Review

A narrative review of arthrodesis of the ankle joint

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Abstract

Ankle arthrodesis is a common treatment used for patients with end-stage ankle osteoarthritis (OA). Approximately 80% of ankle OA is post-traumatic. Clinical examination and weightbearing radiographs are sufficient to asses ankle OA. Initial conservative treatment is effective and should be attempted in any stage of OA. From a pharmacological point of view, non-steroidal anti-inflammatory drugs (NSAIDs) and intra-articular infiltrations can produce temporary relief of symptoms. After the failure of conservative medical treatment, surgical intervention can be considered. There are many variations in operative technique including different approaches (open or arthroscopic) and various fixation methods. Each technique has its advantages and disadvantages. The surgical goal of arthrodesis is to align the tibiotalar joint in slightly valgus (0°-5°), neutral dorsiflexion and slightly external rotation (5°-10°). In our review article we described the indications and goals of arthrodesis for treatment of end-stage ankle OA. A systematic step by step operative technique guide is described for the arthroscopic, open anterior and open lateral approaches including a postoperative protocol and possible complications.

Keywords

Ankle; OA; Arthrodesis; Fusion; Open surgery; Arthroscopy

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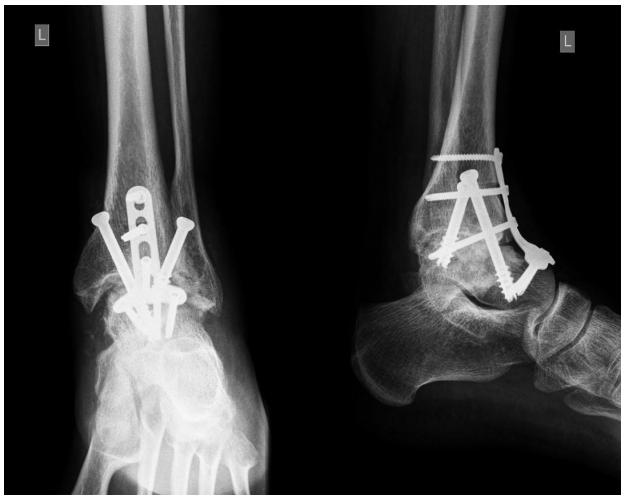

Fig. 1. Post-operative x-ray of ankle arthrodesis with open anterior approach with pre-contoured ankle arthrodesis plate and two posterior cannulated compression screws, anterior-posterior (left) and lateral (right) view

Introduction

Osteoarthritis of the ankle (OA) is a chronic condition that affects approximately 1% of the world's population, with an estimated incidence of 30 cases per 100 000 population.[1] The main cause, accounting for 75–80% of all cases, is a traumatic event (post-traumatic ankle OA). Fractures in the ankle region (malleolus, distal tibia, talus, etc.) are responsible for 62% of cases and the remaining 16% are due to chronic ligamentous instability, especially when the lateral collateral ligament of the ankle is involved (what some authors refer to as ligamentous ankle OA). Idiopathic OA of the ankle is present in only 7–9% of cases.[2,3]

Clinical examination together with native weight bearing and radiographs in anterior-posterior, lateral and mortise views are sufficient to assess OA of the hindfoot and ankle.[4] Routine physical examination includes careful inspection of the entire hindfoot and ankle, assessment of alignment and stability, and measurement of range of motion.[5] The typical clinical presentation includes pain, stiffness, limited range of motion, chronic swelling, alignment deformities, etc.[6]

The modified Kellgren-Lawrence score is usually used to assess ankle OA, which is as follows: Grade1: Osteophytes of doubtful significance at the medial or lateral malleolus, rare tibial sclerosis, joint space width unaffected; Grade 2: Definite osteophytes at the medial malleolus, joint space width unaffected; Grade 3: Definite osteophytes at the medial and/or lateral malleolus, moderate (<50%) narrowing of the joint space width – subgrade 3a talar slope <2°; Subgrade 3b talar tilt >2° and grade 4: Definite osteophytes at the medial and lateral malleolus and at the tibio-talar joint margins, severe (>50%) to complete joint space narrowing, constant tibio-talar sclerosis.[7]

Ankle deformities and degeneration correlate strongly with systemic arthritis, such as rheumatoid arthritis. Michelson and colleagues[8] showed that most rheumatoid arthritis patients had foot and ankle OA, of which 20% had radiographic changes. Saltzman and colleagues[9] found that 12% of patients in their study had arthritic ankles secondary to rheumatism.

