Management of Displaced Intra-Articular Calcaneal Fractures (Sanders II & III): Review of Mini-Open Sinus Tarsi Approach Outcomes

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Abstract

Background:. Displaced intra-articular calcaneal fractures, particularly Sanders type II and III, present significant challenges in orthopedic trauma due to their complex anatomy, high-energy mechanism, and risk for long-term disability. While the extensile lateral approach has long been the gold standard for operative fixation, it is associated with substantial soft-tissue complications. The mini-open sinus tarsi approach has emerged as a less invasive alternative, aiming to balance adequate fracture reduction with reduced wound morbidity. However, the reported outcomes and indications for this approach in Sanders II and III fractures remain an area of active investigation. This review synthesizes current evidence regarding the outcomes of the mini-open sinus tarsi approach for displaced intra-articular calcaneal fractures of Sanders type II and III. The goal is to evaluate functional and radiological results, complication rates, and compare these with conventional surgical techniques, providing clarity on the approach's utility and limitations. A comprehensive literature review was conducted, encompassing studies published over the past two decades that evaluated the mini-open sinus tarsi approach in Sanders II and III calcaneal fractures. Primary outcomes assessed include postoperative function (using AOFAS, Maryland Foot Score, and other validated metrics), radiological reduction, wound healing, and overall complication rates. Comparative data with extensile lateral and percutaneous techniques are highlighted when available.

Conclusion: Current evidence suggests that the mini-open sinus tarsi approach offers favorable functional and radiological outcomes with a notably reduced risk of wound complications compared to the extensile lateral approach, especially for Sanders II and III fractures. Despite some limitations regarding direct visualization of fracture fragments and challenges in achieving optimal reduction in more complex patterns, the approach provides a valuable balance between invasiveness and efficacy. Continued research is warranted to further refine patient selection criteria and to establish long-term outcome data. The review underscores the importance of individualized treatment planning and highlights areas for future investigation in optimizing surgical management for these challenging injuries.

Keywords: *Displaced Intra-Articular Calcaneal Fractures, Mini-Open Sinus Tarsi , Outcome*

Introduction

Displaced intra-articular calcaneal fractures represent one of the most challenging injuries in orthopedic trauma. These fractures typically result from high-energy mechanisms such as falls from height or motor vehicle accidents, leading to complex disruption of the subtalar joint and the surrounding bone structure. Sanders type II and III fractures, which account for the majority of intra-articular patterns, involve a varying number of articular fragments and pose significant difficulties in achieving anatomical reduction and restoring function[1]. The standard of care has traditionally centered on open reduction and internal fixation (ORIF) using the extensile lateral approach, which allows direct visualization and precise restoration of the articular surface. However, this method carries a substantial risk of wound complications due to the vulnerable soft tissue envelope overlying the lateral calcaneus[2].

Over the past two decades, less invasive techniques have gained popularity, aiming to minimize surgical

trauma while maintaining adequate reduction and fixation. The mini-open sinus tarsi approach has emerged as a promising alternative, particularly for Sanders II and III fractures, offering a balance between adequate exposure for reduction and a reduced risk of wound complications[3]. Despite the growing body of literature supporting this approach, controversy persists regarding its effectiveness in achieving comparable functional and radiological outcomes to the extensile lateral approach, especially in more complex fracture patterns.

The primary aim of this review is to synthesize current evidence on the outcomes of the mini-open sinus tarsi approach in the management of displaced intra-articular calcaneal fractures, specifically Sanders II and III. By evaluating both functional and radiological results, as well as complication rates, this review seeks to clarify the role of this approach in modern orthopedic practice. Furthermore, the review addresses existing research gaps, including the need for standardized outcome measures and long-term follow-up data. Through critical appraisal of the available evidence, this article aims to provide clinicians with an up-to-date resource for guiding the management of these complex injuries[4].

Anatomy and Biomechanics of the Calcaneus

The calcaneus, commonly known as the heel bone, is the largest tarsal bone in the foot and plays a pivotal role in weight-bearing and locomotion. Its unique anatomy, characterized by a complex trabecular structure and a thin cortical shell, is specifically adapted to absorb and transmit forces generated during walking, running, and jumping[5]. The superior surface of the calcaneus articulates with the talus at the subtalar joint, which is critical for hindfoot motion and allows for inversion and eversion of the foot. The anterior aspect forms the calcaneocuboid joint, contributing to the stability of the lateral column of the foot[6].

