Foot and Ankle Surgery xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

Review

Ankle Arthritis Networking: Getting the right treatment to the right patient first time

Stephen Bendall[a,*], Paul Halliwell[b], Andrew Goldberg[c], Andrew Robinson[d]

[a] Sussex Orthopaedic Treatment Centre, Brighton and Sussex University Hospitals, Lewes Road, RH16 4EX, United Kingdom
[b] Royal Surrey Hospital, Egerton Road Guildford, GU2 7XX, United Kingdom
[c] UCL Institute of Orthopaedics, Royal National Orthopaedic Hospital, Stanmore, HA7 4LP, United Kingdom
[d] Cambridge University Hospitals, NHS Foundation Trust, Cambridge CB2 0QQ, United Kingdom

ARTICLE INFO

Article history:
Received 22 November 2020
Received in revised form 7 February 2021
Accepted 8 March 2021
Available online xxx

Keywords:
Ankle arthritis
Total ankle replacement
Ankle joint fusion
Networks
Review

ABSTRACT

End stage ankle joint arthritis is a debilitating condition. Surgical treatment, most commonly ankle arthrodesis or fusion, can be highly effective. The authors outline the nature and prevalence of ankle arthritis and show that the frequency of each type of procedure varies geographically. They present data supporting the hypothesis that units performing ankle replacement more frequently tend to have better outcomes, both clinically and financially. Adoption of country-wide Ankle Arthritis Networks is proposed, ensuring that every patient seeing a foot and ankle orthopaedic surgeon has potential access to all treatment options whether their surgeon chooses to perform replacement or not. The case is made that establishment of Ankle Arthritis Networks will avoid the need for units to perform a low number of replacements per year, homogenise treatment availability across the country and enables the right patient to receive the right treatment first time.
Level of evidence: IV.

Contents

* Corresponding author.
E-mail addresses: stephen.bendall@btinternet.com (S. Bendall), paul.halliwell7@virginmedia.com (P. Halliwell), andy@medicalfutures.co.uk (A. Goldberg), fred.robinson@cam-med.co.uk (A. Robinson).

https://doi.org/10.1016/j.fas.2021.03.006
1268-7731/

Please cite this article as: S. Bendall, P. Halliwell, A. Goldberg et al., Ankle Arthritis Networking: Getting the right treatment to the right patient first time, Foot Ankle Surg, https://doi.org/10.1016/j.fas.2021.03.006

1. Introduction

Total Ankle Replacement (TAR) and fusion are the main treatments for end stage ankle joint disease, whether post-traumatic, primary or inflammatory in aetiology [1].

The incidence of ankle osteoarthritis (OA) in the United Kingdom (UK) has been estimated to be 47.7 per 100,000 [2]. Ankle OA is significant in socioeconomic terms, the degree of physical impairment being estimated as equivalent to end stage hip arthrosis [3], as well as end-stage kidney disease or congestive heart failure [4].

Of the 29,000 symptomatic cases referred to specialist surgeons in the UK each year, approximately ten percent undergo arthrodesis or arthroplasty [2]

Trauma is considered to be the most common cause for patients developing ankle osteoarthritis with 80% of all cases being trauma-related, including ankle fractures or recurrent severe sprains [5].

In fractures articular damage is associated with poorer outcomes [6]. The fracture pattern leading to the highest incidence of OA is the Weber C combined with medial malleolar fracture. More than one third of these patients developed advanced radiographic degenerative changes in an 18-year retrospective review of 102 ankle fractures [7]. The presence of a posterior malleolar fracture has also been shown to correlate with poorer clinical and radiographic outcomes, especially if there is inadequate reduction of the posterior malleolar articular fragment [8]. Following severe or poorly managed ankle fractures the majority of arthritic change has been reported to occur in the first 12–18 months [9].

Osteochondral injuries are also linked to the development of OA [10]. The determining factor is probably the depth and location of cartilage damage. In a recent 13 year follow up of 109 patients, lesions on the anterolateral talar dome, posteromedial tibia and medial malleolus had the worst long-term outcomes both radiographically and clinically.

