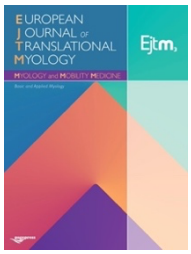
European Journal of Translational Myology



pISSN: 2037-7452 eISSN: 2037-7460

https://www.pagepressjournals.org/index.php/bam/index

Eur J Transl Myol 2026 [Online ahead of print]

To cite this Article:

Catananti M, Rovere G, D'Ambrosio M, et al. **Anterolateral approach for total ankle arthroplasty, preliminary results of a less-invasive surgical pathway: an observational retrospective study.** *Eur J Transl Myol* doi: 10.4081/ejtm.2026.15586

Submitted: 21 April 2026

Accepted: 2 June 2026

Early access: 6 July 2026

Anterolateral approach for total ankle arthroplasty, preliminary results of a less-invasive surgical pathway: an observational retrospective study

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Abstract

Total Ankle Arthroplasty (TAA) has evolved into a reliable treatment option for end-stage ankle osteoarthritis; however, wound healing complications remain a significant concern, particularly with traditional anterior approaches. These complications are largely related to the vulnerability of the anterior soft-tissue envelope and may negatively affect early outcomes. The purpose of the present study was to evaluate the safety and early clinical outcomes of a curvilinear anterolateral approach for TAA, with particular focus on wound healing and soft-tissue complications. A retrospective observational study was conducted on 48 consecutive patients undergoing TAA between January 2023 and December 2025. A total of 49 ankle arthroplasties were performed using a curvilinear anterolateral approach. Patient demographics, comorbidities, and perioperative variables were recorded. Primary outcomes included wound-related complications and time to complete healing. Secondary outcomes included functional improvement assessed using the Foot and Ankle Outcome Score (FAOS). Three patients (6.1%) developed wound-related complications. Two patients (4.1%) experienced superficial wound dehiscence, which resolved with conservative treatment. One patient (2.0%) developed a deeper wound complication involving the soft tissues without prosthetic involvement; this case occurred in a high-risk patient with multiple comorbidities and was successfully managed with advanced wound care. No cases of deep prosthetic infection were observed. All remaining cases (93.9%) achieved uneventful wound healing within 12 to 21 days. Functional outcomes showed a significant improvement, with mean FAOS increasing from 40 ± 5 preoperatively to 75 ± 5 at final follow-up. The curvilinear anterolateral approach for TAA

demonstrated a low rate of wound-related complications and consistent early functional improvement. By preserving the tibialis anterior tendon sheath and optimizing incision placement, this technique may reduce both vascular and mechanical risk factors associated with wound healing disorders. It represents a safe and reproducible alternative to traditional anterior and transfibular approaches, particularly in patients at increased risk for soft-tissue complications.

Key words: total ankle arthroplasty; anterolateral approach; wound complications; soft-tissue preservation; surgical technique; foot and ankle outcome score.

Introduction

Over the past two decades, Total Ankle Arthroplasty (TAA) has undergone substantial evolution. Early-generation implants were associated with high failure and revision rates, which initially limited their widespread adoption. However, the introduction of modern prosthetic designs, together with advances in surgical techniques and improved patient selection, has significantly enhanced implant survivorship and functional outcomes.[1–3] As a result, TAA has progressively emerged as a reliable alternative to ankle arthrodesis for the treatment of end-stage ankle osteoarthritis, particularly in active patients, offering the advantage of preserving joint motion and improving overall function.[2–4]

Comparative studies have reported similar levels of patient satisfaction between ankle arthrodesis and TAA; however, growing evidence from specialized centers increasingly favors ankle replacement, demonstrating superior preservation of ankle kinematics, improved gait patterns, and better patient-reported outcome measures, with acceptable complication rates.[2–5] Consequently, the number of TAA procedures performed worldwide has steadily increased.

