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CASE REPORT

Supramalleolar Tibial Osteotomy for the Prevention of Asymmetric Crus Arthrosis: A Case Report

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Abstract: Asymmetric ankle osteoarthritis, whether congenital or posttraumatic, develops from disruption of the mechanical axis and leads to progressive joint degeneration. Supramalleolar osteotomy (SMO) is a joint-preserving procedure that restores alignment and redistributes joint-loading forces. However, conventional fixation often involves bulky implants or external fixators, resulting in excessive surgical trauma, high metal consumption, and prolonged rehabilitation. The optimal fixation strategy for SMO remains a topic of debate. We present a 54-year-old woman with asymmetric ankle osteoarthritis and a 13-degree varus deformity of the tibia. The patient underwent a minimally invasive SMO stabilized with a customized low-profile titanium mini-plate. Postoperative radiographs confirmed restoration of the mechanical and anatomical tibial axes and correction of the varus deformity. At the 2-month follow-up, functional outcomes improved markedly. The AOFAS ankle-hindfoot score increased from 56 preoperatively to 86 postoperatively, the Visual Analog Scale (VAS) for pain decreased from 7/10 to 2/10, and the Foot and Ankle Disability Index (FADI) improved from 58% to 88%. No complications were observed. This case highlights the potential of a customized low-profile mini-plate to achieve stable fixation with minimal implant use and reduced surgical trauma. The approach allowed early mobilization, symptomatic relief, and functional recovery within a short follow-up period. Although the favorable short-term outcome supports the feasibility of this minimally invasive method, further studies with larger cohorts and longer follow-up are needed to validate its effectiveness and cost-efficiency compared with traditional fixation techniques.

Keywords: osteoarthritis, ankle, varus deformity, congenital abnormalities, osteotomy, tibial, osteotomy, wedge

Introduction

Osteoarthritis (OA) of the ankle joint is a common disease affecting approximately 1% of the world's population and leading to significant costs.[1,2] Most cases of OA of the ankle joint are of post-traumatic origin.[1,3] Two-thirds of cases of OA of the ankle joint demonstrate an asymmetric lesion affecting mainly either the medial or lateral part of the tibia.[4] The asymmetric position of the ankle joint of a congenital or acquired nature leads to the development of a violation of the mechanical axis, and this, in turn, leads to the development of arthritis in the ankle joint. The angle between the longitudinal axis of the tibia and the tibial pylon, measured medially, is 93° (range 84°–100°).[1] The joint can support up to 4 times the body weight during the walking support phase. The load is distributed over a very small contact area of 522 mm2.[5] Supra-ankle reconstruction optimizes the orientation of the back of the foot and the tilt of the elbow joint.[6] However, there are currently no clear principles for the treatment of asymmetric OA using SMO, and more rigorous randomized controlled trials are needed.[7,8]

Supramalleolar osteotomy (SMO) is aimed at correcting extra-articular deformities of the distal tibia. There are several indications, the most common of which is asymmetric OA of the ankle joint. The rationale for this indication is to change the distribution of tension and pressure in the ankle joint by reorienting the axis of the limb. SMO is an extra-articular osteotomy aimed at restoring the mechanical and anatomic axes of the lower leg and harmonizing ankle pressure: accumulated stress on the joint surface can lead to asymmetric cartilage wear and joint deformity, forming a vicious circle leading to OA.[1] Due to the lack of a special plate, SMO is performed with improvised metals and various

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methods (transosseous compression-distraction osteosynthesis using the device of G.A. Ilizarov, intra- and extramedullary implants). One of the main disadvantages of these technologies is the excessive trauma of surgical access, high metal consumption, and a relatively long rehabilitation period. The postsurgical period is one of the main stages; success ensures the achievement of a positive result of surgical treatment. Among previous studies, Kim et al suggested that 2 single-opening wedge plates and screws can be used to stabilize the osteotomy site to achieve the normal tibial-ankle surface and tibial-lateral surface angles. This minimal operative technique allowed full weight-bearing at 6 weeks postoperatively.[9] Another approach of internal fixation with a prefibular Blount staple, suggested by Colin et al, provided satisfactory short- and intermediate-term clinical results.[10] In the last 2 decades, many fixatives have been proposed to reduce the number of complications typical of SMO, but the search for the optimal one is still ongoing.[11]

The objective of this case report is to present the successful application of a minimally invasive supramalleolar tibial osteotomy using a customized low-profile plate for the treatment of asymmetric ankle osteoarthritis and to highlight its potential advantages over conventional fixation methods.