Chronic lateral ligamentous instability of the ankle may also lead to the development of medial degenerative change. Harrington performed a radiographic review of 36 patients with chronic lateral ankle instability, at a minimum of 10 years. The patients complained of increasing ankle pain, with degenerative change over the medial talar and tibial surfaces of the ankle. These changes were observed radiographically and confirmed arthroscopically [11].

There are clearly questions yet to be explored as to whether changing our approach to ankle trauma management could in turn influence the progression to end stage arthritis.

2. Discussion

2.1. End-stage ankle disease (in the UK); contemporary treatment patterns

Once all non-operative management options have been exhausted, the disease can be considered as end stage ankle arthritis (ESAA) for which the most commonly used surgical treatments are ankle fusion (ankle arthrodesis; AA) and total ankle replacement (TAR). There are other options, including hindfoot realignment [12], joint distraction [13] and partial resurfacing [14]. This diversity of acceptable management options in ankle arthritis is unusual when compared to other joints.

In 2017/8 the number of ankle fusions done in England and Wales was 1858, with 1681 being primary fusions of which 551 were done arthroscopically (NHS Improvement data). There were 177 revision ankle fusions of which 6 were arthroscopically performed.

In the same 2017/18 time frame, the number of TAR done in England and Wales was 739 although by extrapolation it is estimated that across the whole UK perhaps 1200 TAR are performed per year (NHS Improvement Data). This suggests that 1 TAR is done for every 2–3 AA.

The 2018 UK National Joint Registry (NJR) figures show an eight fold variation in TAR activity per head of population. The reasons for this variation is not easily explained, but one potential explanation is surgeons who are adept at fusion but perform few TAR's will direct patients to fusion rather than referring onwards for TAR.

In 2015, the Get It Right First Time (GIRFT) Programme is a quality improvement programme challenging unwanted variations in clinical practice to improve outcomes and thereby provide cost savings. To achieve this, in the case of end stage ankle arthritis it is important to understand which patients are best treated with fusion and which with TAR. This question remains unanswered. However recent evidence has challenged the belief that significant deformity is a contra-indication to TAR [15–21]. Indeed, evidence is now accumulating that it is the patients with more severe, multiple-joint disease, often with deformity, who gain more from TAR compared to AA [22] as long as the deformities are recognised and corrected [15,17], often by 2-stage surgery [23].

The NJR data shows a lack of uniformity of practice across England and Wales and therefore a proportion of patients may not be getting the right operation first time. Equally concerning is the "low-volume" of procedures undertaken within some centres, raising concerns around both outcome and cost.

There may also be a particular issue with revision TAR as the cumulative annual failure rates for TAR have been estimated at 1.7% (95% CI 1.2–2.2) which is higher than that seen with total hip and knee replacements [24]. We are likely to see an increasing cohort of TARs requiring revision.

One way to address these issues is to establish collaborative ankle arthritis networks, with surgeons who do and do not replace ankle joints, providing consistency of patient selection for AA or TAR. By rationalising a region's ankle arthritis service, there are good reasons to expect such networks to improve surgeon volumes, outcomes and costs. The range of recognised treatments for end stage ankle arthritis and the necessity to address the whole foot differentiate TAR from other joint replacements and this must be reflected in the construction of the ankle networks to optimise care.

2.2. Stakeholder commitment

The General Medical Council's 'Good Medical Practice – duties of a doctor' guide 2 clearly states in the section on working in partnership with patients that doctors should:

–Listen to patients and respond to their concerns and preferences
–Give patients the information they want or need in a way they can understand
–Respect patients' right to reach decisions with the doctor about their treatment and care
–Support patients in caring for themselves to improve and maintain their health

This is best achieved by face to face consultations between the patient and their surgeon. Indeed the surgeon, has been demonstrated to have the most significant influence of a patients' determination of treatment choice in ankle arthritis [25].

Continuity and co-ordination of care are also essential parts of the General Medical Council's Good Medical Practice guidance 2.

Therefore when treating a patient there has to be a clear commitment from all stakeholders to include the patient, clinician and the healthcare funding source or commissioner to support and participate in the complete care pathway to encompass the diagnosis, treatment, after care, outcome monitoring, adverse event management and cost analyses.

2.3. TAR in UK and does volume matter?

There is considerable evidence within the orthopaedic literature that higher volumes of surgical procedures in lower limb replacement lead to better patient-outcomes, as assessed by dislocation, revision, infection and mortality rates.

