BJO

FOOT & ANKLE

Cost-utility analysis of cast compared to removable brace in the management of adult patients with ankle fractures

H. Nwankwo,
J. Mason,
M. L. Costa,
N. Parsons,
A. Redmond,
H. Parsons,
A. Haque,
R. S. Kearney

From University Hospital Coventry and Warwickshire, Univertisy of Warwick, Coventry, UK

Aims

To compare the cost-utility of removable brace compared with cast in the management of adult patients with ankle fracture.

Methods

A within-trial economic evaluation conducted from the UK NHS and personnel social services (PSS) perspective. Health resources and quality-of-life data were collected as part of the Ankle Injury Rehabilitation (AIR) multicentre, randomized controlled trial over a 12-month period using trial case report forms and patient-completed questionnaires. Cost-utility analysis was estimated in terms of the incremental cost per quality adjusted life year (QALY) gained. Estimate uncertainty was explored by bootstrapping, visualized on the incremental cost-effectiveness ratio plane. Net monetary benefit and probability of cost-effectiveness were evaluated at a range of willingness-to-pay thresholds and visualized graphically.

Results

The incremental cost and QALYs of using brace over a 12-month period were £46.73 (95% confidence interval (CI) £-9 to £147) and 0.0141 (95% CI (-0.005 to 0.033), respectively. The cost per QALY gained was £3,318. The probability of brace being cost-effective at a £30,000 per QALY willingness-to-pay threshold was 88%. The results remained robust to a range of sensitivity analyses.

Conclusion

This within-trial economic evaluation found that it is probable that using a removable brace provides good value to the NHS when compared to cast, in the management of adults with ankle fracture.

Cite this article: *Bone Jt Open* 2022;3-6:xxx–xxx.

Keywords: cost-utility analysis, ankle fracture, cast

Introduction

Ankle fracture is one of the most common fractures among adults, representing a substantial proportion of the trauma workload.[1] As the population ages and more people choose to remain active in later years, the burden of ankle fracture is expected to increase,[2] leading to cost pressures on the NHS due to the considerable costs associated with managing ankle fractures.[3]

Ankle fractures can be managed with or without surgery, but for both, initial management includes a period of immobilization. Immobilization may be either by a plaster or synthetic cast, or by a removable brace. Cast management may increase muscle atrophy, joint stiffness, and the incidence of deep vein thrombosis, which is associated with prolonged immobilization.[4] A removeable brace, that allows earlier movement, may address such risks, but does not provide the same degree of support to healing bones.[5]

A recent randomized controlled trial (RCT) comparing these two management strategies demonstrated that there was no statistically significant difference in the patient-reported Olerud Molander ankle score at 16 weeks and removable brace management was safe.[6] To date, the cost-effectiveness of these alternatives is unknown, but such evidence should help inform resource allocation decisions in the NHS.[3]

Correspondence should be sent to Henry Nwankwo; email: henry.nwankwo@warwick.ac.uk

doi: 10.1302/2633-1462.36.BJO-2022-0036

Bone Jt Open 2022;3-6:xxx–xxx.

This is the first study to assess the cost-effectiveness of removable brace compared to cast in operatively and non-operatively managed adult patients with ankle fracture.

Methods

Background of trial. Data were available from the Ankle Injury Rehabilitation (AIR) trial; its protocol and trial results are reported in detail elsewhere.[6,7] AIR was a UK-based, pragmatic, multicentre, RCT that recruited patients between October 2017 and September 2019. Patients were eligible for inclusion if they were aged 18 years and over and presented to the hospital with an ankle fracture, whether treated operatively or nonoperatively, for which the clinician would consider cast a reasonable management option. Further details on eligibility can be found in the protocol[7] and the main clinical results.[6] The AIR trial was approved by the UK National Research Ethics Committee (17/WM/0239).

Trial recruitment and demographics. There were 334 patients randomized to cast and 335 patients randomized to removable brace. The mean age of participants was 46.3 years (standard deviation (SD) 17), and more than half the participants were female (57%). All participants had a clear ankle fracture on a radiograph, with 624 (93%) showing lateral malleolar involvement, 194 (29%) medial malleolar involvement, and 120 (18%) posterior malleolar involvement. Surgery was performed in 364 of 669 the randomized participants. Further details on trial recruitment and demographic information of participants can be found in the clinical paper.[6]

Resource use data. Data were recorded using case report forms at six, ten, 16, and 24 weeks, and 12 months post-randomization. Use of medication, outpatient visits, community care services, and in-patient care were recorded by participants. Non-medical health care resource use, such as aids and adaptations and personal social services (PSS), were also recorded. Data on lost productivity due to injury were collected at each time point. The resource items collected reflects an NHS and PSS perspective, and a broader societal perspective, additionally including lost productivity costs and private health and non-medical healthcare costs incurred.