The structural integrity of the calcaneus is reinforced by several ligamentous attachments, including the interosseous talocalcaneal and calcaneofibular ligaments, which maintain subtalar joint stability. The sustentaculum tali, a prominent bony projection on the medial side, supports the talus and provides an attachment site for key ligaments and tendons, such as the flexor hallucis longus[7]. Biomechanically, the calcaneus acts as a lever arm for the Achilles tendon, transmitting the force generated by the gastrocnemius-soleus complex to facilitate ankle plantarflexion.

Due to its unique shape and force distribution, the calcaneus is particularly susceptible to compressive forces that, when excessive, can cause the characteristic collapse and displacement seen in intra-articular fractures. Disruption of the posterior facet—the primary weight-bearing surface—can significantly impair subtalar joint function and lead to chronic pain, arthritis, and gait disturbances[8]. Understanding the complex anatomy and biomechanics of the calcaneus is essential for appreciating the challenges involved in restoring normal foot function following intra-articular fractures.

Classification of Calcaneal Fractures: Focus on Sanders II & III

The classification of calcaneal fractures is critical for determining the appropriate management strategy and predicting clinical outcomes. Among several systems developed over the years, the Sanders classification is the most widely utilized for intra-articular fractures. It is based on coronal and axial computed tomography (CT) scans, which provide detailed visualization of the posterior facet of the subtalar joint[5]. The Sanders system divides intra-articular fractures into four main types according to the number and location of fracture lines affecting the posterior facet. This imaging-based approach allows orthopedic surgeons to assess the extent of articular involvement and to plan the most suitable surgical intervention.

Sanders type II fractures are characterized by a single fracture line that divides the posterior facet into two fragments, typically involving either the medial, central, or lateral segment. These fractures are generally considered less complex and, with appropriate reduction, are associated with more favorable outcomes[6]. In contrast, Sanders type III fractures involve two fracture lines that split the posterior facet into three articular fragments. This added complexity makes achieving anatomical reduction and stable fixation more challenging, and these fractures have been linked to higher rates of postoperative

complications and subtalar joint dysfunction[7]. The nuanced distinction between these types underpins the importance of meticulous CT evaluation prior to surgery.

Accurate classification of intra-articular calcaneal fractures has significant implications not only for surgical planning but also for prognostication and comparative research. Studies have demonstrated that interobserver and intraobserver reliability of the Sanders system is generally high, providing consistency in research and clinical practice[8]. However, even within the same Sanders type, variation in comminution, displacement, and soft tissue status can influence outcomes and should be considered in decision-making. For instance, Sanders type III fractures with significant displacement or associated soft tissue compromise may not respond as favorably to minimally invasive approaches as less complex fractures[9]. Ultimately, while Sanders classification is indispensable, it should always be interpreted in the broader clinical context.

Recent research highlights the need for comprehensive preoperative imaging and individualized fracture assessment. Even small differences in fracture morphology, such as the extent of lateral wall blowout or the degree of comminution, can influence the technical difficulty of surgery and long-term prognosis[10]. The focus of this review on Sanders II and III fractures is particularly relevant, as these are the most common types encountered in clinical practice and are widely considered suitable for mini-open sinus tarsi approaches due to their fracture characteristics. A deep understanding of the Sanders classification system remains a cornerstone of effective calcaneal fracture management and surgical outcome optimization.

Overview of Surgical Approaches

The management of displaced intra-articular calcaneal fractures has evolved significantly over the past several decades, with the primary goal being restoration of the articular surface, heel alignment, and overall foot function[11]. Traditional approaches to surgical treatment include the extensile lateral approach, percutaneous fixation techniques, and more recently, the mini-open sinus tarsi approach. Each technique offers distinct advantages and disadvantages, and the selection of an approach is typically influenced by fracture pattern, soft tissue condition, and surgeon experience.

The extensile lateral approach has long been regarded as the gold standard for calcaneal fracture fixation, as it provides unparalleled visualization of the posterior facet, allows for direct manipulation and reduction of articular fragments, and enables the use of conventional plating systems[12]. However, this approach is associated with a high rate of wound complications, including superficial and deep infections, wound dehiscence, and even osteomyelitis. The risk is particularly pronounced in patients with comorbidities such as diabetes or smoking history, or when there is significant soft tissue injury at presentation. These drawbacks have prompted exploration of less invasive alternatives in recent years.

