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REVIEW

Ankle arthrodesis: A systematic approach and review of the literature

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Abstract

Ankle arthrodesis is a common treatment used for patients with end-stage ankle arthritis (ESAA). The surgical goal of ankle arthrodesis is to obtain bony union between the tibia and talus with adequate alignment [slight valgus (0°-5°)], neutral dorsiflexion, and slight external rotation positions) in order to provide a pain-free plantigrade foot for weightbearing activities. There are many variations in operative technique including deferring approaches (open or arthroscopic) and differing fixation methods (internal or external fixation). Each technique has its advantage and disadvantages. Success of ankle arthrodesis can be dependent on several factors, including patient selection, surgeons' skills, patient comorbidities, operative care, *etc*. However, from our experience, the majority of ESAA patients obtain successful clinical outcomes. This review aims to outline the indications and goals of arthrodesis for treatment of ESAA and discuss both open and arthroscopic ankle arthrodesis. A systematic step by step operative technique guide is presented for both the arthroscopic and open approaches including a postoperative protocol. We review the current evidence supporting each approach. The review finishes with a report of the most recent evidence of outcomes after both approaches and concerns regarding the development of hindfoot arthritis.

Key words: Ankle; Osteoarthritis; Arthrodesis; Review; Ankle fusion

Core tip: Ankle arthrodesis is an effective treatment option for end stage arthritis. There is no current consensus on the most optimal approach and fixation method. It is thus important for the surgeon to understand both the open and arthroscopic approach and when each approach is indicated. Joint alignment must be slightly valgus (0°-5°), neutrally dorsiflexed and slightly in an externally rotated position. Limb length discrepancies should also be minimal (less than 2.5 cm or 1.0 inch). Failure to address these biomechanical aspects may result in pain and an altered gait pattern. The importance of adequate preoperative forefoot balance cannot be understated to allow for successful postoperative mobility. When performed according to these principles ankle arthrodesis leads to functional improvement and adequate joint fusion in patients with end stage arthritis.

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INTRODUCTION

Ankle arthrodesis and ankle arthroplasty are the two common operative treatments used in end stage ankle arthritis (ESAA)[1,2]. Recent clinical evidence suggests that ankle arthroplasty leads to superior functional outcomes over ankle arthrodesis[3-7]. However, ankle arthroplasty is associated with higher rates of postoperative complications and revision surgeries[3-8]. Despite the increasing popularity of ankle arthroplasty, a large database has indicated that ankle arthrodesis still remains the most common surgical treatment for ESAA[9,10].

There are several operative techniques for ankle arthrodesis including open or arthroscopic approaches[11-15]. Although successful clinical outcome can be achieved following both approaches[11-15], reported outcomes have varied and are conflicted[16]. The differences in techniques, surgeon skill, patient selection and populations, and outcome measurements utilized all contribute to the variability in outcome after arthrodesis. Ankle arthrodesis should be performed judiciously in young patients, highly active patients, and patients with advanced foot and ankle deformity.

The purpose of this manuscript is to provide: (1) to provide an evidence-based review of ankle arthrodesis for ESAA; and (2) to describe a standardized approach to both open and arthroscopic ankle arthrodesis.

INDICATIONS AND GOALS OF ARTHRODESIS

Ankle arthrodesis is indicated for patients with ESAA that failed a minimum of 3 mo of conservative treatment. The goal of ankle arthrodesis is to provide a pain-free plantigrade foot during weightbearing activities[17]. Alignment following ankle arthrodesis must be slight valgus (0°-5°), neutral dorsiflexion, and slightly externally rotation. Equinus position of the ankle joint can accompany genu recurvatum and a varus position of hindfoot can develop painful callosities to the lateral forefoot[18], which may cause hindfoot pain[19,20]. Additionally, the surgeon should attempt to minimize limb length discrepancies (less than 2.5 cm or 1.0 inch)[21-23]. Limb length discrepancies can result in a symptomatic malalignment with altered gait pattern[24].

