JAJS VOLUME 8 NUMBER 3 JULY-SEPTEMBER 2021 PAGES 205-308

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Knee & Shoulder Arthroscopy And Arthroplasty ISKSAA

JOURNAL OF ARTHROSCOPY AND JOINT SURGERY

JAJS

Official Journal of the International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty (ISKSAA)

Indexed In Scopus & Embase

Special Issue: Foot and Ankle

Guest Editor: Maneesh Bhatia

Volume 8 Number 3 July-September 2021

E-ISSN: 2214-9635
P-ISSN: 2542-6001

Available online at www.sciencedirect.com

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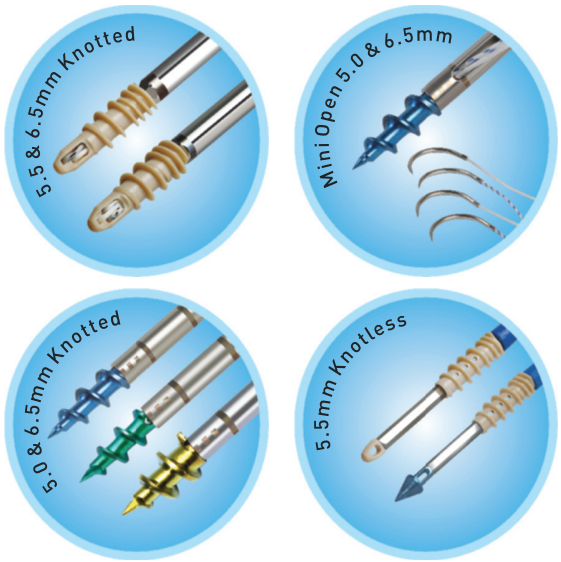

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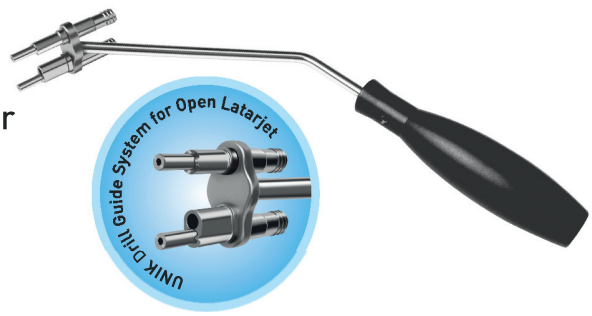

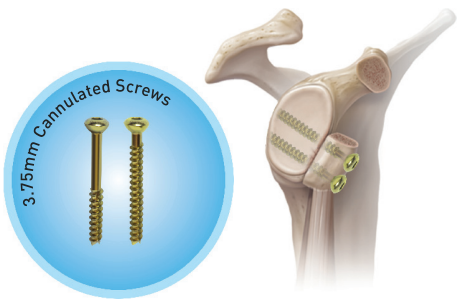

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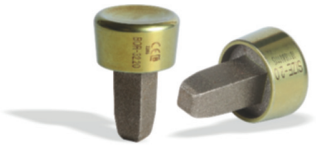

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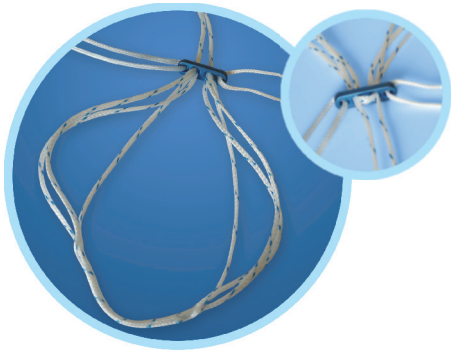

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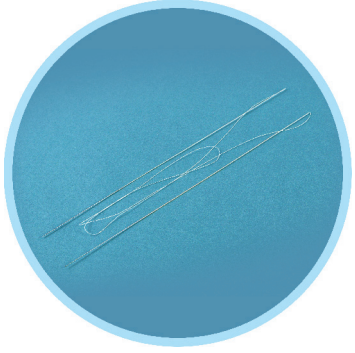

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Journal of Arthroscopy and Joint Surgery

An official publication of International Society for Knowledge for Surgeons on Arthroscopy and Arthroplasty