In patients with end-stage OA, subjective ankle function, quality of life and activity level deteriorate significantly.[10] Non-surgical treatment of ankle OA may include activity restriction and modification, non-steroidal anti-inflammatory medications, nutritional supplements, a cane or crutches, physical therapy including range of motion training, footwear modification with a rocker bottom sole, an ankle foot orthosis (AFO) with a fixed ankle pad heel, a custom leather ankle orthosis, or an AFO to support the patellar tendon.[11-13] If conservative treatment does not provide adequate relief of symptoms, surgical intervention may be considered. These include arthroscopic debridement, synovectomy, removal of interfering osteophytes, joint distraction, supra-/infra-malleolar osteotomies, arthroplasty or arthrodesis.

Indications

The main indication for arthrodesis is painful end-stage OA of the ankle joint with or without concomitant deformity.[14,15] Additionaly, deformities of the ankle that interfere with wearing shoes and walking, such as ankle equinus, valgus or varus deformities, can be treated with an ankle arthrodesis if other joint-sparing corrections are not possible. Other indications for ankle arthrodesis include failed implants, neoplasms, infections, avascular necrosis, Charcot and congenital deformities.[16-19] The typical

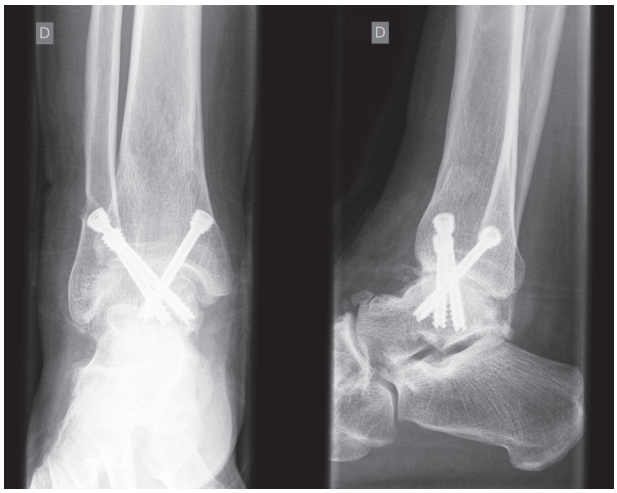

Fig. 2. *Post-operative x-ray of arthroscopic ankle arthrodesis with 3 screws, anterior-posterior (left) and lateral (right) view*

candidate presents with a history of trauma, often with joint damage to the ankle such as crush injuries, comminuted fractures or sprains of the ankle joint in which the articular cartilage has been damaged.[10]

The most important aspect of ankle arthrodesis is adequate soft tissue quality. Other comorbidities such as peripheral vascular disease, lymphedema and venous congestion can put the patient at risk for infection and amputation.[19-21] Smoking has also been shown to have a negative impact on bone fusion.[22] Other factors such as the patient's age, activity level, quality of life, the complexity of the lower limb deformity and the risk/benefit ratio of the surgery must be considered.In children and adolescents, ankle joint arthrodesis is typically avoided whenever possible because of the open growth plates.

Preoperative assessment

The patient's history of systemic diseases such as obesity, osteoporosis, gout, OA, infections, diabetes mellitus, neuropathy and peripheral vascular disease should be obtained and medication reviewed. The physical examination includes standard neurovascular tests and palpation for tender points indicating concomitant disease. The biomechanical examination follows a standard protocol, assessing walking and statics, with particular attention to hindfoot alignment. This examination should be a bilateral examination of the lower extremities, taking into account any existing deformity that could prevent a plantigrade foot. Sometimes the patient has a limb or postural deformity that prevents a pain-free functional surgical result with normal ankle alignment. In the presence of forefoot valgus the ankle joint can be aligned to a more neutral position. Conversely, for forefoot varus, a valgus position of more than 5 degrees can be considered.[23]

Standard procedures for preoperative assessment include weight-bearing radiographs, anterior-posterior, mortise and lateral views. Characteristics of an arthritic ankle are osteophyte formation, reduced joint space and asymmetric joint contour.[24] Additional imaging modalities such as magnetic resonance or computed tomography, including three-dimensional reconstructions, should be performed when a complex surgical fusion is being considered. These modalities allow a more detailed examination of deformity, bone density, congruency and remaining hardware.[25]