Arthroscopic ankle arthrodesis is typically reserved for patients with little to no joint deformity (less than 15° of varus or valgus in the coronal plane). Open arthrodesis is best utilized for patients with moderate to severe deformity as this allows for better visualization for malalignment correction. Additionally, as fusion of the ankle joint will inevitably lead to a lack of motion, preoperative balance of the forefoot is essential. Therefore, careful examination of forefoot balance without excessive pronation or supination is needed[25]. Arthroscopic or open debridement with subsequent external fixation would be preferred by the authors in patients with significant malalignment, comprised skin, limbs discrepancies, and active/previous infection.

TYPES OF ANKLE ARTHRODESIS

Numerous surgical techniques for ankle arthrodesis have been described[11-15]. The technique should be selected based on patient characteristics, function and goal of treatment, as well as the preference of the surgeon.

Approach

The approach to ankle arthrodesis is broadly divided into open and arthroscopic techniques. The open approach is further subdivided into the anterior approach, posterior approach, lateral approach, medial approach, and combined medial and lateral approach. Compared with the arthroscopic approach, the main benefit of an open approach includes less difficulty in correcting malalignment, and ease in applying plates and bone grafts. However, open arthrodesis is associated with higher rates of wound complications due to the extensive amount of soft tissue dissection required[3-7]. This can subsequently lead to longer hospitalization and recovery. Therefore, open approaches are generally reserved for patients with moderate to severe ankle deformities with healthy skin.

Arthroscopic ankle arthrodesis is as a less invasive procedure enabling shorter operative time with comparable union rates[26-28]. This procedure is most commonly performed using anterior ankle arthroscopy, however recent studies have suggested that posterior ankle arthroscopic arthrodesis may provide better fusion rates[29]. Arthroscopic ankle arthrodesis is indicated for patients with minimal ankle joint deformity (less than 15° of varus or valgus in coronal plane) or patients who are at higher risk of wound complications (*e.g.,* immunosuppressed, diabetics, rheumatoid arthritis patients). Although arthroscopic arthrodesis is increasingly becoming popular, open ankle arthrodesis remains the mainstay procedure

Table 1 Open ankle arthrodesis

Investigator	Year	Method	No. of patients	Union rate	Outcome(s)
Charnley *et al*[51]	1951	Charnley compression	19	79%	N/A
Boobbyer[52]	1981	Internal and external fixation	37	84%	N/A
Kenzora *et al*[53]	1986	External fixation	26	69%	N/A
Sowa *et al*[54]	1989	Compression blade plate	17	94%	10 excellent; 2 good; 2 fair (out of 14; Mazur)
Helm *et al*[55]	1990	Charnley compression	47	85%	N/A
Mann *et al*[11]	1991	Screws from talus to tibia	18	94%	N/A
Kitaoka *et al*[56]	1992	External fixation and bone graft	26	77%	N/A
Wang *et al*[57]	1993	T plate on lateral side	11	91%	N/A
Chen *et al*[58]	1996	Cross screws	40	95%	N/A
Patterson *et al*[59]	1997	Anterior sliding graft with screws	27	93%	N/A
Levine *et al*[44]	1997	Internal fixation and bone graft	22	92%	N/A
Mann *et al*[12]	1998	Internal fixation and fibular graft	81	88%	74 (AOFAS)
Dereymaeker *et al*[60]	1998	Internal and external fixation	14	64%	N/A
Ben-Amor *et al*[61]	1999	80% internal fixation, 20% external fixation	36	97%	56.2 (Duquennoy)
Takakura *et al*[62]	1999	Anterior sliding graft with screws	43	93%	77.9 (Takakura)
Coester *et al*[20]	2001	Internal or external fixation	23	N/A	27 limiation, 38 pain, 47 disability (Foot Function Index)
Bertrand *et al*[63]	2001	84% internal fixation, 16% external fixation	23	87%	69.7 (Duquennoy)
Anderson *et al*[64]	2002	Internal and external fixation	29	89%	N/A
Fuchs *et al*[65]	2003	22% internal fixation, 78% external fixation	18	95%	59.4 (Olerud and Molander)
Buchner *et al*[66]	2003	38% internal fixation, 62% external fixation	45	92%	73.6 (AOFAS)
Kopp *et al*[67]	2004	Internal fixation with staples and screws	41	93%	72.8 (Mazur)
Kennedy *et al*[16]	2006	Internal fixation with screws	41	95%	80.6 (AOFAS)
Thomas *et al*[39]	2006	Internal fixation with transfibular approach	26	100	74 (AOFAS)
Trichard *et al*[68]	2006	60% internal fixation, 40% external fixation	25	N/A	64.7 (Duquennoy)
Smith *et al*[69]	2007	Internal fixation	25	96%	43.7 (AOFAS)
Colman *et al*[70]	2007	Transfibular approach with grafting	48	96%	69 (AOFAS)

for ESAA in the United States of America[9,10].