(ISSN: 2214-9635)

Volume 8, Number 3, July–September 2021

Aims and Scope

Journal of Arthroscopy and Joint Surgery (JAJS) is committed to bring forth scientific manuscripts in the form of original research articles, current concept reviews, meta-analyses, case reports and letters to the editor. The focus of the Journal is to present wide-ranging, multi-disciplinary perspectives on the problems of the joints that are amenable with Arthroscopy and Arthroplasty. Though Arthroscopy and Arthroplasty entail surgical procedures, the Journal shall not restrict itself to these purely surgical procedures and will also encompass pharmacological, rehabilitative and physical measures that can prevent or postpone the execution of a surgical procedure. The Journal will also publish scientific research related to tissues other than joints that would ultimately have an effect on the joint function.

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Review article

Current concepts for arthroscopic ankle fusion

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ARTICLE INFO

Article history:
Received 27 April 2021
Accepted 2 May 2021
Available online 7 May 2021

Keywords:
Ankle
Arthritis
Arthroscopy
Fusion
Arthrodesis
Tibiotalar
Union
Technique

ABSTRACT

Ankle arthrodesis is the gold standard treatment for end stage ankle arthritis as it provides pain relief, whilst also allowing patients to regain function and mobility. Although it is conventionally performed via an open approach, arthroscopic ankle arthrodesis (AAA) is rapidly gaining in popularity. This article reviews the current literature regarding AAA including its benefits and limitations, and various techniques used.

1. Introduction

Osteoarthritis (OA) is a common disease which accounts for significant disability and socioeconomic burden worldwide. Primary osteoarthritis of the ankle, however, is fairly rare, and represents less than 10% of patients with ankle pain, with the majority of patients being diagnosed with posttraumatic ankle arthritis (Fig. 1).[1–3] Patients with end stage ankle arthritis often present with severe pain and loss of function, which has a negative impact on their quality of life.[4] Conservative management for them includes analgesics, non-steroidal anti-inflammatory drugs (NSAIDs) and orthotic devices which aim to immobilise the ankle to provide pain-relief and support.[5] Intra-articular corticosteroid injections are also recommended by the National Institute for Health and Care Excellence (NICE) as a temporary measure, in order to provide pain relief.[6] For patients who have failed conservative treatment, ankle arthrodesis is considered to be the gold standard surgical treatment for end stage arthritis.[7]

Ankle arthrodesis provides pain relief whilst also allowing patients to regain function and mobility. Although it is conventionally performed via an open approach since the late 1800s, arthroscopic ankle arthrodesis (AAA) is now rapidly becoming the norm.[8]

2. Pre-operative evaluation

Symptomatically, patients with ankle arthritis complain of pain that is exacerbated by movements such as climbing up stairs. This is followed by ankle stiffness, locking and finally pain at rest, as the disease progresses. As stated above, the majority of patients will have had a history of trauma to the ankle joint. A thorough history helps clinicians understand exactly how much of an effect the patient's symptoms are having on his/her life, which can then guide treatment. Patients with significant co-morbidities such as diabetes, or those on long term immunosuppression may have a higher risk of complications associated with wound healing,[9] and therefore require meticulous planning prior to operative intervention.

Clinical signs suggestive of ankle arthritis include disruption of the gait cycle and patients' need to use walking aids. Examination should ascertain the degree of any valgus/varus hindfoot deformity present, and whether the deformity is correctable, in addition to the range of movement present in the tibiotalar and the subtalar joints. It is also important to assess the knee and neurovascular status of the leg, prior to deciding a management plan.

Weightbearing radiographs of the ankle joint (mortise and lateral views) form the first line investigation for patients with suspected ankle arthritis. Computed tomography (CT) is a useful tool to assess the degree of arthritis present in the ankle and surrounding joints, presence of cysts and to determine the presence of any large osteophytes which may act as barriers to performing

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https://doi.org/10.1016/j.jajs.2021.05.001

Fig. 1. Antero-posterior (AP) and lateral weight bearing radiographs of a patient (Mr X) with post-traumatic ankle arthritis. A united, high fibula fracture can be seen on the radiographs following internal fixation. There is loss of joint space, presence of anterior osteophytes and increased sclerosis of the ankle joint, confirming the diagnosis. There is a less than 15° coronal plane deformity in this case.

