■ WRIST AND HAND

Cost effectiveness of treatment with percutaneous Kirschner wires *versus* volar locking plate for adult patients with a dorsally displaced fracture of the distal radius

ANALYSIS FROM THE DRAFFT TRIAL

**S. Tubeuf,
G. Yu,
J. Achten,
N. R Parsons,
A. Rangan,
S. E. Lamb,
M. L. Costa**

From University of Leeds, Leeds, United Kingdom

■ S. Tubeuf, PhD, Associate Professor, Academic Unit of Health Economics
■ G. Yu, PhD, Research Fellow, Academic Unit of Health Economics
University of Leeds, 101 Clarendon Road, Leeds LS6 9LJ, UK.

■ J. Achten, PhD, Senior Research Fellow, Kadoorie Centre
■ M. L. Costa, PhD, FRCS (Tr&Orth), Professor of Orthopaedic Trauma, Kadoorie Centre
University of Oxford John Radcliffe Hospital, Headley Way, Oxford, OX3 9DU, UK.

■ N. R Parsons, PhD, Statistician, Warwick Medical School
University of Warwick, Gibbet Hill Road, Coventry CV4 7AL, UK

■ A. Rangan, FRCS (Tr&Orth), Professor of Orthopaedic Surgery
The James Cook University Hospital, Marton Road, Middlesbrough TS4 3BW, UK.

■ S. E. Lamb, MSc; MA; MCSP; Grad Dip Statistics; DPhil, Professor of Trauma Rehabilitation, NDORMS University of Oxford, Windmill Road, Headington Oxford, OX3 7LD, UK.

Correspondence should be sent to Dr S. Tubeuf; e-mail: s.tubeuf@leeds.ac.uk

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We present an economic evaluation using data from the Distal Radius Acute Fracture Fixation Trial (DRAFFT) to compare the relative cost effectiveness of percutaneous Kirschner wire (K-wire) fixation and volar locking-plate fixation for patients with dorsally-displaced fractures of the distal radius.

The cost effectiveness analysis (cost per quality-adjusted life year; QALY) was derived from a multi-centre, two-arm, parallel group, assessor-blind, randomised controlled trial which took place in 18 trauma centres in the United Kingdom. Data from 460 patients were available for analysis, which includes both a National Health Service cost perspective including costs of surgery, implants and healthcare resource use over a 12-month period after surgery, and a societal perspective, which includes the cost of time off work and the need for additional private care.

There was only a small difference in QALYs gained for patients treated with locking-plate fixation over those treated with K-wires. At a mean additional cost of £714 (95% confidence interval 588 to 865) per patient, locking-plate fixation presented an incremental cost effectiveness ratio (ICER) of £89 322 per QALY within the first 12 months of treatment. Sensitivity analyses were undertaken to assess the ICER of locking-plate fixation compared with K-wires. These were greater than £30 000.

Compared with locking-plate fixation, K-wire fixation is a 'cost saving' intervention, with similar health benefits.

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Fractures of the distal radius are extremely common injuries. Most can be treated non-operatively in a plaster cast or splint. However, if the bone fragments are displaced, surgical fixation is often indicates. Surgery may provide functional benefits, but carries the risk of complications and increases potential expense for the healthcare system. Much of that expense is related to the choice of fixation.

The two most common forms of surgical treatment for dorsally displaced fractures are percutaneous Kirschner wire (K-wire) fixation and volar locking-plate fixation. In the last five years, there has been a rapid rise in the use of locking plates and a concomitant increased cost.[1] This change in practice was predominantly based on the results of single-centre trials, which have suggested that locking plates provide improved radiological and/or functional outcomes.[2-8]

We present a health economic evaluation from a multi-centre randomised controlled trial of percutaneous K-wire fixation against volar locking-plate fixation in the treatment of adult patients with a dorsally displaced fracture of the distal radius (DRAFFT).

