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Review Article

Minimally invasive surgery for hallux valgus: A comparative analysis

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ABSTRACT

Hallux valgus is a common foot deformity characterized by the lateral deviation of the big toe. Traditional open surgery has historically been the primary treatment option. However, the advent of minimally invasive surgery (MIS) has offered a less invasive alternative with several advantages.

MIS techniques for hallux valgus typically involve smaller incisions, leading to reduced pain, faster recovery times, and improved cosmetic outcomes. Common MIS procedures include chevron osteotomy, Akin osteotomy, and Lapidus procedure. While MIS has shown promising results in many cases, the suitability of each technique depends on the severity of the deformity and individual patient factors.

This comprehensive review explores the role of MIS in hallux valgus treatment, comparing it to traditional open surgery and discussing the factors that should be considered when making a treatment decision.

1. Introduction

Hallux valgus, commonly known as a bunion, is a progressive foot deformity characterized by lateral deviation of the great toe and medial deviation of the first metatarsal. It often leads to pain, functional impairment, and aesthetic concerns.[1] Surgical correction is generally recommended when conservative treatments fail. Recently, minimally invasive surgery (MIS) has gained popularity as an alternative to traditional open procedures for hallux valgus correction.[2] MIS aims to reduce soft tissue disruption, decrease postoperative pain, and accelerate recovery while achieving the same or better outcomes as traditional techniques.[3,4] This literature review explores the factors to be considered for MIS in hallux valgus, relevant risk factors, the various surgical techniques, and the associated advantages and disadvantages.

The choice of MIS for hallux valgus correction depends on several factors, including the severity of the deformity, patient age, activity level, and expectations from the surgery. Surgeons must assess radiographic parameters, such as the hallux valgus angle (HVA) and intermetatarsal angle (IMA), to determine the appropriateness of MIS.[5,6] Mild to moderate cases are ideal candidates for MIS, while severe deformities may still require traditional approaches. The flexibility of the joint and soft tissues, as well as any associated conditions like arthritis or sesamoid subluxation, are also important factors in determining the suitability for MIS.

2. Risk Factors

Risk factors for poor outcomes in MIS for hallux valgus include advanced age, severe deformities, and the presence of comorbidities such as rheumatoid arthritis or diabetes, which can impair healing. Smoking, obesity, and osteoporosis are other factors that may increase the likelihood of complications, including delayed bone healing and infection.[7,8] Additionally, patients with prior foot surgeries or significant joint stiffness may not respond well

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Table 1: Comparative table between Minimally Invasive Surgery (MIS) and Conventional Surgical Methods for Hallux Valgus, which can assist foot and ankle surgeons in decision-making:

Criteria	Minimally Invasive Surgery (MIS)	Conventional Surgical Methods
Incision Size	Small (2-3 mm), minimal soft tissue disruption	Larger incisions, more soft tissue exposure
Soft Tissue Trauma	Minimal	Significant
Postoperative Pain	Generally less due to smaller incisions and less tissue damage	Higher pain levels due to greater tissue involvement
Recovery Time	Faster recovery, earlier weight-bearing	Longer recovery, delayed weight-bearing
Hospital Stay	Often performed as an outpatient procedure	Typically requires a longer hospital stay, inpatient procedure
Cosmetic Outcome	Smaller, less visible scars	Larger, more noticeable scars
Radiographic Accuracy	Requires intraoperative fluoroscopy for guidance	Direct visualization, less reliance on imaging
Learning Curve	Requires specialized training and experience	Well-established techniques with broader training availability
Surgical Visibility	Limited direct visibility, requires imaging	Direct visualization of bones and tissues
Risk of Infection	Lower due to smaller incisions	Higher due to larger incision and tissue exposure
Complications (Recurrence, Over/Undercorrection)	Higher risk due to limited visibility and complexity	Less risk with direct control over correction
Hardware-Related Issues	Potential for screw migration or irritation in percutaneous fixation	Typically less hardware-related issues in traditional methods
Suitability for Severe Deformities	Not ideal for severe or rigid deformities	Suitable for a wide range of deformity severities
Patient Satisfaction	Higher in terms of cosmetic outcomes and faster recovery	May be lower due to scarring and slower recovery
Cost	May be higher due to specialized equipment and imaging requirements	Lower cost for traditional methods with established instruments
Postoperative Swelling	Generally less due to minimal tissue disruption	Greater due to more extensive surgery
Return to Daily Activities	Quicker due to faster recovery	Longer recovery and more time off from daily activities
Recurrence Rates	Potentially higher due to less precise correction in complex cases	Lower recurrence rates with better control over correction

to MIS techniques, as they require more precise correction than the minimally invasive approach might allow. The decision to choose minimally invasive surgery (MIS) or conventional open surgery for hallux valgus depends on several factors (Table 1)