Collection and valuation of resource use. We used methods recommended by the National Institute of Health and Care Excellence (NICE) guide to methods of technology appraisal.[8] Medication used was identified and valued using 2019/2020 NHS Prescription cost analysis data for England,[9] and the 2019 British National Formulary.[10] Inpatient care procedures were derived from the relevant Health Care Resource Group (HRG) and OPCS Classification of Interventions and Procedures version 4 (OPCS4) codes of reported procedures and/or clinical diagnosis. These procedures were valued using Department of Health and Social Care Reference Costs.[11] Costs associated with out-patient services were derived using Department of Health and Social Care Reference Costs. Unit costs for community and PSS were obtained from the Personal and Social Service Research Unit (PSSRU) cost compendium.[12] Costs for aids and adaptations used were obtained from the NHS supply chain catalogue 2019.[13]

Costs were calculated by multiplying resource use by item unit costs, in pounds sterling using the 2019/2020 prices. If necessary, costs were inflated or deflated using the Health and Community Health Prices Pay and Price Inflation Index.[13] No discounting of costs was applied since cost-effectiveness was determined in the first year following treatment.

For the base case analysis NHS and PSS costs were included. Non-prescribed medications, private physiotherapy services, and services not normally provided by the NHS were considered private expenses. Costs associated with lost productivity were estimated using the human capital approach, where median daily wage was multiplied by number of days off work due to injury.

Health outcomes. The primary health outcome for the economic evaluation was the QALY in accordance with NICE guidelines.[8] Health-related quality of life of trial participants was assessed at baseline (pre and post injury), six, ten, 16, and 24 weeks, and 12 months post-randomization using the EuroQol five-dimension five-level (EQ-5D-5L) instrument.[14] The EQ-5D-5L defines health in relation to five domains: mobility, self-care, usual activities, pain and discomfort, anxiety, and depression. Each domain is expressed in five levels of increasing severity ranging from no problems to extreme problems.

Responses to the EQ-5D-5L instrument were converted to utilities by mapping responses from the EQ-5D-5L to the EuroQol five-dimension three-level (EQ-5D-3L) valuation set using a mapping function[15] as recommended by NICE.[16] QALYs were generated for each patient using the trapezoidal rule.

Statistical analysis. Analysis followed intention to treat (ITT) principles, providing summaries, and estimates of effects based on allocated (as per randomization) treatment groups. Free text resource-use responses were recoded within cost categories where possible or removed if they were deemed not relevant to the trial treatments by clinical experts. Resource use categories, costs, and utilities were summarized by trial arm and differences were tested for statistical significance by independent-samples *t*-test. A two-sided significance level of 5% was used.

Cost-utility analysis. Cost-effectiveness is presented as an incremental cost-effectiveness ratio (ICER), calculated as the ratio between of the mean difference in costs and QALYs. The removable brace was selected as the test intervention and cast as usual care (control). For the base case model, 5000 bootstrapped replicates of incremental

Table I. Mean NHS and social services costs in GBP (£) between 0 to 12 months for cases with complete data in 2019/2020 prices.

Variable	Brace (n = 335), mean (SD)	Cast (n = 334), mean (SD)	Mean difference* (95% CI)	p-value*
Inpatient care	270.75 (1921.84)	134.55 (610.32)	136.20 (-187.10 to 459.51)	0.407
Medication	15.92 (44.55)	24.52 (57.35)	-8.60 (-19.77 to 2.57)	0.131
Community health services	35.44 (92.84)	32.61 (107.97)	2.83 (-17.78 to 23.45)	0.787
Outpatient services	454.46 (494.57)	470.56 (432.02)	-16.10 (-119.05 to 86.86)	0.759
Aids and adaptation	18.75 (32.37)	23.46 (59.06)	-4.71 (-14.96 to 5.55)	0.367
Personnel social services	0 (0)	1.06 (8.83)	-1.06 (-2.47 to 0.35)	0.141
Productivity loses	3012.78 (4,137.19)	2968.13 (4,305.27)	44.64 (-847.31 to 936.59)	0.922

*Mean difference and p-value calculated using Student's *t*-test, two-tail unequal variances.
CI, confidence interval; SD, standard deviation.

Table II. Complete case EQ-5D-5L utility estimates and mean difference between the groups for those with complete data.