The number of ankle replacements per annum increased by 15.6% in 2018 [27]. In contrast hip and knee replacements increased by 3.5 and 3.8% respectively. The median number of TAR per consultant per year is 3, with just 14% of units performing more than 10 TAR per year, and 4.6% of units performing more than 20 TAR per year. These numbers have increased slightly over the last 9 years (Table 1). In contrast, in England and Wales, the average number of hip or knee replacements per surgeon per year is 53 [26].

In total elbow replacement, which faces similar low volumes issues to TAR, reviews of both the Finnish [28] and Scottish [29] Arthroplasty registers and from a study in New York State [30] indicates that the survivorship of total elbow replacement is better in patients operated on by higher-volume surgeons. The same groups, and others, have indicated that meaningful outcome data cannot be obtained for surgeons and hospitals purely based on the operative experience of 1–2 total elbow replacements annually.

A US study analysing 4800 TAR, identified that the 90th centile for surgeon volume was 21 cases per year. Mean length of stay was 2.8 ± 2.3 days and mean hospital charges were \$45 963 $\pm$ \$43 983. On multivariate analysis, high-volume surgeons had decreased complications (OR 0.5, $P = .034$) and rate of medial malleolus fracture (OR 0.1, $P = .043$), decreased length of stay (–0.9 days, $P < .001$), and decreased hospital charges (–\$20 904, $P < .001$) [31].

A UK study that matched 1,185 TAR against the Hospital Episodes Statistics (HES) database demonstrated 30-day readmission rates for any cause following primary and revision ankle replacement of 2.2% and 1.3%, respectively [32]. Reoperation other than for revision (that is, implants were not removed) in the 12 months following primary and revision TARs was 6.6% and 9.3%, respectively. In the same time period, the revision rate (where implants were removed) was 1.2%, with increased odds in those orthopaedic units preforming less than 20 ankle replacements per year

Whilst some small retrospective case series have argued that volume does not correlate with worse outcomes [33,34], the evidence appears to indicate that lower volumes equates to higher rates of complications and poorer outcomes.

2.4. A place for regional Ankle Arthritis Networks

In view of the evidence associating low volume TAR surgery with sub-optimal outcomes and higher costs, there is a rationale for reducing the number of provider-centres.

The centralisation of specialist practice to defined centres is not new in the UK and historically emerged in neurosurgery, vascular surgery, cardiothoracic surgery, cancer services as well as in plastic surgery. In orthopaedics specialist hospitals have been long been part of the landscape for example the Robert Jones and Agnes Hunt Hospital in Oswestry which was founded in 1933. More recently we have established the Major Trauma networks around trauma centres [35]. Some surgeons have already begun organising their informal regional networks for TAR provision but there is as yet no nationwide structure.

It is clear that any new network will need to adopt a pragmatic approach with a degree of flexibility at the outset. There are two types of network that can be considered, the first is a regional hub where the peripheral “spoke” hospitals refer which is the traditional hierarchal model similar to the networks described above.

The second potential model is a horizontal hierarchy with higher volume centres supporting a wider network of surgeons and teams, more akin to a web with treatment centre “nodes”. The structure would be flexible but would support lower volume TAR surgeons with patient selection via a multidisciplinary team MDT approach. Such a model allows for a greater emphasis on networking at the clinical assessment and treatment-indication stage, which is important for arthritis of the ankle. The NHS England plan to combine services into Integrated Care Systems [36] with single orthopaedic departments and waiting list management parallel this horizontal model. The use of IT has been accelerated by the COVID-19 pandemic which further underpins this way of working.

The model adopted is a matter for continued dialogue, but a model that is inclusive is far more likely to promote the cultural changes needed to ensure that the best procedure is selected for any individual patient. Such a network model would support the principles within the GIRFT programme by providing or enabling:

- A balanced approach to resolving the current apparent inequities in the delivery of care for EAA? End stage ankle arthritis

Table 1
Chart demonstrating procedure volume by year and the number of units performing greater than 10 and greater than 20 TAR per annum. Adapted from National Joint Registry 16th Annual Report [26].