Fixation methods

Both internal and external fixation may be used in ankle arthrodesis. Each has its unique advantages; successful outcomes having been demonstrated with both fixation methods[11-15].

Various methods of internal fixation have been described, including screws, plates, and retrograde intramedullary nails. Many surgeons prefer to use screw fixation as the primary means of internal fixation, because screws are easy to use, have low morbidity (they only require small percutaneous incisions) and are cheaper compared to most other methods. However, higher nonunion rates of the ankle joint have been reported with screw fixation especially in osteoporotic bone[30,31]. Plates are advantageous for ankle arthrodesis because there are many options when using plates. The surgeon has choices with regard the type of plate needed (*e.g.*, conventional or locking), how many plates and where to place the plates. While some surgeons prefer plates because they are stiffer constructs than screws that may achieve better union rates, the extensive dissection needed to place the plate can lead to a higher risk of infection and morbidity[32-34]. A combination of plates and screws may also be used. A recent biomechanical study found that a combination of plate and screw fixation provided significantly greater stiffness than plates or screws alone. In this study there were no significant difference between 3 compression screws, anterior plate and lateral plate fixation[34]. Retrograde intramedullary arthrodesis is typically reserved for arthrodesis of both the ankle and subtalar joints[35-38]. Patients with ESAA typically have concomitant subtalar arthritis. In these patients, it is difficult to delineate whether the pain is coming solely from the tibiotalar joint, the subtalar joint or a combination of both. The surgeon must determine this preoperatively because it is best to avoid arthrodesis of the subtalar joint whenever possible especially when the ankle will be fused. In the setting of a tibiotalar arthrodesis the subtalar joint is critical for gait stability[20,39,40]. The subtalar joint allows for inversion and eversion of the ankle joint and therefore, this can compensate for a more stable gait when joint motion is permanently reduced post-arthrodesis.

External fixation is typically indicated for complex patients with significant bone defects, limb length discrepancies discrepancies, poor bone quality, and active or previous infection[31]. Overall, union rates and outcomes measures of external fixation are inferior to internal fixation (Table 1).

OPERATIVE TREATMENT

Two standardized methods of ankle arthrodesis for ESAA is described here: Open and arthroscopic. For both methods, the joint is fixed with two or more screws. Patients are placed in a short leg cast and immobilized for 6 wk. Patients have achieved successful outcomes following either approach in our experience[16].

Figure 1 Lateral transfibular approach.

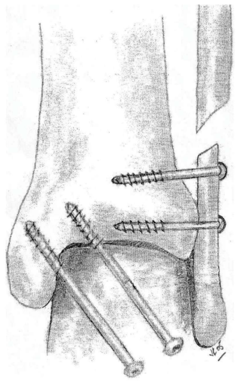

Figure 2 Anteroposterior scheme shows the placement of screws.

Open arthrodesis with screw fixation

Patient positioning and equipment: The patient is placed in the supine position with the feet at the edge of the bed. A tourniquet is typically used at the level of the thigh and applied before the start of the case. All equipment should be confirmed prior to the onset of the case. Osteotomes, a bone saw, and curettes are needed for the osteotomy and debridement of the joint surface. A large fragment cannulated drill set and screws (4.0/6.5/7.3 mm) are required to fuse the ankle joint. Fluoroscopy should be used to confirm ankle alignment and screw positions.

