■ TRAUMA

Acetabular Fractures in older patients Intervention Trial (AceFIT): a feasibility triple-arm randomized controlled study

A. Carrothers,
R. O'Leary,
P. Hull,
D. Chou,
J. Alsousou,
J. Queally,
S. J. Bond,
M. L. Costa

From Addenbrookes, Cambridge University NHS Foundation Trust, Cambridge, UK

Aims

To assess the feasibility of a randomized controlled trial (RCT) that compares three treatments for acetabular fractures in older patients: surgical fixation, surgical fixation and hip arthroplasty (fix-and-replace), and non-surgical treatment.

Methods

Patients were recruited from seven UK NHS centres and randomized to a three-arm pilot trial if older than 60 years and had a displaced acetabular fracture. Feasibility outcomes included patients' willingness to participate, clinicians' capability to recruit, and dropout rates. The primary clinical outcome measure was the EuroQol five-dimension questionnaire (EQ-5D) at six months. Secondary outcomes were Oxford Hip Score, Disability Rating Index, blood loss, and radiological and mobility assessments.

Results

Between December 2017 and December 2019, 60 patients were recruited (median age 77.4 years, range 63.3 to 88.5) (39/21 M/F ratio). At final nine-month follow-up, 4/60 (7%) had withdrawn, 4/60 (7%) had died, and one had been lost to follow-up; a 98% response rate (50/51) was achieved for the EQ-5D questionnaire. Four deaths were recorded during the three-year trial period: three in the non-surgical treatment group and one in the fix-and-replace group.

Conclusion

This study has shown a full-scale RCT to be feasible, but will need international recruitment. The Acetabular Fractures in older patients Intervention Trial (AceFIT) has informed the design of a multinational RCT sample size of 1,474 or 1,974 patients for a minimal clinically important difference of 0.06 on EQ-5D, with a power of 0.8 or 0.9, and loss to follow-up of 20%. This observed patient cohort comprises a medically complex group requiring multidisciplinary care; surgeon, anaesthetist, and ortho-geriatrician input is needed to optimize recovery and rehabilitation.

Cite this article: *Bone Joint J* 2024;106-B(4):xxx–xxx.

Introduction

There are approximately 2,000 acetabular fractures each year in the UK. More than 70% occur in patients older than 65 years, where the incidence is rising.[1,2] This is leading to an increasing burden on health systems. The Swedish Fracture Register has described acetabular fracture epidemiology, concluding that the one-year mortality for elderly patients with acetabular fracture is similar to the mortality after hip fracture, and that a similar multidisciplinary approach to care for these patients should be considered.[3] Current treatments for acetabular fractures in older patients include non-surgical management, surgical intervention with open reduction internal fixation, and surgical fixation with simultaneous hip arthroplasty (fix-and-replace).[4,5]

Non-surgical treatment involves the patient keeping full weight off the affected leg until the fracture has healed, leading to an increase in comorbidities (chest infection and pressure sores), prolonged immobility, delayed rehabilitation, and

Correspondence should be sent to A. Carrothers; email: andrewdcarrothers@gmail.com

doi:10.1302/0301-620X.106B4.BJJ-2023-1080.R1 $2.00

Bone Joint J 2024;106-B(4):xxx–xxx.

Table I. Characteristics of study participants at baseline.

Variable	SF	SF + HA	NST	Total
Patients, n	19	21	20	60
Median age, yrs (range)	71.7 (63.3 to 88.5)	79.2 (65 to 92.4)	82.5 (62.1 to 94.8)	76.6 (62.1 to 94.8)
Sex, n (%)				
Female	4 (21)	12 (57)	5 (25)	21 (35)
Male	15 (79)	9 (43)	15 (75)	39 (65)
Median BMI, kg/m² (range)	24.3 (19.3 to 36.7)	25 (17.6 to 36.7)	24 (18.1 to 34.6)	24.6 (17.6 to 36.7)
Smoking status, n (%)				
Ex-smoker	7 (37)	9 (43)	7 (35)	23 (38)
Never smoked	11 (58)	9 (43)	12 (60)	32 (53)
Currently smokes	1 (5)	3 (14)	1 (5)	5 (8)
Consumes alcohol, n (%)				
Yes	14 (74)	9 (43)	8 (40)	31 (52)
No	5 (26)	12 (57)	12 (60)	29 (48)
Mean alcohol units consumed	9	9	9	9
Median Abbreviated Mental Test Score (range)	10 (4 to 10)	10 (2 to 10)	10 (2 to 10)	10 (2 to 10)
Sufficient mental capacity, n (%)				
Yes	16 (84)	17 (81)	17 (85)	50 (83)
No	3 (16)	4 (19)	3 (15)	10 (17)

NST, non-surgical treatment; SD, standard deviation; SF, surgical fixation; SF + HA, surgical fixation and hip arthroplasty.

frequent failure to return to the pre-injury level of function and independence.[6] Furthermore, as the hip joint anatomy has not been restored, patients may also exhibit compromised hip function and quality of life.[7,8] Surgical fixation has the advantage of restoring the hip joint anatomy, however as the bone is generally of poorer quality, full weightbearing is not permitted on the affected leg until healing allows. Moreover, fracture reduction with joint congruency can be difficult to achieve and maintain in this patient cohort. Approximately 30% of operatively or nonoperatively managed fractures require conversion to total hip arthroplasty (THA) within five years from injury.[9]

In contrast, fix-and-replace involves simultaneous surgical fixation of the acetabular fracture with hip arthroplasty. This has the advantage of allowing patients to weightbear immediately, which would bring care in line with National Institute of Health Care and Excellence (NICE) guidelines for the management of hip fractures and may enable patients to regain function earlier.[10] The potential downsides to fix-and-replace include a longer operating time, increased blood loss, a higher risk of hip dislocation and infection, a higher risk of early prosthesis failure, and increased cost.

There is no clear evidence to guide surgeons in deciding between these treatments. A recent systematic review and meta-analysis indicated that fix-and-replace had functional outcomes and complication rates similar to open reduction and internal fixation and delayed THA, but offered lower revision rates, although the quality of studies was mixed.[7] The aim of this study was to assess the feasibility of conducting a full-scale, appropriately powered, randomized controlled trial (RCT) between surgical treatments for acetabular fractures in older patients.

Methods

The objective of this trial was to assess the feasibility of conducting a full-scale, appropriately powered RCT. An Acetabular Fractures in older patients Intervention Trial (AceFIT) feasibility trial in advance of a future definitive RCT was reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) statement 2010.[11]

Seven NHS major trauma centres (MTCs) in the UK recruited study participants if they were older than 60 years, had a displaced acetabular fracture where the treating surgeon considered it to be sufficiently displaced to consider surgery, and if appropriate consent had been obtained. Exclusion criteria included open fractures, contraindication to anaesthesia, total/partial hip arthroplasty in situ, immobility prior to injury, and other injuries that would influence surgery, recovery, or rehabilitation.

The randomization sequence was generated by the Cambridge Clinical Trials Unit through a secure web-based randomization service on a 1:1:1 basis, using the minimization technique of Pocock and Simon[12] and capacity status (with and without) as a minimization factor.