Percutaneous fixation techniques represent another option, relying on limited incisions and indirect reduction maneuvers to minimize soft tissue disruption[13]. These methods are particularly appealing for patients at high risk for wound complications, but they can be technically demanding and are associated with a learning curve. Additionally, achieving and maintaining anatomic reduction can be difficult, especially in more complex fracture patterns with significant comminution. Outcomes data on percutaneous techniques show variable results, with some studies suggesting higher rates of malreduction and loss of fixation compared to open approaches.

The mini-open sinus tarsi approach has gained increasing popularity as an intermediate option that seeks to balance adequate visualization with soft tissue preservation[14]. This approach involves a small incision over the sinus tarsi, allowing for targeted exposure of the posterior facet and direct reduction of key articular fragments. By limiting the extent of dissection, the risk of wound complications is significantly reduced compared to the extensile lateral approach. Early and mid-term outcomes suggest that the mini-open sinus tarsi approach is particularly well-suited to Sanders type II and III fractures, offering similar functional and radiological results with fewer complications.

As surgical technology and techniques continue to advance, hybrid methods combining elements of open

and minimally invasive approaches have also emerged. These techniques often utilize limited open reduction with percutaneous fixation or adjunctive arthroscopic assistance to optimize articular reduction and minimize soft tissue injury[15]. The ongoing refinement of surgical strategies underscores the need for individualized treatment planning, taking into account patient factors, fracture characteristics, and available expertise to achieve the best possible outcomes for displaced intra-articular calcaneal fractures.

Indications for Mini-Open Sinus Tarsi Approach

The mini-open sinus tarsi approach has emerged as a viable alternative to the traditional extensile lateral approach for the treatment of selected displaced intra-articular calcaneal fractures. Its primary indication is in Sanders type II and III fractures, where the complexity of the fracture pattern is sufficient to necessitate open reduction, but the soft tissue envelope and the morphology of the fragments are amenable to limited exposure[16]. This approach is particularly indicated in patients at increased risk for wound complications, such as those with comorbidities (diabetes, peripheral vascular disease), obesity, smokers, and individuals with tenuous soft tissue conditions at the time of presentation.

Patient selection is critical when considering the mini-open sinus tarsi approach. Fractures involving significant medial wall comminution, severely displaced fragments, or Sanders type IV injuries generally fall outside the recommended indications due to the limited exposure provided by the sinus tarsi window[17]. Conversely, the approach is ideal for two- or three-part intra-articular fractures where direct reduction of the posterior facet is achievable through the limited incision. The mini-open approach is also advantageous in cases where early mobilization is a priority, as reduced soft tissue disruption can facilitate faster wound healing and rehabilitation initiation.

In addition to fracture characteristics, timing of surgery and soft tissue considerations play important roles in determining appropriateness for the mini-open sinus tarsi approach. Surgery is best performed after resolution of acute swelling but before the development of skin contractures or blisters, typically within 10–14 days post-injury[18]. This window allows for optimal visualization and handling of tissues. Patients with closed fractures, minimal contamination, and no significant delay to presentation are also preferred candidates. Surgeons must assess each case individually, balancing the potential benefits of the approach against the risk of inadequate exposure in more complex fracture patterns. Adherence to strict patient selection criteria has been shown to improve outcomes and reduce complications with this technique.

Surgical Technique: Mini-Open Sinus Tarsi Approach

The mini-open sinus tarsi approach is performed with the patient positioned in a lateral decubitus or supine position, depending on surgeon preference and fracture characteristics[19]. A small incision, typically 3–5 cm in length, is made over the sinus tarsi, beginning just distal and anterior to the tip of the lateral malleolus and extending towards the base of the fourth metatarsal. This incision provides access to the lateral aspect of the calcaneus, allowing direct visualization of the posterior facet, crucial for achieving anatomical reduction in Sanders type II and III fractures.

Following skin incision, blunt dissection is carried down through the subcutaneous tissue, carefully protecting the sural nerve and peroneal tendons. The extensor digitorum brevis muscle is gently retracted or partially elevated to enhance exposure. Hemostasis is meticulously achieved to minimize hematoma formation and optimize the operative field. Using specialized reduction clamps and small periosteal elevators, the surgeon can manipulate the main fracture fragments under direct vision, aiming for precise restoration of the articular surface[20]. Temporary fixation is typically achieved with K-wires, followed by definitive fixation using low-profile plates or cannulated screws introduced through the same incision. Fluoroscopic guidance is integral to this technique, enabling confirmation of reduction quality and hardware positioning in multiple planes[21]. The use of intraoperative imaging helps detect residual step-offs or malalignment that may not be apparent through the limited exposure. Bone grafting is considered in cases with significant metaphyseal voids or comminution, to provide structural support and prevent loss of reduction. Once fixation is confirmed, meticulous layered closure of the wound is performed, and

a sterile dressing is applied. Early range-of-motion exercises can often be initiated soon after surgery due to the limited soft tissue disruption, which contributes to improved postoperative rehabilitation and outcomes.