Steps of the procedure: (1) Marking anatomical landmarks: Anatomical landmarks are marked using a sterile surgical marker. In this procedure, the lateral malleolus (LM), medial malleolus (MM), ankle joint line, fourth metatarsal, fifth metatarsal, superficial peroneal nerve, and sural nerve are all identified and marked. Then, a hockey-stick-shaped incision is outlined over the lateral aspect of the LM, starting approximately 7.0 cm above the tip of the LM and extending distally to the base of the fourth metatarsal. Additionally, a longitudinal medial skin incision line is marked over medial gutter of ankle joint; (2) Skin incision and osteotomy of distal fibula: The first skin incision is made over the fibula along the previously described outline. Once distal tibiofibular joint is identified, soft tissues including the anterior inferior talofibular ligament, interosseous ligament, and interosseous membrane are resected. An osteotomy of the distal fibula is then made in a beveled fashion approximately 2.5 cm proximal to the ankle joint using a sagittal oscillating saw. The resected bone block (medial side of fibula) should be kept for local autologous bone grafting later on in the case (Figure 1). After the osteotomy is complete, the lateral aspect of the fibula is retracted posteriorly. It is important to preserve the fibula as best as possible to minimize the risk of non-union; (3) Debridement of joint surface cartilage: After the fibular osteotomy, the ankle joint is distracted using a lamina spreader. Any inflammation or scar tissue within the ankle joint is debrided and/or removed carefully to fully expose the joint surface. Careful attention during exposure of the joint surface is essential to avoid injury to the neurovascular bundle located anterior of the ankle joint capsule. If the full joint surface cannot be visualized at this point, a medial incision with arthrotomy may be needed to reduce the future potential of saphenous nerve damage. After fully exposing the joint surface, cartilage is removed from both the tibia and talus to expose the subchondral bone. The authors prefer to use an osteotome and curette rather than a bone saw or burrs to minimize the risk of thermal necrosis of the subchondral bone. The debridement should also be minimalized to maintain joint congruency; (4) Fusion of tibiotalar joint: The tibiotalar joint is fixed typically using two to three 7.3 mm cannulated screws after adequate alignment is obtained. The alignment of tibiotalar joint should be slightly valgus (0°-5°), neutrally dorsiflexed, and slightly external rotated. The talus should be reduced in a posterior position to obtain the largest possible contact area of joint surfaces. This is to reduce the lever arm of the foot on the mechanical construct. The alignment is evaluated using fluoroscopy in two planes. Two to three guide wires are then inserted in the inferolateral aspect of the base of the talar neck. This technique is similar to what was previously described by Mann *et al*[12]. The positions of the guide wires should be confirmed using fluoroscopy. Three 7.3 mm cannulated screws are then inserted through the guide wires starting at the talus through the ankle joint and into the tibia. The authors believe that two to three screws are optimal to fuse the joint, as too few screws results in the inadequate compression of the bony surfaces and too many screws reduces the availability of bony surface for osseous integration[16]; (5) Fusion of lateral malleolus to tibia (Figure 2): Two 4.0 mm screws are used to fix the lateral malleolus and distal tibia into place. Guide wires may be placed before insertion of the screws to ensure adequate alignment. The position of the screws/guide wires should be confirmed with fluoroscopy. Bone graft may be placed around the fusion site to facilitate union. This is especially recommended when there might be factors that could complicate the union such as osteonecrosis of the talus, previous non-union or bony defects[41-45]. Bone graft can be prepared through the morselization of bone acquired

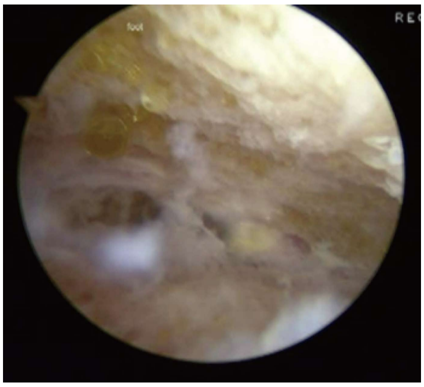

Figure 3 Any remaining cartilage on the tibia, the talus or in the medial or lateral gutters is debrided.

during the distal fibula osteotomy and placed around the site of fusion.

Arthroscopic arthrodesis with screw fixation

Patient positioning and equipment: General arthroscopy equipment is required for an arthroscopic arthrodesis. A 2.7/4.0 mm, 30°/70° arthroscope is typically used. Shavers are required for debridement of soft tissue and for bony resection. A non-invasive distractor and irrigation system are both helpful to obtain good visualization. The fluid pressure is usually set at 50 to 60 mmHg with the fluid flow rate at 0.5 L/min. The ankle joint is fixed using equipment from the large fragment cannulated drill and screw set (6.5 mm). For this procedure, fluoroscopy is necessary.

