence[7] (**Fig. 3**). With severe cases, recurrence rates between MIBS and open midfoot fusion surgery (Lapidus-type bunionectomy). On the other hand, Cody and colleagues[35] showed a comparative study between chevron-osteotomy MIBS and Lapidus. They observed some cases with a progressive medialization of the proximal fragment of the osteotomy with a recurrence of the deformity in the MIBS group.[34]

The authors believe that MIBS can stabilize the first ray and address the majority of the cases of HV with hypermobility. We believe that there is a need for a series of cases with long-term follow-up to analyze the behavior of first tarsometatarsal joint and intercuneiform joint after MIBS. The authors currently advocate Lapidus-type fusion (over MIBS) first tarsometatarsal joint arthrosis and/or "severe hypermobility." However, defining severe hypermobility is challenging and it is very possible that MIBS would be suitable for these cases.

In an attempt to make an anecdotally objective decision on whether to fuse, the authors perform a preoperative radiographic squeeze test by manually splaying the first and second metatarsals on a non-weightbearing anteroposterior radiograph (**Fig. 4**). The surgeon assesses whether 100% of head lateralization with MIBS can cover the first metatarsal space. There are 3 scenarios: (1) metatarsal head > intermetatarsal space; (2) metatarsal head = intermetatarsal space; and (3) metatarsal head < intermetatarsal space. In the first scenario, when the metatarsal head is bigger/wider than the intermetatarsal space then MIBS would be effective as there should adequate bone-to-bone contact. In the second scenario, when the metatarsal head the same size/width as the intermetatarsal space, then there would likely be 100% lateral displacement of the capital fragment to correct the deformity with MIBS. In the third scenario, when the metatarsal head is smaller/narrower than the intermetatarsal space, then there could be over 100% lateral displacement of the capital fragment with MIBS, suggesting a proximal osteotomy or Lapidus-type fusion may be more appropriate (depending on the surgeon's MIBS experience).

CONTROVERSY 5: OSTEOTOMY CONFIGURATION: TRANSVERSE VERSUS CHEVRON

Much of the current literature is based on the third-generation chevron-osteotomy MIBS, which has been well established as the predominant technique with good results and low complications. The original description described a 130° chevron cut at the neck of the first metatarsal. Alternatively, a transverse or linear cut of the metaphysis could be performed, which is again considered a fourth-generation MIBS. Both osteotomy configurations are accepted methods of performing MIBS, and each has its advantages and disadvantages.

The chevron osteotomy MIBS is an inherently stabile technique due to the "V" nature as well as increased bone-on-bone contact, which theoretically promotes a high rate of osteotomy consolidation. The transverse osteotomy MIBS has less surface area for bone healing when compared to the chevron. Additionally, the chevron osteotomy also preserves the metatarsal head plantar vascularization, also decreasing the risk of metatarsal head necrosis.[16,36] The transverse osteotomy has a high anatomic risk of injuring the plantar vascularization of the first metatarsal head.[9] Bone healing

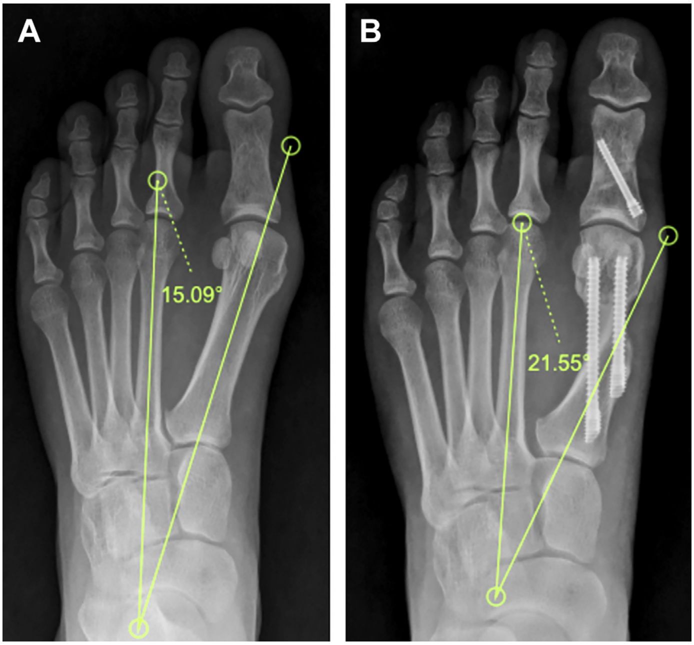

Fig. 3. (A) Preoperative and (*B*) Postoperative radiograph showing an increased varus displacement of the proximal fragment of the first metatarsal osteotomy.