Despite these advancements, soft-tissue complications remain a major concern in the early postoperative period and represent one of the leading causes of morbidity following TAA.[6–8] In particular, wound healing disorders have been consistently associated with prolonged recovery, increased healthcare burden, and, in severe cases, compromised implant survival.[6,7] The anterior aspect of the ankle is characterized by thin soft-tissue coverage and limited vascularity, making it particularly vulnerable to surgical trauma.[7]

The standard anterior approach, although widely adopted due to its excellent visualization of the tibiotalar joint and facilitation of accurate implant positioning, has been associated with a relatively high incidence of wound complications, with reported rates of wound dehiscence reaching up to 20–30% in selected series.[7–9] From an anatomical standpoint, these complications are largely attributable to disruption of the anterior tibial angiosome and violation of the tibialis anterior tendon sheath. In addition, retraction or displacement of the anterior neurovascular bundle may further compromise local perfusion, increasing the risk of ischemic wound breakdown.[7–10] Mechanical factors may also contribute, as disruption of the tibialis anterior sheath can generate a "bowstring effect," subjecting the wound to repetitive tension during ankle motion and potentially leading to delayed healing or dehiscence.[9,10]

Patient-related factors, including diabetes mellitus, smoking, peripheral vascular disease, and previous hindfoot surgery, further exacerbate these risks by impairing microvascular perfusion and tissue healing capacity.[5,7] Consequently, there has been growing interest in developing surgical approaches that preserve soft-tissue integrity while maintaining adequate joint exposure.

Several alternative techniques have been proposed. The transfibular lateral approach avoids disruption of the anterior vascular network and provides excellent lateral visualization; however, it requires fibular osteotomy, thereby increasing surgical complexity and introducing risks of delayed union, nonunion, and hardware-related complications.[12–14] Moreover, access to the medial gutter and comprehensive joint visualization may be limited, particularly in cases requiring precise coronal alignment.[13] Posterior approaches, although useful in selected cases, are technically demanding, offer limited exposure, and pose potential risks to the posterior neurovascular structures, which has restricted their widespread adoption.[15]

Within this context, modified anterior and anterolateral approaches have been developed with the aim of optimizing the balance between surgical exposure and soft-tissue preservation.[11] The curvilinear anterolateral approach, in particular, was designed to reduce wound-related complications by lateralizing the incision, respecting Langer's lines, and preserving the tibialis anterior tendon sheath, thereby minimizing vascular disruption and mechanical stress on the wound.

By utilizing a curvilinear skin incision and a dissection plane between the tibialis anterior and extensor hallucis longus tendons, this technique aims to maintain adequate exposure of the ankle joint while reducing ischemic risk. Furthermore, the shorter incision length compared with traditional anterior approaches may provide additional benefits in terms of wound healing and soft-tissue recovery.

The purpose of this study is to present the anatomical rationale, surgical technique, and early clinical outcomes of the curvilinear anterolateral approach in a consecutive series of patients undergoing total ankle arthroplasty, with particular attention to wound-related complications and early soft-tissue healing.

Materials and Methods

Study design and patient population

This retrospective observational study was conducted to evaluate the safety and early clinical outcomes of a curvilinear anterolateral approach for TAA. All consecutive patients undergoing TAA between January 2023 and December 2025 at a single tertiary referral center were included.

A total of 48 patients were enrolled, accounting for 49 ankle arthroplasties, as one patient underwent staged bilateral procedures. All surgeries were performed by the same experienced orthopedic surgical team, ensuring consistency in surgical technique and perioperative management.

Two third-generation total ankle prosthetic systems were used according to implant availability and patient-specific anatomical considerations. Surgical technique, perioperative protocols, and postoperative rehabilitation were standardized across all cases.

