Arthroscopic ankle arthrodesis: the technique to do

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Background
End-stage ankle arthritis severely affects patients' health-related quality of life. When nonoperative treatments fail, ankle arthrodesis surgery or total ankle arthroplasty can improve pain, function, and health-related quality of life. For patients with isolated end-stage ankle arthritis and minimal deformity outside the ankle requiring osteotomies or fusions, ankle arthrodesis remains the mainstay of operative treatment. Open ankle arthrodesis has been the standard operative treatment for advanced osteoarthritis ankle not responsive to any nonoperative measures, but arthroscopic technique gained high popularity owing to high rate of fusion with a low incidence of complications.

Aim
This study aims to evaluate the role and results of arthroscopic assisted ankle arthrodesis in advanced ankle osteoarthritis (AOS).

Patients and methods
A total of 40 patients with post-traumatic arthritis, primary osteoarthritis, and rheumatoid arthritis were treated by ankle arthroscopic arthrodesis between January 2011 and January 2016 in Suez Canal University Hospital. The ankle was fixed with two cannulated percutaneous screws. The wound healing, complications, postoperative radiographs, and AOS score were evaluated. Both the pain and disability components were used to calculate the total score.

Results
All the cases united, with the average time for union being 12.8±1.19 weeks. The average duration of the surgery was 85.55±17.31 min (67–134). The mean hospital stay postoperatively was 1.2±0.52 days. The mean follow-up period was 36.4±4.38 weeks. The early results showed major decrease in AOS from 116±8.6 preoperatively to 19.4±2.3 postoperatively. This shows that the arthroscopic fusion was able to decrease the score by an average of 97.7±10.2 points. No incidences of deep infections, deep venous thrombosis, or revision surgery were observed. Screws' length had been changed in four patients because of prominence.

Conclusion
Arthroscopic ankle arthrodesis could be considered as an alternative method for traditional open techniques for the management of severe ankle arthritis.

Keywords:
ankle arthritis, ankle arthrodesis, arthroscopy, cannulated screws

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Introduction

Ankle arthrodesis is considered by many surgeons as the standard operative treatment for end-stage ankle arthritis [1]. The aims of ankle arthrodesis are to eliminate pain and deformity of the joint and to get a plantigrade foot for painless mobilization [2]. There are more than 40 open procedures described for the management of ankle osteoarthritis (AOS) in addition to total ankle replacement, external fixation, and arthroscopic ankle fusion. Until now, orthopedic surgeons have not reached a common consensus on the best method of ankle fusion with no or less complications [3–5].

Complications associated with ankle fusion include early and late complications, which vary from wound problems, infection, nonunion, malunion to late secondary arthrosis of subtalar or talonavicular joints, with an overall complication rate of up to 60%, which has led to a continuous search for a better technique [6].

In the past 2 decades, arthroscopic assisted ankle fusion has reach immense popularity, and many studies have been carried out to understand the best indications and real advantages, or disadvantages, compared with open surgery. Advantages of arthroscopic technique over open techniques include better postoperative pain control [7], low postoperative morbidities, absence of limb-threatening complications, low blood loss,

shorter hospital stay, faster rehabilitation and mobilization, low complication rate, and decreased time to union [8,9]. It also has the advantage of not compromising the soft tissue envelopes. Therefore, it can deal with patients with both poor skin and wound healing potentials, which are contraindications for open techniques.

Despite these advantages, some concerns have been expressed regarding arthroscopic ankle fusion, including the ability of correcting significant angular deformities or bone loss with the arthroscopic technique. In addition, it has been shown that both arthroscopic and open ankle arthrodesis lead to early osteoarthritic changes in adjacent joints, mainly the subtalar joint [1,10].

Aim

The aim was to evaluate the role and results of arthroscopic assisted ankle arthrodesis in advanced AOS.