Clinical Demonstration

Patient I., 54 years old, came to our clinic complaining of recurrent aching pains in the left ankle joint, deformity of the lower third of the left shin, limping, and dysfunction of the left lower limb. It is known from medical history that the primary injury occurred 3 years before contacting us as a result of a fall from his own height. The patient was diagnosed with partial damage to the talofibular ligament of the left ankle joint. Due to the appearance and intensification of the above-mentioned complaints, the patient was consulted by the doctors of our clinic.

At the initial consultation, the patient presented with significant functional limitations. The American Orthopaedic Foot and Ankle Society (AOFAS) ankle–hindfoot score was 56, indicating impaired joint function. Pain intensity was rated at 7/10 on the Visual Analog Scale (VAS), while the Foot and Ankle Disability Index (FADI) was 58%, reflecting restricted mobility and compromised daily activity performance.

The patient moves independently, limping on his left lower limb. On examination of the left lower limb, varus deformity of the lower third of the left shin and the posterior part of the foot is visualized (Figure 1A and B). Movements in the left ankle joint are complete and painless. Palpation of the ankle and tarsal joints is without features; severe soreness is detected on

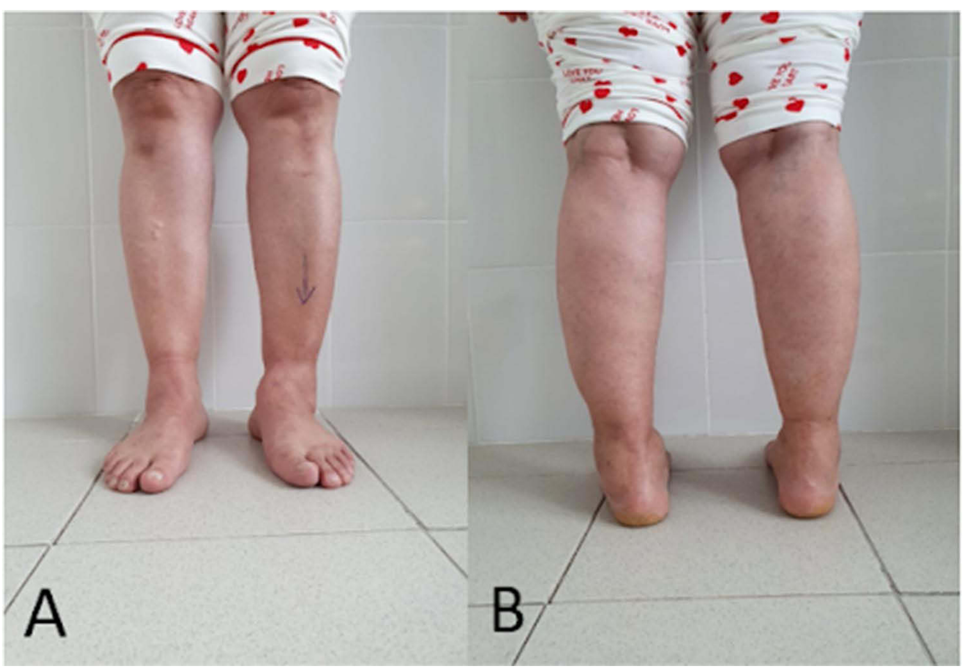

Figure 1 Photographs before surgery: (**A**) Front view, (**B**) Back view.