arthroscopic procedures.[10]

3. Indications and contraindications

AAA has gained popularity over open ankle arthrodesis due to multiple studies suggesting that it is associated with a quicker recovery period and shorter hospital stay, lower morbidity and a faster time to union than the latter.[11–13] It is most commonly performed for patients with end stage ankle arthritis. Other indications for AAA include osteochondritis of the talar dome, avascular necrosis of talus and inflammatory arthritis of the ankle joint. AAA is especially preferred for those patients with poor skin and/or those who may be more susceptible to wound related complications following surgery. It is contraindicated in patients with an active infection in the ankle joint and charcot arthropathy. In the past varus/valgus deformity of more than 15° has been considered as a relative contraindication to AAA. The rationale behind this is that a greater degree of correction in the form of osteotomies would be required to achieve joint congruency in such cases, which would not be feasible arthroscopically.[14,15] However, in recent times, AAA is being performed more and more commonly on patients with varus deformities greater than 15° with favourable results.[16–18]

4. Arthroscopic technique

4.1. Approach

AAA is most commonly performed via the standard anterior approach using anteromedial and anterolateral portals, although some authors suggest that the posterior approach may result in a higher union rate.[19] For the anterior approach, the patient is positioned supine with a thigh tourniquet. A bolster is placed underneath the thigh to flex the hip to 45°, and a non-invasive ankle distractor is attached using adjustable straps. Standard anteromedial and anterolateral portals are most commonly used, whilst taking care to avoid injuring the superficial peroneal nerve.[12]

When using the posterior approach, the patient is positioned prone with his/her foot just off the bed. A bolster or foot support is placed underneath the ankle in order to allow it to be moved freely. A thigh tourniquet is also used to provide a bloodless field for the arthroscopic procedure. Standard medial and lateral para-achilles portals are used, whilst taking care not to injure the neurovascular structures.[20]

The anterior approach is a relatively safe and reliable technique to carry out an AAA, and results in a high union rate. However, it does not allow access to approximately 10% of the posterior aspect of the ankle joint.[21] The posterior approach on the other hand allows over 95% of the joint to be debrided.[15] Moreover, it can be especially useful in cases where the patient also needs to undergo a talocalcaneal fusion in addition to a tibiotalar arthrodesis, or when large anterior osteophytes prevent access to the ankle joint through the anterior approach. However, it is only technically feasible if there is no equinus or a malunited posterior malleolus. Given the fact that the majority of patients have posttraumatic ankle arthritis, this limits the number of patients for which the posterior approach can be utilised.[22]

4.2. Debridement

Once access to the ankle joint is gained either via the anterior or posterior approach, both the tibial plafond and the talar dome need to be debrided in order to remove cartilage and restore joint alignment. Whilst it is assumed that removing less cartilage will compromise fusion rates,[8,15,22] as has been demonstrated for a

subtalar arthrodesis,[23] currently there is a dearth of literature that suggests a direct relationship between the amount of joint area debrided and ankle arthrodesis union rates. Achieving appropriate alignment of the talus within the ankle mortise is more important (Fig. 2), and it therefore may be necessary to prepare the medial and lateral gutters which may have osteophytes that interfere with joint reduction and/or deformity correction.

4.3. Fusion

In AAA, fixation is achieved by using 2 or 3 percutaneous, cannulated, large diameter (6.0–7.5 mm) screws in various configurations (Fig. 3). Currently, there is no consensus in the literature as to the number and/or screw configurations that should be used. Both cadaveric[24] and finite element analysis studies,[25] have demonstrated better mechanical stability and Goetzman et al.[26] showed a higher union rate when 3 screws were used. However, it can be technically quite difficult to insert the screws in the relatively small space available.[27] The configuration of the screws also has an impact on the time to union. Yoshimura et al.[28] revealed that not only was the time to fusion significantly shorter in patients who had had 3 screws compared to 2 screws, patients with 3 parallel, transmedial malleolar screws had an even shorter time to fusion as opposed to patients with 3 crossed transmalleolar screws. This is probably due to the fact that whilst crossed screws provide a more rigid fixation, parallel screws allow greater compression.[15]