Health status	Brace (n = 335), mean (SD)	Cast (n = 334), mean (SD)	Mean difference* (95% CI)	p-value*
EQ-5D baseline	0.212 (0.310)	0.238 (0.311)	-0.027 (-0.074 to 0.021)	0.271
EQ-5D 0 to 6 wks	0.534 (0.258)	0.497 (0.272)	0.037 (-0.010 to 0.084)	0.120
EQ-5D 7 to 10 wks	0.660 (0.180)	0.647 (0.192)	0.013 (-0.021 to 0.047)	0.442
EQ-5D 11 to 16 wks	0.730 (0.177)	0.702 (0.198)	0.028 (-0.005 to 0.061)	0.096
EQ-5D 17 to 24 wks	0.778 (0.176)	0.767 (0.193)	0.011 (-0.023 to 0.045)	0.535
EQ-5D 25 to 52 wks	0.812 (0.192)	0.825 (0.171)	-0.013 (-0.046 to 0.020)	0.438
EQ-5D AUC	0.723 (0.153)	0.720 (0.149)	0.003 (-0.030 to 0.034)	0.890

*Mean difference and p-value calculated using Student's *t*-tests, two-tail unequal variances.
AUC, area under the curve; CI, confidence interval; EQ-5D-5L, EuroQol five-dimension five-level; SD, standard deviation.

costs and QALYs were used to populate the ICER plane, reflecting sampling uncertainty. The cost-effectiveness acceptability curve (CEAC) was generated showing the probability that brace is cost-effective compared to cast at different willingness-to-pay thresholds. The net monetary benefit (NMB) of using a removable brace was calculated at the different willingness-to-pay thresholds, where a positive incremental NMB would indicate that the brace is cost-effective compared to the cast. The expected value of perfect information (EVPI) was calculated and represented graphically, indicating the monetary value of removing all uncertainty from the cost-effectiveness estimate at a range of willingness to pay thresholds.

Missing data. Missing costs and health utility data were imputed under the missing at random (MAR) assumption, at each time point using fully conditional multiple imputation by chain equations implemented through the MICE package in Stata 16 (StataCorp, USA). The appropriateness of using MAR assumption was evaluated by investigating the missing data patterns and comparing attributes with and without missing cost and health-related quality of life data.

The multiple imputation model used baseline covariates (age, sex, and ankle fracture treatment, either operatively managed or nonoperatively managed). Unobserved costs and QALYs were imputed at each follow-up time point using observed values. Iterations of the imputation model were assessed for convergence, and the distribution of observed, imputed, and completed data for costs and QALYs were compared graphically.

Imputation was conducted separately for each trial arm in line with best practice,[17] generating 50 imputation draws. The number of draws was initially selected reflecting the extent of missing data and verified by assessing the fraction of missing information reported by the base case model. Bivariate regression using seemingly unrelated regression (Sureg) was used to estimate costs and QALYs, adjusting for baseline covariates (age, sex, and ankle fracture treatment) and baseline utility. The Mi function in Stata provided estimates for the imputed model applying Rubin's rule,[18] reflecting the variability within and across imputations. Joint distributions of costs and outcomes were generated through non-parametric bootstrapping of the imputed model, and incremental costs and QALYs were estimated.

Sensitivity analysis. Sensitivity analyses were conducted to test the robustness of the cost-effectiveness estimates. These include re-estimating the cost-effectiveness estimates (i) using complete case data (ii) adopting a wider societal perspective, including private costs incurred and productivity losses due to work absences.

Results

Completeness of data. Of 669 participants randomized, data for 228 were missing at the six-week follow-up time and 285 were missing at the 12-month follow-up. The level of missingness of data was similar in each treatment arm. Imputation was done at the aggregate resource use level at each follow-up timepoint. A detailed breakdown of the missingness of health economic data for each

Table III. Cost-effectiveness of cast compared to removable brace (£, 2019).

				Cost effectiveness threshold					
Variable	**Incremental cost (95% CI)**	**Incremental QALY (95% CI)**	**ICER**	**Probability***	**Probability†**	**Probability‡**	**NMB*, mean (95% CI)**	**NMB†, mean (95% CI)**	**NMB‡, mean (95% CI)**
Base case§	46.73 (--9 to 147)	0.014 (-.005 to 0.033)	3,318	0.81	0.84	0.88	164.52 (-191.10 to 527.21)	234.93 (-203.03 to 686.02)	375.76 (-229.72 to 1007.94)
Complete case¶	289.65 (-133 to 712)	0.013 (-0.020 to 0.047)	21,499	0.41	0.48	0.58	-87.56 (-817.6 to 597.73)	-20.19 (-880.26 to 818.70)	114.54 (-1050.34 to 1263.19)
Societal perspective§	101.42 (-495 to 697)	0.014 (-0.005 to 0.033)	7,264	0.63	0.68	0.76	108.02 (-622.48 to 836.32)	177.84 (-614.23 to 951.36	317.47 (-580.70 to 1190.58)

*At £15,000.
†At £20,000.
‡At £25,000.
§Imputed model: costs and qualtiy of life years (QALYs) adjusted for age, sex, and ankle fracture management; QALYs adjusted for baseline EuroQol five-dimension (EQ-5D).
¶Attributable costs and QALYs adjusted for age, sex, and ankle fracture management; QALYs adjusted for baseline EQ-5D.
CI, confidence interval; ICER, incremental cost-effectiveness ratio ; NMB, net monetary benefit.