Interventions. Each patient was randomized to non-surgical treatment, surgical fixation, or fix-and-replace performed at the next opportunity. Each participating centre had surgeons appropriately trained in both surgical fixation and fix-and-replace, and both procedures were routinely performed at each centre. There was no blinding to group assignment of participants, caregivers, and those assessing the objectives.

In the non-surgical treatment group, the exact form of treatment was left to the treating consultant surgeon, with weightbearing being encouraged as early as possible. In the surgical fixation group, although the principles of internal fixation were inherent to the procedure, the details of the surgery were left to the treating consultant surgeon to ensure that results could be generalized. Patients were rehabilitated, with weightbearing being encouraged as early as possible. In the fix-and-replace group, although the principles of internal fixation and hip

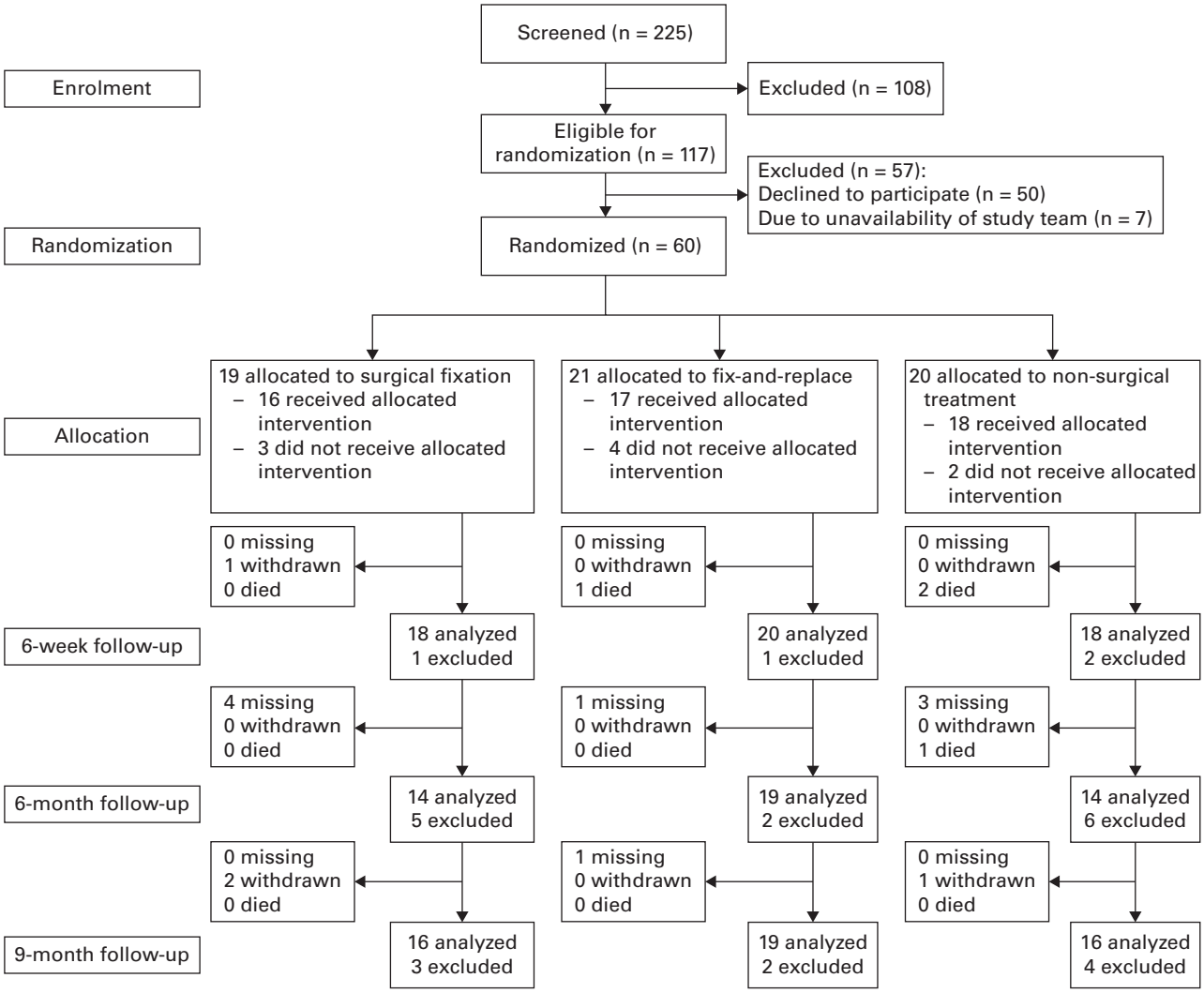

Fig. 1

Consolidated Standards of Reporting Trials diagram.

arthroplasty were inherent in the procedure, the techniques used were left to the treating consultant surgeon to ensure that results could be generalized. Patients were rehabilitated with immediate full weightbearing. Operation details, postoperative care, and weightbearing variables were recorded within the data collection set.

Outcomes. Feasibility was assessed by the willingness of patients to participate and of clinicians to recruit, the drop-out rates, the ability to capture all data, estimates of standard deviation (SD) to inform the sample size calculation for the full trial, and completion rates to inform design of a future definitive trial.

The primary clinical outcome measure was the EuroQol five-dimension questionnaire (EQ-5D) at six months following injury. The EuroQol five-dimension five-level (EQ-5D-5L) version was used, which provides a health description based on five dimensions.[13] The EQ-5D health status instrument was chosen, as it is validated for completion by proxy in patients with cognitive impairment and for use in older patients sustaining other hip fractures.[14,15] The primary outcome time was chosen to be at six months after injury because the majority of functional recovery will have been achieved in this timeframe, without a significant loss of patients to death.

As recommended by NICE,[16] EQ-5D responses were converted to health state utility values using the cross-walk method, [17] and if death occurred during the study patients were assigned a score of 0 (a score of 1 is equivalent to full health).[18]

The secondary outcome measures included the Oxford Hip Score (OHS)[19,20] and the Disability Rating Index (DRI).[21] Both the OHS (0 to 48, where 48 represents best function) and DRI (0 to 100, where 100 denotes complete disability) are self-administered patient questionnaires assessing symptoms and disability related to the lower limb.[21,22] These scores were only collected for patients without cognitive impairment as they are not validated for collection by proxy. The EQ-5D and secondary outcome measures were completed in person at baseline, six weeks, and nine months, and by post or telephone at

Table II. Medical comorbidities at the time of presentation and study enrolment.