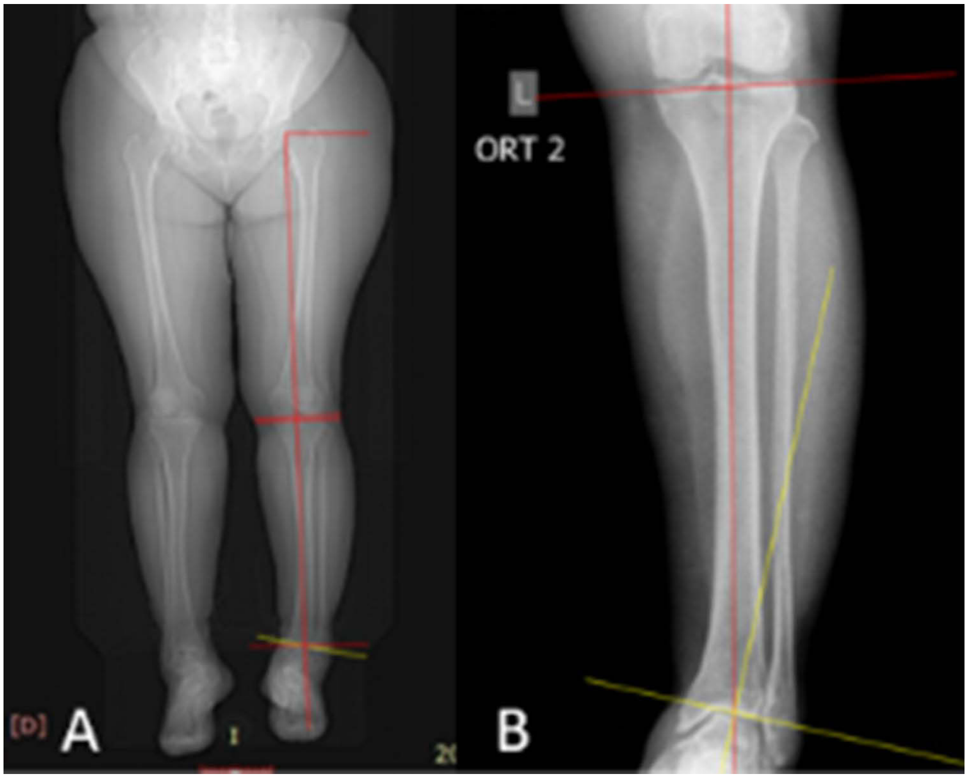

Figure 2 Radiographs of both bones of the left shin with the capture of adjacent joints of patient I., when coming first to the clinic in direct projections: (**A**) lower extremities, (**B**) left leg region.