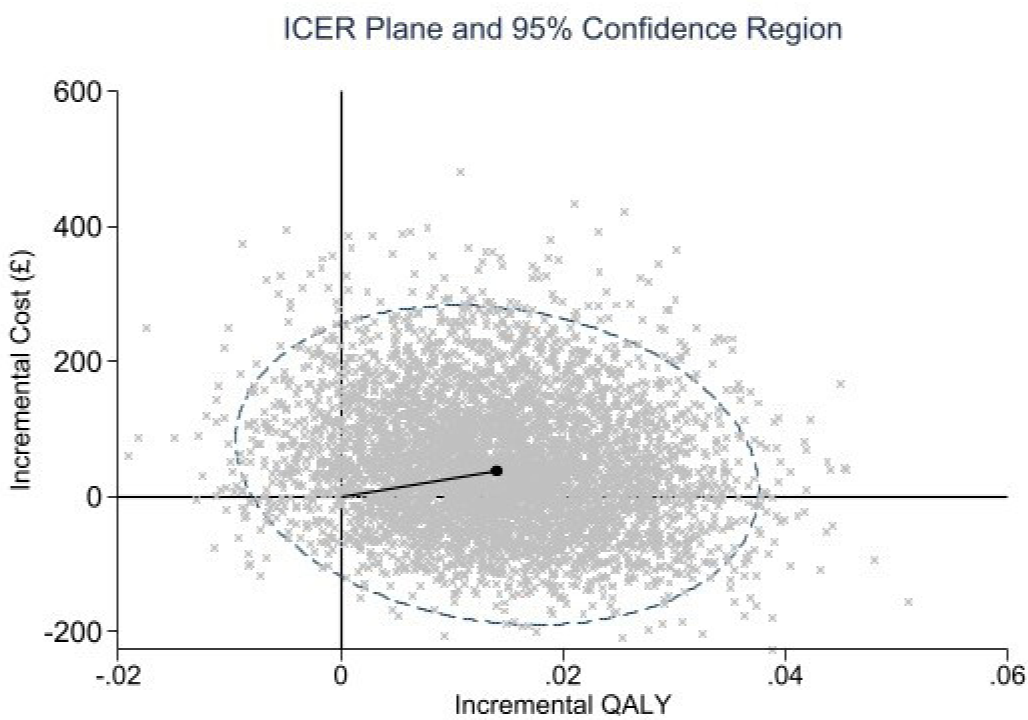

Fig. 1

Incremental cost-effectiveness ratio plane with 95% confidence region.

resource use category, and at each follow-up time point, can be found in Supplementary table i.

Health and social care costs and resource use. There were no statistically significant differences in resource use categories between the treatment groups. A detailed breakdown of the health and social care resource use by follow-up timepoints in each group can be found in Supplementary Material table ii. At follow-up time periods between baseline and 12 months, the mean NHS and PSS costs for those with complete data were also generally similar with small, non-significant differences. Intervention costs were £108.64 for removable brace and £35.71 for cast.[19] Over the entire follow-up period, mean total NHS and PSS costs were non-significantly higher in the brace group compared to the cast group. With the addition of intervention costs,[19] the mean between group difference for those with complete data was £278.08 (95% CI £-153.80 to £709.95).

Table I reports the mean cost for each resource use category, alongside productivity loses, over the follow-up