Patients and methods

This is a prospective study of 40 patients who presented with advanced AOS. They underwent arthroscopic ankle arthrodesis in Suez Canal University Hospital between January 2011 and June 2016. Inclusion criteria were the same as indications for arthroscopic ankle arthrodesis: AOS [canadian orthopeadic foot ankle sociaty (COFAS) grades 1, 2, and 3] with failure of more than 6 months of conservative treatment, minimal or mild correctable deformity in the coronal plane less the 15°, and no active infections. Conservative treatment included anti-inflammatory medications, bracing, orthoses, and walking aids. Contraindications were varus or valgus malalignment greater than 15°, angulation less than 15° that is not correctable, significant bone loss, active infection, previous failed fusion, complex regional pain syndrome, neuropathic destructive process in the ankle, and anterior-posterior translation of the ankle joint. There were 34 males and six females. A total of 28 right ankles and 12 left ankles underwent arthroscopic ankle arthrodesis, respectively. The mean±SD age at surgery was 31±12.7 years (range: 23–62). The causes of the ankle arthritis were post-traumatic arthritis in 20 ankles (50%), resolved septic arthritis in six ankles (15%), avascular necrosis of the talus in two ankles (5%), rheumatoid arthritis of the ankle in four ankles (10%), four with neglected ankle dislocation (10%) without anteroposterior translation, and primary osteoarthritis in four ankle (10%) (Table 1).

Table 1 Demographic characteristics

Sex	Male	34
	Female	6
Age		31±12.7
Etiology	Post-traumatic	20
	Postinfection	6
	AVN	2
	Rheumatoid arthritis	4
	Neglected dislocation	4
	Primary arthritis	4
Total		40

AVN, avascular necrosis.

Before any operative measurements, patients were asked to complete an AOS scale as a standard method to assess the pain and disability of the affected ankle [11]. The same questionnaires were repeated at 1-year follow-up.

Preoperative assessment

Preoperative workup for ankle arthrodesis should take into account several factors, such as axial deformities, bone defects, bone quality, condition of the skin, and underlying infections [12].

Physical examination of the arthritic ankle was done to evaluate range of motion, pain and swelling, and sensory functions and to exclude sensory neuropathies. Examination of the adjacent joints (knee, subtalar, and tarsal) was done to compensate for the lack of motion due to ankle fusion, and they should be free from degenerative changes. Weight-bearing anteroposterior, lateral, and mortise views of both ankles were required. MRI and computed tomography scans were useful when evaluating bone defects (e.g., necrosis of the talus and pilon fracture) and pathologies involving soft tissues. Written consent was obtained from all patients after full explanation of hazards and benefits of the management procedure.

Surgical technique

Under spinal anesthesia and in supine position, a leg holder was used to put the ankle in proper position. A tourniquet was positioned around the thigh and inflated (150 mmHg above systolic pressure). Slight noninvasive traction was applied to the foot for a better visualization of the joint. The joint was then injected with 10–15 ml of saline solution to expand the joint space. Arthroscopy was performed with a 4-mm 30° arthroscope. Two standard portals (anteromedial and anterolateral) were established. The anteromedial portal, medial to the tibialis anterior tendon, was placed first. The anterolateral portal (lateral to the extensor digitorum communis tendon) was

established under direct vision. Both portals were performed with a skin incision, and a blunt dissection of the subcutaneous tissue with a mosquito clamp or a trocar was done. Once the portals have been established, debridement of the hypertrophied inflamed synovium was done using an arthroscopic shaver. Once adequate visualization had been achieved, the posterolateral portals were established for fluid flow and debridement of the posterior part of the joint.

The articular surface is then prepared using a motorized arthroscopic burr to decorticate the articular surface and expose the cancellous bone. A curette can be used to remove osteophytes blocking the joint motion to allow bringing the two surfaces together. In some cases, resection of anterior tibiotalar osteophytes was required to access the joint better. The medial and lateral malleolus articular surfaces were removed as well. Thereafter, microfracture was performed at both of the tibiotalar surfaces. Once an accurate preparation was completed, the traction was released and the ankle was realigned.