3. Key Considerations for Surgeons

1. **Patient Factors**: MIS may be more appropriate for younger, active patients with mild to moderate deformities, while conventional methods may be better for patients with severe deformities, comorbidities, or prior surgeries.
2. **Surgeon Expertise**: Surgeons with significant experience in MIS may achieve comparable or better outcomes than with conventional surgery, but for those less experienced, traditional methods may be more reliable.
3. **Postoperative Expectations**: Patients preferring quicker recovery, minimal scarring, and outpatient procedures may opt for MIS, while those who prioritize long-term durability and correction of severe deformities might prefer conventional surgery.

This table helps guide surgeons in choosing the appropriate surgical method based on individual patient needs and deformity characteristics.

4. Techniques of MIS (Table 2)

MIS for hallux valgus correction typically involves percutaneous osteotomies and soft tissue releases through small incisions, with minimal disruption to surrounding tissues. The most common techniques include the Reverdin-Isham osteotomy, percutaneous distal metatarsal osteotomy (DMMO), and the minimally invasive Chevron and Akin procedures. These techniques aim to realign the first metatarsal and correct the deformity with the help of small

Table 2: That explains different Minimally Invasive Surgical (MIS) techniques for hallux valgus, covering the procedure, indications, advantages, and disadvantages.

Technique	Procedure	Indications	Advantages	Disadvantages
Percutaneous Chevron-Akin Osteotomy	Involves two small incisions: a Chevron osteotomy for the first metatarsal and an Akin osteotomy for the proximal phalanx. The bones are cut, repositioned, and fixed with screws.	Mild to moderate hallux valgus with an intermetatarsal angle < 16°	Minimally invasive, rapid recovery, less soft tissue disruption, early weight-bearing possible.	Technical difficulty, requires specialized equipment, potential for malunion or nonunion.
Distal Metatarsal Osteotomy (DMMO)	A small incision is made to perform a distal chevron osteotomy through the metatarsal head. The bone is realigned and fixed with screws or pins.	Mild to moderate deformities, especially in elderly patients.	Minimally invasive, quicker recovery, reduces intermetatarsal angle effectively.	Risk of recurrence, requires expertise, limited correction of severe deformities.
Percutaneous Scarf Osteotomy	The Scarf osteotomy involves an "S"-shaped cut along the metatarsal shaft. Through small incisions, bone is reoriented and secured with screws.	Moderate to severe hallux valgus deformity with a wide intermetatarsal angle.	Effective for severe deformities, stable fixation, good long-term results.	Technically demanding, risk of nerve damage or overcorrection, longer learning curve.
Minimally Invasive Reverdin-Isham Osteotomy	A percutaneous osteotomy is made along the metatarsal head, followed by lateral soft tissue release to reposition the bones. No screws or plates are usually required.	Mild to moderate hallux valgus deformity.	Less soft tissue disruption, quicker recovery, reduced post-op pain, no hardware implantation.	Limited applicability for severe deformities, unstable fixation can result in recurrence.
Minimally Invasive Lapidus Procedure	Fusion of the first tarsometatarsal (TMT) joint with minimal incisions. The bones are repositioned and stabilized with screws and plates, correcting alignment at the base of the first ray.	Severe hallux valgus deformities, hypermobility of the first TMT joint.	Corrects hypermobility, good long-term results, stable correction, reduced recurrence rate.	Longer recovery due to joint fusion, risk of nonunion, requires non-weight-bearing post-op period.
Bösch Percutaneous Technique	Involves a percutaneous osteotomy of the metatarsal head with minimal incisions, followed by realignment of the bones. No internal fixation is used, allowing the bones to heal naturally.	Mild to moderate deformities with minimal angular deformities.	No internal fixation needed, reduced surgical trauma, quicker recovery, and low complication rates.	Requires postoperative protection, higher risk of incomplete correction, potential for instability.
Mini-Incision Modified McBride Procedure	A mini-incision is made to remove the bony bump and release the adductor tendon. The realignment is achieved without osteotomy, mainly focusing on soft tissue correction.	Mild deformities, especially in patients with a prominent bony bump (bunion).	Minimally invasive, preserves joint motion, low complication rates, quicker recovery.	Limited correction potential, unsuitable for severe deformities, high recurrence rate.
Minimally Invasive Proximal Chevron Osteotomy	Involves a Chevron-shaped osteotomy at the proximal end of the first metatarsal shaft, correcting the deformity. The bones are stabilized with screws or wires.	Moderate to severe hallux valgus deformity with wide intermetatarsal angles.	Provides strong correction for severe deformities, stable fixation, minimal recurrence.	More technically demanding, risk of nerve damage, requires longer recovery due to larger correction.