Patients and methods

Intervention and sample. Patients were eligible for the trial if they had a dorsally displaced fracture of the distal radius within 3 cm of the radiocarpal joint, and were aged 18 years or over. The only other inclusion criterion was that the treating surgeon believed that the patient would benefit from surgical fixation of the fracture. Further details of the protocol are reported elsewhere.[9] The primary outcome measure was the Patient Rated Wrist Evaluation (PRWE).[10] The analysis of the clinical results of this trial concluded that there was no difference in functional outcome between percutaneous K-wires and volar locking plates for patients with a dorsally displaced fracture of the distal radius.[11]

Perspective. We compared the cost effectiveness of volar locking-plate fixation with that of

percutaneous K-wire fixation for the treatment of a distal radial fracture from the perspective of the National Health Service (NHS) and from a societal perspective. The NHS perspective considers only resources used within the NHS setting, whereas the societal perspective additionally considers private costs, including time off work, as a consequence of the treatment. All costs were adjusted to 2012 prices using the CCEMG-EPPI Centre Cost Converter.[12] The analysis uses the 'within-trial period' (12 months following the injury), it was not necessary to discount for future costs or health outcomes. The currency used was the pound sterling (£).

Quality of life. In line with the National Institute for Health and Care Excellence (NICE) reference case[13] the primary outcome for the economic evaluation was quality-adjusted life years (QALYs). Each patient's health-related quality of life (QOL) was assessed using the EQ-5D-3L questionnaire[14] for pre-injury (patients retrospectively assessed their QOL before their injury), at baseline and at three, six and 12 months after their surgery the combination of answers to EQ-5D led to a health profile of five digits,[15] which was converted into a utility score using standard United Kingdom tariff values.[16] A utility score represents the patient's overall QOL and is multiplied by the time spent in each state to generate QALYs.[15]

Mean QALYs between adjacent time points were used between those time points. QALYs represent a quality-weighted survival value, in which one QALY is the equivalent of one year of full health.

Use of resources and valuation. The total cost of each arm of the trial was calculated by combining the initial cost of surgery and the reported resource usage over the 12-month follow-up period, with the unit cost data obtained from national databases such as the British National Formulary (BNF) and Personal Social Services Research Unit (PSSRU) Costs of Health and Social Care.[17]

Patients reported their use of resources within the trial at three-, six- and 12- month time points. For the three-month data, the recall period was since discharge from hospital. For the other time points, it was since completion of the previous questionnaire. The questionnaires included the number of further inpatient admissions after the initial operation; the number of outpatient, primary and community care consultations and the use of aids, adaptations and medication. Patients also reported their use of personal social services related to their treatment, such as deliveries of frozen/hot 'meals on wheels' and laundry services.

Resource usage figures were converted into costs by using unit cost figures from the PSSRU costs of health and social care 2012[17] and the Department of Health's reference costs.[18] Table I presents the summary of healthcare use collected and associated unit costs

Further inpatient care after the initial operation was priced as 'Minimal Elbow and Lower Arm Procedures for Non-Trauma' tariff[19] unless the patient had undergone metal removal or debridement by six-week follow-up, in which case inpatient stay was costed according to the appropriate 'trauma' tariff.

Unit costs for medications were obtained from the BNF[20] and the NHS Electronic Drug Tariff.[21] Patients reported their total use of medication. Total medication costs were then calculated using the mean cost per dose for each product.

Unit costs for aids and adaptations were taken from Mobility Smart[22] which supplies the NHS. Patients reported any equipment they had needed to protect their injury or make their daily life manageable. Reported aids, adaptations and unit prices are available in Table II.