Variable	SF	SF + HA	NST	Total
Patients, n	19	21	20	60
Clinically significant conditions prior to injury, n (%)				
Yes	18 (95)	21 (100)	20 (100)	59 (98)
No	1 (5)	0 (0)	0 (0)	1 (2)
Medical condition, n (%)				
Asthma/COPD	2 (10.5)	5 (23.8)	4 (20)	11 (18.3)
CVA/TIA	2 (10.5)	1 (4.8)	2 (10)	5 (8.3)
Dementia	1 (5.3)	2 (9.5)	2 (10)	5 (8.3)
Diabetes	4 (21.1)	6 (28.6)	6 (30)	16 (26.7)
DVT/PE	0 (0)	3 (14.3)	1 (5)	4 (6.7)
Cardiac disease	8 (42.1)	2 (9.5)	7 (35)	17 (28.3)
Hypertension	8 (42.1)	14 (66.7)	10 (50)	32 (53.3)
Malignancy	1 (5.3)	2 (9.5)	2 (10)	5 (8.3)
Osteoarthritis	4 (21.1)	4 (19)	3 (15)	11 (18.3)
Parkinson's disease	1 (5.3)	0 (0)	0 (0)	1 (1.7)
Rheumatoid arthritis	1 (5.3)	1 (4.8)	0 (0)	2 (3.3)
Other	11 (57.9)	15 (71.4)	15 (75)	41 (68.3)

COPD, chronic obstructive pulmonary disease; CVA, cerebral vascular accident; DVT, deep vein thrombosis; HA, hip arthroplasty; NST, non-surgical treatment; PE, pulmonary embolism; SF, surgical fixation; TIA, transient ischaemic attack.

Table III. Oxford Hip Scores from pre-fracture baseline to nine months, across the three treatment arms.

Median OHS (range)	SF	SF + HA	NST	Total
Baseline	47 (10 to 48)	43 (12 to 48)	44 (2 to 48)	44 (2 to 48)
n	17	17	17	51
6 wks	20 (7 to 42)	27 (4 to 41)	19 (0 to 46)	22.5 (0 to 46)
n	16	17	15	48
6 mths	33 (0 to 45)	38 (7 to 47)	34 (9 to 48)	35 (0 to 48)
n	11	17	10	38
9 mths	40.5 (8 to 48)	43 (4 to 48)	34 (7 to 48)	39 (4 to 48)
n	14	16	13	43

NST, non-surgical treatment; SF, surgical fixation; SF + HA, surgical fixation and hip arthroplasty.

Table IV. EuroQol five-dimension five-level questionnaire sample size calculation, using pooled standard deviation of the six-month utility score (not adjusted or corrected for baseline).

Power	MCID	SD	n (95% CI)
0.9	0.03	0.411	7,890 (5,464 to 12,338)
0.9	0.06	0.411	1,974 (1,366 to 3,086)
0.9	0.08	0.411	1,110 (770 to 1,736)
0.8	0.03	0.411	5,894 (4,082 to 9,218)
0.8	0.06	0.411	1,474 (1,022 to 2,306)
0.8	0.08	0.411	830 (574 to 1,298)

CI, confidence interval; MCID, minimal clinically important difference; SD, standard deviation.

six months. Complications were collected and grouped as either intraoperative or postoperative.

Nine-month follow-up radiographs (standard anterior-posterior pelvis, lateral hip, and Judet acetabular views) were used to evaluate Tönnis-grade osteoarthritis,[23] malalignment/femoral head medialization, femoral head collapse, fracture union, metalwork failure, and any other fixation or arthroplasty issues.

Sample size. As this was a feasibility trial, no sample size calculation was performed. The aim was to collect primary clinical outcome data on a minimum of 36 patients (at least 12 in each arm) to inform a sample size calculation for a full-scale randomized trial.[24] Therefore, a target recruitment of 60 patients was set, which, allowing for 20% loss to follow-up and 20% mortality at six months, would generate six-month follow-up data for 36 patients. The analysis was performed on an intention-to-treat basis and included all eligible patients that received any study treatment and had at least one post-baseline assessment. A pooled estimate of the SD of the primary outcome was calculated to inform the sample size of a future trial.

Statistical analysis. Forest plots of the EQ-5D utility index, DRI, and OHS by treatment and time were produced. Pre-planned exploratory analyses of the EQ-5D, DRI, and OHS by age (below 70 years, above 70 years and below 80 years, above 80 years) were undertaken in a similar manner. For the EQ-5D outcomes, exploratory analysis by capacity status (with/without) was also undertaken. All analysis was carried out with the software R (R Foundation for Statistical Computing, Austria).

Results

From 1 December 2017 to 23 December 2019, 225 patients were screened, of whom 117 were found to be eligible for the trial (Figure 1). Of these, 50 declined to participate and seven were not randomized as the research team were unavailable; 60 patients were therefore randomized. Cambridge University NHS Foundation Trust (lead site) contributed 38/60 (63%) of the recruited patients.

Nine (15%) participants did not receive the intervention to which they had been assigned: two participants randomized to non-surgical treatment instead underwent surgery (one fix-and-replace and one THA with bone graft); three participants randomized to surgical fixation received non-surgical treatment,[3] THA,[3] and fix-and-replace;[3] two participants randomized

Table V. Injury characteristics.

Variable	SF	SF + HA	NST	Tota
Patients, n	19	21	20	60
Acetabular fracture side, n (%)				
Left	8 (42)	10 (48)	15 (75)	33 (55)
Right	11 (58)	11 (52)	5 (25)	27 (45)
Fracture type, n (%)				
ABC	4 (21)	3 (14)	1 (5)	8 (14)
Anterior column post hemitransverse	9 (47)	12 (57)	14 (70)	35 (59)
Transverse	0 (0)	1 (5)	0 (0)	1 (2)
Transverse + post wall	1 (5)	1 (5)	1 (5)	3 (5)
T type	1 (5)	0 (0)	0 (0)	1 (2)
Anterior column	2 (11)	2 (10)	2 (10)	6 (10)
Posterior column	0 (0)	1 (5)	1 (5)	2 (3)
Other	2 (11)	1 (5)	1 (5)	3 (5)
Mechanism of injury, n (%)				
High-energy fall	4 (21)	3 (14)	1 (5)	8 (13)
Low-energy fall	13 (68)	16 (76)	17 (85)	46 (77)
Road traffic accident	1 (5)	1 (5)	2 (10)	4 (7)
Other	1 (5)	1 (5)	0 (0)	2 (3)
Other significant injuries, n (%)				
Yes	4 (21)	4 (19)	6 (30)	14 (23)
No	15 (79)	17 (81)	14 (70)	46 (77)
Admission haemoglobin, g/dL				
Mean (SD)	11.8 (1.6)	11.6 (1.9)	11.1 (2.1)	11.5 (1.8)
Median (range)	11.8 (9.2 to 14.9)	11.1 (9.1 to 15.2)	11.3 (6.2 to 14.8)	11.2 (6.2 to 15.2)
Time to MTC admission, days				
Mean (SD)	6.3 (11.7)	3.0 (3.1)	3.2 (3.1)	4.1 (7.1)
Median (range)	2 (0 to 42)	2 (0 to 10)	2.5 (0 to 11)	2 (0 to 42)

MTC, major trauma centre; NST, non-surgical treatment; SF, surgical fixation; SF + HA, surgical fixation and hip arthroplasty.

to fix-and-replace instead received non-surgical treatment;[4] and two participants randomized to fix-and-replace underwent surgical fixation only.[4] In all cases, the decision was made by the treating surgeon in the best interests of the participant.