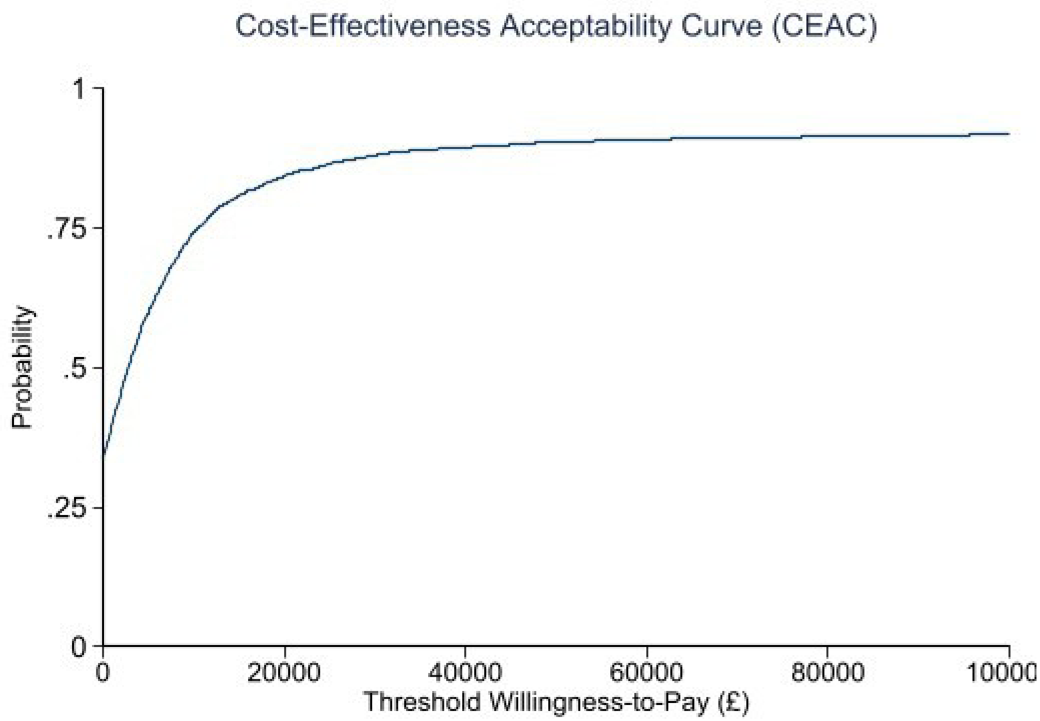

Fig. 2

Cost-effectiveness acceptability curve.

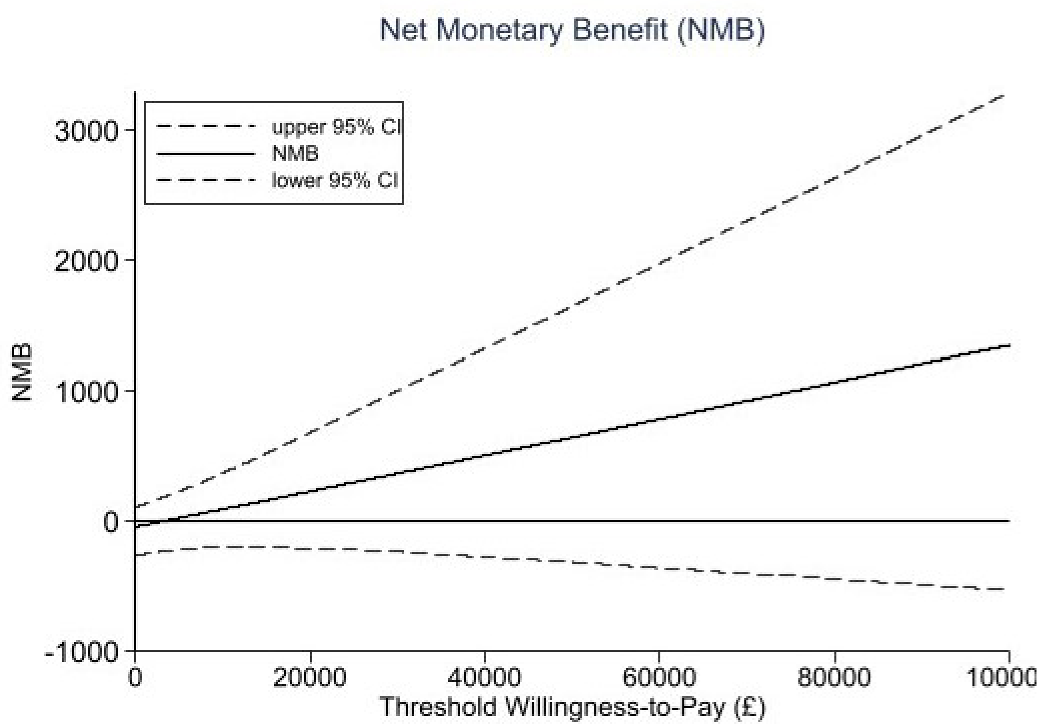

Fig. 3

Net bonetary benefit with 95% confidence interval.

