



Integrated Surgical, Nursing, and Rehabilitation Approaches in Ankle Arthroplasty

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Abstract

Background: Total ankle arthroplasty (TAA) is a motion-preserving surgical procedure for end-stage ankle arthritis, historically managed with ankle arthrodesis (fusion). While arthrodesis provides reliable pain relief, it sacrifices joint motion, leading to altered gait mechanics and secondary arthritis in adjacent joints. TAA has evolved through several generations of implant designs to better replicate native ankle biomechanics and improve long-term outcomes.

Aim: The procedure aims to alleviate pain and restore functional ankle motion, thereby enabling patients to resume higher levels of daily activity. It seeks to provide a more physiological alternative to fusion, distributing forces more evenly across the lower extremity to prevent degenerative changes in neighbouring joints.

Methods: TAA involves the resection of degenerated tibial and talar joint surfaces and their replacement with prosthetic components. The standard surgical approach is anterior, utilizing specialized cutting guides for precise bone preparation. Modern, third-generation implants often feature mobile-bearing designs and are supported by advanced preoperative planning, including CT scans and patient-specific instrumentation.

Results: Successful TAA results in significant pain reduction, improved range of motion, and a more normalized gait. However, the procedure carries risks, including wound healing complications, prosthetic joint infection, intraoperative fracture (particularly of the medial malleolus), and long-term issues like component loosening and osteolysis.

Conclusion: When performed on carefully selected patients by a coordinated, interprofessional team, TAA is a clinically significant intervention that effectively restores function and enhances quality of life, positioning it as a pivotal motion-preserving option in the management of end-stage ankle arthritis.

Keywords: Total Ankle Arthroplasty, Ankle Replacement, Ankle Arthritis, Arthrodesis, Prosthetic Joint Infection, Implant Loosening, Rehabilitation.

Introduction

Total ankle arthroplasty (TAA), or total ankle replacement, is an advanced reconstructive surgical procedure in which the degenerated articular surfaces of the ankle joint are excised and replaced with a prosthetic implant designed to restore congruent joint motion. It is primarily indicated for patients with end-stage ankle arthritis who present with persistent pain, functional limitation, and impaired mobility that are refractory to conservative measures.[1] By substituting the diseased tibiotalar articulation with a biomechanically engineered prosthesis, TAA seeks

not only to alleviate pain but also to maintain or re-establish physiological range of motion, thereby enabling patients to resume higher levels of daily and occupational activity.[1][2] Historically, ankle arthrodesis was regarded as the gold standard for managing end-stage ankle arthritis, offering reliable pain relief at the expense of joint motion.[2][4] Although fusion effectively eliminates painful motion at the tibiotalar joint, it inevitably results in a rigid ankle, which can alter gait mechanics and increase compensatory stresses on adjacent joints in the foot, knee, and even the spine.[4] Over time, such altered

loading patterns may predispose to secondary degenerative changes in neighboring articulations, potentially leading to progressive functional decline. As clinical awareness of these long-term sequelae has grown, so too has interest in motion-preserving alternatives such as TAA, reflected in steadily rising utilization rates over recent decades.[1][2]

Modern TAA originated in the 1970s as part of a broader shift in orthopedic reconstructive strategies toward preserving joint mobility in degenerative conditions, paralleling developments in total hip and knee arthroplasty.[3] Early implant designs were constrained by limited understanding of ankle biomechanics and suboptimal materials, which contributed to variable outcomes and higher failure rates.[3] Subsequent generations of prostheses, however, have benefited from advances in implant geometry, fixation techniques, and polyethylene technology, resulting in more anatomical kinematics, improved wear characteristics, and enhanced survivorship. These design refinements have reinforced the conceptual advantage of TAA over arthrodesis by allowing restoration of near-physiological ankle motion while maintaining stability and pain relief.[3][4] From a functional standpoint, preserving the motion of the ankle joint through arthroplasty rather than arthrodesis promotes a more normalized gait pattern, with better distribution of joint reactive forces across the lower extremity.[4] This has important implications for long-term musculoskeletal health, as maintaining dynamic ankle function can reduce compensatory overloading of adjacent joints and help mitigate secondary osteoarthritic changes.[1][4] Collectively, these considerations position TAA as a key motion-sparing option in the management algorithm for end-stage ankle arthritis, complementing rather than completely replacing arthrodesis, and highlighting the ongoing evolution of reconstructive strategies in foot and ankle surgery.[2][3]

Anatomy and Physiology

A comprehensive understanding of the anatomy and physiology of the ankle joint is fundamental to informed patient selection, precise surgical planning, and optimal postoperative outcomes in total ankle arthroplasty. The ankle is a complex hinged synovial joint that forms the critical interface between the leg and the foot, allowing controlled motion necessary for gait, balance, and load transmission. Structurally, the joint is composed of the tibial plafond superiorly, the medial malleolus forming the medial buttress, the lateral malleolus of the fibula providing lateral stabilization, and the superior articular surface of the talus inferiorly. These articulating surfaces form the tibiotalar joint, which permits primarily dorsiflexion and plantarflexion while offering subtle components of rotation and translation essential for accommodating uneven terrain and maintaining smooth gait mechanics. The stability of the ankle joint

relies on an intricate interplay between static and dynamic stabilizers that collectively maintain joint congruency under varying mechanical loads. Static stabilizers include the osseous architecture and the ligamentous structures, such as the deltoid ligament complex medially and the lateral collateral ligament complex laterally, both of which provide restraint against excessive inversion, eversion, and rotational forces. The joint's bony configuration, particularly the mortise created by the tibia and fibula, further enhances mechanical stability, especially during weight-bearing activities.