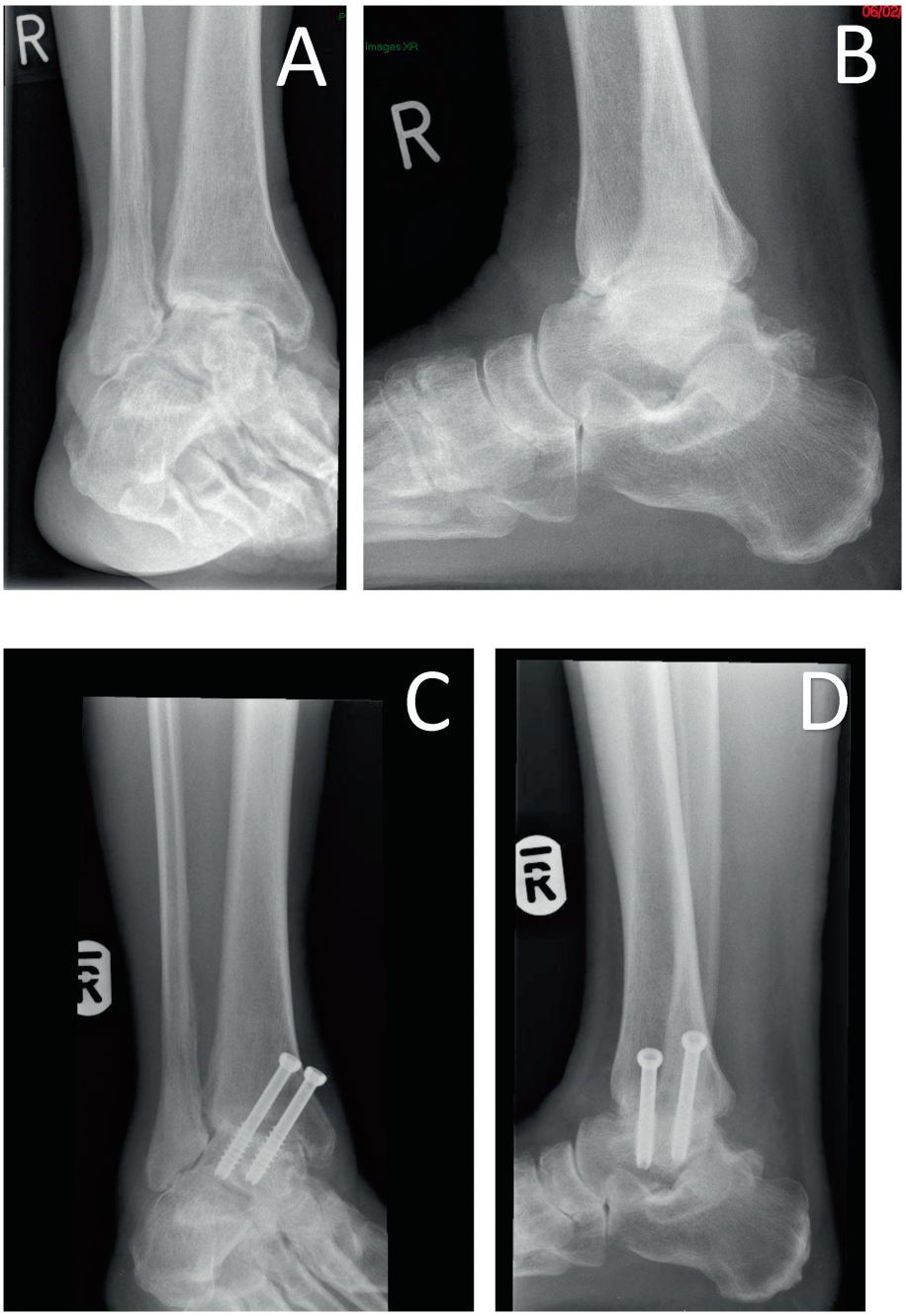

Fig. 2. (A and B): AP and lateral weight bearing radiographs of a 72 year old gentleman, demonstrating severe ankle osteoarthritis with a significant valgus deformity.Fig. 2 (C and D): AP and lateral weight bearing radiographs of the same gentleman 5 months following arthroscopic ankle arthrodesis and correction of the valgus deformity.