Postoperatively, patients are typically maintained non-weight bearing for 6–8 weeks, depending on the quality of fixation and degree of comminution. Gradual progression to weight bearing is instituted under close radiographic and clinical supervision. The streamlined nature of the mini-open sinus tarsi approach, when executed with careful technique and appropriate patient selection, provides a favorable balance between adequate reduction and minimized soft tissue morbidity, making it an increasingly preferred option for Sanders II and III fractures[22].

Outcomes of Mini-Open Sinus Tarsi Approach

Functional Outcomes

Numerous studies have documented the functional results of the mini-open sinus tarsi approach for Sanders II and III displaced intra-articular calcaneal fractures. Most series report satisfactory to excellent outcomes, as measured by validated scoring systems such as the American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot score and the Maryland Foot Score[23]. Average AOFAS scores in these cohorts typically range from 80 to 90 at one to two years postoperatively, reflecting restoration of pain-free ambulation, improved subtalar joint mobility, and a high rate of return to pre-injury activity levels. Patient-reported satisfaction rates are also high, with many individuals able to resume work and recreational activities without significant limitation.

Several comparative studies have demonstrated that, for Sanders II and III fractures, the mini-open approach achieves functional results comparable to those obtained with the extensile lateral approach, but with a reduced risk of wound complications and faster recovery[24]. Early initiation of postoperative mobilization, made possible by the less invasive exposure, is associated with better long-term foot function and less joint stiffness. However, some studies note a modest reduction in subtalar motion and occasional complaints of mild residual discomfort, though these findings are not unique to the mini-open approach and may be related to the nature of the injury itself.

Radiological Outcomes

Radiological assessment is an essential component of evaluating surgical success following calcaneal fracture fixation. Studies consistently report good to excellent restoration of Böhler's angle, Gissane's angle, and hindfoot alignment when the mini-open sinus tarsi approach is utilized in appropriately selected cases[25]. Postoperative CT and plain radiographs confirm that direct visualization through the sinus tarsi window allows for accurate reduction of the posterior facet, which is a key predictor of long-term subtalar joint function. Maintenance of reduction over time has also been shown to be satisfactory, with low rates of secondary displacement or hardware failure when modern fixation techniques are employed.

Long-term radiographic follow-up has demonstrated that the majority of patients maintain joint congruity and heel height, with a relatively low incidence of post-traumatic subtalar arthritis in Sanders II fractures[26]. The risk of late collapse or malunion is minimized through careful surgical technique and adequate structural support at the time of fixation. Nonetheless, Sanders III fractures, due to their greater initial complexity, remain at somewhat higher risk for residual incongruity or the development of arthritic changes, although overall outcomes are still favorable compared to traditional open techniques.

Complication Rates

One of the most significant advantages of the mini-open sinus tarsi approach is its lower complication rate, especially regarding soft tissue morbidity. Multiple prospective and retrospective studies have reported wound complication rates as low as 0–5%, compared to rates exceeding 20% with the extensile lateral approach[27]. The limited incision and minimal periosteal stripping reduce the risks of infection, wound breakdown, and sural nerve injury. Rates of deep infection, hardware exposure, and need for secondary wound procedures are correspondingly low, supporting the safety profile of this technique.

Other complications, such as malreduction, hardware failure, or the need for secondary subtalar arthrodesis, are generally comparable to those observed with open approaches and are more related to the initial fracture pattern and technical execution rather than the surgical approach itself[28]. Overall, the evidence suggests that the mini-open sinus tarsi approach delivers favorable outcomes for Sanders II and III calcaneal fractures, combining excellent functional and radiological results with a substantially reduced risk of wound complications.