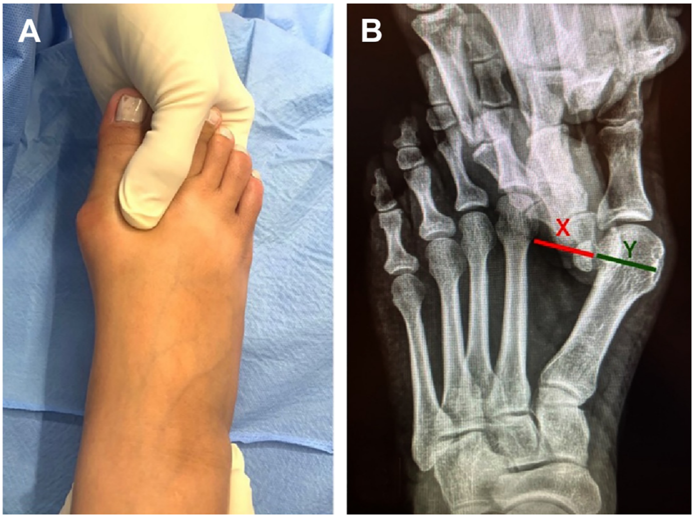

Fig. 4. (*A*) Clinical and (*B*) radiographic image of the first ray squeeze test. Observe that a 100% lateral displacement of the metatarsal head covers the first intermetatarsal space. The first metatarsal head size (*green line*; Y) is equal to the intermetatarsal space (*red line*; X).

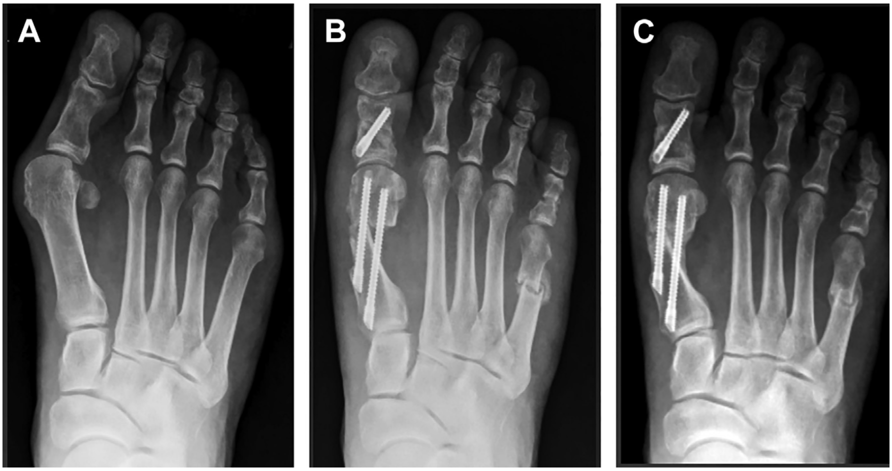

Fig. 5. Radiographic series of a 64 year old male who underwent a transverse osteotomy MIBS. Preoperative (*A*), 06 weeks postoperative and (*B*) and 12 weeks postoperative (*C*) showing a good bone healing.

studies that directly compare these two osteotomy studies have yet to be performed. However, in a retrospective radiographic review characterizing bone healing in 172 feet, Blitz and colleagues[12] described a Transveron osteotomy MIBS, though there was not a description of the proprietary osteotomy configuration.

The 3 dimensional correction can also be achieved with MIBS based on the osteotomy configuration. The "V" cut when translated makes rotation of the metatarsal head difficult, particularly with translations less than 100%. The transverse osteotomy, however, has the ability to correct all severities of coronal/sagittal plane deformity and rotational deformities of the metatarsal articulation regardless of the amount of translation.[6] While the transverse cut allows more rotational correction, it is an inherently unstable osteotomy configuration. The literature on biomechanical studies and clinical trials comparing the 2 osteotomy shapes are still lacking. There is only one biomechanical study carried out in cadavers which compared the transverse and chevron osteotomy in MIBS.[16] Eighteen cadaveric specimens were randomized for both types of osteotomies and submitted to a biomechanical analysis. They demonstrated no significant differences in the load to failure, yield load, and stiffness between chevron and transverse MIBS osteotomy techniques in a cadaveric cantilever bending model.

The authors of the present article believe there is a tendency to use transverse osteotomy (Fig. 5). The nature of the transverse cut is maintenance of the Cortical Purchase Zone (CPZ) of the lateral first metatarsal shaft, a necessary portion of the bone require for a stabile fixation construct[6,9,11–13,16] (Fig. 6). When a chevron-osteotomy is performed its important not to make the "V" cut angle more acute as this could increase the risk of fracture (ie, metatarsal explosion) at the CPZ.[11,13,16,36] Independently of the type of cut, we believe providing a stable rigid fixation construct is necessary, and currently perform this with 2 metatarsal screws as described by Redfern and Vernois.[30]