Patient selection

Patients were included according to predefined criteria. Inclusion criteria included: i) end-stage ankle osteoarthritis (primary or post-traumatic); ii) age between 35 and 80 years; iii) ability to comply with postoperative rehabilitation and follow-up; iv) availability of complete preoperative and postoperative Foot and Ankle Outcome Score (FAOS) data. Exclusion criteria included: i) active infection or skin ulceration at the surgical site; ii) severe peripheral vascular disease; iii) neuropathic arthropathy (e.g., Charcot joint); iv) immunosuppression or uncontrolled diabetes mellitus; v) concomitant subtalar arthrodesis performed during the same procedure

Preoperative planning and postoperative protocol

Preoperative evaluation included clinical and radiographic assessment of the ankle and subtalar joint. In selected cases, staged subtalar arthrodesis was preferred over simultaneous procedures to reduce the risk of talar vascular compromise. All patients followed a standardized postoperative protocol consisting of multimodal analgesia, early mobilization, and progressive weight-bearing based on clinical and radiographic findings. Postoperative wound and clinical assessments were performed at standardized intervals: 7 days (first dressing change), 14 days (suture removal), and 1 month postoperatively.

Outcome measures

The primary outcome measures were: i) incidence of wound dehiscence; ii) occurrence of superficial or deep surgical site complications; iii) time to complete wound healing; iv) association between wound complications and patient comorbidities.

Wound complications were classified based on clinical severity: i) major complications: full-thickness wound dehiscence requiring advanced wound care; ii) minor complications: superficial skin compromise resolving with conservative treatment.

Secondary outcomes included functional assessment using the FAOS, recorded preoperatively and at final follow-up.

Surgical technique

Curvilinear anterolateral approach

The patient is positioned supine with the operative limb extended. A support is placed beneath the distal tibia to facilitate exposure and fluoroscopic control. A thigh tourniquet is applied according to institutional protocols.

This technique is based on the anterolateral approach described by Hirao *et al.*,[14] with key modifications aimed at improving soft tissue preservation. Specifically, a curvilinear skin incision is used instead of a straight incision, and the deep dissection plane is shifted medially between the tibialis anterior and extensor hallucis longus tendons.

Skin incision and superficial dissection

Anatomical landmarks are identified and marked prior to incision. The incision begins at the distal third of the tibia, lateral to the tibialis anterior tendon, and curves distally toward the second metatarsal ray, terminating at the level of the talar neck (Figure 1).

The incision measures approximately 12 cm and is positioned more laterally than in the traditional anterior approach, allowing preservation of the tibialis anterior tendon sheath and reducing mechanical stress on the overlying skin.

Subcutaneous dissection is performed with meticulous identification and protection of the superficial peroneal nerve, which is gently mobilized and retracted laterally under direct visualization (Figure 2).

Deep dissection and joint exposure

The extensor retinaculum is incised lateral to the tibialis anterior sheath, preserving its integrity. Dissection proceeds through the intermuscular plane between the tibialis anterior and extensor hallucis longus tendons (Figure 3).

The anterior neurovascular bundle is identified, isolated, and carefully mobilized medially, allowing safe exposure of the tibiotalar joint while minimizing vascular compromise (Figure 4).

This approach provides adequate visualization of both the tibiotalar and fibulotalar joint surfaces without the need for accessory incisions or extensive soft tissue stripping (Figure 5).

Implantation

Bone preparation, trialing, and definitive implantation are performed according to the manufacturer-specific technique of the selected prosthetic system. Fluoroscopic guidance is used when necessary to ensure accurate component positioning (Figure 6).

Closure

Layered closure is performed with particular attention to restoring the extensor retinaculum and protecting the superficial peroneal nerve. Skin closure is achieved without tension to optimize wound healing and reduce the risk of postoperative complications (Figures 7 and 8).

Results

Patient population

The study population included 48 patients, accounting for a total of 49 ankle arthroplasties, as one patient underwent staged bilateral procedures. The mean age at the time of surgery was 61 years (range: 39–78).

The cohort included 26 males (55%) and 22 females (45%), with a mean Body Mass Index (BMI) of 28 kg/m².

Regarding laterality, 24 procedures (50%) were performed on the right side, 23 (48%) on the left, and one patient (2%) underwent staged bilateral ankle arthroplasty.

Relevant comorbidities were present in a significant proportion of patients, including diabetes mellitus in 5 patients (10.4%), active smoking in 6 patients (12.5%), and cardiovascular disease in 17 patients (35.4%).