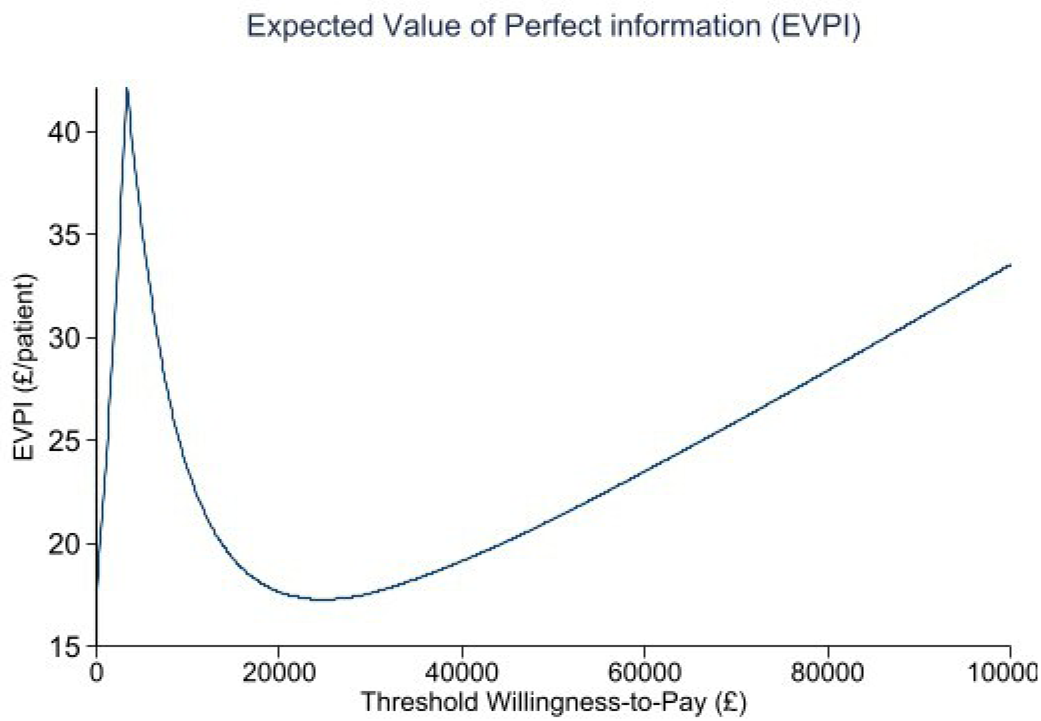

Fig. 4

Expected value of perfect information.

period for cases with complete data. A detailed breakdown of mean NHS and PSS costs, and productivity loses at each follow-up timepoint can be found in Supplementary table iii.

Health outcomes. Table II summarizes the EQ-5D utility estimates and estimated mean difference between the two trial groups for each study period. There were no statistically significant differences in EQ-5D utility between treatment groups at any time point. The mean QALYs for brace recipients were similar to cast (0.723 vs 0.720; p = 0.890). The mean difference of 0.013 was not statistically significant at a 5% level.

Cost-utility analysis. Cost effectiveness results are presented in Table III with removable brace as the intervention and cast as the control treatment. Point estimates of the incremental costs and QALYs (and 95% CIs) are presented, generated from the bootstrapped, imputed model. The probability of brace being cost-effective is presented at cost-effectiveness thresholds (£15,000, £20,000, and £30,000); the mean net monetary benefit (and 95% CI) is similarly presented. The analytic time horizon covers the period from baseline to 12 months.

Participants in the brace group had a small non-significant increase in cost (£46.73; 95% CI £-9 to £147) a small and non-statistically significant increase in QALYs (0.0141; 95% CI -0.005 to 0.033). Together, these increases result in a base case ICER of £3318 per QALY gained from the NHS and PSS perspective. Assuming thresholds of £15,000/QALY, £20,000/QALY and £30,000/QALY, the probability that the brace is cost-effective was 0.81, 0.84, and 0.88 respectively. The mean net monetary benefit was positive at the reported thresholds and the expected value of perfect information was £17.60 per patient at a threshold of £30,000/QALY. *supported* the base case findings showing brace was cost-effective at the £30,000/QALY threshold. For the complete case analysis, the ICER increased to £21,499/QALY, with a lower probability that the use of brace was cost-effective (p = 0.578 at £30,000/QALY willingness-to-pay). Figures 1 to 4 visualizes the ICER plane, EVPI, as well as the probability that brace is cost-effective and net monetary benefit of brace at varying willingness-to-pay thresholds (£0 to £100,000/QALY). Use of the brace is likely to be cost-effective at a cost-effectiveness threshold of £30,000/QALY in the population studied. However, the ICER is composed of small non-significant increases in cost and QALYs. Sensitivity analysis conducted (complete case and societal perspective) supported the base case findings showing brace was cost-effective at the £30,000/QALY threshold. For the complete case analysis, the ICER increased to £21,499/QALY, with a lower probability that the use of brace was cost-effective (p = 0.578 at £30,000/QALY willingness-to-pay).