Dynamic stabilizers, in contrast, consist of the musculotendinous units that cross the ankle and actively contribute to joint control during movement. Among the most influential are the peroneal tendons, which function to resist inversion stresses and assist in maintaining lateral ankle stability during gait. Additional dynamic contributors include the tibialis anterior and posterior, gastrocnemius-soleus complex, and flexor and extensor tendons that coordinate limb propulsion and shock absorption. A thorough appreciation of these anatomical and biomechanical relationships is essential in the context of ankle arthroplasty, as implant alignment, component sizing, and postoperative rehabilitation all depend on respecting native joint kinematics. Understanding how static and dynamic stabilizers interact allows clinicians to anticipate surgical challenges, tailor implant selection, and design rehabilitation protocols that support joint function, thereby enhancing the likelihood of long-term procedural success.

Indications

Total ankle arthroplasty (TAA) is primarily indicated for patients suffering from unilateral or bilateral end-stage ankle osteoarthritis who experience persistent pain, functional impairment, and reduced quality of life despite exhaustive conservative management. The ideal candidate is typically a healthy, low-demand adult with a relatively active lifestyle but without participation in high-impact activities that would place excessive stress on the prosthetic components. Patient selection plays a crucial role in optimizing outcomes, as the longevity and stability of the implant depend heavily on the biomechanical environment in which it functions. A normal or low body mass index is preferred because excessive weight increases axial loading on the prosthesis and may accelerate wear, potentially leading to complications such as aseptic loosening or implant subsidence. Furthermore, appropriate hindfoot alignment significantly contributes to postoperative success. A stable, well-aligned hindfoot allows for even distribution of mechanical forces across the implant, reducing abnormal shear stresses that compromise implant integrity. When coronal plane deformities or instability exist, they must be correctable either preoperatively or intraoperatively to ensure optimal prosthetic positioning and function. Another critical

factor is the integrity of the surrounding soft tissue envelope. Robust, healthy soft tissue coverage around the ankle enhances wound healing, reduces infection risk, and supports early mobilization—an important consideration in rehabilitation and functional recovery. Additionally, maintaining a sufficient range of motion in the ankle joint is highly desirable prior to arthroplasty. As noted by Wood et al., patients with at least 5° of ankle dorsiflexion are considered ideal candidates because preserved motion facilitates more natural postoperative gait patterns and contributes to improved kinematic outcomes after prosthetic implantation.[5] When these clinical, biomechanical, and anatomical characteristics align, TAA offers a valuable motion-preserving alternative to arthrodesis, with the potential to restore mobility, alleviate pain, and enhance long-term functional independence.



Fig. 1: Total Ankle Arthroplasty.

Contraindications

Total ankle arthroplasty is contraindicated in several clinical scenarios where the risk of postoperative failure, complications, or poor functional outcomes outweighs the benefits of joint replacement. One of the most absolute contraindications is the presence of an active infection, whether localized to the ankle region or systemic, because bacterial contamination can lead to catastrophic implant failure, chronic osteomyelitis, or the need for prosthetic removal.[6] Similarly, peripheral vascular disease significantly impairs wound healing and increases the likelihood of soft tissue necrosis, infection, and ultimately, surgical failure. Adequate blood supply is essential for postoperative recovery, and compromised vasculature undermines the stability and longevity of the implant. Charcot arthropathy represents another strong contraindication due to its destructive neuro-osteoarthropathy, marked by joint instability, bone fragmentation, and deformity. In such cases, the altered biomechanics and lack of protective sensation create an extremely high risk of prosthesis subsidence, malalignment, and wound complications. Likewise, severe osteoporosis poses challenges for achieving secure fixation of the prosthetic components, as weakened bone cannot reliably support the mechanical demands of the implanted hardware.[6] Osteonecrosis

of the talus also presents a significant contraindication, given that viable talar bone is necessary for stable anchorage of the prosthesis; necrotic bone increases the likelihood of collapse and implant loosening. Peripheral neuropathy—whether due to diabetes, trauma, or systemic neurological disease—further complicates TAA candidacy because diminished sensation leads to unrecognized trauma, abnormal loading, and increased risk of deformity. Additionally, patients with inadequate or compromised soft tissue envelopes around the ankle face heightened risks of poor wound healing, dehiscence, and infection, all of which jeopardize implant survival. Collectively, these contraindications highlight the importance of rigorous preoperative screening to ensure that only appropriate candidates undergo TAA, thereby safeguarding outcomes and minimizing postoperative complications.[6]

