Ankle fractures
facts and fiction

INTRODUCTION

Most orthopaedic surgeons have cut their teeth, at an early stage of training, by operating on ankle fractures. Some, contributing to a general trauma service, will continue to operate on ankle fractures throughout their careers. It is an area where many orthopaedic surgeons feel they have a degree of expertise, and yet ankle fractures are also an injury that can be unforgiving, with relatively high rates of complications,[1] which when suffered inevitably lead to an impaired outcome. It is certainly an injury where 'getting it right first time' pays dividends.[2] It is also an area that has experienced a resurgence of keen academic interest, with an exponential explosion in peer-reviewed publications in the last decade (Fig. 1). Some, like the Ankle Injury Management (AIM) trial, have been high-profile publications that have attracted interest from both within and outside of our own specialty.[3] Several areas, including the treatment of the posterior malleolus and the syndesmosis, arouse strongly felt opinions and have sparked heated controversy.[4] Yet, despite this heat, only a modest amount of light has been shed into the dark corners of the ankle, and even in some of the most routine areas of our practice there remains little clarity or consensus. This paper aims to review the existing literature and indicate where recent publications have added to the evidence base.

DIAGNOSING INSTABILITY

Isolated undisplaced lateral malleolar fractures are stable and are usually treated nonoperatively with good long-term outcomes.[5] In contrast, fractures with evident radiographic talar shift, and both bimalleolar and trimalleolar injuries, are unstable and usually require surgical intervention.

Diagnostic uncertainty commonly lies in between those poles – in distinguishing the stable isolated lateral malleolar fracture (supination-external rotation (SER) type 2) from the unstable SER type 4 injury with an associated deep deltoid ligament injury. Medial-sided tenderness and/or bruising may indicate a complete or partial deltoid ligament injury, but should be interpreted with caution.[6] Admission radiographs are a common trap for the unwary, as they are often taken with a plantar-flexed ankle. This brings the narrow, posterior part of the talus into the mortise, giving the illusion of talar shift (Fig. 2).

Stress radiographs, either gravity-assisted or manual, are still commonly used internationally, although they have poor diagnostic accuracy.[7,8] No consensus has been reached on the maximal medial clear space that should be considered normal, although 4 mm and 5 mm are

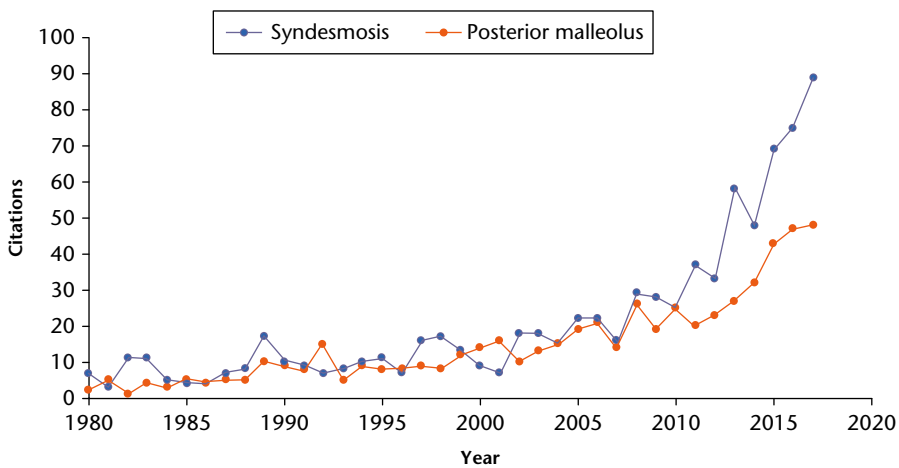

Fig. 1 Annual number of PubMed citations between 1980 and 2017 including the words 'syndesmosis' and 'posterior malleolus'.

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Fig. 2a Fig. 2b Fig. 2c Fig. 2d

Fig. 2 a) Anteroposterior ankle radiograph demonstrating apparent talar shift with increased medial clear space. b) Lateral ankle radiograph of the same patient, demonstrating plantar flexion of the talus, with the smaller posterior aspect of the talus articulating with the mortise. c) Anteroposterior radiograph of the same patient with the ankle now in d) a plantargrade (neutral) position with elimination of the initial apparent talar shift.

both commonly cited as indications for surgery; radiographic assessment is often inaccurate as the size of this medial clear space is significantly affected not only by ankle flexion, but also the position of rotation that the leg is held in at the moment the radiograph is taken.[9,10] Moreover, several clinical trials reporting on the outcomes of 'stress-positive' ankle fractures, which would commonly be treated surgically, have in fact shown satisfactory union and return to normal function with nonoperative treatment.[7,11,12] The high false positive rate for stress radiographs undoubtedly leads to unnecessary surgical treatment of stable ankle fractures, with unwarranted risk.[13] Unfortunately, no other investigation, including assessment of deep deltoid ligament competency using magnetic resonance imaging, has been shown to be effective.[12]