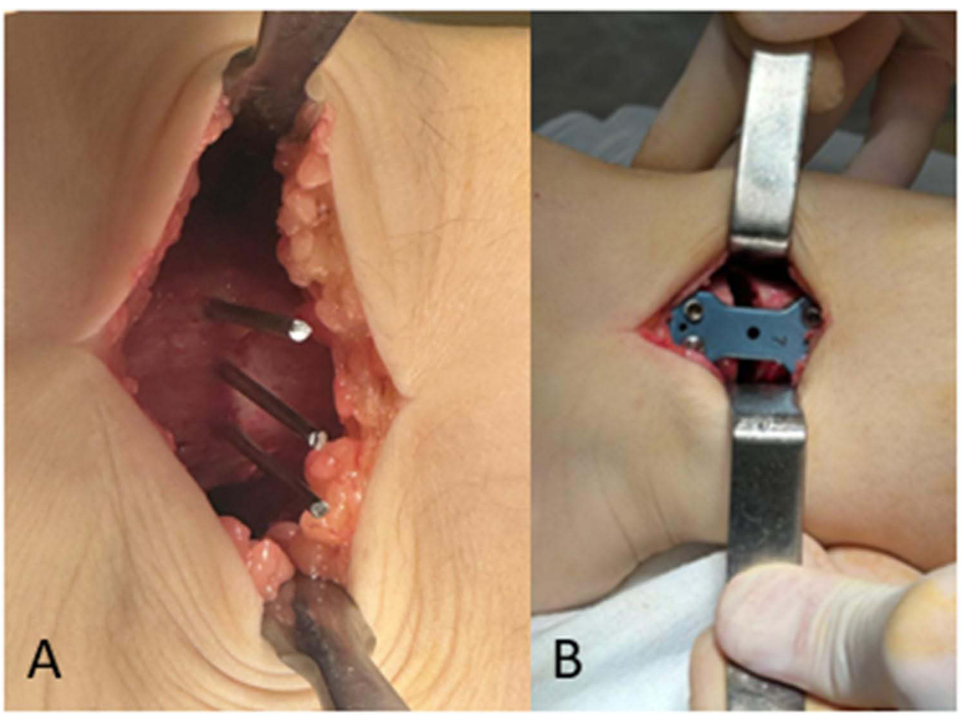

Figure 3 Intraoperative photographs: (**A**) 3 marking needles for osteotomy, (**B**) the medial distal tibial mini-plate is installed.

palpation of the tip of the lateral ankle, and the formation of a dense consistency is noted, immobile. There are no neurological or vascular disorders on the periphery of the left lower limb at the time of examination.

According to computed tomography images and radiographs of the bones of the left shin with the capture of adjacent joints, obliteration of the medial articular fissure to the medial sulcus with contact with the subchondral bone is determined. The chondromic body of the tibiofibular joint is visualized. Varus installation of the posterior part of the foot. Asymmetrical OA of the left ankle joint of the third degree. The angle of deviation of the mechanical axis is 12.5° (Figure 2A and B).

Taking into account the medical history, clinical examination, and the results of instrumental data, it was decided to perform a minimally invasive surgical treatment in the following volume: supramalleolar opening osteotomy of the left tibia and mini-plate synthesis. Removal of bone and cartilage formation.

The patient was placed in the supine position on the operating table, and spinal anesthesia was administered. A pneumatic tourniquet was applied to the mid-thigh of the left leg after exsanguination, and the operative field was prepared and draped in a sterile manner using povidone-iodine solution followed by alcohol.

A mini-incision was first made over the projection of the lateral malleolus. The skin and subcutaneous tissue were dissected, and the distal fibula was skeletonized subperiosteally. Intraoperative fluoroscopy revealed a small bony fragment measuring approximately 10×5 mm, which was excised. The wound was irrigated, closed in layers, and covered with a sterile dressing.

Through a second mini-incision of approximately 4 cm along the medial surface of the distal tibial metaphysis, the skin and subcutaneous tissue were dissected, and the tibia was exposed subperiosteally. Under fluoroscopic guidance, a guidewire and three marker needles were placed to define the osteotomy plane. An incomplete oblique opening wedge osteotomy of the distal tibia was then performed. A custom medial distal tibial mini-plate was applied across the osteotomy site, and the osteotomy was opened to correct the 13-degree varus deformity, thereby restoring the mechanical axis. Fixation stability was confirmed fluoroscopically (Figure 3A and B). The wound was irrigated with sterile saline, closed in layers, and covered with an aseptic dressing.

The custom mini-plate was fabricated from Ti6Al4V ELI titanium alloy (ISO 5832-2, trauma implant standard). The plate measured 39 mm in length with a uniform thickness of 2.5 mm. Its width was 28 to 31.4 mm at the screw hole region and tapered to 12 mm at the wedge region. A 20 mm-wide section of the plate incorporated two threaded holes (3.5 mm diameter) oriented obliquely in two planes, each positioned 5 mm from the lateral edges. The central axis of the plate contained two holes (2.2 mm diameter) for preliminary fixation with Kirschner wire placement, located 2.5 mm