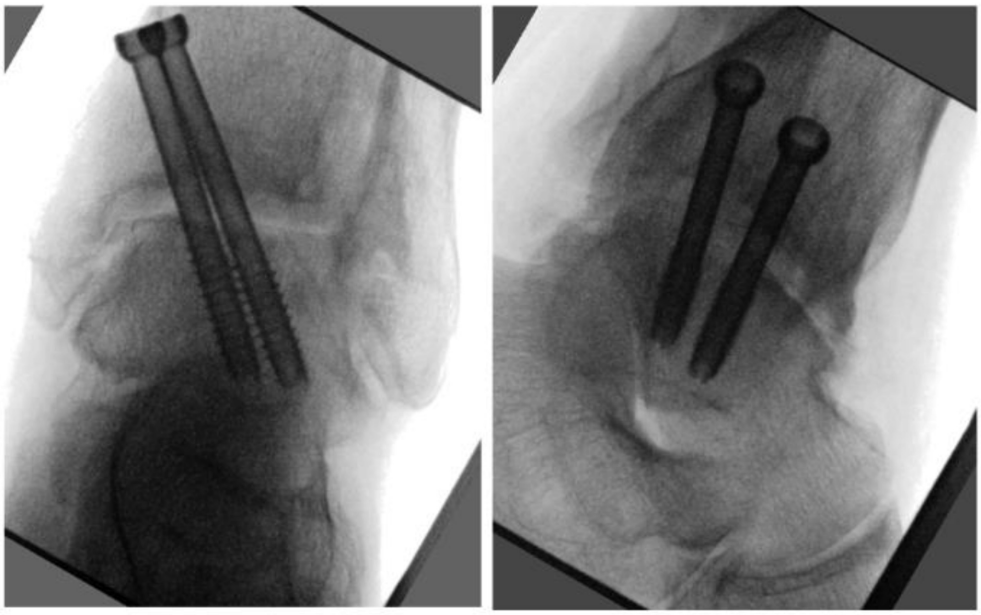

Fig. 3. Intra-operative fluoroscopy images of Mr X – AP and lateral views. 2 cannulated, parallel screws can be seen crossing the ankle joint from proximal-medial to distal-lateral.

Crossed screws can be useful when addressing varus deformity by first inserting the lateral screw as this brings the ankle in neutral alignment (Fig. 4).

4.4. Optimum foot position

Obtaining the correct foot position during fusion of the tibiotalar joint is of paramount importance as it provides patients with a stable platform on which to mobilise on. Ideally, the ankle should be fused in a neutral position with approximately 0–5° of valgus angulation and 0–5° of external rotation. This allows for a more normal gait with the other joints of the foot compensating for the lack of movement at the ankle.[30,31] Failure to achieve this can result in patients having an abnormal gait pattern which can then lead to the development of callosities and pain.

5. Post-operative care

Traditionally, patients are kept non-weightbearing after an AAA for 6 weeks, followed by weight bearing in plaster cast, with the total duration in plaster being 3 months. Cannon et al.[34] however allowed patients without any peripheral neuropathy or pre-operative talar collapse, to fully weight bear as tolerated from day 1 following surgery, and did not find a detrimental effect on their outcomes.

6. Outcomes

Ankle arthrodesis provides significant pain relief and improvement in quality of life, as demonstrated by the improvement seen in patient reported outcome measures (PROMs) such as the ankle osteoarthritis scale (AOS), short form – 36 (SF-36), physical component summary (PCS) and foot and ankle ability measure (FAAM).[35,36] AAA does however lead to changes in the gait, resulting in a slight decrease in stride length, cadence and gait efficiency.[37] Studies have also shown that patients have a reduced ability to perform an emergency stop after ankle arthrodesis, with longer brake reaction timings compared to healthy volunteers,