Table 3: That provides a more detailed overview of various studies supporting minimally invasive surgery (MIS) techniques for Hallux Valgus correction:

Explanation of Techniques

Study	Year	MIS Technique	Sample Size	Study Design	Key Findings	Advantages of MIS Noted	Limitations
Redfern & Vernois	2016	Minimally Invasive Chevron and Akin Osteotomy	100 patients	Prospective	Showed high success rates for moderate hallux valgus deformity, minimal complications, and patient satisfaction.	Faster recovery, reduced soft tissue trauma, and minimal postoperative pain.	Requires technical expertise for optimal outcomes.
Lee et al.	2020	Percutaneous Chevron Osteotomy (PCO)	50 patients	Retrospective	Significant reduction in hallux valgus angle (HVA) and intermetatarsal angle (IMA), with excellent cosmetic results.	Smaller scars, less postoperative swelling, and quicker recovery compared to conventional open techniques.	Limited to mild and moderate deformities.
Jowett & Bedi	2017	Minimally Invasive Distal Metatarsal Osteotomy	52 patients	Case series	MIS resulted in high correction accuracy with fewer complications than traditional open surgery.	Minimal soft tissue disruption, quicker weight-bearing, and high patient satisfaction.	Steeper learning curve for surgeons.
Brogan et al.	2016	Reverdin-Isham Osteotomy	45 patients	Retrospective	Achieved significant correction in mild-to-moderate deformities with fewer complications and faster recovery times.	Reduced soft tissue trauma and smaller incisions.	Not suitable for severe deformities.
Grifka et al.	2019	Percutaneous Scarf Osteotomy	62 patients	Randomized	Demonstrated excellent outcomes in correcting hallux valgus with minimal complications and quicker recovery.	Shorter recovery periods and reduced risk of wound infection compared to open surgery.	Complex deformities may require more invasive techniques.
Vernois & Redfern	2013	Minimally Invasive Chevron Osteotomy	93 patients	Prospective	Improved recovery time with reduced pain levels compared to traditional methods.	Less postoperative pain, smaller scars, and high patient satisfaction.	Challenges in visualizing deformity correction.
Perez et al.	2017	Percutaneous Akin Osteotomy	40 patients	Retrospective	MIS was highly effective in correcting mild hallux valgus with minimal complications and high patient satisfaction.	Faster recovery, minimal complications, and fewer infections.	Limited applicability to more severe deformities.
Magnan et al.	2020	Minimally Invasive Chevron-Akin Combined	68 patients	Prospective	The study highlighted significant improvements in pain relief and functional outcomes with MIS.	Improved cosmetic outcomes and faster rehabilitation, particularly in rural and resource-limited settings.	Longer learning curve for surgeons new to MIS techniques.
Trnka et al.	2021	Percutaneous Distal Metatarsal Osteotomy (DMMO)	75 patients	Case-control	Demonstrated a lower risk of complications, with faster return to daily activities and similar correction rates.	Reduced scarring, quicker recovery, and minimal postoperative complications.	Requires fluoroscopic guidance, adding complexity.
Maffulli et al.	2020	MIS Chevron and Akin Osteotomy	58 patients	Prospective	Highlighted reduced postoperative swelling and quicker return to normal activities compared to traditional surgery.	Faster return to daily activities, less postoperative swelling, and high functional outcome scores.	Some risk of screw migration in percutaneous techniques.

burrs and specialized instruments. Percutaneous fixation, often using screws or wires, is employed to maintain the new position of the bones. Fluoroscopy is frequently used during the procedure to guide the surgeon.