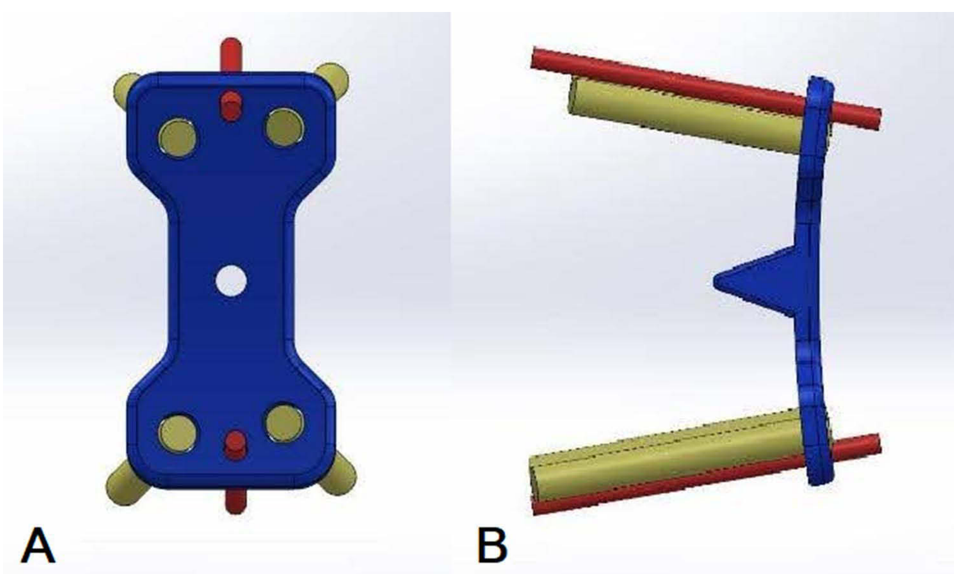

Figure 4 The custom mini-plate used for supramalleolar osteotomy: (**A**) superior view, (**B**) lateral view.

from the proximal and distal margins. In addition, a single M4 threaded hole with a depth of 5 mm was positioned in the wedge region to allow secure attachment of the impactor during insertion (Figure 4A and B).

On the first day after the operation, the patient underwent postoperative wound dressing and a control radiography of the bones of the left shin with the capture of adjacent joints, on which an oblique opening osteotomy was performed at the level of the distal metaphysis of the tibia with the synthesis of fragments with a mini-plate with a wedge-shaped spacer. The axis of the tibia was straightened (Figure 5).