The foot and ankle were held in neutral dorsiflexion, with 0–5° hindfoot valgus and external rotation equal to the opposite side. If the opposite side was abnormal, the operated ankle was then positioned at 5–10° of external rotation [6,12]. While this position was maintained, the guide pins were advanced into the talus. The first wire was inserted anteromedially, ~2–3 cm above the joint line, at an angle of 40–45° to the long axis of the tibia. This wire was placed in a slightly anterior-to-posterior direction so that the wire gains purchase into the talus body. A second wire was placed laterally at approximately the same level and angled in a posterior-to-anterior direction as the posterior location of the fibula mandates. The position and depth of the pins should be determined using fluoroscopy.

Fixation was achieved with internal two cannulated interfragmentary compression percutaneous screws (diameter 6.5 mm), which were placed under image intensifier control passing over the guide wires. The screws were tightened alternately until compression was obtained, as they were eccentrically placed. Once fixation was completed, the arthrodesis was examined clinically for subtalar motion and crepitus. Fluoroscopy was used to ascertain proper screw placement, with particular attention to verify that the subtalar joint has not been violated. The skin incisions were closed, and a sterile bulky dressing and below-knee cast was applied to hold the ankle in neutral dorsiflexion, with 0–5° hindfoot valgus and external rotation equal to the opposite side.

Postoperative care

The patient was discharged and sent home the day of surgery or the day after. After surgery, a complete below-knee cast was applied, and the patient was kept non-weight-bearing for 6–7 weeks. The patient was allowed partial weight bearing for 4 weeks. The patient was allowed full weight-bearing for a final 2-week period. At 12 weeks after surgery, if clinical and radiological signs of fusion are present, the patient can return to full daily activities.

Union was defined as a clinically stable ankle, painless on manipulation and weight bearing, with radiographic evidence of bridging trabeculae without failure of internal fixation or change in position. AOS was assessed when fusion was evident both clinically and radiologically.

Statistical analysis

Gathered data were processed using SPSS version 19 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as means±SD, whereas qualitative data were expressed as numbers and percentages.

Results

The average follow-up time was 35 months (range: 24–46 months). There was no bone grafting, and a fusion rate of 100% was achieved. The average duration of the surgery was 85.55±17.31 minutes (67–134 minutes). There were two cases that required about 2 h owing to severe arthritis with anterior osteophytes, narrow joint space, and joint fibrosis, which represented obstacles during the initial phase of arthroscopy. The mean hospital stay was 1.2±0.52 days, and 85% of patients discharged within first 24 h postoperative. Only one patient was discharged on the second day postoperatively owing to bleeding from incisions, as he underwent posterior tibial nerve release and planter fascia release at the same session of ankle fusion. During surgery, some intraoperative extra measures were needed to ensure plantigrade ankle, as two patients required a plantar fascia release. Luckily, none of the patients required change of the technique to an open one. All the cases united, with an average time for union of 13.8±2.1 weeks. Of 40 ankles, 26 ankles (65%) showed signs of clinical and radiological union by 12 weeks, whereas 10 ankles (25%) fused by 14 weeks. Four ankles (10%) fused by 16 weeks, as these patients had rheumatoid arthritis and were on methotrexate and steroid therapy that affected the bone healing.

The AOS is the major determinant of the efficacy of the arthrodesis technique. The early results showed

major decrease in AOS from 116±8.6 preoperatively to 18.3±2.3 postoperatively. This shows that the arthroscopic fusion was able to decrease the score by an average of 97.7±10.2 points. A total of 30 (75%) patients showed excellent results within the first year postoperative regarding pain and disability, with no intraoperative or postoperative complications. There were three patients who needed a change of the length of screws after partial weight bearing and another two patients who needed removal of the screws after complete union owing to pain resulting from their prominence in the subtalar joint.

Long-term follow-up was 35±11 months, during which the early postoperative results did not change significantly; 75% of patients still had excellent outcome, and eight patients (20%) develop subtalar osteoarthritis, where four of them needed further subtalar fusion.