Equipment

Since total ankle arthroplasty (TAA) was first introduced, multiple generations of implant designs and associated instrumentation have evolved, each aiming to address the limitations and failure modes of its predecessors.[7][8] Early, first-generation prostheses were characterized by highly constrained designs that attempted to reproduce simple hinge-like motion at the tibiotalar joint. These systems typically consisted of 2 components, a concave polyethylene tibial component and a convex metallic talar component, most commonly fabricated from cobalt-chrome alloys. In some configurations, the geometry was reversed so that the talar component was concave and the polyethylene element convex.[7] Both components were cemented to the resected tibial and talar surfaces, and substantial bone resection was required to accommodate their bulk and achieve fixation. Although these implants were conceptually straightforward, their constrained nature resulted in high mechanical stresses at the bone–implant interface. Over time, these stresses contributed to high rates of aseptic loosening, osteolysis, component subsidence, and mechanical failure, leading to generally disappointing long-term outcomes and limiting the widespread acceptance of first-generation designs.[7][8] Second-generation TAA implants were developed in response to these early shortcomings, particularly the extensive bone sacrifice and high loosening rates. These designs shifted toward fixed-bearing constructs in which the polyethylene articular surface was integrated into either the tibial or talar component, allowing for a lower profile and more bone preservation compared with earlier implants.[8] Notable examples of second-generation systems include the Buechel-Pappas Total Ankle Replacement (Endotec, South Orange, NJ) in the United States and the Scandinavian Total Ankle Replacement (STAR; Waldemar Link, Hamburg, Germany) in Europe. Rather than relying primarily on cement, these implants were often designed for press-fit fixation, frequently with porous or coated surfaces to encourage

biological ingrowth and improve long-term stability. Bone cuts were more conservative, which not only preserved native bone stock but also facilitated potential revision surgery if required. Despite these refinements, however, many second-generation devices still exhibited relatively high failure rates, largely driven by polyethylene wear, debris-induced osteolysis, and subsequent loosening. This highlighted the importance of improving bearing materials, optimizing contact mechanics, and refining implant kinematics beyond simple hinge motion.[7][8]

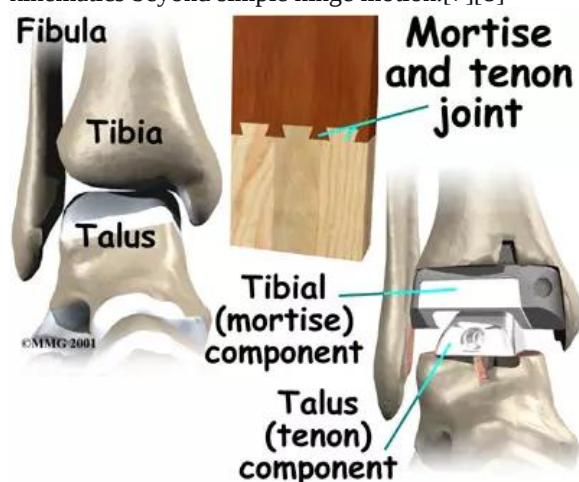


Fig. 2: Ankle Arthroplasty.

Modern third-generation TAA systems have been designed specifically to address these recognized failure mechanisms, with a focus on more anatomic replication of ankle motion, improved load distribution, and reduction of wear.[9] Representative examples include the Salto (Tornier SA, Saint Ismier, France), Hintegra (Newdeal SA, Lyon), Mobility (DePuy, Warsaw, IN), and Bologna-Oxford (BOX; Finsbury Orthopaedics, Leatherhead, Surrey, UK) implants.[9] A key distinguishing feature of many third-generation prostheses is the use of a standalone polyethylene bearing, which is not rigidly built into either the tibial or talar component. This configuration allows for mobile-bearing or semi-constrained designs that can better accommodate physiological rotational and translational movements, thereby decrease edge-loading and reducing wear. These implants are intended to minimize bone resection, preserving as much of the tibial plafond and talar dome as possible while still achieving accurate alignment and stable fixation. However, the success of third-generation implants is highly dependent on meticulous soft tissue balancing and restoration of proper ligamentous tension, as these designs rely heavily on the integrity of the surrounding ligamentous structures to maintain stability and guide motion.[9] Consequently, specialized instrumentation has co-evolved with implant technology. Modern TAA systems are accompanied by refined cutting jigs, alignment guides, and trial components, which assist the surgeon in

achieving precise bone cuts, accurate component positioning, and appropriate joint line restoration.

In parallel, advances in imaging and planning technologies have significantly influenced the equipment used in TAA. Preoperative computed tomography (CT)-based planning enables three-dimensional assessment of deformities, bone stock, and alignment, allowing surgeons to simulate implant placement and determine optimal resection planes before entering the operating room.[10] Building on this, patient-specific instrumentation (PSI) has emerged, in which 3-dimensional printed cutting guides are manufactured based on individual CT data. These customized guides are designed to fit the patient's unique osseous anatomy, directing saw cuts and drill trajectories with high accuracy. The use of PSI and 3D-printed jigs has been shown to reduce operative time and fluoroscopic exposure while maintaining or improving implant positioning accuracy.[10] Collectively, the evolution from first- to third-generation TAA implants reflects an increasingly sophisticated understanding of ankle biomechanics, materials science, and surgical technique. The current armamentarium of implants, cutting guides, imaging modalities, and patient-specific instruments forms an integrated equipment ecosystem that supports more reproducible, anatomically aligned, and durable total ankle replacements, ultimately aiming to improve functional outcomes and implant longevity in appropriately selected patients.[9][10]