Participants crossing treatment arms were included in all analyses on an intention-to-treat basis. A total of 51 (85%) patients were followed up for nine months and completed three monthly EQ-5Ds, DRIs, and OHSs (four deaths, four withdrawn, one had a private THA, one lost to follow-up). Regarding treatment groups, data were available for 16/20 (84%) for the non-surgical treatment group, 16/19 (84%) for the surgical fixation group, and 19/21/ (90%) for the fix-and-replace group (see Table I).

Patient characteristics are shown in Table I. Briefly, the median age was 77.4 years (63.3 to 88.5), 39/60 (65%) were male, the median BMI was 25 kg/m^2 (18 to 37), 83% of patients (n = 50) had full mental capacity, and 70% (n = 42) were admitted from their own home. Overall, 77% of fractures (n = 46) were due to falls from standing height and 59% (n = 35) were classified as anterior column posterior hemitransverse. Table II shows the relevant clinical details for the study group and indicates that 59/60 patients had significant medical comorbidities, however there were no observed differences between age, BMI, mental capacity, or alcohol or smoking habits.

Feasibility outcomes. Of the 117 eligible patients, 50 declined to participate in the trial, while the clinicians were reported to be happy to recruit all eligible patients to the trial. Four of the 60 (7%) patients recruited to the trial withdrew by the final nine-month review. During the follow-up period after randomization, four (7%) patients died, and one patient (2%) was lost to follow-up.

At the six-week follow-up, 56/56 (100%) of remaining participant EQ-5D questionnaires were received and were completed either by the participant or by a proxy. At the six-month follow-up, 85% (47/55) of questionnaires were received and at the final nine-month follow-up 98% (50/51) were received.

As patients lacking mental capacity could not complete the OHS or DRI, fewer patients completed these at each timepoint compared to the EQ-5D, however for those with capacity the return rates were very good. For both OHS and DRI, the return rate for those with capacity was 100% at six-week follow-up, 97% at six-month follow-up, and 100% at nine-month follow-up. All data relating to perioperative physiological variables had good completion rates.

OHSs from pre-fracture baseline to nine months, across the three treatment arms, are shown in Table III, while Table IV shows sample-size estimations using pooled SDs of the six-month EQ-5D (not adjusted or corrected for baseline), with 95% confidence intervals (CIs) for a two-arm (surgical fixation vs fix-and-replace) randomized trial with 80% and 90% power and minimum clinically important differences of 0.03, 0.06, and 0.08.

Clinical outcomes. Acetabular fracture injury characteristics are described in Table V, and patients' social and mobility history is described in Table VI.

Table VI. Social and mobility history.

Variable	SF	SF + HA	NST	Total
Patients, n	19	21	20	60
Location from which patients were admitted, n (%)				
Own home	16 (84)	13 (62)	13 (65)	42 (70)
Nursing home - nursing care provided	0 (0)	1 (5)	0 (0)	1 (2)
Warden accommodation	0 (0)	0 (0)	1 (5)	1 (2)
Another hospital	0 (0)	5 (24)	5 (25)	10 (17)
Family/friends	2 (11)	0 (0)	1 (5)	3 (5)
Other	1 (5)	2 (10)	0 (0)	3 (5)
Home support, n (%)				
Lives alone	4 (21)	11 (52)	6 (30)	21 (35)
Lives with someone	15 (79)	7 (33)	13 (65)	35 (58)
Lives with carers	0 (0)	1 (5)	0 (0)	1 (2)
Home care package	0 (0)	0 (0)	1 (5)	1 (2)
Institution care	0 (0)	2 (10)	0 (0)	2 (3)
Mobility limitation, n (%)				
None	11 (58)	10 (48)	14 (70)	35 (58)
Pain	1 (5)	1 (5)	1 (5)	3 (5)
Breathlessness	4 (21)	4 (19)	2 (10)	10 (17)
Other	3 (16)	6 (29)	3 (15)	12 (20)
Walking distance without rest (m), n (%)				
Patient could walk more than 800 m (1/2 mile)	10 (53)	3 (14)	10 (50)	23 (38)
Patient could walk up to 800 m (1/2 mile)	2 (11)	8 (38)	6 (30)	16 (27)
Patient could walk up to 400 m (1/4 mile)	1 (5)	6 (29)	1 (5)	8 (13)
Patient could walk less than 100 m	6 (32)	4 (19)	3 (15)	13 (22)
Mobility score, n (%)				
None, patient bedbound	0 (0)	0 (0)	0 (0)	0 (0)
Chair transfer	0 (0)	0 (0)	0 (0)	0 (0)
Mobilize with assistance of 2	0 (0)	0 (0)	1 (5)	1 (2)
Mobilize with assistance of 1	2 (11)	1 (5)	1 (5)	4 (7)
Independent with walking aid	7 (37)	9 (43)	8 (40)	24 (40)
Independent without walking aid	10 (53)	11 (52)	10 (50)	31 (52)

NST, non-surgical treatment; SF, surgical fixation; SF + HA, surgical fixation and hip arthroplasty.

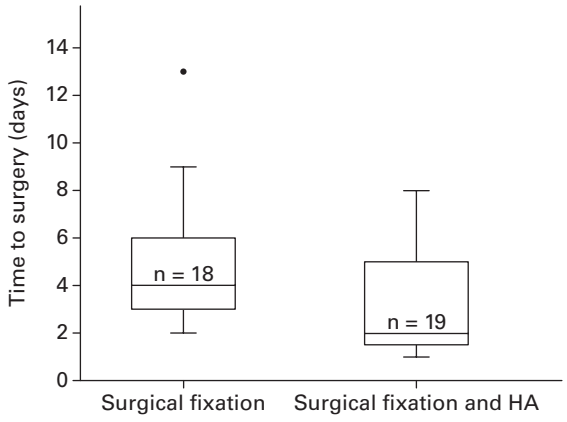

Fig. 2

Surgical arms (surgical fixation and fix-and-replace) box and whisker plots of time to surgery (days) from randomization. HA, hip arthroplasty.

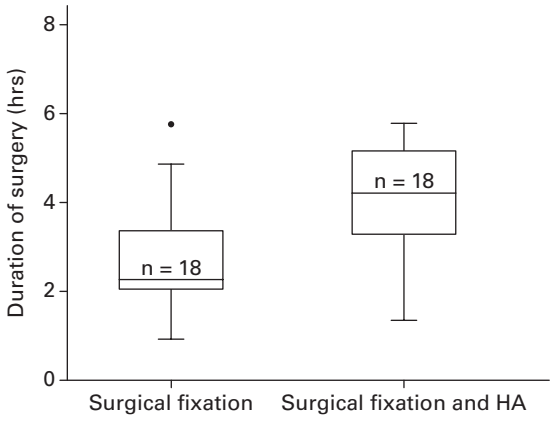

Fig. 3

Surgical arms (surgical fixation and fix-and-replace) box and whisker plots of duration of surgery including any change of patient positioning for intraoperative different surgical approaches. HA, hip arthroplasty.