In the absence of a useful diagnostic investigation, the simple dynamic walking test, whereby the patient is permitted to weight-bear as tolerated in a removable orthosis applied in the Emergency Department, seems to be most accurate and simple to administer: a subsequent outpatient radiograph taken within two weeks will identify unstable fractures with new talar shift. This policy, widely adopted in many UK centres with a significant reduction in unnecessary surgery, is supported by the current British Orthopaedic Association Standards for Trauma (BOAST) guidelines.[14,15]

NONOPERATIVE MANAGEMENT

A successful outcome after ankle fracture can be anticipated where the talus is reduced anatomically under the mortise and held there until fracture union, regardless of how this is achieved. Surgical management, even in the elderly, has been traditionally recommended for unstable fractures.[16] However, as surgery in this patient group is associated with significant complications, including secondary loss of reduction and infection,[17,18] there has been a recent revival of interest in conservative management, including close-contact casting (CCC). Willet et al[3] conducted the multicentre AIM trial, comparing CCC with internal fixation in 620 patients over 65 years of age. They reported equivalent patient-related outcome at six-months, despite an overall 12% rate of wound complications in the operative group. In the CCC group, 25% of patients required further manipulation or conversion to internal fixation, with a further 15% going on to malunion. This trial has demonstrated a potential role for nonoperative management in the elderly, but with 40% of patients failing to achieve satisfactory union after initial management, surgeons may prefer to continue with the more dependable internal fixation.

PERCUTANEOUS FIXATION

Open surgical fixation has changed little in the last 50 years, and a standard AO technique is favoured for most ankle fracture surgery in young, healthy patients; this traditionally consists of open reduction, lag screw fixation if possible, and neutralization with a lateral or posterolateral plate. However, there are well-documented complications associated with open surgery, including: prominent metalwork often requiring further surgery for removal;[19] wound dehiscence and infection, particularly in the elderly, in diabetics, and those with neuropathy or poor compliance;[20] and construct failure in fragile bone, with complication rates reported of up to 30%. Any of these complications results in compromised overall outcome.[20] Delaying surgery for in-patient elevation to allow soft tissues to 'settle' is expensive and increases wound infection rates four-fold.[21] Locking-plate technology does not improve stability, and also increases wound complications.[22] An alternative strategy, of percutaneous fibular nailing (Figs 3 and 4), addresses each of these problems with soft-tissue preservation and more robust biomechanical stability.[23] Jain et al[24] reviewed the outcomes of 1008 patients from 17 studies of intramedullary ankle fixation and reported 98.5% union rates and 91.3% good or excellent outcomes. Two prospective randomized trials

Fig. 3 The fibular nail is inserted and secured through three small percutaneous incisions, leaving the swollen and blistered 'high-risk' skin undisturbed.

have confirmed that fibular nailing reduces wound problems and produces comparable or better clinical outcomes to plate fixation, whilst reducing overall cost.[1,25] Care must be taken to observe some technical considerations,[26] and pragmatic multicentre trials are needed to confirm generalizability of the technique following these smaller randomized studies.

THE MEDIAL MALLEOLUS

The significance of the medial malleolus on ankle joint stability has long been debated. A landmark paper by Yablon et al[27] stated that "the talus always faithfully follows the lateral malleolus upon reduction", and this is almost certainly true except for supination-adduction fractures. Isolated medial malleolar fractures are managed well with conservative treatment, even in the presence of initial displacement.[28,29] In contrast, fixation of these fractures carries operative morbidity, including wound infection, metalwork prominence, and possible damage to the posterior tibial tendon and local neurovascular structures.[30,31] Minimally invasive percutaneous techniques and headless screws have shown promising results in small cohort studies.[32-34] Extrapolating this principle to the management of the medial component of bimalleolar and trimalleolar fractures also seems to hold true: recent interest in conservative management of well-reduced medial malleolar fractures following fibular stabilization have demonstrated equivalent outcomes to fixation groups, with the avoidance of medial-sided wound dehiscence, infection, and nonunion.[35] It seems likely that fixation of the medial malleolus, particularly in weak, osteoporotic bone, may add little to the stability of inversion-type ankle fractures, and further level 1 data are needed to confirm this concept.

Fig. 4 Anteroposterior radiograph taken six weeks following surgery for treatment of an isolated lateral malleolus fracture.