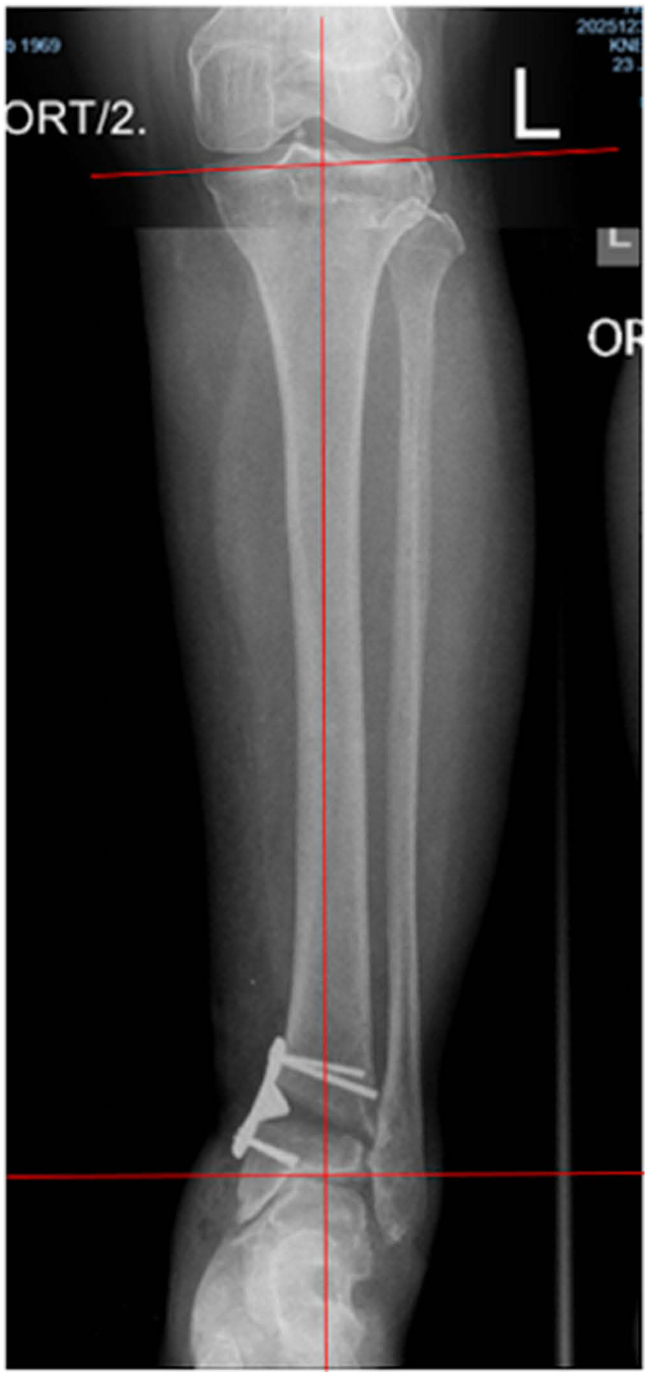

Figure 5 A radiograph of both bones of the left shin with capture of adjacent joints of patient I., after surgery (direct projection).

Figure 6 Photographs of the postsurgical wound: (**A**) 1 day after surgery, (**B**) 7 days after surgery, (**C**) 10 days after surgery.

The patient was kept active with the help of crutches without a supporting load on the left lower limb on the first day after surgery. He fully carried out the doctor's prescriptions and actively developed the fingers of his left foot. The day after the operation, the rehabilitation physician appointed the first stage of rehabilitation.

It is recommended to follow an orthopedic regimen for up to 3 months after surgery, regularly perform physical exercises at home in order to prevent the formation of movement restrictions in the operated limb and muscle hypotrophy, and consult a rehabilitation physician after a follow-up radiography to determine the stage of rehabilitation.

On the 5th day after the operation, the patient was discharged for outpatient treatment by a traumatologist at his place of residence in satisfactory condition. Recommendations are given on the extent of the load on the diseased limb, the timing of control radiographs, and the duration of immobilization of the posterior plaster splint. The wound was healed by primary tension. The stitches were removed 10 days after the operation (Figure 6A–C). The rehabilitation period was uneventful.

After observing all the recommendations, the patient came for a follow-up examination 2 months later with radiography imaging results, where a partially consolidating osteotomic fracture of the lower third of the tibia was noted, the anatomical axis of the tibia was not broken, the articular surfaces of the knee and ankle joints are in the same plane, parallel to each other, respectively, prevention of the development of OA of the ankle and knee joints was performed in as a result of the asymmetry of the articular surfaces and the violation of joint congruence, by correcting the latter (Figure 7). Visually, the correction of the heel axis relative to the anatomical axis of the shin is noted, in comparison with the preoperative data (Figure 8A and B).

Respectively, at the 2-month follow-up, the patient demonstrated marked functional improvement following SMO for the prevention of asymmetric crus arthrosis. The AOFAS ankle–hindfoot score improved from 56 preoperatively to 86 postoperatively. Pain levels decreased substantially, with the VAS score reducing from 7/10 to 2/10. Functional mobility also improved, as reflected by the FADI, which increased from 58% to 88%. These findings indicate early restoration of function, reduced pain, and enhanced daily activity performance, supporting the effectiveness of minimally invasive plate fixation in the management of asymmetric ankle osteoarthritis.

Removal of plaster immobilization with a measured support load on the operated limb is recommended; undergoing physiotherapy and physical therapy with passive-active joint development of the lower limb, and observation by an orthopedic traumatologist at the place of residence. The date of the subsequent follow-up examination was set for the third month after the surgical intervention.