Personnel

The successful and safe execution of total ankle arthroplasty (TAA) relies on a coordinated, multidisciplinary operative team, each member contributing specialized expertise essential to the procedure. At minimum, the team must include an anesthetist or anesthesiologist, whose role encompasses preoperative assessment, intraoperative hemodynamic management, and postoperative pain control, ensuring the patient remains stable throughout the intervention. The surgical technician or scrub technician provides critical support by preparing and maintaining the sterile field, organizing the necessary instruments, and anticipating the needs of the surgical team during each phase of the arthroplasty. Complementing this role, the circulating nurse functions outside the sterile field, managing equipment, facilitating communication, and ensuring procedural flow and patient safety. The foot and ankle surgeon serves as the principal operator, responsible for preoperative planning, precise implant alignment, and management of any intraoperative challenges. Working alongside the surgeon is the surgical assistant, who may be a physician associate or certified first assistant, offering hands-on support with exposure, retraction, soft tissue handling, and limb positioning to facilitate accurate implant placement. After the procedure, the recovery nurse assumes

responsibility for monitoring the patient during the immediate postoperative period, ensuring stable vital signs, adequate pain control, and safe progression toward recovery. An additional valuable member of the team is the implant device representative. Although non-clinical, their presence ensures availability of appropriate implant components and instrumentation. They also provide technical guidance on specialized equipment, updated device protocols, and implant-specific nuances that help maintain procedural efficiency and accuracy. Together, this integrated team structure optimizes surgical workflow, enhances procedural precision, and supports patient safety and outcomes during total ankle arthroplasty.

Preparation

Patient History

Proper preparation for total ankle arthroplasty (TAA) begins with a comprehensive and meticulously documented patient history. Before determining whether a patient is an appropriate candidate for TAA, clinicians must obtain a detailed past medical history that includes chronic illnesses such as diabetes, peripheral vascular disease, or inflammatory arthropathies, as these conditions may influence both surgical candidacy and postoperative recovery. Equally important is a thorough past surgical history, with special emphasis on any prior operations involving the affected ankle, including fracture fixation, ligamentous reconstruction, arthroscopy, or previous arthrodesis attempts. Such interventions may alter anatomy, compromise bone stock, or affect soft tissue conditions, thereby influencing implant selection and surgical planning. Clinicians should also review the patient's medication list—including anticoagulants, immunosuppressants, and corticosteroids—as well as allergies, particularly to metals, antibiotics, or anesthetic agents. A complete history of trauma is essential, as chronic instability or malalignment from previous injuries is a common precursor to degenerative ankle changes. Additionally, all prior conservative management strategies—including bracing, physical therapy, injections, or pharmacologic therapy—must be reviewed to confirm that nonoperative treatment has been exhausted before proceeding with arthroplasty.

Clinical Assessment

A detailed clinical assessment is indispensable for evaluating the functional and structural integrity of the ankle. This begins with a full physical examination, including inspection of the limb for deformity, swelling, muscle atrophy, or skin compromise. Gait assessment allows clinicians to identify antalgic patterns, compensatory mechanisms, or malalignment that may affect postoperative implant mechanics. Evaluation of active and passive ankle range of motion provides insight into joint stiffness, capsular contracture, and the potential for postoperative functional restoration. Assessment of ankle stability—through stress testing and palpation of ligamentous structures—is equally important for determining the

need for adjunctive soft tissue procedures. Vascular evaluation of the limb, including pulses, capillary refill, and skin temperature, helps identify circulatory insufficiency that may predispose the patient to wound complications. The overall condition of the soft tissue envelope, including skin integrity and scar quality, is crucial, as compromised skin significantly increases postoperative risks.

Imaging Modalities

Ankle X-ray

Initial imaging typically includes weight-bearing anterior–posterior, lateral, and oblique radiographs, which allow assessment of joint space narrowing, osteophyte formation, cystic changes, and deformity. Weight-bearing films provide critical information about axial alignment and mechanical loading, both essential for accurate preoperative templating and implant positioning. In many cases, full-length leg radiographs are obtained to assess global lower extremity alignment and identify proximal deformities that may contribute to ankle pathology.[11]

Ankle Computed Tomography

Computed tomography (CT) offers detailed visualization of bone stock, subchondral cysts, and talar dome morphology. CT scans have become increasingly important with the advent of advanced implant systems requiring patient-specific three-dimensional printed cutting guides. These guides, tailored to the patient's anatomy, allow precise bone resections and implant placement, thereby improving surgical accuracy. To generate these guides, a high-resolution preoperative CT scan must be obtained and supplied to the implant manufacturer.[11]

Ankle Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) provides critical soft tissue and bone detail beyond that available through X-ray or CT. MRI allows clinicians to evaluate the extent of arthritic involvement, assess subchondral bone loss, characterize cyst size and location, and detect areas of osteonecrosis that may significantly influence implant selection or contraindicate arthroplasty. MRI may also reveal tendon pathology, ligamentous insufficiency, or occult deformities that must be addressed during surgery to optimize postoperative outcomes.[11] Collectively, a thorough history, comprehensive clinical assessment, and multimodal imaging ensure that surgical planning for TAA is precise, patient-specific, and aligned with the biomechanical and anatomical demands of the procedure.