The cost of treating a fracture operatively was assessed using NHS reference costs and HRG tariff for 'Minor Elbow and Lower Arm Procedures for Trauma'.[19] Costs for the initial operative period were estimated for each patient using the mean length of stay (LOS) as reported in the patient records for the primary surgery. They were assumed to be £1375.34 for a day case or £1983.39 for an overnight admission. Excess bed day costs were used when a patient experienced a LOS beyond the mean reported LOS. For example, the cost to NHS was £1375.34 if a patient was discharged the same day, £1983.39 if the patient needed overnight hospital care for at least one night, but no more than the average LOS. Extra bed day costs (based on a bed day cost of £278.07) were added if a patient stayed more than the average LOS. This cost was taken to include all expenditure incurred before discharge, including any items provided to patients before their departure. The costs of surgical equipment for both locking-plate and K-wire fixation were provided by the University Hospitals of Coventry and Warwickshire finance department. Following the NICE guide to the health technology appraisal, our analysis used standard NHS reference costs to estimate the cost of initial surgery, and did not take into account micro-costing such as theatre operating time and anaesthetic.

Productivity and private costs. Cost from the societal perspective were calculated by combining loss of earnings because of work absence, private costs such as treatments within private settings and out-of-pocket expenses incurred as a result of the wrist surgery, and reported use of personal social services related to the treatment. Personal social services included number of weeks of frozen/hot meals on wheels, laundry services, and number of visits of carers and social workers. Unit costs were assigned using PSSRU and information from Centres of Personal Social Services.[23]

Patients reported their time off work in days or in terms of lost income at every time point. A 'human capital approach'[24] was used to generate the cost of lost productivity per day using the gross median weekly pay rate for full-time employees from the Office for National Statistics (£506, April 2012) divided by five.

Missing data. The mean total cost per patient from an NHS perspective was calculated by adding the costs of inpatient stay, outpatient visit, consultations, medication, equipment and intervention costs for all patients where response data were available. Respondents who failed to complete

Table I. Summary of patient-reported health care use and associated unit costs

Item	Unit cost (£)/time	Source
Initial operation		
Cost for average distal fracture surgery (19 yrs and over)	1983.39	National schedule of reference costs year 2011 to 2012 - Minor Elbow and Lower Arm Procedures for Trauma - HA73C
Day case	1375.34	National schedule of reference costs year 2011 to 2012 - Minor Elbow and Lower Arm Procedures for Trauma - HA73C
Adjustment per day ± av. LOS (19 yrs and over)	278.07	National schedule of reference costs year 2011 to 2012 - Elective Inpatient Excess day - HA73C
Average LOS for distal fracture (days)	0.95	
VLP: average LOS (days)	0.98	*t*-test p-value 0.696
K-wire: average LOS (days)	0.92	
Average surgery time (mins)	53.57	
VLP: average surgery time (mins)	70.0	*t*-test p-value 0.000
K-wire: average surgery time (mins)	37.18	
VLP: implant + consumables	£818.26	The University Hospital of Coventry and Warwickshire (UHCW)
K-wires: implant + consumables	£54.23	
Subsequent inpatient care		
Inpatient (orthopaedics – wrist/arm)		
Cost for average LOS	2064.71	National schedule of reference costs year 2011 to 2012 - HB79Z
Day case	692.04	National schedule of reference costs year 2011 to 2012 - HB79Z
Adjustment per day ± av. LOS	302.01	National schedule of reference costs year 2011 to 2012 - HB73Z
Inpatient (orthopaedics – other bones)		
Cost for average LOS	3556.04	National schedule of reference costs year 2011 to 2012 - HB99Z
Day case	928.36	National schedule of reference costs year 2011 to 2012 - HB99Z
Adjustment per day ± av. LOS	293.08	National schedule of reference costs year 2011 to 2012 - HB99Z
Inpatient (other non-surgery)		
Cost for average LOS	2688.10	National schedule of reference costs year 2011 to 2012 - HB91Z
Day case	602.61	National schedule of reference costs year 2011 to 2012 - HB91Z
Adjustment per day ± av. LOS	261.21	National schedule of reference costs year 2011 to 2012 - HB91Z
Inpatient (other)		
Rehabilitation unit	985.00	PSSRU 2012, p.114, weekly service costs per bed
Outpatient care		
Orthopaedics*	103.72	National schedule of reference costs year 2011 to 2012 - 110T
Pathology† (for blood tests)	60.74	National schedule of reference costs year 2011 to 2012 - 822
Radiology (for x-rays, per event)	153.21	National schedule of reference costs year 2011 to 2012 - 811
Physiotherapy (per session)	40.70	National schedule of reference costs year 2011 to 2012 - 650
Primary and community care		
GP surgery visit	40.00	PSSRU2012, p.182-3, £3.40 per min, average 11.7 min visit
GP clinic visit	58.00	PSSRU2012, p.182-3, £4.3 per min, 17.2 min per visit
GP home visit	101.00	PSSRU2012, p.182-3, £258 per hour, average 23.4 min visit
GP phone contact	24.00	PSSRU2012, p.182-3, 7.1 min contact
Practice nurse surgery visit	11.63	PSSRU2012, p.180-1, £45 per hour, average 15.5 min visit
Practice nurse home visit	18.75	PSSRU2012, p.180-1, £45 per hour, average 25 min visit
Practice nurse phone contact	3.50	PSSRU2012, p.180-1, £35 per hour, average 6 min visit
District nurse surgery visit	10.85	PSSRU2012, p.175, £42 per hour, average 15.5 min visit
District nurse home visit	21.83	PSSRU2012, p.175, £61 per hour, average 20 min visit
District nurse phone contact	4.2	PSSRU2012, p.175, £42 per hour, average 6 min visit
Physiotherapist surgery visit	15.00	PSSRU2012, p.167, £30 per hour, average 30 min per visit
Physiotherapist home visit	44.16	PSSRU2010, p.151, £39 per hour, average 60 min, inflated
Occupational therapist surgery visit	15.00	PSSRU2012, p.167, £30 per hour, average 30 min per visit
Occupational therapist home visit	44.16	PSSRU2010, p.151, £39 per hour, average 60 min visit