Comparison with Other Surgical Approaches

The mini-open sinus tarsi approach has increasingly been compared with the traditional extensile lateral approach and percutaneous fixation in both prospective and retrospective studies. One of the most significant distinctions lies in the soft tissue complication rate, which is substantially lower with the mini-open sinus tarsi technique. While the extensile lateral approach offers wide exposure and facilitates anatomical reduction, it carries a reported wound complication rate as high as 20–25% in some series, especially in patients with comorbidities or poor soft tissue conditions[29]. In contrast, the mini-open approach has consistently demonstrated wound complication rates below 5%, making it especially attractive in patients at elevated risk for infection, necrosis, or delayed healing.

Functional and radiological outcomes are another area of comparison. Multiple studies indicate that the mini-open approach yields functional results equivalent to those of the extensile lateral approach in Sanders II and III fractures, with no significant differences in AOFAS or Maryland Foot Scores at one- or two-year follow-up[30]. Restoration of key radiological parameters, such as Böhler's angle, hindfoot alignment, and posterior facet congruity, is also comparable between these techniques in properly selected cases. However, the extensile lateral approach may still provide superior reduction in very complex fractures (Sanders IV), where broader access is required, underscoring the importance of appropriate patient selection for the mini-open approach.

When compared with percutaneous fixation, the mini-open sinus tarsi approach offers a balance between the two extremes of exposure. Percutaneous techniques, while least invasive and offering the lowest risk of soft tissue complications, are highly dependent on surgeon expertise and fluoroscopic guidance, with a steeper learning curve and greater potential for malreduction or hardware misplacement in less experienced hands[31]. Some evidence suggests a higher rate of suboptimal reduction and fixation failure with percutaneous methods, especially in comminuted fractures. Conversely, the mini-open approach provides direct access for articular reduction while still preserving soft tissue, offering a compromise between maximal visualization and minimal invasiveness.

The choice of surgical technique ultimately depends on fracture pattern, patient characteristics, and the surgeon's familiarity with each approach. The literature suggests that for Sanders II and III displaced intra-articular calcaneal fractures, the mini-open sinus tarsi approach achieves a similar or better balance of outcomes compared to more invasive methods, without compromising reduction quality or increasing long-term complications. Ongoing randomized trials and meta-analyses continue to inform best practices, but current evidence supports the mini-open approach as a highly effective and safe option for the majority of these injuries[32].

Factors Influencing Outcomes

Patient Factors

Patient-related factors play a significant role in determining both the short- and long-term outcomes of displaced intra-articular calcaneal fractures treated with the mini-open sinus tarsi approach. Age, overall health status, comorbidities, and lifestyle choices such as smoking have all been correlated with postoperative healing and complication rates[33]. Older patients or those with diabetes mellitus, peripheral vascular disease, or immune suppression are at increased risk for delayed wound healing and infection, although the mini-open approach mitigates this risk compared to more extensive exposures. Obesity is another known risk factor for complications, particularly due to the increased soft tissue thickness and mechanical load on the repair, but careful technique and patient optimization can help

reduce adverse outcomes.

Smoking, in particular, has been identified as a modifiable risk factor strongly associated with higher rates of wound complications, delayed union, and overall poorer functional results. Studies have shown that patients who abstain from smoking before and after surgery experience better outcomes than those who continue the habit[34]. Furthermore, patient compliance with postoperative protocols—including non-weight bearing, wound care, and participation in rehabilitation—also greatly influences final outcomes. Early patient education and multidisciplinary support are essential in optimizing recovery and minimizing complications.

Fracture Pattern

The complexity and specific morphology of the fracture itself are critical determinants of surgical difficulty and eventual success. Sanders II fractures, with their simpler two-part pattern, are generally associated with higher rates of anatomic reduction, stable fixation, and excellent functional outcomes when treated with the mini-open sinus tarsi approach[35]. In contrast, Sanders III fractures, which involve three articular fragments and often greater comminution, are inherently more challenging to reduce and stabilize, and they carry an increased risk of residual displacement, subtalar incongruity, and post-traumatic arthritis. The presence of additional medial wall comminution or extension into the calcaneocuboid joint further complicates management and can negatively affect both short- and long-term results.

Careful preoperative imaging and planning are essential to determine the appropriateness of the mini-open approach for a given fracture. Fractures with severe displacement, poor bone quality, or extensive soft tissue injury may require more extensile approaches or adjunctive techniques to achieve optimal outcomes[36]. Nevertheless, for the majority of Sanders II and many Sanders III patterns, the mini-open sinus tarsi approach provides reliable exposure and access for direct articular reduction.