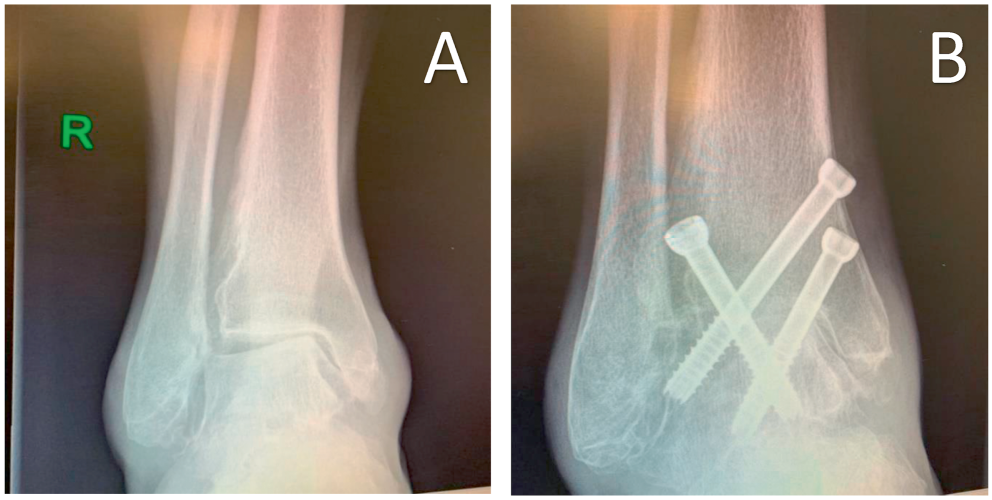

Fig. 4. (A): AP weight bearing radiographs demonstrating significant varus deformity of the right ankle Fig. 4 (B): AP weight bearing radiograph demonstrating correction of the varus deformity following AAA using 3 cross screws.

Table 1
Risk factors for delayed- and non-union following arthroscopic ankle arthrodesis. BMI – body mass index.

Local	Systemic
Open fracture leading to posttraumatic ankle arthritis	High BMI
Pre-operative coronal plane deformity	Smoking
Poor bone quality	Diabetic neuropathy
Massive bone defect	

although this does not exceed the safety criteria set by the US federal highway.[38,39]

6.1. Non union

A systematic review by Yasui et al.[13] found that the average union rate following an AAA was 94% (range, 70–100%). This was better than the 89% average union rate seen following an open ankle arthrodesis (range, 64–100%). Risk factors for delayed- and non-union included systemic and local causes as described in Table 1.

Whilst multiple studies have reported high BMI to be associated with an increased risk of delayed- or non-union, likely as a result of excessive shear strain on the ankle joint,[28,40] Goetzmann et al.[26] found no such association. Smoking also has a negative effect on union rates, as does diabetic neuropathy.[41–43] Patients with a history of an open ankle fracture resulting in post-traumatic arthritis are at a higher risk of developing a non-union, and therefore should be appropriately counselled pre-operatively.[41] Other risk factors include poor bone quality and significant bony defects, which can potentially be countered by the use of bone grafts and/or bone substitutes.[40,44] Interestingly, studies have also found that patients with a smaller pre-operative coronal plane deformity have a significantly shorter time to union as compared to those who need bigger corrections,[18,28] although Gougoulias et al.[19] reported no difference in the overall union rates. Patients with symptomatic non-unions tend to undergo revision surgeries which can either be an open ankle arthrodesis or a total ankle replacement.[45] Low intensity pulsed ultrasound (LIPUS) treatment, which has helped achieve fusion in small foot joints, has not been hugely successful in treating non-unions of ankle arthrodesis.[46]

6.2. Revision surgery

Literaure suggests that apart from symptomatic non-unions, approximately 9–31% of patients tend to undergo revision surgery following an AAA for removal of prominent screws.[11,47] Most techniques involve placing at least one compression screw from the medial tibial border to the lateral aspect of the talus, *trans*-articularly. This can result in the screw head being quite prominent and causing discomfort. One way of tackling this issue is to use headless compression screws which allow the entire screw length to be buried in the bone, thus preventing the need for revision surgery for prominent metalwork. However, it has been suggested that headless screws produce less inter-fragmentary compression compared with headed screws.[47]

Table 2
Complications following arthroscopic ankle arthrodesis.