Technique or Treatment

Anesthesia

Total ankle arthroplasty (TAA) is typically performed under general anesthesia in combination with a regional nerve block, most commonly a popliteal fossa block. This combined anesthetic strategy provides reliable intraoperative anesthesia while also offering extended postoperative analgesia, which can reduce systemic opioid requirements and facilitate early mobilization. The regional block targets the sciatic

nerve in the popliteal region, thereby providing dense sensory blockade to the operative field and contributing to improved patient comfort in the immediate postoperative period. Standard anesthetic protocols include careful preoperative evaluation of the patient's comorbidities, airway status, and medication profile. During induction, prophylactic intravenous antibiotics are administered to minimize the risk of surgical site infection, with timing coordinated to ensure adequate tissue levels at the time of incision. Continuous monitoring of hemodynamic parameters and appropriate fluid management are maintained throughout the procedure to support tissue perfusion and reduce perioperative complications.

Patient Position

Following successful induction of anesthesia, the patient is positioned supine on a radiolucent operating table, which allows unobstructed intraoperative fluoroscopic imaging. Proper positioning is critical for both surgical access and accurate radiographic assessment of implant alignment. A nonsterile tourniquet is placed as proximally as possible on the operative extremity, allowing for a bloodless field when inflated and improving visualization of anatomical landmarks. Careful padding is applied to protect the skin and underlying neurovascular structures. Nonsterile drapes are used to delineate operative and nonoperative zones, maintaining a clear boundary between the sterile field and surrounding areas. A large bump or support may be positioned under the ipsilateral hip or leg to elevate the operative extremity, thereby improving exposure to the anterior ankle and facilitating intraoperative maneuvering. Attention to comfortable and stable positioning also reduces the risk of pressure injuries and nerve compressions during the often prolonged duration of TAA procedures.

Approach

The standard approach for TAA is an anterior incision. The tibialis anterior tendon is first palpated just proximal to the ankle joint, serving as a key landmark. An incision is made slightly lateral to this tendon using a scalpel, and full-thickness skin flaps are carefully elevated with a scalpel and Metzenbaum scissors to preserve vascularity and minimize soft tissue trauma. Deep dissection is performed meticulously toward the ankle joint, with particular care to protect the tendon sheaths, synovial tissues, and branches of the superficial and deep nerves, including the medial dorsal cutaneous branches. On reaching the extensor retinaculum, this structure is incised longitudinally, while deliberately avoiding disruption of the tibialis anterior tendon sheath to reduce the risk of postoperative adhesions or tendon irritation. The interval between the tibialis anterior and extensor hallucis longus tendons is then identified and developed, allowing each tendon to be retracted safely as needed to gain access to the anterior joint line. Within this interval, the anterior tibial artery and vein,

together with the deep peroneal nerve, are identified and protected throughout the procedure, as injury to these structures can result in significant vascular or neurological morbidity. The ankle joint capsule and periosteum are subsequently incised to create capsular and periosteal flaps, which are often tagged with sutures for accurate reapproximation and repair at closure, helping to restore soft tissue integrity and stability.

Bone Cuts

Once adequate exposure has been obtained, the surgeon proceeds to the bone preparation phase using implant-specific cutting guides. These guides are designed to facilitate precise and reproducible resection of the distal tibia and talar dome according to the geometry of the chosen prosthesis. Accurate positioning of the tibial cutting block is essential to achieve correct coronal and sagittal alignment and to maintain appropriate posterior slope. During the tibial cuts, particular attention is paid to avoiding excessive medial resection, as aggressive medial cutting can predispose to iatrogenic medial malleolar fracture. Awareness of the medial malleolus thickness, often informed by preoperative imaging, is crucial. In cases where the medial malleolus appears thin or at risk, prophylactic fixation with one or more screws or pins may be performed to reinforce the structure and prevent fracture during or after the procedure. Similar precision is applied to the talar cuts, which must respect the anatomy of the talar dome while creating a stable platform for the talar component. The goal is to balance maximal bone preservation with sufficient resection to remove diseased cartilage and allow correct implant seating. Throughout this stage, intraoperative fluoroscopy may be utilized to confirm alignment and depth of cuts, thereby reducing the risk of malposition or excessive bone loss.

Trialing and Insertion of Components

After the bone cuts are completed, trial tibial and talar components are inserted to assess initial fit, alignment, and joint balance. These trial implants are available in a range of sizes, allowing the surgeon to determine the most appropriate final components based on bone coverage, joint congruence, and range of motion. Soft tissue balancing is then undertaken, which may involve selective release of tight capsular or ligamentous structures or addressing residual deformities. Proper balancing is critical to achieving symmetrical motion, stable implant function, and reduced edge-loading on the polyethylene insert. Guide holes for future fixation, such as pegs, keels, or screws depending on the implant design, are typically drilled through the trial components to ensure accurate positioning. Once the surgeon is satisfied with trial reduction and soft tissue balance, the definitive tibial and talar components are implanted, usually as press-fit devices with or without the adjunct of cement, according to the system and bone quality. After seating the definitive metal components, trial polyethylene

liners are inserted again to reassess joint motion, stability, and soft tissue tension. Only when satisfactory dorsiflexion, plantarflexion, and coronal plane stability are observed is the final polyethylene insert implanted. Fluoroscopy is employed to confirm appropriate positioning of all components, verifying neutral alignment and proper implant seating relative to the mechanical axis.