Tibiopedal motion is defined as the arc of motion between maximum dorsiflexion and maximum planter flexion, the angles being those subtended by the long axis of the tibia and foot in the lateral projection. A total of 28 patients (70%) with arthroscopic ankle fusion had 15–20° of tibiopedal motion after about 4-year follow-up, which was markedly beneficial in walking and talk-off and enhanced excellent outcome.

Only two patients were not satisfied with their surgery, as they had post-traumatic avascular necrosis of the talus. They showed union in 14 weeks. However, they continued to complain of ankle pain, which appeared to be subtalar pain, resulting from subtalar arthritis, and they refused to do any further surgeries.

Four patients had fair results, as they had severe osteoporosis and took long time for radiological healing; moreover, they had rheumatoid arthritis and were on steroid and methotrexate therapy for a long time (Table 2, Fig. 1).

Discussion

Ankle arthritis has become more common and is affecting the daily activities of more patients every day due to the pain and the severe limitation of function [13,14]. Although different treatment modalities are available starting from medical treatment (NSAIDs) to braces, surgical treatment remains the most effective and the most successful in helping patients gain their normal activity [15].

Table 2 Clinical rate scaling

Rating	Clinical characteristics	Early F/U
Excellent	Solid fusion, no pain, no limp, no job restrictions, excellent appearance	30
Good	Solid fusion, mild pain, mild inconstant limp, same job with some restrictions, acceptable appearance	4
Fair	Solid fusion, moderate pain, constant limp, job change, poor appearance	4
Poor	Any ankle with fusion failure or severe pain	2

Figure 1

(a and b) Anteroposterior and lateral view of a 23-year-old male who presented with painful left ankle. The patient had advanced osteoarthritis ankle after long history of septic ankle 4 years ago for which debridement was done. Radiography showed decreased joint space with sclerosis of articular surfaces. (c and d) 12-week postoperative radiography showed the orientation of the screws and the rigid union of the tibiotalar contact. (e) Thirty-week follow-up anteroposterior radiography showed solid fusion after removal of the screws.

Ankle arthrodesis has become the 'gold standard' treatment for a painful degenerated ankle not responding to conservative treatment. The formal goals of an ankle arthrodesis are to eliminate pain and deformity of the degenerated ankle joint and obtain a plantigrade foot to achieve painless mobilization. This can be achieved by a variety of techniques varying in approach (open, mini open, and arthroscopic), use of bone graft, and type of fixation (internal and external) [2,8].

Since its first description in 1983, arthroscopic ankle arthrodesis has gained increasing popularity as it offers many advantages over open technique, being less invasive and having a more rapid recovery with less soft tissue dissection. Improved instrumentation and greater experience have produced encouraging results, with most recent studies demonstrating shorter hospital stays and reduced time to solid fusion while maintaining fusion rates equivalent to those associated with open techniques [16].

An arthroscopic approach also extends the scope of ankle arthrodesis to include patients with compromised adjacent soft tissue who may be considered to have a relative contraindication to an open procedure, such as patients with pain caused by arthritis not responsive to conservative therapy, in addition to patients with wound healing problems, such as peripheral vascular disease, dermatological problems, or rheumatoid arthritis, which would previously have been a contraindication to the open technique [17].

Successful arthroscopic ankle arthrodesis is based on the fundamental principles of newer open approaches to ankle arthrodesis. Preservation of the ankle mortise bony contour lends stability to the large contact area of cancellous bone mass maintained by rigid compression from transmalleolar screw fixation [18–20]. With a union rate comparable to that of newer open techniques, the advantages of the arthroscopic procedure lie with the more rapid rate of union and decreased period of immobility. In addition, it has been found that this technique protects periarticular blood supply, which probably enhances the process of fusion and facilitates a more rapid time to union [5,14,21–23].

This is an interventional prospective study conducted to assess the results of arthroscopic assisted ankle arthrodesis in the treatment of end-stage isolated ankle arthritis.