Number of primary replacements during each year	Year of surgery							
	<2010	2011	2012	2013	2014	2015	2016	2017
Operations (n)	417	523	583	552	546	613	719	734
Units (n)	111	128	145	133	137	143	140	139
Mean number of primary replacements per unit	3.8	4.1	4	4.2	4	4.3	5.1	5.3
Median (IQR) number of any primary replacements per unit	2 (1–4)	2 (1–5)	2 (1–4)	2 (1–5)	2 (1–4)	2 (1–5)	2 (1–6.5)	2 (1–6)
Units who entered more than 10 procedures (n)	10	7	10	10	10	10	16	14
Units who entered more than 20 procedures (n)	3	3	3	3	4	5	5	6
Consultants providing operation (n)	114	126	143	132	126	140	133	135
Mean number of operations per consultant	3.7	4.2	4.1	4.2	4.3	4.4	5.4	5.4
Median (IQR) number of operations per consultant	2 (1–4)	3 (2–5)	2 (1–5)	3 (1–5)	3 (2–5)	2 (1–6)	2 (2–8)	3 (1–8)
Consultants who entered >10 operations (n)	9	10	10	11	8	13	16	21
Consultants who entered >20 operations (n)	2	2	2	2	2	4	5	5

- Giving low volume surgeons the choice to increase their activity by pooling cases and by dual surgeon operating to overcome the issue of the so called learning curve [37] or to relinquish TAR activity.
- An MDT approach to network pathways and decision making
- A frictionless referral system for an opinion on surgery and any complications for instance wound breakdown or deep infection.
- Benchmarking of agreed performance indicators both within the network, nationally and internationally.
- Central commissioning to reduce implant related costs

The question remains as to whether there should be an overarching structure to co-ordinate activity within individual networks. This is an area for development, but there is currently a National TAR users forum and the expectation is that the new networks will support this. The ambition is for this user group to invite feedback from the public with regard to ankle arthritis treatments and services.

2.5. Structures and services required within an Ankle Arthritis Network

There are specific requirements that are needed within units performing TAR and complex ankle arthritis surgery. These would include:

- Support for a multi-disciplinary team structure with regular meetings being paramount. The meetings should involve all surgeons in the region who treat ankle arthritis, whether they replace ankles or not.
- To be fully resourced, with all appropriate staff and all equipment routinely available in theatres for primary and revision ankle replacement surgery.
- Appropriate radiology staff and facilities.
- Appropriate microbiology services.
- Appropriate physiotherapy/Allied Health Professions support.
- Support to analyse data from all available datasets including HES, NJR and the BOFAS registry.

Particularly for revision and complex primary cases, there should also be ready access to

- Vascular surgery
- Plastic surgery
- Appropriate HDU/ITU facilities

The design of such a network will be governed by local resources and geography but there will generally be only one or two high volume centres (HVC) within a certain area.

The area defining a regional centre is open to discussion, but following the pattern of NHS regions which have evolved from the Strategic Health Authorities would mirror the NJR geographic orientation and seem to be sensible.

Most often, the HVC will be an established teaching centre, but it could equally be a district hospital, since the status of any centre will be defined by the expertise and resources already established.

If a region has too many centres this will dilute case numbers. In this circumstance the TAR surgeons within that region should have the initial opportunity to discuss and agree the set up after considering patterns and numbers of referrals. If uncertainty continues, then the GIRFT programme has indicated it will inform the decision based on good quality data in relation to NHSi, NJR numbers, unit resources, and performance.

The performance of procedures by two consultants should be considered reasonable practice for primary and revision ankle replacements, although there should be flexibility in that arrangement.

With joint operating becoming more commonplace there needs to be recognition within the National Joint Registry to attribute the procedure to both consultants.

Within each region, surgeons should have flexibility via their regular MDT meetings to decide on the patient referral processes and the post-operative follow up pathways.

MDT related activity as well as joint operating should be reflected in consultant job planning.

If referral to a centralised unit is decided, the referring centres will provide patients with information about TAR and include a rationale of why they need to travel to another centre.

On rare occasions patients travelling to a HVC will be either impractical or be refused funding, and the procedure may then have to be undertaken at the more local unit. Under this circumstance, it would be expected that the surgeons who perform the TAR surgery are the same surgeons who already have established links with the main centres.