Surgical Timing

Timing of surgical intervention is another important factor influencing outcomes. Optimal results are achieved when surgery is performed after resolution of acute swelling but before the development of skin contractures or significant soft tissue compromise, typically within 10–14 days after injury[37]. Delayed intervention can increase the risk of wound complications and make reduction more technically challenging due to early fracture healing or soft tissue fibrosis. Conversely, operating too early—before soft tissue swelling subsides—raises the likelihood of wound dehiscence and infection, even with minimally invasive techniques. Appropriate timing requires close coordination between the surgical team and perioperative staff to ensure that the soft tissue envelope is in the best possible condition for surgery.

In summary, successful outcomes following the mini-open sinus tarsi approach are maximized by careful patient selection, individualized assessment of fracture pattern, meticulous preoperative planning, and thoughtful timing of surgical intervention. When these factors are addressed, the approach offers a predictable pathway to excellent functional and radiological results in the majority of Sanders II and III calcaneal fractures[38].

Challenges and Limitations

Despite the many advantages of the mini-open sinus tarsi approach, several challenges and limitations remain that must be carefully considered when planning surgical management. One of the primary challenges is the restricted visualization of the medial and central portions of the posterior facet, particularly in more complex Sanders III fractures with greater comminution or displacement[39]. While the approach allows direct access to the lateral aspect of the posterior facet, achieving perfect articular reduction in the deeper or more medially located fragments may be difficult. Inadequate reduction of these fragments can lead to residual step-offs, loss of subtalar congruity, and increased risk of post-traumatic arthritis, all of which can compromise long-term function.

The limited exposure inherent to this technique can also complicate the identification and management of associated injuries, such as fracture extensions into the sustentaculum tali or calcaneocuboid joint.

These injuries, if unrecognized or insufficiently addressed, may contribute to suboptimal outcomes and ongoing pain or dysfunction[40]. Surgeons utilizing the mini-open sinus tarsi approach must therefore be proficient in interpreting intraoperative fluoroscopy and, when necessary, supplementing the exposure with additional small incisions or percutaneous maneuvers. Some authors have advocated for adjunctive use of arthroscopy to further improve visualization, although this adds complexity and is not universally available.

Another limitation involves the learning curve associated with the mini-open approach. Surgeons must be adept at working within a confined field, manipulating fracture fragments under direct but limited visualization, and relying on fluoroscopic assessment to confirm reduction quality and hardware placement[41]. This can be especially challenging for less experienced surgeons or in hospitals where advanced imaging modalities are not readily accessible. Additionally, fixation options may be restricted by the limited exposure, and placement of certain plates or screws may require additional technical finesse.

Finally, while the risk of wound complications is substantially lower than with extensile exposures, the mini-open approach is not entirely without risk. Superficial wound infection, sural nerve irritation, or delayed healing can still occur, especially in high-risk patients or with inadequate soft tissue handling[42]. Furthermore, long-term outcome data—particularly in terms of the development of subtalar arthritis or need for secondary arthrodesis—are still relatively limited, and ongoing surveillance is required to fully establish the durability of this approach. Recognition of these challenges is essential for proper case selection, preoperative counseling, and achieving the best possible outcomes for patients.

Conclusion

The mini-open sinus tarsi approach has established itself as a highly effective and reliable option for the management of displaced intra-articular calcaneal fractures, particularly those classified as Sanders type II and III. This approach offers a valuable compromise between achieving direct articular reduction and minimizing soft tissue complications, which have historically plagued more extensive lateral exposures. Functional and radiological outcomes following this method are consistently favorable, with low rates of wound complications and patient-reported satisfaction comparable to traditional open techniques. Critical to the success of this technique are meticulous patient selection, careful preoperative planning, and adherence to established surgical principles. While the approach is best suited to two- and three-part fractures, it can be adapted for more complex injuries in experienced hands with careful attention to detail and intraoperative imaging. Challenges remain, particularly in the management of highly comminuted or medially displaced fragments, but ongoing refinements in surgical instrumentation and technique continue to expand the utility of the sinus tarsi window.

As evidence accumulates, the mini-open sinus tarsi approach is likely to remain a mainstay in the treatment of calcaneal fractures that require operative fixation but for which soft tissue preservation is a priority. Continued research, especially long-term outcome studies and prospective randomized trials, will be essential to further define its indications, limitations, and potential for broader application. Ultimately, the mini-open sinus tarsi approach represents a significant advancement in the quest to optimize both functional outcomes and patient safety in the challenging landscape of calcaneal fracture care.

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