Wound Closure

Upon completion of implant placement and final fluoroscopic checks, the surgical field is thoroughly irrigated with copious amounts of warm, sterile normal saline. This helps remove debris, bone fragments, and potential contaminants, reducing infection risk. The extensor retinaculum is then carefully reapproximated, guided by the previously placed tagging sutures, and closed with an absorbable, polyfilamentous suture to restore retinacular integrity and maintain tendon stability. The deep dermal layer is similarly closed using an absorbable suture to reduce dead space and support the skin closure. The skin is closed with the surgeon's preferred technique, often employing interrupted or running sutures or staples to achieve a tension-free, well-approximated wound. Sterile, soft dressings are applied, including an occlusive petroleum-based gauze over the incision, followed by 4x4 gauze pads and a compressive wrap. Finally, a short leg splint is placed to immobilize the ankle, protect the wound, and facilitate initial soft tissue rest.

Postoperative Protocol

Postoperative management is critical to the long-term success of TAA. In a standard protocol where no additional procedures such as ligament reconstruction or corrective osteotomies have been performed, the patient remains in a short leg splint for approximately two weeks to allow for soft tissue healing and edema control. During this period, the limb is typically elevated and the patient is maintained non-weight bearing with the assistance of crutches or a walker. At around two weeks postoperatively, the splint and skin sutures are removed, and the patient is transitioned to a removable boot or similar device. Supervised ankle range of motion exercises are initiated to prevent stiffness, promote joint nutrition, and encourage restoration of functional movement. Weight-bearing is generally restricted for a total of about four weeks, after which progressive loading is introduced in accordance with radiographic and clinical findings. Throughout the postoperative period, serial radiographs are obtained at defined intervals to evaluate implant position, alignment, and integrity. These images also help identify complications such as peri-implant fractures, lucent lines suggesting loosening, subsidence of components, or concerning changes in bone stock around the tibial and talar interfaces. Rehabilitation programs are tailored to the individual, focusing on gradual strengthening, proprioceptive training, and gait normalization. Although the anterior approach is most commonly

used, it is important to note that a lateral approach requiring a distal fibular osteotomy is an alternative technique; however, this method is associated with fewer compatible implant designs and is consequently employed far less frequently in contemporary practice.[12]

Complications

Wound Healing

Wound healing complications are among the most frequent early adverse events following total ankle arthroplasty and can range from minor superficial problems to serious deep soft tissue compromise. The anterior approach used in most TAA procedures traverses relatively thin soft tissue with limited vascularity, making the incision particularly vulnerable to ischemia, tension, and delayed healing.[12] Superficial issues such as minor wound dehiscence, stitch abscesses, localized cellulitis, and marginal necrosis are well-documented and, although often manageable with local care and short courses of antibiotics, may serve as a portal for deeper infection if not promptly addressed.[12][13] Meticulous surgical technique is therefore essential to minimize these complications. Gentle handling of the soft tissues, limited use of self-retaining retractors, and preservation of perforating vessels help maintain tissue viability. During closure, the use of tension-reducing suturing techniques and layered closure of the retinaculum, subcutaneous tissue, and skin decrease mechanical stress on the incision, thereby reducing the risk of dehiscence.[13] In addition, application of a well-molded, compressive dressing immediately postoperatively has been shown to lower the incidence of wound problems by limiting edema, supporting the soft tissue envelope, and protecting the incision from shear forces.[12][13] Patient-related factors such as smoking, diabetes, peripheral vascular disease, and poor nutritional status further influence wound healing and must be optimized preoperatively whenever possible. Early recognition and management of wound complications, including timely debridement or negative pressure wound therapy when indicated, are crucial to prevent progression to deep infection and preserve the integrity of the prosthesis.

Prosthetic Joint Infection

Prosthetic joint infection (PJI) after TAA is one of the most serious complications and is associated with substantial morbidity, prolonged treatment courses, and a high risk of implant failure.[14] Reported infection rates for primary TAA in the literature vary widely, from 0% up to 13%, reflecting differences in patient selection, surgical technique, follow-up duration, and diagnostic criteria.[14][15] Infection is even more prevalent and problematic in the revision setting, where compromised soft tissue, prior scarring, and altered vascularity create a less favorable biological environment.[15] PJIs may present acutely within the first few weeks after surgery or manifest

later as chronic, indolent infections. Acute infections, typically defined as those occurring within approximately three weeks postoperatively, are often managed with an aggressive but joint-preserving strategy: thorough surgical debridement, copious irrigation, exchange of the polyethylene insert, and retention of well-fixed prosthetic components, accompanied by culture-directed intravenous and/or oral antibiotic therapy.[14][15]



Fig. 3: Complications of Total ankle arthroplasty.

When intervention is timely and organisms are susceptible, this approach can eradicate infection while preserving the prosthesis. Chronic infections, by contrast, usually require more extensive measures. The standard surgical management often entails complete removal of all prosthetic components, exhaustive debridement of infected and necrotic tissues, and placement of an antibiotic-impregnated spacer to maintain limb length and soft tissue tension.[15] This is followed by a prolonged course of systemic antibiotics, guided by infectious disease consultation, and may necessitate multiple staged debridements before reimplantation, conversion to arthrodesis, or, in severe cases, consideration of amputation. As of 2023, there are no diagnostic criteria specific to PJI in TAA; instead, clinicians typically rely on algorithms and laboratory thresholds originally developed for hip and knee arthroplasty, including serum inflammatory markers, synovial fluid analysis, and microbiologic cultures.[16] This lack of ankle-specific criteria underscores the diagnostic challenges and highlights the need for continued research focused on TAA-related PJI.[16]