The HVC should facilitate and provide training for consultants and orthopaedic trainees wishing to gain more experience in ankle replacement surgery.

Training Fellowships need to be provided to produce the next generation of TAR surgeons.

2.6. The rehabilitation pathway within an Ankle Arthritis Network

Centres performing TAR should have the resources to provide specialist physiotherapy services, where dedicated staff have experience of treating patients following ankle arthritis surgery. Physiotherapy may be undertaken closer to home if necessary, but this should be left to the individual networks to organise.

The hub physiotherapy service should act as a reference point for all physiotherapists in the wider network, and should provide a post-operative rehabilitation ‘prescription’ for every patient whose care is transferred to the “spoke” hospital physiotherapists. On going advice, support and training will need arrangement.

Ideally individual networks would have named therapists at each site, who act as a liaison. Their role will need to facilitate transfer and to support the physiotherapy teams treating the patients closer to home to ensure the best possible advice and post-operative rehabilitation is given to these patients.

The network will develop agreed pathways to deal with serious complications that arise for instance wound healing problems.

2.7. The collection of outcome data

All cases must be recorded in the NJR including relevant Patient-reported outcomes measures (PROMS) and resources should be in place to facilitate outcome data collection on quality metrics including:

- Length of stay
- Re-admission rate within 30 days
- PROMS pre-procedure, and post procedure
- Infection/other adverse events (e.g. thromboembolic events)
- Reoperation rates
- Revision rates
- Mortality
- Associated procedures and deformities
- Why ankle replacement rather than fusion chosen
- Computer guided/robotic/CT jig provision
- Costing

Table 2
Chart demonstrating current coding practice — data obtained from NHS Improvement 2018 figures.

Primary codes		
O321	Primary total prosthetic replacement of ankle joint NEC	719
Revision codes		
0322	Conversion to total prosthetic replacement of ankle joint NEC	8
0323	Revision of total prosthetic replacement of ankle joint NEC	61
0325	Revision of one component of total prosthetic replacement of ankle joint NEC	14
Other unspecified codes		
0324	Attention to total prosthetic replacement of ankle joint NEC	40
0328	Other specified total prosthetic replacement of ankle joint	0
0329	Unspecified total prosthetic replacement of ankle joint	2

Given the fact that ankle replacements have higher revision rates than hip or knee replacements, patients will need annual follow up with PROMS and appropriate imaging.

- PROM scores to be utilized would include clinically specific outcomes, such as the MOXFQ [38,39] scoring systems.
- EQ5D [40] may be used for assessment of quality of life and economic analysis.
- Scores should be captured preoperatively and at a minimum of six months following intervention and then annually if possible. This will allow longitudinal analysis to determine the magnitude of treatment effect and consequences of any treatment related adverse events.

Local networks will provide patient information on risks and benefits of TAR, including the quality metrics outlined above. They will also supply clinician information and ensure access to NJR reports and regional audit data.

Network activity will be overseen by GIRFT but networks will also be encouraged to present its data in relevant meetings, such as the national TAR user groups forum and the British Orthopaedic Foot & Ankle Society.

2.8. Research opportunities

There is an opportunity to answer questions on TAR, including the indications, implant performance, longevity, patient selection, management of complications, and costings. The NJR has recently funded an NJR Fellow to focus on ankle arthritis and already has a heritage of publications arising out of the NJR. A TAR network could augment this. An NIHR HTA funded project is underway exploring the clinical and cost effectiveness of TAR versus AA [41].

2.9. TAR in independent practice

TAR in the independent sector is funded either by the NHS as part of the eReferral (Patient Choice) system or by independent means (self funding or via private health insurance). The expectation is the standards outlined in this document would be upheld within all sectors irrespective of the payor.

2.10. Clinical coding

Appropriate diagnostic and procedural coding of procedures is vital for correct HRG mapping and for accurate data collection. This is especially true for TAR where a balanced foot is essential to joint function and hence patients may have had surgery on tendons or ligaments or in correction of deformity. Data collection should reflect this and be relatable to the NJR dataset. It is also critical that all complications and comorbidities (CCs) are recorded. For best practice in coding it is important for clinicians to engage with trained coders to ensure that all clinical coding standards are followed and that consistency of coding is ensured.