Discussion

This study shows that use of a removable brace is likely to be cost-effective compared to use of cast among patients with ankle fracture, assuming a willingness to pay threshold of £30,000 per QALY.[20] Removable brace had a non-statistically significant incremental cost of £47 compared to cast and an incremental QALY gain of 0.014.

This is the first within-trial economic evaluation to consider the cost-effectiveness of a removable brace compared to a cast in the management of adults with ankle fracture. A previous study, in a paediatric population, found a removable brace to be a cost-effective alternative to casting in the management of low-risk ankle fracture.[21] Another study found a removable brace to be a cost-effective alternative to a cast in the management of patients with Achilles tendon rupture[19] Thus, our results showing removable brace as a cost-effective alternative to casting are consistent with previous findings following other injuries.

A strength of this study was the large number of participants in one of the largest RCTs among adult patients with ankle fracture. The comprehensive assessment of health and social care resource use at various timepoints further strengthens the study. A limitation was the extent of missing data which may challenge the internal validity of the study. However, sensitivity analysis supported the conclusion of the base case analysis. Another limitation is that medication and aids and adaptation costs were not collected beyond 24 weeks' follow-up. This was, however, unlikely to affect the results as the mean difference in medication and aids and adaptation costs at earlier timepoints was very small.

In conclusion, this study provides robust evidence that functional brace is a cost-effective alternative to cast in operatively and nonoperatively managed adult patients with ankle fracture under commonly assumed thresholds of societal willingness to pay.

Take home message

- This is the first study to examine the cost-effectiveness of removable brace compared with cast in the management of operatively and nonoperatively managed adult patients with ankle fracture.
- Ankle fractures represent a major trauma workload in the UK and this study provides evidence that a removable brace is a cost-effective alternative to cast in managing patients with a fracture of the ankle.

Supplementary material

Tables showing missingness of data, use of health and social care resources, and mean NHS and social services costs at follow-up periods.

References

1. **Jennison T**, **Brinsden M**. Fracture admission trends in England over a ten-year period. *Ann R Coll Surg Engl*. 2019;101(3):208–214.
2. **Court-Brown CM**, **Duckworth AD**, **Clement ND**, **McQueen MM**, **et al**. Fractures in older adults. A view of the future? *Injury*. 2018;49(12):2161–2166.
3. **Murray AM**, **McDonald SE**, **Archbold P**, **Crealey GE**, **et al**. Cost description of inpatient treatment for ankle fracture. *Injury*. 2011;42(11):1226–1229.
4. **Richey JM**, **Ritterman Weintraub ML**, **Schuberth JM**. Incidence and Risk Factors of Symptomatic Venous Thromboembolism Following Foot and Ankle Surgery. *Foot Ankle Int*. 2019;40(1):98–104.
5. **Hedström M**, **Ahl T**, **Dalén N**. Early postoperative ankle exercise. A study of postoperative lateral malleolar fractures. *Clin Orthop Relat Res*. 1994;300:193–196.
6. **Kearney Ret al**. Use of cast immobilisation versus removable brace in adults with an ankle fracture: multicentre randomised controlled trial. *BMJ*. 2021;374.
7. **Kearney RS**, **McKeown R**, **Stevens S**, **et al**. Cast versus functional brace in the rehabilitation of patients treated for an ankle fracture: protocol for the UK study of ankle injury rehabilitation (AIR) multicentre randomised trial. *BMJ Open*. 2018;8(12):e027242.
8. **NICE**. Guide to the methods of technology appraisal. April 4, 2013. https://www.nice.org.uk/process/pmg9/chapter/foreword (date last accessed 20 April 2022).
9. **NHS Digital**. Prescription Cost Analysis–England 2019. https://www.nhsbsa.nhs.uk/statistical-collections/prescription-cost-analysis-england/prescription-cost-analysis-england-2019 (date last accessed 2019).
10. **Joint Formulary Committee**. *BNF 77 (British National Formulary)*. Pharmaceutical Press, 2019.
11. **NHS Improvement**. Reference costs. In: *NHS Improvement. Highlights, Analysis and Introduction to the Data November*. 2018. https://www.england.nhs.uk/publication/2018-19-national-cost-collection-data-publication/ (date last accessed 20 April 2022).
12. **Curtis LA**, **Burns A**. *Unit Costs of Health and Social Care*. Kent, UK: Personal Social Services Research Unit, 2019: 176.
13. **Curtis L**, **Burns A**. Inflation indices. In: *Unit Costs of Health and Social Care*. Kent, UK: Personal Social Services Research Unit, 2018: 166.
14. **Herdman M**, **Gudex C**, **Lloyd A**, **et al**. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L. *Qual Life Res*. 2011;20(10):1727–1736.
15. **van Hout B**, **Janssen MF**, **Feng Y-S**, **et al**. Interim scoring for the EQ-5D-5L: mapping the EQ-5D-5L to EQ-5D-3L value sets. *Value Health*. 2012;15(5):708–715.
16. **NICE**. Position statement on use of the EQ-5D-5L value set for England. October 2019. https://www.nice.org.uk/about/what-we-do/our-programmes/nice-guidance/technology-appraisal-guidance/eq-5d-5l (date last accessed 20 April 2022).
17. **Faria R**, **Gomes M**, **Epstein D**, **White IR**, **et al**. A guide to handling missing data in cost-effectiveness analysis conducted within randomised controlled trials. *Pharmacoeconomics*. 2014;32(12):1157–1170.
18. **Little RJ**, **Rubin DB**. *Statistical Analysis with Missing Data*. Vol 793. John Wiley & Sons, 2019.
19. **Costa ML**, **Achten J**, **Marian IR**, **et al**. Plaster cast versus functional brace for non-surgical treatment of Achilles tendon rupture (UKSTAR): a multicentre randomised controlled trial and economic evaluation. *Lancet*. 2020;395(10222):441–448.
20. **Claxton K**, **Sculpher M**, **Palmer S**, **Culyer AJ**, **et al**. Causes for concern: is NICE failing to uphold its responsibilities to all NHS patients? *Health Econ*. 2015;24(1):1–7.
21. **Boutis K**, **Willan AR**, **Babyn P**, **Narayanan UG**, **Alman B**, **Schuh S**, **et al**. A randomized, controlled trial of A removable brace versus casting in children with low-risk ankle fractures. *Pediatrics*. 2007;119(6):e1256-63.