Complications following arthroscopic ankle arthrodesis
Infection – superficial or deep
Deep Vein thrombosis
Pulmonary embolism
Changes in gait
Metalwork prominence
Non-union
Mal-aligned ankle joint

Table 2 shows the complications that can occur after an AAA. There are also cases of patients complaining of persistent pain in the foot. This was initially thought to be as a result of the development of subtalar and chopart joint arthritis following an AAA, as these joints compensate for the lack of movement at the ankle joint.[18] However, a systematic review by Ling et al.[48] has disproven this theory, suggesting that the arthritis in adjacent joints probably pre-existed. Interestingly, a higher rate of adjacent joint arthritis has been found in patients following an open ankle arthrodesis (OAA) compared with AAA.[13]

7. Advantages of AAA

In addition to offering a high union rate as stated above (Fig. 5), AAA is also a cost-saving procedure compared to OAA. Patients with AAA have a significantly shorter hospital stay, which is likely a result of them being in less pain due to the limited soft tissue disruption involved in the technique over OAA.[11,49] Zvijac et al.[44] have reported performing AAA as a day case procedure and in future this is likely to be the trend.[44] Moreover, there is significantly less blood loss and a shorter time to union in AAA than OAA, again due to the limited periosteal stripping needed and preservation of blood supply.[12,49,50] Unsurprisingly, multiple studies have shown better AOS scores at the 1 year postoperative mark.[50–52] Despite this, no significant difference has been seen in terms of infection and complication rates, or incidence of revision arthrodesis after AAA or OAA.[13,52,53] Table 3 summarises the advantages and disadvantages of AAA compared with OAA.

8. Drawbacks of AAA

As stated above, traditionally AAA is not used for patients with moderate to severe coronal plane deformities,[14,15] with the rationale being that an open procedure will allow for better visualisation and correction of the deformity with osteotomies.[13] However, in a study by Yang TC et al.,[54] no significant difference in union rate and PROMs was found between patients who had had AAA for mild or severe coronal plane deformities. Similarly, other groups too demonstrated achieving near-normal tibiotalar alignment for patients with severe coronal plane deformities and AAA.[18,52] Townshend et al.[52] suggest that the coronal plane deformity is often a result of the talus tilting within the ankle mortise, and not due to the deformity being within the tibia or talus. This can therefore be corrected intra-operatively, without the need for major bone resection or osteotomies.

9. AAA versus total ankle replacement (TAR)

Another treatment option for treating end-stage ankle arthritis is a TAR. A multicentre, prospective cohort study found that TAR demonstrated significant improvement in PROMs compared with ankle arthrodesis. Although the patients undergoing a TAR had an increased number of complications and required more revision surgeries, no significant difference was found between the 2 groups when adjusted for age, sex, BMI and comorbidities.[35] These findings echoed those by Veljkovic et al.[36] who too found significantly improved AOS and higher rate of revision surgery for patients with TAR compared with AAA or OAA.

10. Conclusion

AAA is a safe and reliable treatment option for patients with

Fig. 5. AP and lateral weight bearing radiographs of Mr X 4 years following an AAA. Union is demonstrated in all 4 cortices on the 2 radiographs.

end-stage ankle arthritis, including those with severe coronal plane deformities. It can be performed either via the anterior or the posterior approach, depending on where in the ankle the pathology lies. It is associated with a shorter hospital stay and a shorter time to union when compared with OAA, and has a high union rate.

We certify that we have participated sufficiently in the intellectual content, conception and design of this work or the analysis and interpretation of the data (when applicable), as well as the writing of the manuscript, to take public responsibility for it and have agreed to have our name listed as a contributor. We believe the manuscript represents valid work. Each author confirms they meet the criteria for authorship as established by the ICMJE. Neither this manuscript nor one with substantially similar content under our authorship has been published or is being considered for publication elsewhere, except as described in the covering letter. We certify that all the data collected during the study is presented in this manuscript and no data from the study has been or will be published separately. We attest that, if requested by the editors, we will provide the data/information or will cooperate fully in obtaining and providing the data/information on which the manuscript is based, for examination by the editors or their assignees. Financial interests, direct or indirect, that exist or may be perceived to exist for individual contributors in connection with the content of this paper have been disclosed in the cover letter.

Table 3
Advantages and disadvantages of AAA compared to OAA.