Discussion

OA of the ankle joint is a serious orthopedic problem, especially with its asymmetrical shape, when the load is distributed unevenly, exacerbating degenerative processes. In this regard, the choice of optimal surgical intervention plays a key role in restoring joint function and improving the patient's quality of life.[7]

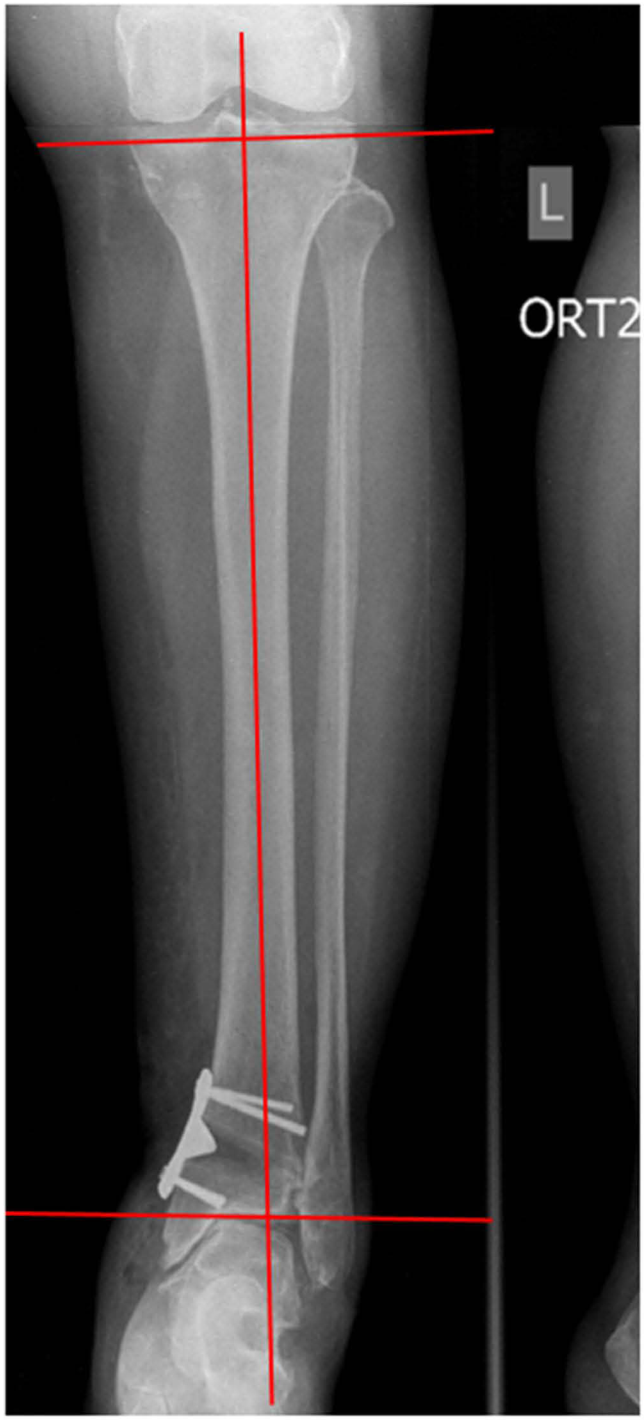

Figure 7 A radiograph of both bones of the left shin with capture of adjacent joints of patient I., 2 months after surgery (direct projection).

In the given clinical case, the successful experience of minimally invasive treatment of a patient with asymmetric arthrosis of the ankle joint was demonstrated. The installation of a mini-plate was chosen as the main method of surgical intervention. This decision was due to several factors.

Conventional supramalleolar osteotomy often requires extensive surgical exposure, large-volume implants, or the use of external fixation systems such as the Ilizarov device, all of which are associated with higher material costs, increased operative time, and prolonged rehabilitation.[12,13] By contrast, the present method utilizes a low-profile customized mini-

Figure 8 Photographs after surgery: (**A**) front view, (**B**) back view.

plate that minimizes metal consumption and reduces the need for bulky fixation systems. While a formal economic evaluation was not performed, the reduction in implant size, operative trauma, and recovery time suggests that this approach may be more cost-effective than traditional techniques, particularly in healthcare systems with limited resources.