CONTROVERSY 6: SINGLE VERSUS DUAL METATARSAL SCREW FIXATION

The original Redfern-Vernois chevron-MIBS calls for dual metatarsal fixation. With large metatarsal head translations coupled with early weightbearing, rigid and stable

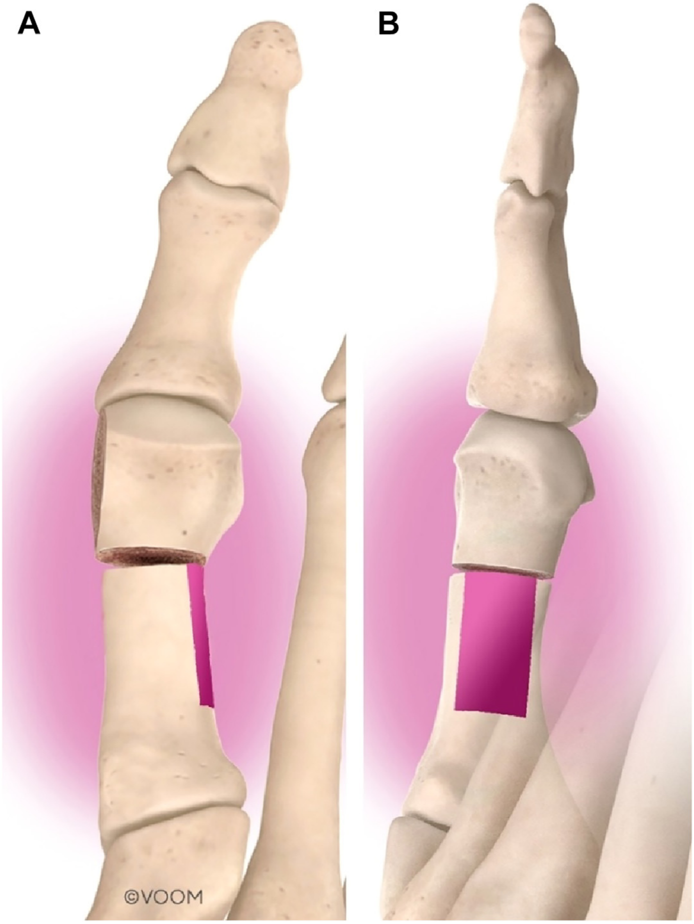

Fig. 6. The CPZ is the available region of cortical bone of the lateral metatarsal shaft (proximal to the osteotomy) where the minimally invasive screw(s) exit. Top-down view (*A*) and view of the lateral first metatarsal (*B*). A transverse osteotomy maximizes the proximal bony real estate adjacent to the osteotomy. (*From*: Reprinted from: Blitz NM, Grecea B, Wong DT, Baskin ES. Defining the Cortical Purchase Zone in New Minimally Invasive Bunion Surgery. A Retrospective Study of 638 Cases. *J Min Invasive Bunion Surg*. 2024;1:92777. doi:10.62485/001c.92777. From: @Voom.)

fixation has been attributed to its success. Two points of fixation seem to satisfy classic osteotomy/fracture/fusion fixation guidelines providing stability and anti-rotation. A dual-screw fixation is currently the most utilized and studied fixation construct for third-generation MIBS. However, implant-related complications/issues (ie, screw head soft tissue irritation, hardware migration) have necessitating additional procedures.[4,5]

Single metatarsal screw fixation has also been suggested as adequate form of MIBS fixation. In 2022, Harrasser and colleagues[37] performed the first comparative study in 50 total patients (33 feet with 2 screws, and 22 feet with 1 screw) with both groups having similar outcomes; however, 32% of patients were dissatisfied with dual metatarsal