The patient is placed in the supine position with the ipsilateral hip flexed and supported by a well-padded leg holder. The position of the holder should be proximal to popliteal fossa to avoid constriction of the neurovascular bundle. The ankle and hindfoot is held with a sterile distraction strap.

Steps of the procedure: (1) Marking anatomical landmarks and establishing portals: The careful identification of anatomical landmarks is critical for any arthroscopic procedure of the ankle. The most commonly injured nerve following anterior ankle arthroscopy is the superficial peroneal nerve (up to 2.9%)[46]. Anterior ankle arthrodesis is performed using anteromedial (AM), anterolateral (AL) and occasionally posterolateral (PL) portals. The lateral malleolus (LM), medial malleolus (MM), peroneus tertius, tibilais anterior tendon (TAT), superficial peroneal nerve, and sural nerve are all identified and marked. At the level of ankle joint, the AM portal is established just medial to the medial border of the TAT and the AL portal is placed lateral to peroneus tertius. The PL portal is marked 1.0 mm anterior to the lateral borders of Achilles tendon with also bring at horizontal level with the inferior pole of the MM and the tip of LM. Arthroscopic portals are created using "nic and spread" technique to decrease the risk of iatrogenic nerve damage. After the skin incision, subcutaneous blunt dissection is performed using a mosquito clamp. A 2.7 mm arthroscope sleeve with a trocar is then carefully advanced. Once the anterior aspect of tibia can be palpated with the trocar, it is switched out for a 2.7 mm arthroscope. The authors prefer the insertion of portals in the following order: AM portal, AL portal and PL portals; (2) Debridement and exposure: Debridement of the synovium and scar tissue is typically required to improve visualization of the ankle joint surface. Any remaining cartilage on the tibia, the talus or in the medial or lateral gutters is then debrided using a shaver, burr, or curette (Figure 3). To fully visualize the posterior aspect of the joint, the PL portal may need to be utilized. In several previous studies, investigators have suggested that poor debridement of the posterior portion of the ankle joint may compromise ankle fusion rates[47,48]. Adequate debridement can be assessed by the visualization of blood arising from the subchondral bone of the talus and tibia when inflow pressure is decreased; and (3) Tibiotalar fixation: The tibiotalar joint is fixed typically using two to three large cannulated screws. A Kirschner wire is first inserted 10° to 20° starting at the anterolateral tibia approximately 3 to 4 cm above the joint line and towards the posterior aspect of the horizontal axis of the tibia. A second Kirschner wire is then inserted from the anteromedial aspect of the tibia in a similar orientation aiming toward the central talar dome. These Kirschner wires should be altogether inserted at the tibial joint surface. The location of the Kirschner wires should be confirmed by both arthroscopy (Figure 4A) and fluoroscopy. Following the confirmation of adequate talocrural joint alignment, the wires are then advanced into talus (Figure 4B). Screws are then inserted over these Kirschner wires (Figure 4C). A countersink may be required to reduce the prominence of the screw heads.

BIOLOGICS

Biologics may be used to aid in fusion of the ankle in both the open and arthroscopic techniques. Two types of biologics are currently available: Osteoconductive and osteoinductive agents. Osteoconductive agents, *e.g.,* bone allografts, demineralized bone matrix and various apatitic pastes, are agents that serve as a scaffold at the site of fusion. This scaffold acts as a tissue network to facilitate autologous cell interaction for osteogenesis. Osteoinductive agents, *e.g.,* bone morphogenetic proteins, platelet-rich plasma or concentrated bone marrow aspirate, are agents that directly facilitate osteogenesis. This may be in the form of containing growth factors (platelet-rich plasma) or stem cells (concentrated bone marrow aspirate) to stimulate the formation of osteoblasts. Biologics should be placed into the fusion site before and after the final seating of screws.