The median transfer time to MTC from regional trauma units was two days following injury. The median time to surgery from randomization was four days (interquartile range (IQR) 2 to 13) for surgical fixation and two days (IQR 1 to 8) for fix-and-replace, shown in Figure 2. Median surgery time was 2.25 hours (SD 1.32) for surgical fixation and 4.2 hours (SD 1.36) for fix-and-replace, shown in Figure 3. Most surgeries were performed by a pelvic and acetabular consultant – 61%

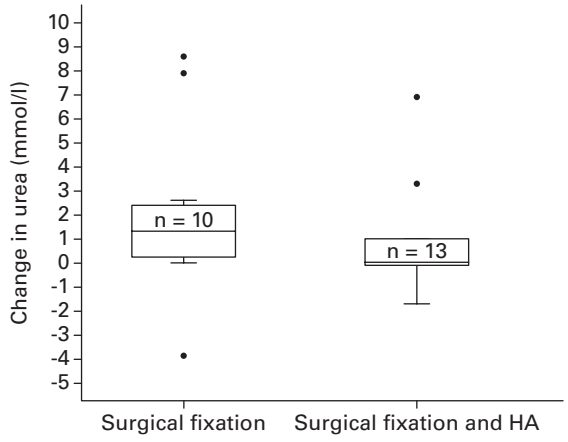

Fig. 4

Renal function (change in urea levels) after surgical fixation and fix-and-replace surgeries. HA, hip arthroplasty.

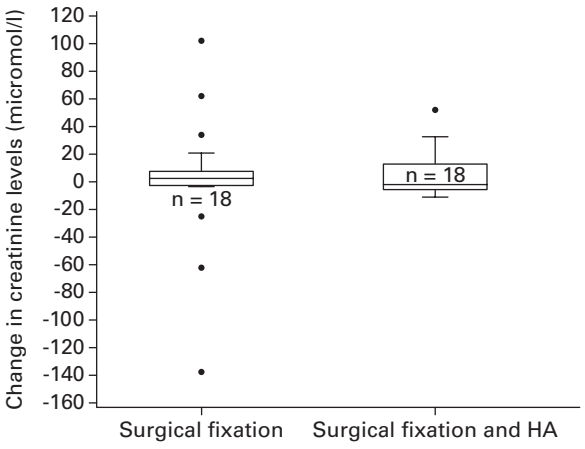

Fig. 5

Renal function (change in creatinine levels, after surgical fixation and fix-and-replace surgeries. HA, hip arthroplasty.

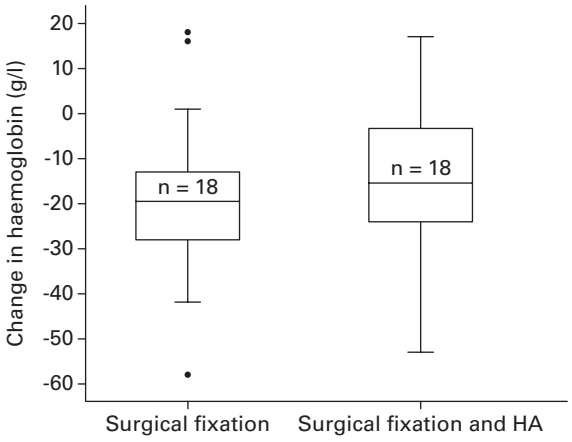

Fig. 6

Change in haemoglobin fter surgical fixation and fix-and-replace surgeries. HA, hip arthroplasty.

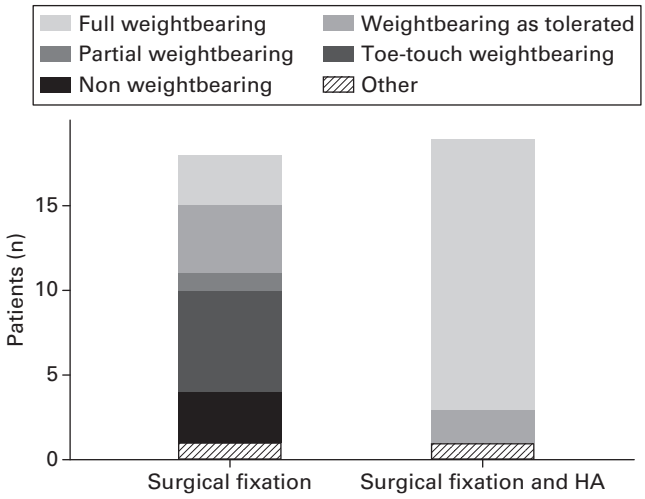

Fig. 7

Stacked bar charts representing postoperative weightbearing instructions for surgical fixation and fix-and-replace. HA, hip arthroplasty.

for surgical fixation and 79% for fix-and-replace – with the remaining surgeries being performed by a consultant-supervised pelvic fellow surgeon.

In the context of this non-powered feasibility study, there was no observed difference in renal function (change in urea levels (mmol/l) or change in creatinine levels (micromol/l) after surgical fixation or fix-and-replace (Figures 4 and 5); or in mean blood loss (surgical fixation 550 ml (93 to 3,000), fix-and-replace 600 ml (380 to 1,000)); or in transfusion, with 33% requiring transfusion in the surgical fixation group compared to 37% in the fix-and-replace group. There was also no observed difference in the mean perioperative change of haemoglobin between the two surgical procedures: surgical fixation -19.5 g/dL (-42.0 to 1.0) and fix-and-replace -15.5 g/dL (-53 to 17) (Figure 6).

The median total length of hospital inpatient stay differed between the groups: non-surgical treatment 11 days (IQR 2 to 43), fix-and-replace 12 days (IQR 6 to 50), and surgical fixation 16 days (IQR 4 to 46). Four deaths were recorded during the three-year trial period (three non-surgical treatment and one fix-and-replace). Two out of four deaths occurred within the MTC, one in the non-surgical treatment group due to pneumonia, and one in the fix-and-replace group due to sepsis. Two out of four occurred following discharge, both unrelated to their fracture or their randomized treatment.

Postoperative weightbearing instructions for the surgical arms are shown in Figure 7. There were observed differences between the groups when judged by ability to move with aids within weightbearing instructions on discharge from the MTC: 21% (4/19) for non-surgical treatment, 58% (11/19) for surgical fixation, and 85% (17/20) for fix-and-replace. There were also observed differences when judged by weightbearing through the fractured side and ‘walking’: 5% (1/19) for non-surgical