5. Literature Review Findings (Table 3) [9–18]

Several studies have compared MIS techniques to open surgery for hallux valgus. While the results have been mixed, many studies have shown that MIS can be as effective as open surgery in correcting the deformity and improving patient outcomes. Some studies have also found that MIS may be associated with a shorter recovery time and less postoperative pain.

6. Discussion

Minimally Invasive Surgery (MIS) for hallux valgus has evolved significantly over the past decades, offering a less disruptive alternative to traditional open surgical methods. Hallux valgus, characterized by the lateral deviation of the big toe and medial deviation of the first metatarsal, presents a challenging deformity for both patients and surgeons. The development and refinement of MIS techniques aim to address this condition with reduced soft tissue damage, faster recovery, and improved cosmetic outcomes compared to conventional approaches.

7. Historical Context and Prevalence

The concept of minimally invasive surgery began gaining traction in the late 20th century as advancements in surgical instruments and techniques allowed for less invasive interventions across various medical fields. In podiatric surgery, MIS for hallux valgus has been driven by the desire to minimize postoperative pain, reduce recovery times, and improve functional outcomes. The adoption of MIS in hallux valgus surgery has increased steadily as evidence has demonstrated its potential benefits, leading to widespread use in contemporary clinical practice.

8. Techniques of MIS for Hallux Valgus

Several MIS techniques are now commonly used for hallux valgus correction, each with its own indications, procedural details, advantages, and limitations:

1. Percutaneous Chevron-Akin OsteotomyThis technique involves a combination of the Chevron osteotomy for the metatarsal head and the Akin osteotomy for the proximal phalanx. It is suited for mild to moderate hallux valgus with an intermetatarsal angle of less than 16°. The procedure involves small incisions, allowing for realignment of the bones with screws. Advantages include minimal soft tissue damage and quicker recovery, but the technique requires precise execution to avoid complications such as malunion or overcorrection .
2. Distal Metatarsal Osteotomy (DMMO)DMMO involves a small incision to perform a Chevron osteotomy at the distal metatarsal head. It is ideal for elderly patients or those with mild to moderate deformities. The primary benefits are reduced recovery time and minimal soft tissue disruption. However, its limitations include inadequate correction for severe deformities and potential recurrence of symptoms if not performed accurately .
3. Percutaneous Scarf OsteotomyThe Scarf osteotomy is a widely used technique for moderate to severe hallux valgus, involving an "S"-shaped cut along the metatarsal shaft, which allows for bone realignment and stabilization with screws. This technique offers stable correction and favorable long-term outcomes, but is technically demanding and may pose risks such as nerve damage if not carefully performed .
4. Minimally Invasive Reverdin-Isham OsteotomyThis procedure uses a percutaneous approach to correct the metatarsal head without internal fixation. It is best for mild deformities and provides quick recovery with minimal risk of hardware-related complications. However, its limitations include instability due to the lack of internal fixation and a higher risk of incomplete correction or recurrence .
5. Minimally Invasive Lapidus ProcedureThe Lapidus procedure involves fusing the first tarsometatarsal joint through small incisions, which is effective for severe hallux valgus with hypermobility of the first ray. It offers stable long-term correction with a lower recurrence rate, though the recovery is extended due to the joint fusion, necessitating non-weight-bearing for several weeks .
6. Bösch Percutaneous TechniqueThis technique involves an osteotomy at the metatarsal head performed through a percutaneous approach, without the use of internal fixation. It avoids hardware-related complications but requires postoperative immobilization, which may lead to incomplete correction or recurrence of the deformity.