POSTOPERATIVE REHABILITATION

The ankle joint is immobilized in a non-weightbearing leg cast for 6 wk. The cast is then removed and

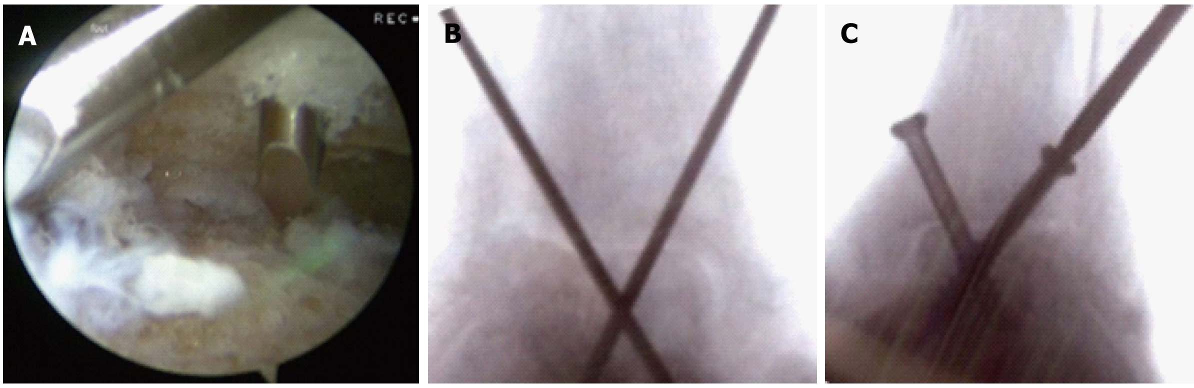

Figure 4 Kirschner wires should be altogether inserted at the tibial joint surface. A: Arthroscopic view shows the location of the Kirschner wires; B: Fluoroscopic view shows location of Kirschner wires; C: Screw fixation.

Table 2 Arthroscopic ankle arthrodesis

Investigator	Year	Method	No. of patients	Union rate	Outcome(s)
Ogilvie-Harris *et al*[71]	1993	Tibiotalar and fibulotalar screws	19	89%	N/A
Dent *et al*[72]	1993	Crossed tibiotalar, charnley clamp	8	100%	N/A
De Vriese *et al*[73]	1994	Arthroscopic arthrodesis	10	70%	N/A
Turan *et al*[74]	1995	Arthroscopic arthrodesis	8 (10 ankles)	100%	N/A
Corso *et al*[75]	1995	Tibiotalar and fibulotalar screws	16	100%	N/A
Crosby *et al*[76]	1996	Arthroscopic arthrodesis	42	93%	N/A
Glick *et al*[77]	1996	Cannulated screws	34	97%	N/A
Jerosch *et al*[78]	1996	Tibiotalar and fibulotalar screws	26	85%	N/A
Cameron *et al*[13]	2000	Arthroscopic arthrodesis	15	100%	N/A
Zvijac *et al*[79]	2002	Arthroscopic arthrodesis	21	95%	N/A
Cannon *et al*[80]	2004	Arthroscopic arthrodesis	36	100%	N/A
Saragas[81]	2004	Arthroscopic arthrodesis	26	96%	63.9 (modified AOFAS out of 78 points)
Winson *et al*[25]	2005	Arhroscopic arthrodesis	116 (118 ankles)	92%	N/A
Ferkel *et al*[82]	2005	Arthroscopic arthrodesis	35	97%	73.9 (Mazur)
Gougoulias *et al*[83]	2007	Arthroscopic arthrodesis	74 (78 ankles)	97%	N/A
Dannawi *et al*[84]	2011	Arthroscopic arthrodesis	55	91%	81.5 (Mazur)

the patient is transferred over to a Controlled Ankle Movement Walker Boot. Radiographs should be taken at intervals of 6 wk, 3 mo, 6 mo and 1 year to assess the position of fusion and adequacy of union. A gradual 10% increase every two weeks in weightbearing is advised. However, as soon as complete union is evident on radiographs, patients may be allowed to fully weightbear.

OUTCOMES AFTER ANKLE ARTHRODESIS: A SYSTEMATIC REVIEW

Clinical studies on ankle arthrodesis were searched for on the MEDLINE and EMBASE databases using the terms: (open OR arthroscopic) AND (ankle) AND (arthrodesis OR fusion). The search revealed 463 papers from MEDLINE and 695 papers from EMBASE. The inclusion criteria were: (1) the studies' intervention included the use of arthrodesis; (2) clinical studies; and (3) published in a peer-review journal. Exclusion criteria were: (1) review studies; (2) cadaver studies; and (3) animal studies. This resulted in the inclusion of 26 studies on open ankle arthrodesis and 16 studies on arthroscopic ankle arthrodesis (Table 2).