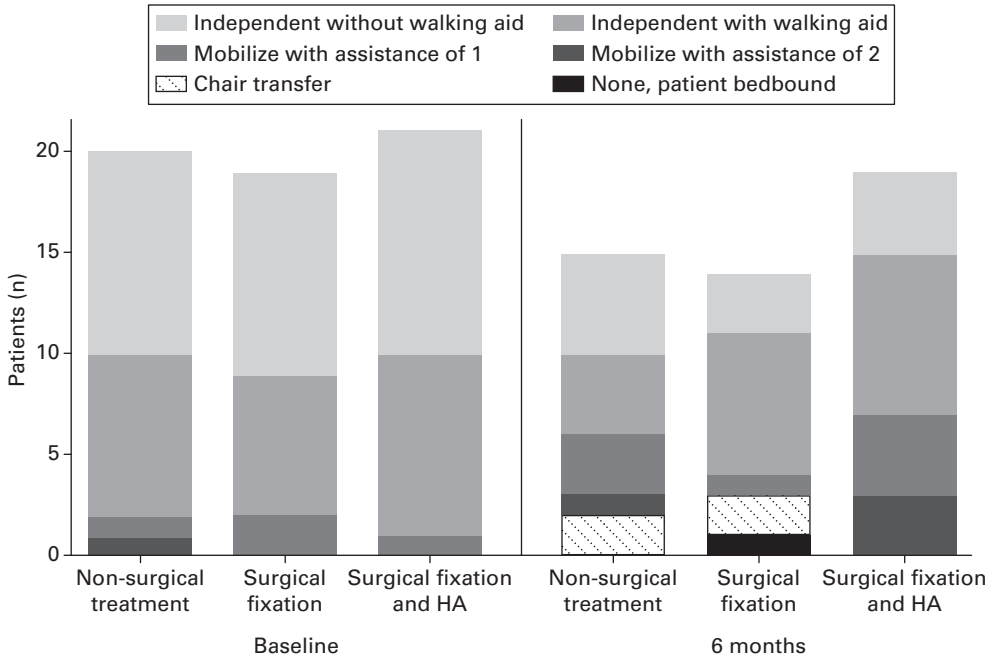

Fig. 8

Patient self-described mobility status at baseline before the acetabular fracture and at six months. HA, hip arthroplasty.

treatment, 21% (4/19) for surgical fixation, and 70% (14/20) for fix-and-replace. Patient-declared mobility before their acetabular fracture and at six months post treatment is shown in Figure 8.

Discharge from MTC to another hospital for onward rehabilitation was 68% (13/19) for non-surgical treatment, 21% (4/19) for surgical fixation, and 70% (14/20) for fix-and-replace. Additional care arrangements were necessary on final hospital discharge for 32% (6/19) for non-surgical treatment, 26% (5/19) for surgical fixation, and 15% (3/20) for fix-and-replace.

In the context of this non-powered feasibility study, Cambridge-only EQ-5D-5L Utility Score individual baseline versus change between baseline and six months, presented by treatment group, is shown in Figure 9.

Radiological evaluation. Not all data for the nine-month follow-up radiological evaluation were collected, due to the UK COVID-19 pandemic restrictions. Radiographs from the closest follow-up timepoint were used instead. Radiographs were evaluated for baseline Tönnis-grade and hip osteoarthritis defined as grade progression on nine-month final radiograph.[23] Non-surgical treatment radiological evaluation demonstrated a 100% rate of osteoarthritis, a 27% rate of femoral head collapse, and a 53% rate of fracture union. Within surgical fixation, there was an 89% rate of osteoarthritis, a 22% rate of femoral head collapse, a 69% rate of fracture union, and a 14% rate of metalwork failure. Within fix-and-replace, there was no radiological evidence of hip-prosthesis loosening or cup migration. All cemented stems had an intact cement mantle. There was a median of 1 mm cemented stem distalization within the stem centralizer at final radiograph and no fix-and-replace metalwork failure at nine months.

Complications. In total, there were 24 adverse events (AEs) reported, with no serious adverse event reported. The distribution of AEs between the treatment arms was surgical fixation 39%, fix-and-replace 28%, and non-surgical treatment 33%. For non-surgical treatment, there was one fractured neck of femur converted to fix-and-replace, one deep vein thrombosis, and two severe hip osteoarthritis progressions with pain and loss of function leading to THA within the trial period.

Within the surgical fixation cohort, there was one significant bleed intraoperatively requiring massive blood transfusion protocol, one fractured neck of femur converted to fix-and-replace, one severe hip osteoarthritis progression with pain and loss of function leading to THA within the trial period, and one ongoing severe osteoarthritic hip with pain, malunion, and femoral head medialization.

In patients who underwent fix-and-replace, there were two early THA dislocations in different patients, reported day 6 and 13 and both reduced in theatre without subsequent issues, and one superficial wound infection which was debrided in theatre without subsequent issue.

Discussion

The primary objective of this trial was to evaluate the feasibility of an appropriately powered RCT which would examine the effectiveness of fix-and-replace compared to surgical fixation as a surgical treatment for acetabular fractures in older patients. To our knowledge, there is currently no other randomized study comparing these treatment methods in acetabular fractures.

Over the two-year recruitment period, 60 patients were enrolled from seven participating centres, and while all clinicians in the study centres were supportive of recruiting all eligible

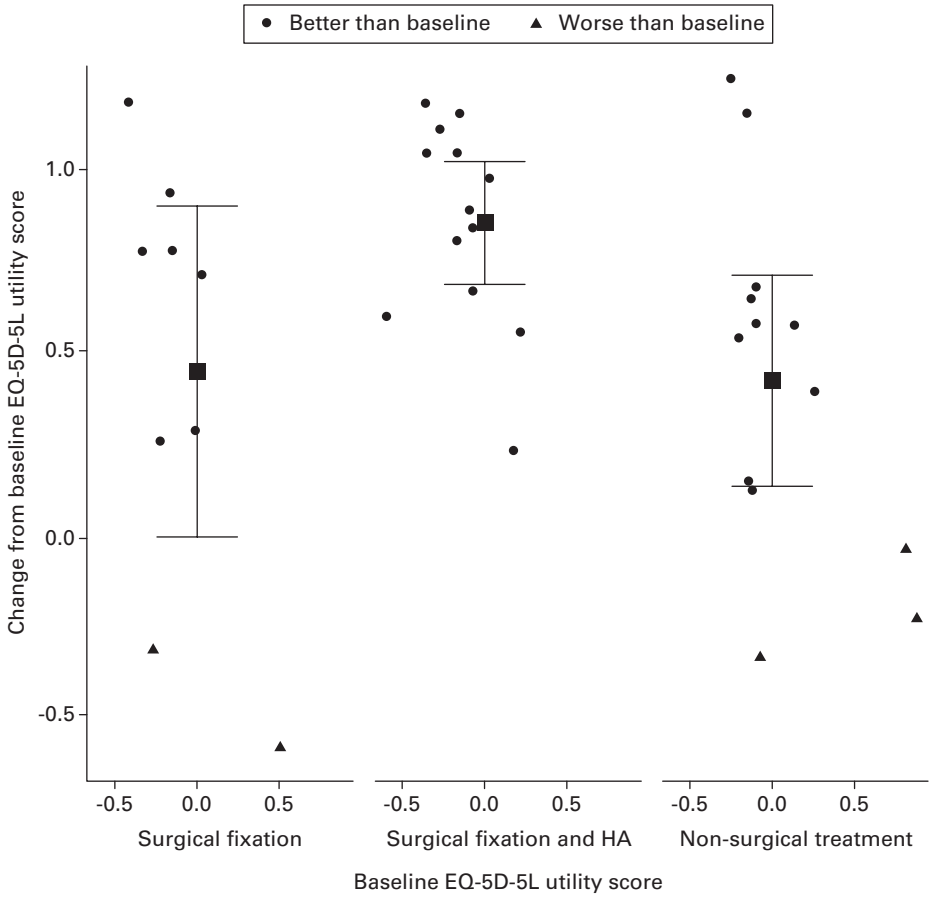

Fig. 9

Cambridge-only EuroQol five-dimension five-level questionnaire (EQ-5D-5L) Utility Score individual baseline vs change between baseline and six months presented by treatment group with mean and 95% confidence intervals.

patients, of the 117 eligible patients 50 declined to participate. Despite this, only four of the 60 (7%) patients recruited to the trial had withdrawn by final nine-month review. The death rate, four (7%) patients, was as expected in this patient population, and one patient (2%) was lost to follow-up at trial conclusion. Of 51 remaining patients, 98% (50/51) completed the primary outcome measure (EQ-5D) at nine months, with excellent rates of completion of secondary outcome measures.