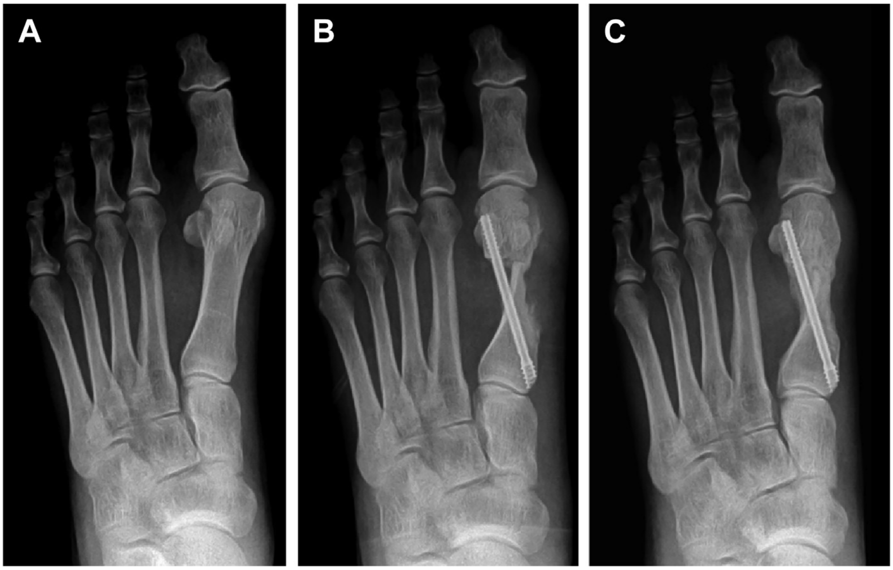

Fig. 7. Radiographic series of a 28 year old woman after MIBS demonstrating the use of the dual-zone Voom Revcon screw as the only point of fixation. Patient was permitted immediate weightbearing in a surgical sandal after surgery. Preoperative (*A*), 2 weeks postoperative (*B*), and 12 weeks postoperative (*C*) demonstrate the robust first metatarsal regeneration. (*Image courtesy* of Dr. Neal Blitz.)

Fig. 8. Radiographic series of a 79 year old female patient with osteoporotic bone who underwent a transverse osteotomy MIBS using a single screw. The authors believe single scree fixation might be particularly advantageous with poor bone quality (combined with a period of nonweightbearing). Preoperative (*A*) and 12 weeks postoperative (*B*).

fixation compared to 3% with the single screw. In 2023, Li and colleagues also performed a comparative study in 103 patients in mild-to-moderate HV treated with chevron-MIBS with at least 12 months of follow-up. Both groups (51 patients with single screw fixation and 52 patients with dual screw fixation) had similar outcomes and results.[38] The single metatarsal screw group demonstrated statistically significant lower operative time and less intraoperative fluoroscopy use. There was no nonunion complication in either group. Prominent hardware requiring screw removal was performing 1.9% of the dual metatarsal screw and no hardware removal of the single screw group. However, this study involved mild/moderate HV (IM <16°) and its unclear based on this study how single screw outcomes would be for larger bunions.

A large retrospective MICA study (247 feet) by Mikhail and colleagues mentions use of a single metatarsal screw fixation construct within their cohort; however, they did not mention the frequency of one construct over another.[39] The authors attributed a single metatarsal screw technique to 2.6% of the bone-healing-related complications without any specific construct detail on these particular cases. In 2024, Blitz and colleagues specifically studied bone-healing patterns after MIBS in 172 feet (86% single screw, 14% double screw).[12] They defined the triangular area available for osseus healing as the regeneration triangle, and identified 3 distinct patterns of healing (a term described as FMR). While the study only looked at healed cases, 84% of the single screw fixation feet demonstrated healing lateral to the single screw, and the remaining 16% had primarily medial osseous integration.

The ideal MIBS fixation construct has yet to be determined by clinical studies, single metatarsal screw fixation shows merit and promise. Recently, an innovative single metatarsal fixation solution was introduced (Revcon Anchor Screw—made commercially available by Voom Medical Devices Inc, New York, NY) that has a novel dual zone pitched shaft to capture the cortical and cancellous aspects of the lateral metatarsal shaft and metatarsal head, respectively (**Fig. 7**). Future comparative clinical and biomechanical studies are the next logical steps that also evaluate the stability to large/severe metatarsal head displacements. In addition, biomechanical studies would be fundamental to substantiate any overlaps in the types of metatarsal fixation. Osteoporotic poor-quality bone is another variable where single screw fixation might be more advantageous, though the authors propose a minimum of 2 weeks non-weightbearing (**Fig. 8**). The authors, otherwise, currently prefer the use on dual metatarsal fixation for MIBS.

SUMMARY

MIBS has evolved in recent years and becoming increasingly popular. While MIBS has become a safe and reliable method to treat HV, there are still controversial and unanswered questions. Future studies will emerge that respond, and resolve, many of the current controversies presented here. The authors believe that MIBS will soon be recognized as the gold standard.

CLINICS CARE POINTS

- It is expected that MIS will become the primary approach for HV, as it has advanced both technically and scientifically.
- It is possible to correct and control the HV rotation parameters. Therefore, it is unclear whether the rotational assessment is indispensable to achieving great results.
- There are a variety of MIS techniques to treat HV. Among them, we have fixed and unfixed techniques, each with its advantages and disadvantages.

- There is a tendency to use the transverse cut in the MIS distal osteotomy since it preserves the medial and lateral cortex and facilitates rotational correction.
- The first ray hipermobility remains as a controversial topic in HV. The MICA mechanism of first-ray stabilization needs validation with more biomechanical and clinical studies with long-term follow up.
- There is a lack in biomechanical analysis of MICA fixation. Therefore, the original MICA fastening with 2 screws remains the safest and most effective approach.

DISCLOSURE

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online. *Financial*: All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this study. *Consent to publish*: The authors affirm that human research participants provided informed consent to publish the images in figures. The participant has consented to the submission of this case series to the journal.

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