The current HRG4+ system is very granular and payment is dependent on the number of CCs. The most common procedural codes for TAR are listed in Table 2.

2.11. Costs

Appropriate remuneration of actual costs for this specialist service is critical. The formation of networks allows for collaboration over procurement of implants and equipment

There is also an opportunity to collaborate with NHS services in Scotland and Northern Ireland if that is desired as well as benchmarking TAR costs and outcomes internationally.

3. Conclusions

Change is needed to ensure that patients with end stage ankle arthritis receive objective and consistent surgical choices at presentation. Regional networks remain a logical development to streamline pathways and procurement. A network can adopt one of two formats and we recommend an inclusive horizontal network rather than a traditional hub and spoke model on the basis that by supporting lower volume and novice TAR surgeons we are less likely to see a disparity of patient access for TAR. This will require hospital Trusts to work more collaboratively and provide appropriate resources to enable best practice and deliver high quality research and audit. The benefits will be safer care, improved patient access, better outcomes, and rationalisation of costs across the UK.

Conflict of interest

The authors declared that they have no conflicts of interest.

Acknowledgements

The authors wish to acknowledge Professor T. Briggs CBE, Chairman of GIRFT, and Mr James Davis, President of the British Orthopaedic Foot and Ankle Society, for their advice and guidance in the preparation of this paper.

References

[1] Veljkovic AN, Daniels TR, Glazebrook MA, Dryden PJ, Penner MJ, Wing KJ, et al. Outcomes of total ankle replacement, arthroscopic ankle arthrodesis, and open ankle arthrodesis for isolated non-deformed end-stage ankle arthritis. J Bone Joint Surg Am 2019;101:1523, doi:http://dx.doi.org/10.2106/JBJS.18.01012.
[2] Goldberg AJ, MacGregor A, Dawson J, Singh D, Cullen N, Sharp RJ, et al. The demand incidence of symptomatic ankle osteoarthritis presenting to foot &