A total of 41 patients (85.4%) had undergone previous staged subtalar arthrodesis prior to total ankle arthroplasty, with a time interval ranging from 6 to 12 months. The remaining 7 patients (14.6%) underwent primary TAA without prior hindfoot fusion.

The main demographic and clinical characteristics of the study population are summarized in Table 1.

Wound healing and complications

Three patients (6.1%) developed wound-related complications.

Two patients (4.1%) presented superficial wound dehiscence characterized by marginal skin suffering. Both cases were successfully managed with conservative treatment and resolved within approximately one month, without impacting postoperative rehabilitation.

One patient (2.0%) developed a deeper wound complication involving the subcutaneous and deeper soft-tissue layers. This patient had multiple comorbidities, including poorly controlled diabetes mellitus and significant cardiovascular disease. Importantly, no involvement of the prosthetic components was observed. The condition was successfully managed with advanced wound care, and complete healing was achieved within approximately 30 days without the need for surgical revision.

No cases of deep prosthetic infection were observed.

No neurovascular injuries, delayed wound healing, implant-related complications, or prosthetic malalignment were recorded.

In the remaining cases (93.9%), complete and uneventful wound healing was achieved within 12 to 21 days.

A summary of surgical outcomes and complication rates is reported in Table 2.

Functional outcomes

Functional outcomes, assessed using the Foot and Ankle Outcome Score (FAOS), demonstrated a consistent improvement across the cohort. Mean FAOS increased from 40 ± 5 preoperatively to 75 ± 5 at final follow-up, corresponding to a mean improvement of 35 points.

Discussion

The present study evaluated the safety and early soft-tissue outcomes of a curvilinear anterolateral approach for TAA, demonstrating a relatively low rate of wound-related complications (6.1%), with only one deep wound complication and no cases of prosthetic joint infection. These findings support the hypothesis that surgical exposure and incision design play a critical role in early postoperative outcomes following TAA.

Wound complications remain a major limitation of TAA

Despite continuous improvements in implant design and surgical technique, wound healing disorders remain one of the most frequent and clinically relevant complications after TAA. Large clinical series have reported wound complication rates ranging from 10% to over 20%, particularly when using traditional anterior approaches.[7,8] These complications are clinically significant, as they may lead to prolonged recovery, reoperations, and, in severe cases, complex reconstructive procedures such as flap coverage.[8,9]

In the present study, the overall rate of wound complications was 6.1%, which compares favorably with previously reported data. Importantly, no cases of deep prosthetic infection were observed, and all complications were successfully managed conservatively. This finding is clinically relevant, as deep infection remains one of the most feared complications following TAA due to its potential impact on implant survival.

Recent evidence has further highlighted the importance of patient-specific factors. Christie et al. demonstrated that reduced anterior soft-tissue thickness is significantly associated with increased risk of wound dehiscence, emphasizing the role of local soft-tissue characteristics in surgical planning.[10] Similarly, systemic comorbidities such as diabetes mellitus, smoking, and cardiovascular disease have been consistently associated with impaired wound healing and increased complication rates.[5] In our cohort, the only deep wound complication occurred in a high-risk patient with poorly controlled diabetes and cardiovascular disease, further supporting this association.

Limitations of the traditional anterior approach

The standard anterior approach remains the most commonly used exposure for TAA due to its excellent visualization of the tibiotalar joint and facilitation of accurate implant positioning. However, it intersects a relatively vulnerable soft-tissue envelope, characterized by limited vascularity and thin coverage.

From an anatomical perspective, the incision crosses the anterior tibial angiosome and often involves the tibialis anterior tendon sheath, potentially compromising both vascular perfusion and

mechanical stability. Angiosome-based approaches have been proposed to address this limitation, suggesting that preservation of vascular territories may reduce wound complications.[11,12] However, even with these modifications, wound healing disorders remain a persistent issue, indicating that additional biomechanical factors may contribute.