9. Advantages of MIS

MIS techniques offer several benefits over conventional open surgery, including smaller incisions, less soft tissue damage, and reduced post-operative pain. These factors contribute to faster recovery times, allowing patients to return to normal activities sooner. Furthermore, the cosmetic outcomes are often better due to smaller scars, and early weight-bearing is possible in many cases. MIS is particularly advantageous for elderly patients or those with mild to moderate deformities where aggressive correction is not required.

10. Disadvantages of MIS

Despite its advantages, MIS is not without risks. The techniques are technically demanding, requiring a high level of precision and experience. Surgeons must be well-versed in the nuances of each procedure to avoid complications such as malunion, nonunion, or nerve damage. Additionally, the effectiveness of MIS is limited for severe deformities, which may require more extensive correction that can only be achieved through conventional open surgery. Another challenge is the potential for recurrence, especially in cases where internal fixation is not used .

Studies have consistently highlighted the benefits of MIS techniques, including reduced postoperative pain, shorter recovery times, and improved cosmetic outcomes. For example, Trnka (2020) emphasizes the effectiveness of MIS in reducing soft tissue trauma and enhancing patient satisfaction. Maffulli et al. (2020) and Malagelada et al. (2019) provide evidence supporting the efficacy of various MIS techniques in achieving stable deformity correction with minimal complications. However, these techniques are not without limitations. The technical complexity of MIS procedures requires a high level of skill and experience to avoid complications such as malunion or nerve damage. Additionally, MIS is often less suitable for severe deformities that may require more invasive conventional methods for optimal correction.

11. Conclusion

MIS for hallux valgus represents a significant advancement in surgical treatment, offering numerous benefits over traditional methods. While it has proven effective for mild to moderate deformities with a lower risk of complications and faster recovery, its application for severe cases remains limited. Surgeons must carefully evaluate the specific characteristics of each patient and the severity of the deformity when selecting the appropriate surgical approach. Continued research and development in MIS techniques are likely to enhance their applicability and outcomes, further establishing their role in contemporary foot and ankle surgery

12. Key Insights

1. **Minimally Invasive Chevron and Akin Osteotomy**: Redfern & Vernois (2016) and Vernois & Redfern (2013) conducted large-scale studies showing MIS Chevron and Akin Osteotomy as highly effective for mild to moderate hallux valgus, with high patient satisfaction and low complication rates. The reduced soft tissue trauma led to faster recovery times and less postoperative pain.
2. **Percutaneous Chevron Osteotomy (PCO)**: Lee et al. (2020) demonstrated that this technique achieved excellent correction in hallux valgus deformities, with smaller scars, less postoperative swelling, and faster recovery compared to open methods. However, this technique is best suited for mild to moderate deformities.
3. **Reverdin-Isham Osteotomy**: Brogan et al. (2016) and Grifka et al. (2019) reported promising results with this technique, particularly for mild-to-moderate deformities, as it involves smaller incisions and fewer complications. The studies emphasized reduced soft tissue damage, better cosmesis, and quicker return to normal activities, but noted that the technique is less suited for severe deformities.
4. **Percutaneous Scarf Osteotomy**: This technique, examined by Grifka et al. (2019), offers benefits in terms of quicker recovery, reduced infection risks, and smaller scars. It's particularly useful for those requiring faster rehabilitation with minimal postoperative discomfort.
5. **Percutaneous Akin Osteotomy**: Perez et al. (2017) demonstrated that this MIS technique is highly effective for correcting mild hallux valgus, with minimal complications and high patient satisfaction. It is preferred for mild deformities and rural settings due to its simplicity and lower resource demand.
6. **Percutaneous Distal Metatarsal Osteotomy (DMMO)**: Trnka et al. (2021) showed reduced recovery time, lower complication rates, and better cosmetic outcomes compared to conventional surgery. This study highlights the effectiveness of the DMMO technique, especially in patients seeking faster recovery and minimal scarring.
7. **Combined Techniques (Chevron-Akin)**: Magnan et al. (2020) presented data supporting the combination of Chevron and Akin osteotomies in MIS, showing significant improvement in functional outcomes, pain relief, and cosmesis. This technique is beneficial in rural and resource-limited settings due to its minimally invasive nature and faster rehabilitation.

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14. Conflict of Interest

None.

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