THE POSTERIOR MALLEOLUS

Posterior malleolar fractures are attracting increasing attention (Fig. 1), with a current vogue for plating even small fragments.[4,36] Some principles related to this injury are well established: ankles where the talus remains subluxed posteriorly after fixation of the medial and lateral malleoli need adjuvant posterior fixation to replace and hold the talus in the mortise;[37] CT scans usually reveal larger and more complex fractures than is appreciated on plain radiographs;[38] and fixation of a large posterior fragment may provide secondary stabilization of the syndesmosis, via an intact posterior-inferior tibiofibular ligament (PITFL).[39,40] Beyond this, there is uncertainty and key issues remain to be established, including: whether any other posterior malleolar fractures benefit from fixation;[4] whether routine CT scans can assist in planning surgery given that the indications for fixation have not been established; and whether the additional risks and costs of posterior plating (surgery in the prone position, additional surgical and tourniquet time, additional implants, an extensile exposure) are worthwhile, in comparison with the known benefits and risks of standard syndesmosis fixation techniques.[41]

Commonly quoted indications for posterior malleolar surgery include fragment size, usually described in terms of the percentage of the plafond involved on lateral radiographs. However, this has not been shown to be of relevance, either in biomechanical[42-45] or clinical[46] studies. Furthermore, not one of the clinical trials[47-51] or systematic reviews[37,46,52] published to date has confirmed any benefit from surgical fixation for any size of posterior malleolar fragment, provided the talus is not subluxed after medial and lateral fixation. In contrast, fixation has been associated with a substantial rate of malunion,[50,53] and other complications in up to 20% of patients,[46,48,51,54-59] some devastating.[59] Prospective clinical trials by interested groups to establish in which patients fixation has efficacy, followed by pragmatic trials to show generalizability, are needed before widespread uptake of this practice is justified.

THE SYNDESMOSIS

Of all the contentious areas of ankle fracture treatment, the syndesmosis has attracted the greatest interest (Fig. 1) and controversy. An early and much-quoted paper by Sagi et al[60] showed that failure to reduce the syndesmosis anatomically resulted in impaired functional outcomes, and a huge volume of subsequent research has sought to determine the best way to assess, reduce, and stabilize the syndesmosis.

Complete assessment of the anatomy of the syndesmosis is impossible on standard radiographs and fluoroscopic images. This is due to the frustral shape of the mortise, which results in major changes in the measured medial clear space (by a factor of two) and tibiofibular overlap (by a factor of five) with only minor degrees of limb rotation,[10] the considerable anatomical variation in the shape of the incisura fibularis,[61] and the fact that rotation of the fibula can only be judged on axial imaging. Judging when the syndesmosis is truly unstable, therefore, is problematic because many surgeons assess this intraoperatively using an external rotation stress test, looking at the medial clear space. This is often abnormal even when the syndesmosis is intact,[62] resulting in the same issue of overdiagnosis as discussed above. With many studies on 'syndesmotic instability' presumably incorporating large proportions of patients with stable ankles, interpretation of the literature is difficult, and it is not, perhaps, surprising that some studies have shown that syndesmotic fixation in these patients is unnecessary[63] or can indeed be deleterious.[64] The hook test, directly assessing opening of the syndesmosis, is more accurate and is greatly to be preferred.[62]

Where syndesmotic instability is confirmed, assessing whether the surgical reduction of the syndesmosis has been adequate after closed surgery, using fluoroscopy, results in the same uncertainties, and several studies have confirmed that open reduction through

an anterior arthrotomy allows a more accurate reduction.[60] The reduction is easier to confirm with the foot in neutral (as opposed to plantarflexion), but dorsiflexion to 'prevent' blocking the talus is an unnecessary but surprisingly tenacious dogma.[65,66]

Holding the reduction intraoperatively can be more difficult than is often appreciated: reduction clamps result in a tendency to overcompress the sydesmosis,[67,68] and careful positioning of the medial tine on the anterior third of the tibia is important to avoid posterior translation,[69] particularly where the incisura is shallow.[70] Manual compression and stabilization seems to result in a more predictable anatomical reduction.[71]

Definitive fixation of the reduced syndesmosis can be achieved with either screws or suture-buttons. Screws have been used successfully for decades, although much debate has ensued over the details of how many screws to use, of what diameter, and whether to engage three or four cortices; there seem to be no important differences between these strategies, although a large fragment screw can be expected to result in a higher rate of later irritation.[72] The evidence does not support routine removal, which is quite unnecessary and courts unnecessary complications.[73,74] More controversial is the recent popularization of suture button devices, with the conceptual advantage of more physiological tibiofibular movement. Two (relatively small) randomized controlled trials (RCTs)[75,76] and eight comparative studies[77-84] have been published, along with three meta-analyses.[85-87] Despite some enthusiastic abstracts, none of the RCTs or meta-analyses show a clinically important difference in either functional or radiographic outcome. Certainly, screws are more cost-effective.[88] There is a concept, repeatedly described in the literature, that the suture button minimizes malreductions by its very flexibility, allowing the fibula to 'self-centre' and find its correct position in the incisura during intraoperative tightening. Although attractive, there is, in fact, no evidence for this; comparative data have been skewed by one cohort trial in which different surgeons performed the two different procedures.[79] Complicating the issue further are recent papers that question whether in fact minor imperfections in reduction do result in a functional difference as has been assumed to date: up to 3 mm translation and 15° rotation appear to be well tolerated.[89] Again, large prospective trials with long-term follow-up will be needed to show whether the higher cost of the suture button is justified.