In particular, disruption of the tibialis anterior sheath has been associated with increased tension across the wound during ankle dorsiflexion, leading to the so-called "bowstring effect" and contributing to delayed healing or dehiscence. This mechanism is supported by reconstructive series demonstrating that tendon exposure in this region is a frequent and challenging complication.[8]

Rationale of the anterolateral curvilinear approach

The curvilinear anterolateral approach adopted in this study was designed to address both vascular and mechanical limitations of the traditional anterior exposure. The lateralization of the incision avoids direct involvement of the anterior tibial angiosome and preserves the tibialis anterior tendon sheath, thereby maintaining both vascular supply and structural integrity.

Furthermore, the curvilinear design of the incision, aligned with Langer's lines, may reduce closure tension and improve tissue perfusion. From a technical perspective, the use of the interval between the tibialis anterior and extensor hallucis longus tendons allows controlled mobilization of the anterior neurovascular bundle, minimizing the risk of iatrogenic injury.

This aspect is particularly relevant given that anatomical studies have identified the superficial peroneal nerve as being at risk during standard anterior approaches.[13] In our series, no neurovascular complications were observed, supporting the safety of this surgical corridor.

Comparison with other anterolateral approaches

The concept of an anterolateral approach is not entirely novel. Hirao *et al.* described a modified anterolateral approach using a straight incision and a different deep interval, reporting favorable wound outcomes.[14] More recent studies have further supported the feasibility of anterolateral access, including its integration with accelerated rehabilitation protocols.[15,16]

However, the present technique introduces two key modifications: a curvilinear incision and the use of the tibialis anterior–extensor hallucis longus interval. These features may provide additional advantages in terms of soft-tissue preservation and neurovascular control, potentially explaining the low complication rate observed in this series.

Comparison with lateral transfibular approaches

The transfibular lateral approach has been proposed as an alternative to reduce anterior wound complications, offering excellent visualization while avoiding disruption of the anterior soft-tissue envelope.[17,18] However, this technique introduces additional morbidity related to fibular osteotomy.

Osteotomy-related complications, including delayed union, nonunion, and hardware irritation, have been reported and may require secondary surgical procedures.[19,20] Therefore, while the transfibular approach may reduce anterior wound complications, it introduces a different set of risks.

In this context, the anterolateral curvilinear approach may represent a balanced solution, preserving the advantages of anterior exposure while minimizing both soft-tissue disruption and bone-related complications.

Role of adjunct strategies in high-risk patients

The occurrence of complications in a high-risk patient within our cohort highlights the importance of individualized perioperative management. In patients with significant comorbidities, additional strategies may be beneficial, including meticulous incision management and, in selected cases, the use of closed-incision negative pressure therapy.[21-25]

These adjunctive measures may further reduce wound-related morbidity and complement surgical techniques aimed at preserving soft-tissue integrity.

Limitations

This study has several limitations. The relatively small sample size and single-center design may limit the generalizability of the findings.
Additionally, the follow-up period was focused on early postoperative outcomes and does not allow evaluation of long-term implant survival or late complications. Furthermore, the mean follow-up period was relatively short and focused primarily on early postoperative wound healing and functional recovery. Therefore, the present findings should be interpreted as preliminary results. Longer-term follow-up is required to determine whether the favorable soft-tissue outcomes observed in this series translate into durable implant survival and sustained clinical benefits.

Conclusions

The curvilinear anterolateral approach for total ankle arthroplasty demonstrated a low rate of wound-related complications and favorable early functional outcomes in this consecutive series. By combining incision lateralization, preservation of the tibialis anterior tendon sheath, and alignment with skin tension lines, this technique addresses both vascular and mechanical factors that may contribute to postoperative wound healing disorders.

The approach provided reliable exposure of the ankle joint while preserving soft-tissue integrity, with no neurovascular injuries or deep prosthetic infections observed during the follow-up period. These findings suggest that the curvilinear anterolateral approach may represent a safe, reproducible, and tissue-preserving alternative to traditional anterior and transfibular approaches, particularly in patients at increased risk for soft-tissue complications.

The favorable clinical and wound-healing outcomes observed in this study support the continued use and further investigation of this surgical technique. Future prospective comparative studies with larger patient cohorts and longer follow-up are warranted to confirm these findings and evaluate their long-term clinical implications.