ankle surgeons in the United Kingdom. Foot (Edinb) 2012;22:163, doi:http://dx.doi.org/10.1016/j.foot.2012.02.005.
[3] Glazebrook M, Daniels T, Younger A, Foote CJ, Penner M, Wing K, et al. Comparison of health-related quality of life between patients with end-stage ankle and hip arthrosis. J Bone Joint Surg Am 2008;90:499, doi:http://dx.doi.org/10.2106/JBJS.F.01299.
[4] Saltzman CL, Zimmerman MB, O'Rourke M, Brown TD, Buckwalter JA, Johnston R. Impact of comorbidities on the measurement of health in patients with ankle osteoarthritis. J Bone Joint Surg Am 2006;88:2366, doi:http://dx.doi.org/10.2106/JBJS.F.00295.
[5] Saltzman CL, Salamon ML, Blanchard GM, Huff T, Hayes A, Buckwalter JA, et al. Epidemiology of ankle arthritis: report of a consecutive series of 639 patients from a tertiary orthopaedic center. Iowa Orthop J 2005;25:44.
[6] McKinley TO, Rudert MJ, Koos DC, Brown TD. Incongruity versus instability in the etiology of posttraumatic arthritis. Clin Orthop Relat Res 2004;44:, doi:http://dx.doi.org/10.1097/01.blo.0000131639.89143.26.
[7] Lubbeke A, Salvo D, Stern R, Hoffmeyer P, Holzer N, Assal M. Risk factors for post-traumatic osteoarthritis of the ankle: an eighteen year follow-up study. Int Orthop 2012;36:1403, doi:http://dx.doi.org/10.1007/s00264-011-1472-7.
[8] Broos PL, Bisschop AP. Operative treatment of ankle fractures in adults: correlation between types of fracture and final results. Injury 1991;22:403, doi:http://dx.doi.org/10.1016/0020-1383(91)90106-o.
[9] Lindsjo U. Operative treatment of ankle fractures. Acta Orthop Scand Suppl 1981;189:1, doi:http://dx.doi.org/10.3109/ort.1981.52.suppl-189.01.
[10] Stufkens SA, Knupp M, Horisberger M, Lampert C, Hintermann B. Cartilage lesions and the development of osteoarthritis after internal fixation of ankle fractures: a prospective study. J Bone Joint Surg Am 2010;92:279, doi:http://dx.doi.org/10.2106/JBJS.H.01635.
[11] Harrington KD. Degenerative arthritis of the ankle secondary to long-standing lateral ligament instability. J Bone Joint Surg Am 1979;61:354.
[12] Lee WC. Extraarticular supramalleolar osteotomy for managing varus ankle osteoarthritis, alternatives for osteotomy: how and why? Foot Ankle Clin 2016;21:27, doi:http://dx.doi.org/10.1016/j.fcl.2015.09.002.
[13] D'Angelantonio AM, Schick FA. Ankle distraction arthroplasty combined with joint resurfacing for management of an osteochondral defect of the talus and concomitant osteoarthritis: a case report. J Foot Ankle Surg 2013;52:76, doi:http://dx.doi.org/10.1053/j.jfas.2012.01.007.
[14] Ettinger S, Stukenborg-Colsman C, Waizy H, Becher C, Yao D, Claassen L, et al. Results of HemiCAP((R)) implantation as a salvage procedure for osteochondral lesions of the talus. J Foot Ankle Surg 2017;56:788, doi:http://dx.doi.org/10.1053/j.jfas.2017.04.001.
[15] Demetracopoulos CA, Cody EA, Adams Jr. SB, DeOrio JK, Nunley 2nd JA, Easley ME. Outcomes of total ankle arthroplasty in moderate and severe valgus deformity. Foot Ankle Spec 2019;12:238, doi:http://dx.doi.org/10.1177/1938640018785953.
[16] Gibson V, Prieskorn D. The valgus ankle. Foot Ankle Clin 2007;12:15, doi:http://dx.doi.org/10.1016/j.fcl.2006.11.001.
[17] Greisberg J, Hansen Jr. ST. Ankle replacement: management of associated deformities. Foot Ankle Clin 2002;7:721.
[18] Hobson SA, Karantana A, Dhar S. Total ankle replacement in patients with significant pre-operative deformity of the hindfoot. J Bone Joint Surg Br 2009;91:481, doi:http://dx.doi.org/10.1302/0301-620X.91B4.20855.
[19] Kim BS, Choi WJ, Kim YS, Lee JW. Total ankle replacement in moderate to severe varus deformity of the ankle. J Bone Joint Surg Br 2009;91:1183, doi:http://dx.doi.org/10.1302/0301-620X.91B9.22411.
[20] Lee GW, Lee KB. Outcomes of total ankle arthroplasty in Ankles with &20 degrees of coronal plane deformity. J Bone Joint Surg Am 2019;101:2203, doi:http://dx.doi.org/10.2106/JBJS.19.00416.
[21] Ryssman D, Myerson MS. Surgical strategies: the management of varus ankle deformity with joint replacement. Foot Ankle Int 2011;32:217, doi:http://dx.doi.org/10.3113/FAI.2011.0217.
[22] Daniels TR, Younger AS, Penner M, Wing K, Dryden PJ, Wong H, et al. Intermediate-term results of total ankle replacement and ankle arthrodesis: a COFAS multicenter study. J Bone Joint Surg Am 2014;96:135, doi:http://dx.doi.org/10.2106/JBJS.L.01597.