Intraoperative Fracture

Intraoperative fracture is another significant complication of TAA, with iatrogenic medial malleolar fracture being the most common form encountered. These fractures generally occur when the narrow residual bone bridge between the tibial cut and

the medial cortex is weakened, particularly if the tibial resection is performed too medially or if excessive force is applied during component insertion.[17] The thin medial malleolus is inherently vulnerable, and fracture propagation through this bone bridge can compromise implant stability and alignment, potentially necessitating intraoperative modification of the procedure or postoperative revision.[17] Prevention of medial malleolar fracture begins with careful preoperative assessment of malleolar morphology on radiographs or CT scans and intraoperative vigilance during tibial cut placement. Surgeons are advised to avoid excessively medial positioning of the tibial cutting guide and to preserve adequate cortical thickness. When the medial malleolus appears at risk—for example, due to osteopenia, deformity, or limited bone stock—prophylactic fixation is recommended. This may be achieved with retained screw fixation inserted before or after the tibial cut, or with temporary Kirschner wire stabilization maintained until all final components are fully seated.[18] Such prophylactic strategies distribute mechanical forces more safely and substantially reduce the incidence of iatrogenic fracture.[18] Should a fracture nevertheless occur, stable fixation at the time of index surgery is essential to maintain alignment and protect the prosthesis, and postoperative weight-bearing protocols may need to be modified accordingly.

Other Common Postoperative Complications

Beyond wound problems, infection, and intraoperative fracture, a range of other complications may affect the outcome of TAA. Sensory deficits or nerve injury can result from traction, compression, or direct trauma to neural structures, particularly the deep peroneal or superficial peroneal nerves during anterior dissection.[19] Patients may experience hypoesthesia, paresthesia, or neuropathic pain, which can be transient or permanent depending on the extent of injury.[19] Component loosening and subsidence remain important long-term concerns. Over time, repetitive loading, suboptimal alignment, or poor bone quality can lead to micromotion at the bone–implant interface, resulting in progressive loosening.[20] The talar component appears to fail more frequently than the tibial component, likely due to the smaller size of the talus, its complex shape, and its relatively limited bone stock, all of which challenge secure fixation and load distribution.[20] Loosening and subsidence can manifest clinically as recurrent pain, instability, and functional decline, often necessitating revision surgery. Osteolysis is another recognized complication, often driven by polyethylene wear debris that induces an inflammatory response and periprosthetic bone resorption.[21] Progressive osteolysis can undermine fixation and predispose to fracture or catastrophic component failure. Close radiographic surveillance is therefore essential for

early detection of radiolucent lines or cavitary lesions around the prosthesis.[21]

Soft tissue and tendon-related complications are also encountered. Iatrogenic tendon injury may occur during the surgical approach or from hardware irritation, while postoperative tendinitis commonly involves the extensor tendons or the tibialis anterior due to altered biomechanics or scar formation.[21][22] These conditions can lead to pain, weakness, or impaired dorsiflexion, often requiring targeted physiotherapy, orthotic modification, or, in some cases, surgical revision. Polyethylene insert displacement or subluxation, although less common with modern designs, may occur in poorly balanced joints or in cases of malpositioned components.[20] This can result in mechanical symptoms, instability, and accelerated wear. Gutter impingement, in which prosthetic or bony structures impinge on the medial or lateral gutters during motion, may cause pain, restricted range of motion, or progressive arthrofibrosis.[21][22] Arthrofibrosis itself is characterized by excessive scar formation and capsular contracture, leading to stiffness and functional limitation despite technically successful implantation.[21][22] Overall, the spectrum of complications following TAA underscores the importance of meticulous surgical technique, careful patient selection, rigorous postoperative follow-up, and close collaboration among the surgical, nursing, and rehabilitation teams to identify and address problems promptly, thereby optimizing long-term outcomes.

Clinical Significance

Total ankle arthroplasty (TAA) has emerged as a rapidly expanding treatment modality for patients with complex, end-stage ankle osteoarthritis, reflecting a broader shift in orthopedic surgery toward motion-preserving strategies. Unlike ankle arthrodesis, which achieves pain relief at the cost of eliminating tibiotalar motion, TAA aims to restore or maintain physiological joint kinematics while still providing durable pain control.[23] By preserving ankle motion, TAA facilitates a more natural gait pattern, enabling improved push-off, smoother stride, and better adaptation to uneven surfaces. This preservation of normal or near-normal biomechanics has important downstream implications for the entire lower extremity kinetic chain. A key clinical advantage of TAA is its potential to prevent or delay degenerative changes in adjacent joints. Ankle arthrodesis, by fusing the tibiotalar joint, redirects mechanical loads to neighboring articulations, such as the subtalar, talonavicular, and midfoot joints, which can accelerate secondary osteoarthritis and contribute to progressive pain and disability over time.[23] In contrast, by maintaining controlled motion at the ankle, arthroplasty distributes forces more evenly, reducing compensatory stress and potentially limiting the development of overload-related pathology in these joints. For many patients, especially those who are

active but not engaged in high-impact activities—this can translate into superior long-term function and improved quality of life.