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Contributions

Matteo Catananti, Giuseppe Roovere ,Matteo D' Ambrosio conceptualization; Marco Peruzzi , Vinceno Di Sanzo , methodology, software, formal analysis, data curation; Giuseppe Rovere, Matteo Catanti, Fernando De Maio validation, writing – original draft preparation; Giuseppe Rovere, Natale Maria Gangemi investigation; Pasquale Farsetti resources; writing – Giuseppe Rovere review and editing; Matteo Catananti, Giuseppe Rovere visualization; Matteo Catananti, Giuseppe Rovere supervision; project administra- tion; all authors have read and agreed to the published ver sion of the manuscript

Funding

The study received no external funding.

Conflict of Interest

The authors declare no conflicts of interest.

Ethics approval

The study was performed in line with the principles of the Declaration of Helsinki. As this is an observational retrospective study, no ethical approval was required. All study procedures were conducted in accordance with the ethical principles outlined in the 1964 Helsinki Declaration and its subsequent amendments. Informed consent for the scientific use of anonymized clinical data was obtained from all patients, in accordance with institutional regulations and the guidelines of the Italian Data Protection Authority ("Garante per la protezione dei dati personali"). In compliance with Italian Legislative Decree No. 196/2003 as amended by Legislative Decree No. 101/2018, and Regulation (EU) 2016/679 (GDPR), the use of fully anonymized clinical data for research purposes does not require prior Institutional Review Board approval. Considering that the data were collected anonymously, that the drugs used in the study represent the standard of care in our institution, and that the study had a retrospective design, after extensive consultation with our internal committee, formal approval from the regional ethics committee was deemed unnecessary.

Availability of data and materials

Data presented in this study are available on reasonable request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

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Figure 1. Preoperative skin marking for the curvilinear anterolateral approach. The planned incision is outlined lateral to the tibialis anterior tendon, following a curved trajectory toward the second metatarsal ray. Anatomical landmarks and the projected surgical corridor are identified to optimize soft-tissue preservation and facilitate safe exposure.

Figure 2. Execution of the curvilinear anterolateral skin incision. The incision is placed lateral to the tibialis anterior tendon and follows a curved distal trajectory, maintaining alignment with skin tension lines and facilitating a soft-tissue–preserving surgical corridor.

Figure 3. Intraoperative measurement of the curvilinear anterolateral incision. The incision length is approximately 12 cm and follows a lateralized trajectory relative to the tibialis anterior tendon, allowing adequate surgical exposure while minimizing soft-tissue disruption.

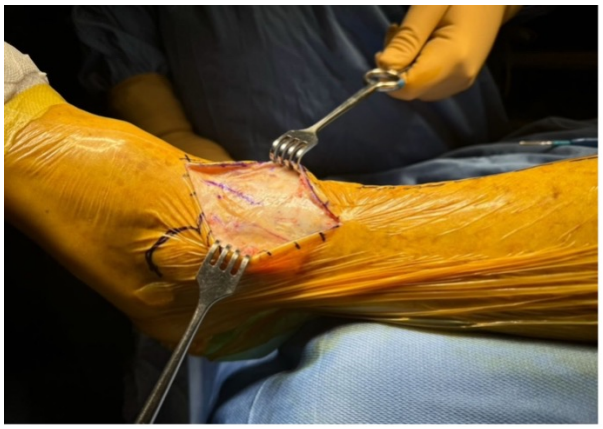

Figure 4. Superficial dissection following the curvilinear anterolateral incision. Skin flaps are gently retracted, exposing the subcutaneous layer and underlying fascia while preserving soft-tissue integrity and vascularity.

Figure 5. Deep dissection through the curvilinear anterolateral approach. The interval between the tibialis anterior and extensor hallucis longus tendons is developed, allowing exposure of the anterior ankle joint while preserving the tibialis anterior tendon sheath and surrounding soft-tissue structures.

Figure 6. Exposure of the anterior neurovascular bundle during deep dissection. The neurovascular structures are identified, isolated, and gently mobilized medially, allowing safe access to the tibiotalar joint while minimizing the risk of vascular compromise.