It was ascertained that the baseline EQ-5D was not consistent across all recruitment sites. Some sites had asked participants to provide responses based on quality of life after the injury, rather than immediately before as the trial design intended. This is because the wording on the EQ-5D questionnaire explicitly asks how the participant is feeling "today". The largest recruiting site, Cambridge, had consistently asked how the participant was after their injury. Several models were built to estimate the SD, adjusting or not for baseline at all sites, or just Cambridge. However, the primary analysis did not adjust for the baseline values, which still provides a valid unbiased comparison between arms, but with additional variability due to the omission of the baseline value. Thus the primary analysis provides a conservative estimate of the SD for power calculations in a future study.

The estimated pooled SD for the EQ-5D was 0.411. To run a full-scale, powered, two-arm trial of surgical fixation versus fix-and-replace would require a total sample size of 1,474 participants for a minimal clinically important difference (MCID) of 0.06 with a power of 0.8, or a sample size of 1,974 participants for a MCID of 0.06 with a power of 0.9, both with a loss to follow-up of 20%.[25] This strongly suggests that a full-scale trial would require international collaboration to allow completion within an acceptable timeframe.

Though a high response rate was achieved for the EQ-5D questionnaire at each follow-up point, the small sample size (n = 56 at six weeks, n = 55 at six months, and n = 51 at nine months) means that clinically valid conclusions about differences between groups cannot be drawn, although this was not one of the study objectives. Similarly, we are unable to comment on differences in patients' clinical outcome scores or quality of life scores. However, it is pertinent to observe that the only treatment arm EQ-5D outcome not to have overlapping confidence intervals between baseline and six months was that of fix-and-replace, indicating that fix-and-replace may be the preferred surgical intervention in any subsequent large-scale powered trial.

This feasibility trial also provided observed safety data including mortality, bleeding, renal function, and other indicators of morbidity for fix-and-replace patients, which can be now used by clinicians when discussing this treatment modality with appropriate patients – previously such prospective data were absent from the medical literature.

A previous systematic review from 2014 found no RCTs in this area.[7] It identified 15 studies limited to retrospective case series. Only one study assessed the outcome of non-surgical treatment, demonstrating that 30% of patients did poorly and were unable to weightbear without severe pain.[8] For patients who had surgical fixation only, pooled data from eight studies demonstrated satisfactory surgical fixation being achieved in only 45% of patients while 23% of patients had significant pain and reduced function to the point where they had to undergo a hip arthroplasty. In the studies that assessed fix-and-replace, no increase in complications was found when compared to surgical fixation alone. It was not possible to reliably determine which patients had better function, as the studies used different functional scores at different intervals after surgery.

The most recent systematic review and meta-analysis on fix-and-replace versus delayed THA after acetabular fracture fixation described five appropriate retrospective studies with a total of 255 patients.[26] The authors concluded that although the quality of studies was mixed, sufficient equipoise now exists to justify a RCT. A total of 138 (54%) were treated with acute and 117 (46%) with delayed THA. The delayed THA group represented a younger cohort compared to the acute group (mean age 64 vs 73 years). The mean follow-up time for the acute and delayed group was 23 and 50 months, respectively. There was no difference in functional outcomes between the two study groups. Complication and mortality rates were comparable, however delayed THA had a higher revision rate compared to the acute group (17.1% vs 4.3%; $p = 0.002$).

The authors accept the current debate regarding RCT trial design in treating individuals for complex multifaceted questions, such as in older acetabular fractures, where previous mobility, patient expectations, degenerative hip condition, comorbidities, surgeon experience, and fracture pattern all need to be considered. There may be a need for an adaptive platform design in the wider major trauma research space, but it could be argued that the RCT is the best of the current options available, with presence of equipoise judged by funding bodies and actual equipoises being monitored with trial governance.

Overall, the current evidence assessing the treatment of acetabular fractures in older patients is of poor quality. There is significant variation between studies, particularly in terms of assessed outcomes, making meaningful comparison between treatments unreliable. To address this, comparing the different surgical treatment options for acetabular fractures in older patients is urgently required.

This feasibility study has demonstrated that in order to run a full-scale, powered trial to show a difference in clinical outcome between surgical fixation and fix-and-replace for acetabular fractures in the older population, one would require a total sample size of 1,474 or 1,974 patients for a MCID of 0.06, with a power of 0.8 or 0.9, and loss to follow-up of 20%. Although shown to be feasible, it would take a multinational RCT to recruit this number of patients within an acceptable trial timeframe. The anticipated AceFIT2 full RCT will provide clinicians with powered information on how to best provide a holistic management strategy for this medically complex patient cohort.

Take home message

- This study has demonstrated that a surgical trial for acetabular fracture surgery is feasible, but should be conducted on a multinational scale.