POSTOPERATIVE MOBILIZATION

Allowing patients to weight-bear early following ankle fracture surgery has been standard practice in many centres for decades, but remains surprisingly controversial in some regions. Cadaveric studies have shown that fixed bimalleolar and trimalleolar fractures remain intact when cycled to represent physiological postoperative weight-bearing.[90] This basic science has been clinically examined in a recently published RCT by Dehghan et al.[91] A total of 110 patients, without syndesmotic injury or operatively managed posterior malleolar fractures, were randomly allocated following fixation to an early weight-bearing group, beginning at two weeks, or a late weight-bearing group, beginning at six weeks. Ankle range of movement was significantly higher in the early weight-bearing group, with no increased risk of failure or infection. Interestingly, patients in the late weight-bearing group experienced a significantly greater rate of troublesome metalwork. The reason for the initial two-week period of non-weight-bearing in this trial is unclear, and a systematic review by Black et al[92] of 555 ankle fractures managed with immediate weight-bearing after surgery confirms this to be unnecessary. Immediate weight-bearing was, in fact, strongly associated with improved range of movement, shorter hospital stays, quicker return to work, and improved patient reported outcome measures. Further convincing evidence by Smeeing et al,[93] in a review of 25 studies including a total of 1376 participants, has demonstrated additional benefit of early ankle exercises combined with early weight-bearing. Our recommended practice is to allow all patients to weight-bear fully in a removable boot unless there is a confirmed syndesmotic injury or significant peripheral neuropathy, in which case patients are instructed to bear no weight for between six and eight weeks following surgery. All patients are strongly encouraged to perform early range of movement exercises, out of boot, to facilitate recovery.

VENOUS THROMBOEMBOLISM

There is now good evidence that thromboprophylaxis is not justified in the management of most ankle fractures. Despite this, there remains concern, driven by well-publicized case reports and the fear of litigation.[94] Most studies, meta-analyses, and guidelines are compromised because they use (surrogate) venographically detected deep vein thrombosis (DVT) as their primary outcome measure. Two recent trials have instead focused on 'clinically important VTE' (CIVTE). The first examined 265 patients with isolated lower limb fractures randomized to either Dalteparin 5000 IU daily for two weeks, or a placebo injection.[95] Interim analysis demonstrated two CIVTEs in the intervention group and three in the placebo group, offset by a slightly higher rate of minor bleeding in the heparin group. The overall rate of CIVTE, at 2%, was considerably lower than allowed for by the initial power calculations, and faced with the inability to complete recruitment to the trial, the steering committee opted to halt the study early. The second study examined 1435 injuries of the lower limb treated in cast, of which 479 were ankle fractures and 94 were tendo Achilles disruptions.[96] The study group received 2500 IU Dalteparin whilst they were in cast (a duration of between three and seven weeks), the control group received a placebo. In the final analysis, there were ten CIVTEs (1.4%) in the intervention group and 13 (1.8%) in the placebo group, which was not statistically significantly different. The conclusions that can be drawn from these two RCTs is that the incidence of CIVTE is low, and that prophylaxis is ineffective in reducing these events. Given the possible adverse effects of prophylaxis (such as haemorrhage and heparin-induced thrombocytopaenia), the risks are greater than the benefits for most patients, although there may be some patients at elevated risk of VTE for whom the risks of thromboprophylaxis might be justified. A precautionary principle seems reasonable, using risk assessment to identify patients with a personal or first-degree family history of a prothrombotic condition, a history of malignancy, morbid obesity, or prothrombotic drugs such as unopposed oestrogens.

CONCLUSION

Ankle fracture fixation is one of the most commonly undertaken orthopaedic procedures, and in healthy young patients many fractures can be treated successfully using standard AO techniques in a manner largely unchanged for half a century. However, this is a time of considerable academic interest and innovation, bringing with it the possibility of exciting advances in patient care, particularly in those 'unsolved' injuries with complex disruptions,

bone fragility, and compromised soft tissues. The concepts of ankle stability, syndesmotic function, and the role of the posterior malleolus are particularly fascinating and deserving of further research. As always, the challenge for our specialty is to train the next generation of surgeons to perform the operations that work well with understanding and skill, and to investigate critically those areas needing innovation and improvement.

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