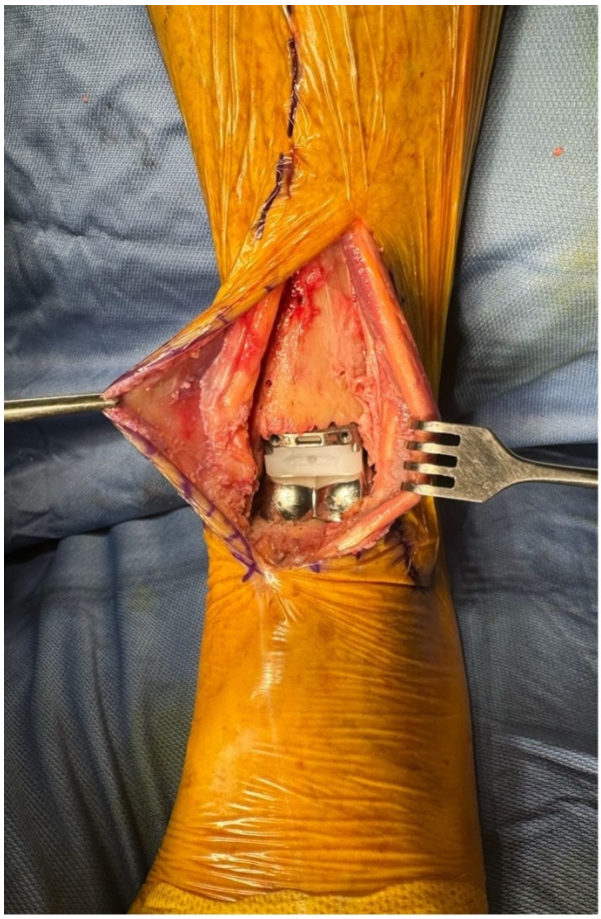

Figure 7. Intraoperative view of the tibiotalar joint following exposure and prosthetic implantation. The components are positioned under direct visualization, with adequate joint exposure achieved through the curvilinear anterolateral approach.

Figure 8. Final wound closure following total ankle arthroplasty through the curvilinear anterolateral approach. Layered closure is performed with restoration of the extensor retinaculum and tension-free skin approximation to optimize soft-tissue healing.

Table 1. Demographic and clinical characteristics of the study population, including age, sex distribution, body mass index, laterality, relevant comorbidities, and prevalence of prior staged subtalar arthrodesis before total ankle arthroplasty.

Variable	**Value (n = 48 patients)**
Age, years, mean (range)	61 (39–78)
Sex (male / female), n (%)	26 (55%) / 22 (45%)
BMI, kg/m², mean	28
Laterality (right / left / bilateral), n	Comparable distribution
Total ankles treated, n	49
Diabetes mellitus, n (%)	5 (10.4%)
Active smokers, n (%)	6 (12.5%)
Cardiovascular disease, n (%)	17 (35.4%)
Previous subtalar arthrodesis, n (%)	41 (85.4%)
Time from subtalar fusion to TAA, months (range)	6–12
Primary TAA (no prior hindfoot fusion), n (%)	7 (14.6%)

Table 2. Postoperative outcomes after total ankle arthroplasty with the curvilinear anterolateral approach, including wound healing complications, perioperative adverse events, and functional outcomes assessed by the Foot and Ankle Outcome Score (FAOS).

Outcome	**Value**
Total ankle arthroplasties performed, n	49
Superficial wound dehiscence, n (%)	2 (4.1%)
Deep wound complication / infection, n (%)	1 (2.0%)
Total wound complications, n (%)	3 (6.1%)
Surgical revision for wound complications, n (%)	0 (0%)
Neurovascular complications, n (%)	0 (0%)
Implant-related complications, n (%)	0 (0%)
Mean time to wound healing	12–21 days
FAOS preoperative, mean ± SD	40 ± 5
FAOS postoperative, mean ± SD	75 ± 5
Mean FAOS improvement	+35