Surgical technique

In ankle arthrodesis, a rough distinction is made between open and arthroscopic techniques. The open approach is further subdivided into anterior, posterior, lateral, medial and the combined medial and lateral approach. Open arthrodesis is best suited for patients with moderate to severe deformity as it allows better visualization for correction of the deformity.[26] Compared to the arthroscopic approach, the main advantage of the open approach is that it is less difficult to correct the deformity and that plates and bone grafts can be inserted more easily. However, open arthrodesis is associated with a higher rate of wound complications due to the required extensive soft tissue dissection.[27-31] This can subsequently lead to a longer hospital stay and a longer recovery. Therefore, open procedures are generally reserved for patients with moderate to severe ankle deformities and healthy skin. Arthroscopic ankle arthrodesis is indicated in patients with minimal ankle deformity (less than 15° varus or valgus in the coronal plane) or in patients with an increased risk of wound complica-

tions (e.g. immunosuppressed patients, diabetics, patients with rheumatoid OA).Various methods of internal fixation are used, such as screws, plates, retrograde intramedullary nails or a combination of these. Many surgeons prefer screw fixation as the primary means of internal fixation because they are easy to use, have low morbidity (requiring only small percutaneous incisions), and are less expensive compared to most other methods. The three most common types of ankle arthrodesis are described below: the open anterior, open lateral approach and the arthroscopic method.

Open anterior approach

The patient is placed in the supine position and a thigh cuff is applied. A 10 cm anterior incision is made immediately to the side of the anterior tibial tendon up to the level of the talonavicular joint. Care must be taken during dissection to ensure that the superficial peroneal nerve is bypassed in the distal area of the incision. The extensor retinaculum is incised longitudinally to facilitate closure. Deep dissection can be performed through the sheath of the anterior tibial tendon, which significantly reduces the risk of injury to the deep neurovascular bundle (anterior tibial artery and vein, deep peroneal nerve). Alternatively, dissection can be performed through the extensor hallucis longus to avoid injury to the anterior tibial tendon sheath. The neurovascular bundle is located directly behind the extensor hallucis longus at the level of the ankle joint. After removal of the tibial and talar osteophytes and preparation of the articular surfaces, the ankle joint is exposed through a longitudinal incision of the joint capsule and the tibial periosteum. Laminar retractors can be used to distract the joint and allow inspection of the articular surface. The remaining articular cartilage of the talar dome and tibial plateau is then removed with a chisel, curette and, if necessary, a sharp drill. A varus or valgus deformity can be corrected with an asymmetric bone resection or with a bone graft. Different bone grafting options are also available in the case of bone defects. A pre-contoured ankle arthrodesis plate, which is used to improve alignment, is positioned and inserted. The optimal alignment of the tibiotalar joint is a slight valgus position (0°-5°), neutral dorsiflexion and slight external rotation (5^{o}-10^{o}), which is verified by intraoperative fluoroscopy in two planes. Compression is achieved using the "Achilles tendon ligament technique", which increases compression over the ankle joint. The concept is to bring the ankle joint into dorsiflexion while tensioning the Achilles tendon, thereby compressing the ankle joint and ensuring neutral dorsiflexion. Fusion can also be achieved with two or three cannulated screws (6.5-7.3 mm) forming a 45° angle with the tibial axis. If bone availability is poor, two posterior large cannulated compression screws can be combined with an anterior pre-contoured plate (Fig. 1). Severe varus/valgus deformities of the ankle joint can be better corrected with the lateral approach.

Open lateral approach

The patient is positioned supine with the feet on the edge of the operating table with a thigh tourniquet applied. The lateral malleolus, the medial malleolus, the ankle line, the fourth metatarsal bone, the fifth metatarsal bone, the superficial peroneal nerve and the sural nerve are marked with a sterile surgical marker. An incision is then made over the lateral aspect of the lateral malleolus, starting approximately 7.0 cm above the tip of the lateral malleolus and extending distally to the base of the fourth metatarsal. After identifying the tibiofibular joint, the soft tissues, including the anterior inferior talo-fibular ligament, the interosseous ligament and the interosseous membrane, are resected. The osteotomy of the distal fibula is performed 2.5 cm proximal to the ankle joint. After the fibula osteotomy, the ankle joint is distracted with a lamina spreader. Following complete exposure of the articular surface, the cartilage is removed from both the tibia and the talus to expose the subchondral bone. Debridement is kept to a minimum in order to maintain joint congruency. The subchondral bone is usually penetrated with several drill holes. The tibiotalar joint is fixed with two to three 6.5 to 7.3 mm cannulated screws once adequate alignment is achieved. The optimal alignment of the tibiotalar joint is in slight valgus (0°-5°), neutrally dorsi-

flexed and slightly externally rotated (5°-10°). The talus is reduced in a posterior position to maximize the contact area of the articular surfaces. During the entire procedure, position of the ankle joint, insertion of the guide wires,screw position and length are checked with intraoperative fluoroscopy in two planes. After achieving the desired position, two to three guide wires are inserted into the inferolateral aspect of the base of the talar neck. Two to three 6.5 mm to 7.3 mm cannulated screws are passed over the guide wires from the talus through the ankle joint into the tibia. The remaining cartilage from the osteotomized lateral malleolus is removed and the lateral malleolus is reattached to the talus and tibia with 3.5 to 4.5 mm screws. If the fixation is unstable, a small antero-medial plate is inserted between the neck of the talus and the anterior tibial plateau to strengthen the construct.