The study was carried out on 40 patients between January 2011 and January 2016. Patients were diagnosed using clinical examination and radiological assessment, and then the AOS score was measured for each patient. Patient selection was done according to the inclusion criteria as mentioned before. All patients had an arthroscopic ankle arthrodesis by the technique previously described.

Frekel and Hewitt [24] stated that patient selection is an essential factor for clinical success, and they found that the ideal patient for the arthroscopic procedure requires an arthrodesis *in situ*; those with significant varus or valgus or rotational deformity are not good candidates and are better treated with an open procedure that allows a correctional osteotomy.

In this study, the mean age at the time of the surgery was 31±12.7 years (range: 23–62 years). This is in contrast to the results of Gougoulias *et al*. in 2007 [25] and David *et al*. in 2013 [26], where the mean age at time of surgery was 51.8±13.5 (range: 18–81) and 59.4±10.6, respectively. This variance could not be related to the cause of the arthritis, as post-traumatic arthritis was the cause of 50% of the cases in our study, 58.3% in the study of Gougoulias and colleagues in 2007, and 77% in the study of David and colleagues in 2013. However, in those previous studies, the authors explained that most of their patients were elderly patients with polyarthritis. In addition, this variance can be explained in terms of better trauma assessment and treatment that patients received in emergency centers outside Egypt. In addition, the age of trauma and road traffic accidents in Egypt have shown a new pattern in the past decade, with most patients' age ranging from 20 to 30 s.

The average duration of surgery in this study was 85.55 ±17.31 min (67–134 min), whereas David *et al*. in 2013 [25] had a mean±SD working time of 99±16.4 min and Gougoulias *et al*. in 2007 [26] had a mean of 99±34 min (range: 55–165). One of the major benefits of arthroscopic arthrodesis is the hospital stay. The mean hospital stay was 1.2±0.52 days, and 85% of the patients were discharged within the first 24 h postoperatively. Only one patient was discharged at the second day postoperatively owing to bleeding from incisions, as he underwent posterior tibial nerve release and plantar fascia release at the same session of ankle fusion. In the study of Winson *et al*. in 2005 [27], the mean hospital stay was 4 days [1–21], whereas the study of David *et al*. in 2013 [26] had an average stay of 2.5±1.3 days and Gougoulias *et al*. in 2007 [25] study showed an average of 3.8±4.5 days (1–27 days). Those numbers were explained by the previous authors as patients who had extended stays usually had

polyarthritis and non-weight-bearing mobilization was difficult.

There were two patients (5%) who required a plantar fascia release and one of them needed posterior tibial nerve release. Although most authors did not describe any additional techniques required intraoperatively during their studies, Gougoulias *et al*. in 2007 [25] described the need for unplanned procedures in seven patients (14.6%) without determining the procedures done. In addition, Winson *et al*. in 2005 [26] mentioned the need for os calcis osteotomy being performed, but the number of patients who required this step was not mentioned. Moreover, Gougoulias *et al*. in 2007 [25] described the need for arthroscopic subtalar arthrodesis in one patient at the same session, but in this study, none of the patients required any intraoperative osteotomy or subtalar arthrodesis. None of the cases in this study required a transfer to open arthrodesis, which happened to be the same in the studies carried out by David *et al*. in 2013 [26], Gougoulias *et al*. in 2007 [25], and by Winson *et al*. in 2005 [27], which is owing to good selection of the cases.

Union or fusion remains to be the aim of the surgery and the golden parameter to assess this technique. In this study, the mean time for union was 12.8±1.19 weeks. The study carried out by Bai *et al*. in 2013 [28] showed that the average time to fusion was 10.5 weeks, whereas according to the study of Tang *et al*. in 2013 [29], the mean time for fusion was 13.5 week. In the study carried out by Gougoulias *et al*. in 2007 [25], union occurred at an average of 13.1±5.8 weeks. Meanwhile, the study carried out by Winson *et al*. in 2005 [27] showed that the mean time to union was 12 weeks (6–20). In another study performed by Ferkel *et al*. in 2005 [24], the average time to union was 11.8 weeks. However, the study of Zvijac *et al*. in 2002 [7] showed an average time to union of 8.9 weeks. These variations can comparable to that reported in the literature, where the mean time to union was 12 weeks after surgery (ranging from 6 to 40). So, compared with other studies, the time to union recorded in this study was on an average. However, different studies had different follow-up protocols than this study, as we had a follow-up visit every 4 weeks but some of the aforementioned studies had a protocol of bimonthly visit.