[23] Hennessy MS, Molloy AP, Wood EV. Management of the varus arthritic ankle. Foot Ankle Clin 2008;13:417, doi:http://dx.doi.org/10.1016/j.fcl.2008.04.006 S1083-7515(08)00043-0 [pii].
[24] Labek G, Klaus H, Schlichtherle R, Williams A, Agreiter M. Revision rates after total ankle arthroplasty in sample-based clinical studies and national registries. Foot Ankle Int 2011;32:740, doi:http://dx.doi.org/10.3113/FAI.2011.0740.
[25] Zaidi R, Cro S, Gurusamy K, Siva N, Macgregor A, Henricson A, et al. The outcome of total ankle replacement: a systematic review and meta-analysis. Bone Joint J 2013;95-B:1500, doi:http://dx.doi.org/10.1302/0301-620X.95B11.31633.
[26] Board NE, editor. National joint registry 16th annual report. National Joint Registry; 2019 p. 163.
[27] Board NE, editor. National joint registry 15th annual report. National Joint Registry; 2018.
[28] Skytta ET, Eskelinen A, Paavolainen P, Ikavalko M, Remes V. Total elbow arthroplasty in rheumatoid arthritis: a population-based study from the Finnish Arthroplasty Register. Acta Orthop 2009;80:472, doi:http://dx.doi.org/10.3109/17453670903110642.
[29] Jenkins PJ, Watts AC, Norwood T, Duckworth AD, Rymaszewski LA, McEachan JE. Total elbow replacement: outcome of 1,146 arthroplasties from the Scottish Arthroplasty Project. Acta Orthop 2013;84:119, doi:http://dx.doi.org/10.3109/17453674.2013.784658.
[30] Gay DM, Lyman S, Do H, Hotchkiss RN, Marx RG, Daluiski A. Indications and reoperation rates for total elbow arthroplasty: an analysis of trends in New York State. J Bone Joint Surg Am 2012;94:110, doi:http://dx.doi.org/10.2106/JBJS.J.01128.
[31] Basques BA, Bitterman A, Campbell KJ, Haughom BD, Lin J, Lee S. Influence of surgeon volume on inpatient complications, cost, and length of stay following total ankle arthroplasty. Foot Ankle Int 2016;37:1046, doi:http://dx.doi.org/10.1177/1071100716664871.
[32] Zaidi R, Macgregor AJ, Goldberg A. Quality measures for total ankle replacement, 30-day readmission and reoperation rates within 1 year of surgery: a data linkage study using the NJR data set. BMJ Open 2016;6:e011332, doi:http://dx.doi.org/10.1136/bmjopen-2016-011332.
[33] Pinar N, Vernet E, Bizot P, Brilhault J. Total ankle arthroplasty - total ankle arthroplasty in Western France: influence of volume on complications and clinical outcome. Orthop Traumatol Surg Res 2012;98:S26, doi:http://dx.doi.org/10.1016/j.otsr.2012.04.004.
[34] Reuver JM, Dayerizadeh N, Burger B, Elmans L, Hoelen M, Tulp N. Total ankle replacement outcome in low volume centers: short-term followup. Foot Ankle Int 2010;31:1064, doi:http://dx.doi.org/10.3113/FAI.2010.1064.
[35] Major trauma centres in England. 2016. . Available at: https://www.nhs.uk/NHSEngland/AboutNHSservices/Emergencyandurgentcareservices/Documents/2016/MTS-map.pdf.
[36] Designing integrated care systems (ICSs) in England. 2019. . June 2019. Available at: https://www.england.nhs.uk/wp-content/uploads/2019/06/designing-integrated-care-systems-in-england.pdf.
[37] Usuelli FG, Maccario C, Pantalone A, Serra N, Tan EW. Identifying the learning curve for total ankle replacement using a mobile bearing prosthesis. Foot Ankle Surg 2017;23:76, doi:http://dx.doi.org/10.1016/j.fas.2016.02.007.
[38] Dawson J, Boller I, Doll H, Lavis G, Sharp R, Cooke P, et al. The MOXFQ patient-reported questionnaire: assessment of data quality, reliability and validity in relation to foot and ankle surgery. Foot (Edinb) 2011;21:92, doi:http://dx.doi.org/10.1016/j.foot.2011.02.002.
[39] Dawson J, Boller I, Doll H, Lavis G, Sharp R, Cooke P, et al. Responsiveness of the Manchester-Oxford Foot Questionnaire (MOXFQ) compared with AOFAS, SF-36 and EQ-5D assessments following foot or ankle surgery. J Bone Joint Surg Br 2012;94:215, doi:http://dx.doi.org/10.1302/0301-620X.94B2.27634.
[40] Herdman M, Gudex C, Lloyd A, Janssen M, Kind P, Parkin D, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). Qual Life Res 2011;20:1727, doi:http://dx.doi.org/10.1007/s11136-011-9903-x.
[41] Goldberg AJ, Zaidi R, Thomson C, Doré CJ, Skene SS, Cro S, et al. Total ankle replacement versus arthrodesis (TARVA): protocol for a multicentre randomised controlled trial. BMJ Open 2016;6:e012716, doi:http://dx.doi.org/10.1136/bmjopen-2016-012716.