Arthroscopic arthrodesis with screw fixation

Arthrodesis of the ankle joint is performed via an anteromedial and an anterolateral portal. After marking the anatomical landmarks (malleolus lateralis, malleolus medialis, peroneus tertius, tibialis anterior tendon, superficial peroneal nerve and sural nerve), the portals are marked. The anteromedial portal is placed just medial to the medial edge of the tibialis anterior tendon and the anterolateral portal lateral to the peroneus tertius. After the skin incision, a subcutaneous blunt dissection is performed using a mosquito clamp. The portals are made in the following order: the anteromedial portal first, then the anterolateral portal. Debridement of the synovium and scar tissue is usually necessary to make the surface of the ankle joint more visible. The remaining cartilage on tibia, talus, medial and lateral groove is then debrided with a shaver, reamer or curette. A guide wire is passed from the posteromedial side of the tibia over the joint line to a targeted site in the neck of the talus. The screw of the appropriate length is then inserted. This screw, which enters the talar head and neck from the posterior surface of the tibia, is called the "home run screw" and is responsible for anterior joint compression. A second guide wire is inserted at the midline of the fibula and guided to the postero-central talus. The second cannulated screw is then inserted. The third guide wire is inserted from an anterior point of the distal tibia and guided to the central talar dome. Once the wire is placed adequately, the cannulated screw of the appropriate length is inserted over the guide wire (Fig. 2).

Postoperative care

After ankle arthrodesis, patients are placed in a non-weight-bearing short-leg cast for 6-8 weeks. In hospital pain management and physical therapy are started. As a rule, patients are discharged on the second postoperative day. Regular wound management in an outpatient clinic is performed until incisions have healed. If the x-rays and clinical examination show a successful arthrodesis after 8 weeks, the patient is slowly introduced to partial and full weight-bearing over the next 4 weeks. This is followed by physical therapy and a gradual change to commercial footwear. On average, it takes 8-12 weeks for the ankle to stiffen.In case of doubt, a post-operative CT scan is performed and immobilization prolonged until fusion is confirmed.

Complications

Infection, numbness, hematoma, nerve entrapment, deep vein thrombosis, delayed union, malunion and nonunion are possible postoperative complications of ankle arthrodesis. The adhesion rates of open ankle arthrodesis with internal fixation such as the tripod screw technique are between 80 and 100 % .[32-34] For tibio-talo-calcaneal arthrodesis with intramedullary nail, similar fusion rates of 89% to 100% at the ankle and slightly less success with simultaneous subtalar fusion rates have been reported.[35,36] In the case of delayed fusion (no evidence of radiographic healing after 3 months), a non-weight-bearing below the knee cast, no weight bearing and an external bone stimulator are indicated. If a nonunion occurs, revision surgery with resection of the fusion site and application of a bone graft is indicated. Recent literature reports nonunion rates of 0% to 9% after open ankle arthrodesis.[37-39] Malunion of the fusion site in plantar flexion, elevated varus or elevated valgus typically leads to increased stress and compensatory motion of the metatarsal and subtalar joints, which may require further surgery.[40-43] Cases

with wound infection and subsequent osteomyelitis are treated with removal of the hardware and placement of an external fixator combined with a 6-week course of antibiotics before revision arthrodesis is performed.[44] Long-term complications and functional problems include leg length discrepancy, gait abnormalities, calluses related to the malalignment, chronic edema, symptomatic shoeing, adjacent hindfoot and tarsal OA, stress fractures, and poorly localized ankle and hindfoot pain.[45]

Summary

Ankle arthrodesis is an effective treatment for end-stage ankle OA that can be performed through either open or arthroscopic approach. There are several fixation options, but the authors favor two to three screws with or without a small anterior plate. It is important to remember that correct positioning of the ankle joint is crucial for achieving appropriate ankle arthrodesis. Complications can occur after ankle fusion, including the need for further surgery due to OA in the subtalar and tarsometatarsal joints. Complications can be minimized through preoperative risk assessment, choosing the appropriate surgical approach, considering complementary procedures, and assuring postoperative patient compliance.

The authors declared no conflicts of interest.

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Cite this paper as

Mujanović N, Žlak N, Drobnič M. A narrative review of arthrodesis of the ankle joint. AOTH. 2024; 75(2):11-18.