Union rate has been shown to be a popular outcome measure following arthrodesis, as indicated by its prevalent use in the current literature. Other popular measures included the AOFAS, Duquennoy, Mazur, Takakura, Foot Function Index and Olerud and Molander scoring systems.

The average union rate following open arthrodesis was 89% (range: 64%-100%) and following arthroscopic arthrodesis was 94% (range: 70%-100%). In the cohort of patients in the four comparative studies, the average union rate in the open group was 89% and in the arthroscopic group was 91%. However, in the only comparative study reporting clinical outcomes, Townshend *et al*[26] demonstrated that clinical outcomes only mildly improved following the use of the arthroscopic technique.

In regards to the effects of ankle arthrodesis on the automobile breaking. Jeng *et al*[49] demonstrated that ankle arthrodesis can significantly decreased the total break reaction time. However, this delay does not exceed the safe reaction brake timing criteria by the United States Federal Highway. Schwienbacher *et al*[50]

Table 3 Open *vs* arthroscopic ankle arthrodesis

Investigator		Year	Method	No. of patients	Union rate	Outcome(s)
Myerson *et al*[28]	Open	1991	Screws from tibia to talus	16	100%	N/A
	Arthroscopic		Cannulated screws	17	94%	
O'Brien *et al*[27]	Open	1999	Open technique	17	82%	N/A
	Arthroscopic		Arthroscopic technique	19	84%	
Nielsen *et al*[85]	Open	2008	Open technique	49	84%	N/A
	Arthroscopic		Arthroscopic technique	58	95%	
Townshend *et al*[26]	Open	2013	Open technique	30	N/A	AOS = 29.2 ± 17.2; SF-36 physical = 38.2 ± 11.8; SF-36 mental = 52.2 ± 12.0
	Arthroscopic		Arthroscopic technique	30		AOS = 17.2 ± 17.9; SF-36 physical = 45.0 ± 9.3; SF-36 mental = 55.1 ± 8.1

performed comparative case series in a driving simulator and found that patients receiving ankle arthrodesis had less of an ability to brake under emergency circumstances compared to healthy volunteers.

Relationship between ankle arthrodesis and adjacent-joint arthritis in the hindfoot

The development of adjacent hindfoot arthritis following tibiotalar arthrodesis remains a concern. A recent systematic review by Ling *et al*[86] investigated the relationship between ankle arthrodesis and adjacent-joint arthritis and demonstrated that there was insufficient evidence to support either that ankle arthrodesis caused adjacent-joint arthritis or that pre-existing joint arthritis could have already existed in those cohort of patients. As the current postulation include that there may be inherent pre-existing adjacent joint arthritis in the majority of patients requiring fusion, no clear consensus can be made on whether ankle arthrodesis can cause or predispose to hindfoot arthritis.

Recently, Yasui *et al*[9] published a large retrospective cohort study that investigated the postoperative adjacent-joint hindfoot arthritis following ankle arthrodesis. The authors found there was significant higher rate of subsequent adjacent-joint arthrodesis in the open cohort than the arthroscopic cohort (7322 open procedures *vs* 1152 arthroscopic procedure, reoperation rate: 5.6% *vs* 2.6%, odds ratio: 2.17, 95% confidence level: 1.49-3.16). Regardless of whether adjacent hindfoot arthritis is present before or develops after arthroedesis the authors believe that these patients more commonly have open procedures. The authors hypothesized that open ankle arthrodesis leads to degenerative OA of the adjacent joints more frequently than does the arthroscopic procedure; or, patients undergoing open ankle arthrodesis develop concurrent degenerative arthritis in the adjacent joints more frequently than does the arthroscopic group. To address this subject, further investigation is necessary (Table 3).

CONCLUSION

Ankle arthrodesis is an effective treatment for ESAA that may be achieved through either the open or arthroscopic approach. Several fixation options exist, however the authors prefer two to three screws. It is difficult to generate a clear consensus on whether open or arthroscopic arthrodesis should the mainstay of treatment for ESAA because conflicting evidence currently exists. As the current success of arthrodesis continues to depend on a variety of factors, the current review aims to summarize an up-to-date knowledge for optimizing the outcomes of ankle arthrodesis.

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