TAA also holds particular significance for individuals with bilateral ankle disease or complex deformities, in whom fusion of one or both ankles would impose severe gait restriction and functional compromise. In such cases, arthroplasty can offer a more balanced and adaptable solution, enabling patients to maintain independence in ambulation, work, and daily activities. Furthermore, advances in implant design, materials, and surgical techniques have led to improved survivorship and reduced complication rates, strengthening the clinical justification for TAA in appropriately selected patients.[23] From a broader healthcare perspective, the clinical significance of TAA extends beyond the operative episode. Successful ankle arthroplasty can lessen reliance on long-term analgesics, reduce the need for assistive devices, and delay or prevent additional procedures on adjacent joints. In doing so, TAA has the potential to decrease cumulative healthcare utilization while enhancing patient-reported outcomes. Collectively, these factors position TAA as a pivotal option in the contemporary management of end-stage ankle osteoarthritis, offering a more physiologic alternative to arthrodesis that prioritizes both pain relief and preservation of function.

Enhancing Healthcare Team Outcomes

Optimizing outcomes in total ankle arthroplasty depends fundamentally on an integrated, interprofessional approach that spans preoperative evaluation, perioperative care, and long-term rehabilitation. Healthcare professionals responsible for managing patients with end-stage ankle arthritis must possess a detailed understanding of TAA, including its indications, contraindications, expected benefits, and potential risks, to accurately identify suitable candidates and counsel them effectively. Foot and ankle surgeons and podiatrists play a central role in this process by synthesizing clinical findings, imaging results, and patient-specific factors to determine whether TAA or an alternative intervention, such as arthrodesis, is most appropriate. Their responsibility also includes setting realistic expectations, discussing implant longevity, and outlining the rehabilitation trajectory so patients can make informed decisions. Patient education is a shared responsibility across the healthcare team. Surgeons, nurses, and advanced practice providers must collaboratively instruct patients on perioperative and postoperative topics such as weight-bearing restrictions, pain management strategies, wound care, recognition of warning signs (e.g., infection or thromboembolic symptoms), and the importance of adherence to rehabilitation protocols. Clear, consistent messaging helps reduce anxiety, promotes engagement in care, and decreases the risk of complications related to noncompliance. Perioperative nurses, in particular, coordinate patient flow before,

during, and after surgery, monitor vital signs and mental status, and promptly alert the surgical or medical team to any concerning changes. Their vigilance and communication are crucial for early detection of complications and timely intervention.

The hospital pharmacist is an equally important member of the TAA care team. By reviewing the patient's medication profile, the pharmacist helps identify potential drug-drug interactions, contraindications, and allergy risks. They also assist in designing safe and effective pain management regimens, including multimodal analgesia strategies that minimize opioid requirements while maintaining adequate pain control. This careful pharmacologic planning supports early mobilization and contributes to a smoother recovery course. Postoperative rehabilitation is typically guided by a physical therapist, who implements structured protocols tailored to the patient's condition, surgical details, and progress. Rehabilitation focuses on restoring range of motion, strengthening periarticular musculature, improving proprioception, and retraining gait to accommodate the new joint mechanics. Ongoing communication between the therapist and the surgical team allows for timely adjustment of activity levels, bracing, or assistive devices based on radiographic and clinical findings. Regular follow-up visits and sequential imaging are central to long-term success. These encounters allow the team to monitor wound healing, assess implant position and integrity, detect early signs of complications such as loosening or osteolysis, and evaluate functional outcomes. Interprofessional communication—among surgeons, nurses, therapists, pharmacists, and primary care or medical specialists—ensures that emerging issues are addressed cohesively rather than in isolation. Ultimately, the best outcomes in TAA are achieved when the entire healthcare team functions as a coordinated unit with shared goals: alleviating pain, restoring function, and preserving joint motion. This integrated, patient-centered model not only enhances clinical results and reduces complication rates but also improves patient satisfaction and the overall performance of the care team.

Conclusion:

Total ankle arthroplasty represents a paradigm shift in the management of end-stage ankle arthritis, moving from the historical gold standard of arthrodesis towards a motion-preserving philosophy. The primary conclusion drawn from the article is that TAA successfully addresses the fundamental limitation of fusion by maintaining tibiotalar motion, which in turn promotes a more natural gait and reduces compensatory stresses on adjacent joints of the foot and lower extremity. This biomechanical advantage is crucial for long-term musculoskeletal health, potentially delaying the onset of secondary osteoarthritis in joints like the subtalar and talonavicular articulations. The success of TAA,

however, is profoundly dependent on meticulous patient selection, surgical precision, and comprehensive postoperative care. Ideal candidates are typically healthier, lower-demand individuals with good bone stock, satisfactory vascular status, and correctable alignment. The evolution of implant design to third-generation, mobile-bearing prostheses and the integration of advanced technologies like patient-specific instrumentation have significantly improved the accuracy of component placement and overall outcomes. Despite these advancements, the procedure is not without significant risks, including wound healing complications, infection, and intraoperative fractures, which underscore the necessity of rigorous surgical technique. Ultimately, the article concludes that the optimal outcomes for TAA are achieved through an integrated, interprofessional team approach. This model, involving surgeons, nurses, physical therapists, and pharmacists, ensures cohesive patient education, meticulous perioperative management, and structured rehabilitation. For the appropriately selected patient, TAA offers a compelling alternative to arthrodesis, providing durable pain relief while crucially preserving ankle function and enhancing overall quality of life.

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