Author information:
- H. Nwankwo, PhD, Research Fellow in Health Economics
- J. Mason, PhD, Professor in Health Economics
- H. Parsons, PhD, Associate Professor in Medical Statistics
- A. Haque, MSc, Research Associate in Medical Statistics
- R. S. Kearney, PhD, Professor of Trauma and Orthopaedic Rehabilitation
Warwick Clinical Trials Unit, University of Warwick, Coventry, UK.
- M. L. Costa, PhD, Professor of Orthopaedic Trauma, Oxford Trauma and Emergency Care, Nuffield Department of Rheumatology, Musculoskeletal and Orthopaedic Sciences, University of Oxford, Oxford, UK.
- N. Parsons, PhD, Associate Professor in Medical Statistics, Warwick Medical School, University of Warwick, Coventry, UK.
- A. Redmond, PhD, Professor of Clinical Biomechanics, Leeds Institute for Rheumatic and Musculoskeletal Medicine, University of Leeds, Leeds, UK.

Author contributions:
- H. Nwankwo: Data curation, Formal analysis, Writing – original draft.
- J. Mason: Conceptualization, Project administration, Formal analysis, Writing – review & editing.
- M. L. Costa: Conceptualization, Visualization, Investigation, Writing – review & editing.
- N. Parsons: Conceptualization, Visualization, Writing – review & editing.
- A. Redmond: Conceptualization, Visualization, Writing – review & editing.
- H. Parsons: Conceptualization, Visualization, Writing – review & editing.
- A. Haque: Visualization, Writing – review & editing.
- R. S. Kearney: Conceptualization, Visualization, Investigation, Writing – review & editing.

Funding statement:

- This study was funded through a National Institute of Health Research (NIHR) research grant. Publication of the article was funded by the University of Warwick, UK.

ICMJE COI statement:

- M. L. Costa reports that the University of Oxford receives research grants from the National Institute for Health Research (NIHR), Wellcome, EU, industry and charities for research into musculoskeletal trauma; H. Parsons reports NIHR funding and funding for RCTs in rehabilitation and orthopaedics, paid to institution; A. Hague and J. Mason report funding by the NIHR rellowship; and R. Kearney, N. Parsons, and H. Nwankwo declare an NIHR payment made to University of Warwick.

Acknowledgements:

- The authors acknowledge Martin Underwood, PhD, Professor of Clinical Trials; Rebecca McKeown, Trial Manager; Siobhan Kefford, Trial Manager; and Jaclyn Brown, Deputy Head of Operations.

Open access funding

- The authors report that they received open access funding for this manuscript from the University of Warwick (institution ID:RINGGOLD-2707).