Unlike traditional methods of osteosynthesis, the mini-plate allows the patient to begin partial strain on the limb at an earlier date, which contributes to faster social adaptation. One of the main advantages of the mini-plate is its small size, which allows for minimally invasive surgical access up to 4.0cm. This is especially important in the area of the distal tibia, associated with the absence of a muscular array of the supra-ankle region. The shape and size of the mini-plate make it possible to work in a narrowly limited area, maintaining blood supply to the tibia through a less damaged periosteum, rapid recovery of motor activity, and reduction of postoperative pain syndrome are noted. With the minimally invasive plate osteosynthesis method, as being a less invasive procedure is expected to have a lower infection rate, suggesting its superiority,[14] while may have a longer surgery time, a longer exposure time for surgeons during intraoperative radiography, and a higher frequency of symptoms of soft tissue irritation by the implant in the post-operative period.[15–18] The need for extensive surgical access for their installation is its main disadvantage; direct or arched access is performed on the medial side of the distal tibia. The incision length is 3–5 cm in the distal tibia, and the incision was completed distally at the apex of the medial malleolus. Next, soft tissues were tunneled proximally with a blunt instrument, after which a plate was inserted through the distal access and 3 proximal accesses of about 1 cm each were performed, depending on the type of planned plate.[19] The thin layer of soft tissue covering this area increases the risk of problems with wound healing above the plate, which can lead to more infections at the surgical site. Moreover, in the presence of risk factors such as diabetes, atherosclerosis of the lower extremities, or smoking, the risk of infection is also significantly higher.[20,21]

The advantages of the mini-plate compared to alternative treatment methods are to preserve the biomechanics of the joint, minimal access, stable synthesis, reduce the risk of complications, and significantly reduce the duration of rehabilitation. The mini-plate also allows for avoiding the loss of correction due to the presence of a wedge-shaped element, which enables setting the exact angle of deformation correction, and two diagonally arranged cortical screws, which give maximum compression of the plate to the bone.

Thus, a successful clinical case demonstrates the validity of choosing a minimally invasive approach using a mini-plate in the treatment of asymmetric arthrosis of the ankle joint. This method proves its effectiveness, providing the patient with a rapid recovery with minimal risk of postsurgical complications.

This report has several inherent limitations. As a single-case study, the findings cannot be generalized to a broader patient population. The follow-up period was limited to two months, which restricts conclusions regarding long-term functional outcomes and implant durability. Furthermore, the absence of comparative data prevents direct evaluation of this technique against established fixation methods. Nevertheless, the favorable short-term results highlight the potential clinical utility of this minimally invasive approach and support further investigation in larger, long-term studies.

Conclusion

The main objectives of surgical intervention for asymmetric osteoarthritis of the ankle joint are restoration of the mechanical and anatomical axes of the tibia, correction of curvature, and stable fixation that permits early mobilization. Traditional supramalleolar osteotomy techniques are often associated with excessive surgical trauma, high metal consumption, and prolonged rehabilitation. The present case demonstrates that a minimally invasive supramalleolar tibial osteotomy using a customized low-profile mini-plate can provide accurate repositioning, firm fixation, reduced hardware burden, and earlier functional recovery.

Data Sharing Statement

All data generated or analyzed during this case are included in this published article.

Ethics Approval and Consent to Participate

Written informed consent was obtained from this patient. The case report was conducted in accordance with the Declaration of Helsinki and approved by the Local Ethical Board of the National Scientific Center of Traumatology and Orthopedics, named after academician N. D. Batpenov (July 19, 2023/No. 2).

Consent for Publication

Written informed consent has been obtained from the patient to publish this paper and all of accompanying images.

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Disclosure

The authors declare that they have no conflicts of interest.

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