Advantages	Disadvantages
High union rate	Surgeon learning curve
Shorter time to fusion	Addressing large coronal plane deformity
Shorter hospital stay	and bone defects are relative contraindications
Less intra-operative blood loss	for AAA as compared to OAA
Better outcome scores	

Sources of outside support of the project are named in the cover letter.

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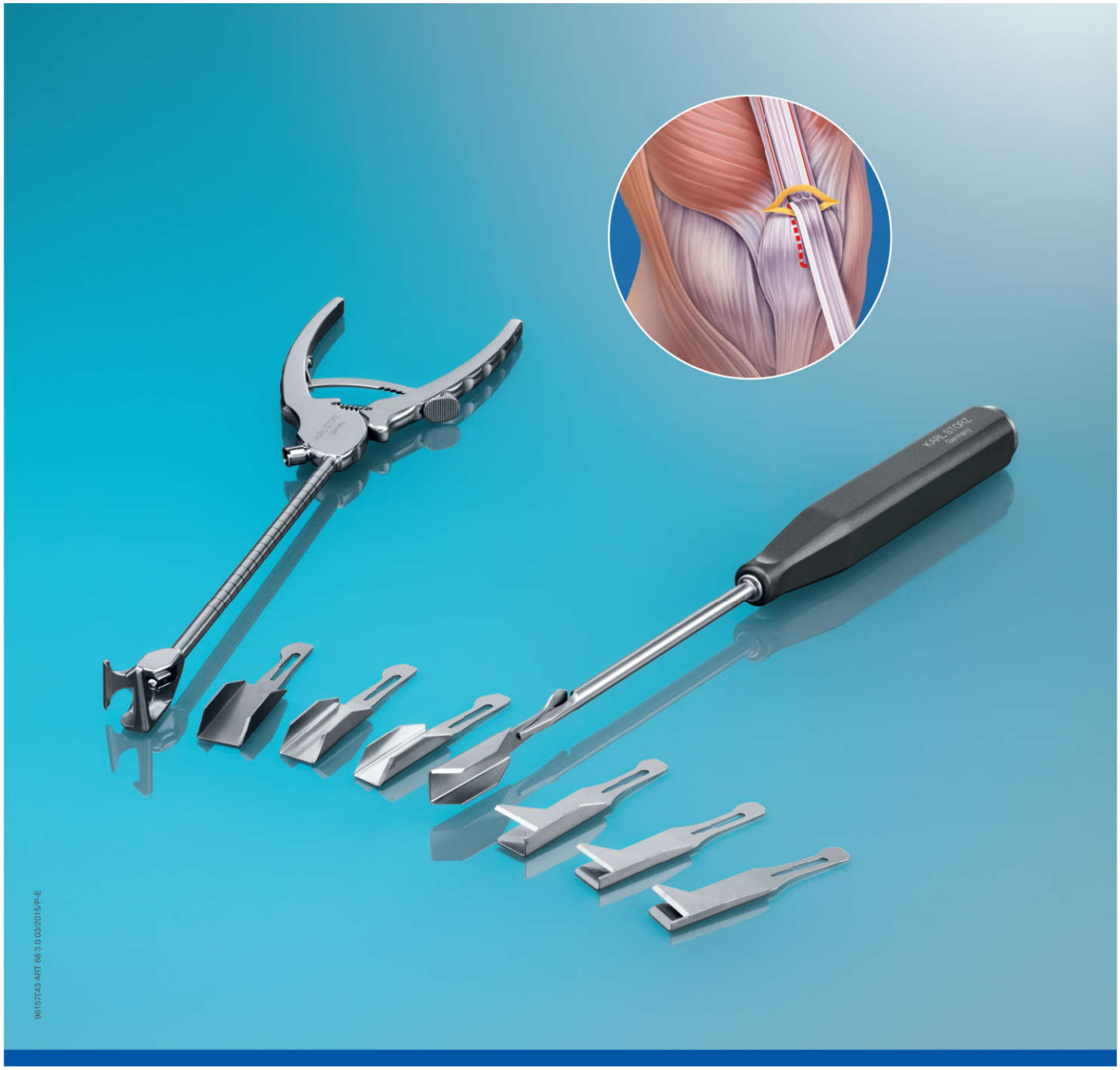

06157C43 ART 68 3.0 03/2015-P-E

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