In this study, a fusion rate of 100% was achieved, as all the cases were united by 16 weeks postoperative. In the study of Bai *et al*. in 2013 [28], the fusion rate was 100%, but in the study carried out by Gougoulias *et al*. in 2007 [25], the fusion rate was 98%. Zvijac *et al*. in 2002 [7] showed a fusion rate of 95% in their study. It is of great value to note that the literature showed that in the early studies of the 1990s, the fusion rates ranged from 90 to 95%, such as the studies by Myerson and Quill, 1991 (94%) [8], and Ogilvie-Harris *et al*., 1993 (89%) [30]. In addition, as the time progressed, the rate of fusion ranged from 95 to 100% [Cannon *et al*. in 2004 (100%) [31] and Ferkel *et al*. in 2005 (97%) [24]]. This trend can be simply explained by the availability of arthroscopy and the increased experience and skills of different surgeons in the field of arthroscopy. The average follow-up of the patients was 35 months (range: 24–56 months). However, compared with other available studies, such as the series by David *et al*. in 2013 [26], follow-up extended to 24 months; Gougoulias *et al*. in 2007 [25], with an average of 21 months and ranging from 6 to 68 months; and also the study of Zvijac *et al*. in 2002 [7], which had a follow-up of 34 months (range: 18–60 months). With respect to the current study, some of the patients assumed no need for further follow-up as long as there is no complaint or complication from the intervention, so patients' compliance can be partly blamed for the difference.

The mean AOS after fusion in this study was 19.4±2.32 points, which is in contrast to the study by David *et al*. in 2013 [26], where the AOS 1-year postoperatively was 17.5±15.9 points. However, this remains a subjective scoring system, as it depends on the patient grading of his own complaint, which varies significantly from one to another.

Another scoring system in our study was the clinical rating scale. In this study, 85% of the patients were excellent or good which is satisfactory compared with other studies. In the study of Gougoulias *et al*. in 2007 [25], 80% of the patients were excellent or good, whereas in the study of Zvijac *et al*. in 2002 [7], this increased to 95%, and finally, up to 100% in the study by Kats *et al*. in 2003 [32].

The major advantage of arthroscopic arthrodesis is the lower rate of complications. In this study, there were three patients who needed to change the length of screws after partial weight bearing (7.5%) and another two patients (5%) needed to remove the screws after complete union owing to pain resulting from their prominence in the subtalar joint. Superficial infection occurred in one case, where the incision over the lateral fixing screw showed superficial infection and dehiscence. Culture and sensitivity were done, and the patient recovered with no need for implant removal. Eight

patients (20%) develop subtalar osteoarthritis, and four of them needed further subtalar fusion. Other reported complications in similar studies were superficial infection that required screw removal, nonunion, subtalar arthritis that was treated with subtalar arthrodesis, deep vein thrombosis that led to pulmonary embolism, and implant failure.

This study was able to prove that arthroscopic ankle arthrodesis was an efficient tool in the management of ankle arthritis. The technique succeeded in decreasing both the pain and disability caused by arthritis with minimal complications.

Conclusion

Arthroscopic assisted ankle arthrodesis is an efficient tool in the management of both pain and disability caused by end-stage ankle arthritis.

Arthroscopic assisted ankle arthrodesis is beneficial in terms of less hospital stay, absence of intraoperative blood loss, in addition to achievement of union rates up to 100%, with fewer complications such as infection.

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Conflicts of interest

There are no conflicts of interest.

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