References

1. **Laird A**, **Keating JF**. Acetabular fractures: a 16-year prospective epidemiological study. *J Bone Joint Surg Br*. 2005;87-B(7):969–973.
2. **Court-Brown CM**, **Caesar B**. Epidemiology of adult fractures: a review. *Injury*. 2006;37(8):691–697.
3. **Albrektsson M**, **Möller M**, **Wolf O**, **Wennergren D**, **Sundfeldt M**. Acetabular fractures: epidemiology and mortality based on 2,132 fractures from the Swedish fracture register. *Bone Jt Open*. 2023;4(9):652–658.
4. **Hislop S**, **Alsousou J**, **Chou D**, **Rawal J**, **Hull P**, **Carrothers A**. Fix and replace: simultaneous fracture fixation and hip replacement for acetabular fractures in older patients. *Injury*. 2022;53(12):4067–4071.
5. **Navarre P**, **Gabbe BJ**, **Griffin XL**, **et al**. Outcomes following operatively managed acetabular fractures in patients aged 60 years and older. *Bone Joint J*. 2020;102-B(12):1735–1742.
6. **Ryan SP**, **Manson TT**, **Sciadini MF**, **et al**. Functional outcomes of elderly patients with nonoperatively treated acetabular fractures that meet operative criteria. *J Orthop Trauma*. 2017;31(12):644–649.
7. **Daurka JS**, **Pastides PS**, **Lewis A**, **Rickman M**, **Bircher MD**. Acetabular fractures in patients aged > 55 years. *Bone Joint J*. 2014;96-B(2):157–163.
8. **Spencer RF**. Acetabular fractures in older patients. *J Bone Joint Surg Br*. 1989;71-B(5):774–776.
9. **Carroll EA**, **Huber FG**, **Goldman AT**, **et al**. Treatment of acetabular fractures in an older population. *J Orthop Trauma*. 2010;24(10):637–644.
10. **No authors listed**. Hip fracture: management. National Institute for Health and Care Excellence. 2023. https://www.nice.org.uk/Guidance/CG124 (date last accessed 14 February 2024).
11. **Eldridge SM**, **Chan CL**, **Campbell MJ**, **et al**. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ*. 2016;355:i5239.
12. **Pocock SJ**, **Simon R**. Sequential treatment assignment with balancing for prognostic factors in the controlled clinical trial. *Biometrics*. 1975;31(1):103–115.
13. **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.
14. **Hounsome N**, **Orrell M**, **Edwards RT**. EQ-5D as a quality of life measure in people with dementia and their carers: evidence and key issues. *Value Health*. 2011;14(2):390–399.
15. **Parsons N**, **Griffin XL**, **Achten J**, **Costa ML**. Outcome assessment after hip fracture. *Bone Joint Res*. 2014;3(3):69–75.
16. **No authors listed**. Position statement on use of the EQ-5D-5L value set for England (updated October 2019). National Institute of Health and Care Excellence. 2019. https://www.nice.org.uk/about/what-we-do/our-programmes/nice-guidance/technology-appraisal-guidance/eq-5d-5l (date last accessed 14 February 2024).
17. **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.
18. **Parsons N**, **Griffin XL**, **Achten J**, **Chesser TJ**, **Lamb SE**, **Costa ML**. Modelling and estimation of health-related quality of life after hip fracture. *Bone Joint Res*. 2018;7(1):1–5.
19. **Dawson J**, **Fitzpatrick R**, **Carr A**, **Murray D**. Questionnaire on the perceptions of patients about total hip replacement. *J Bone Joint Surg Br*. 1996;185–190.
20. **Murray DW**, **Fitzpatrick R**, **Rogers K**, **et al**. The use of the Oxford hip and knee scores. *J Bone Joint Surg Br*. 2007;89-B(8):1010–1014.
21. **Salén BA**, **Spangfort EV**, **Nygren AL**, **Nordemar R**. The disability rating index: an instrument for the assessment of disability in clinical settings. *J Clin Epidemiol*. 1994;47(12):1423–1435.
22. **Dawson J**, **Fitzpatrick R**, **Carr A**, **Murray D**. Questionnaire on the perceptions of patients about total hip replacement. *J Bone Joint Surg Br*. 1996;78-B(2):185–190.
23. **Tönnis D**, **Heinecke A**. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. *J Bone Joint Surg Am*. 1999;81-A(12):1747–1770.

24. **Julious SA**. Sample size of 12 per group rule of thumb for a pilot study. *Pharmaceutical Statistics*. 2005;4(4):287–291.
25. **Walters SJ**, **Brazier JE**. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. *Qual Life Res*. 2005;14(6):1523–1532.
26. **Liang K**, **Gani MH**, **Griffin X**, **Culpan P**, **Mukabeta T**, **Bates P**. Acute versus delayed total hip arthroplasty after acetabular fracture fixation: a systematic review and meta-analysis. *Eur J Orthop Surg Traumatol*. 2023;33(7):2683–2693.

Author information:
A. Carrothers, VR, MBChB, MA (Cantab), DipIMC, FRCS (Tr, Orth), Consultant Trauma & Orthopaedic Surgeon
R. O'Leary, MBChB, PhD, FRCA, FFICM, MFCI, Consultant and Specialty Lead in Neurosciences and Trauma Critical Care
J. Queally, MD, FRCS (Tr, Ortho), M Ed (Surg Ed), Consultant Trauma & Orthopaedic Surgeon
Addenbrookes Hospital, Cambridge, UK.

P. Hull, MBChB, FRCS (Tr, Orth), Consultant Trauma & Orthopaedic Surgeon, Orthopaedic Trauma Department, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK.

D. Chou, MBBS, BSc (Hons), MSc, FRCS (Tr, Orth), Consultant Trauma & Orthopaedic Surgeon, Orthopaedic Trauma Unit, Addenbrookes Hospital, Cambridge, UK.

J. Alsousou, MD, LMSSA (Hons), FRCS (Tr, Orth), PhD, Consultant Trauma & Orthopaedic Surgeon, Manchester Royal Infirmary, Manchester, UK; Musculoskeletal Group, University of Liverpool, Liverpool, UK.

S. J. Bond, PhD, Senior Statistician, Cambridge Clinical Trials Unit, Cambridge University Hospitals NHS Foundation Trust, Cambridge, UK.

M. L. Costa, PhD, FRCS (Tr&Orth), Professor, Oxford Trauma, NDORMS, University of Oxford, Oxford, UK.

Author contributions:
A. Carrothers: Conceptualization, Funding acquisition, Project administration, Investigation, Writing – original draft, Writing – review & editing.
R. O'Leary: Funding acquisition, Investigation, Writing – review & editing.
P. Hull: Funding acquisition, Investigation, Writing – review & editing.
D. Chou: Funding acquisition, Investigation, Writing – review & editing.
J. Alsousou: Funding acquisition, Investigation, Writing – review & editing.
J. Queally: Funding acquisition, Investigation, Writing – review & editing.
S. J. Bond: Data curation, Formal analysis, Funding acquisition, Methodology, Writing –review & editing.
M. L. Costa: Funding acquisition, Investigation, Writing – review & editing.

Funding statement:
The authors disclose receipt of the following financial or material support for the research, authorship, and/or publication of this article: this project is funded by the National Institute for Health Research (NIHR) under its Research for Patient Benefit (RfPB) Programme (Grant Reference Number PB-PG-0815-20054). The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

ICMJE COI statement:
The authors disclose receipt of the following financial or material support for the research, authorship, and/or publication of this article: this project is funded by the National Institute for Health Research (NIHR) under its Research for Patient Benefit (RfPB) Programme (Grant Reference Number PB-PG-0815-20054). The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care. M. L. Costa's employer, the University of Oxford, receives research grant funding from the NIHR and Wellcome Trust for research into musculoskeletal trauma, unrelated to this study.

Data sharing:
The datasets generated and analyzed in the current study are not publicly available due to data protection regulations. Access to data is limited to the researchers who have obtained permission for data processing. Further inquiries can be made to the corresponding author.

Acknowledgements:
We would like to acknowledge Dr Paula Kareclas, Cambridge Clinical Trials Unit, and her team for their help with managing this trial, as well as Rachel Donegan (Statistician).

Ethical review statement:
Full ethical approval was granted under the Research for Patient Benefit (RfPB) Programme (Grant Reference Number PB-PG-0815-20054).

Trial registration number:
ISRCTN16739011

This article was primary edited by A. Wood.