*This includes medical staff costs
† This is the standardised cost per event including the costs of activities relating to pathology testing; an average of ten units of pathology testing can be required in each event
LOS, length of stay; GP, general practitioner, VLP, volar locking plate; PSSR, personal social services research unit

individual items of the EQ-5D were not allocated a utility index score. From the overall sample, missing data represented 7.1% of observations. The complete data analysis was based on 278 patients. For those cases in which either resource usage or QOL data were unavailable, we addressed missing data by using multiple imputations via chained equations,[25] assuming data were randomly missing and using STATA 12 (StataCorp, College Station, Texas). Missing cost data were predicted in terms of QALYs, treatment received, LOS, age, gender, job status, patient's self-reported health status, PRWE score, and Disability of the Arm, Shoulder and Hand score.[26] Missing QALYs data were predicted in terms of this same list (excluding QALYs), plus each of the cost items. In order to remove implausible data, missing cost data were constrained to be positive. A total of ten imputations were created to stabilise

Table II. Summary of patient-reported aids and adaptation, equipment usage, personal social services, private costs and associated unit costs

Item	Unit cost (£)	Source
Aids and adaptation		
Wrist brace/splint	10.00	MobilitySmart
Grab rail	95.00	PSSRU2012, p.111, average total cost
Dressing aids	5.95	MobilitySmart
Long-handle shoe horns	3.98	MobilitySmart
Bathing aids	23.35	MobilitySmart
Kitchen aids (jar/tin openers, etc)	21.44	MobilitySmart
Personal social services		
Frozen meals on wheels (weekly)	41.40	Lewisham council, adult social care
Hot meals on wheels (weekly)	46.00	PSSRU2012 - p125[17]
Laundry services (per load)	4.30	North Yorkshire social care
Care workers/help at home (per visit)	18.00	PSSRU2012, p.193 per weekday hour
Social workers (per visit)	39.00	PSSRU2012, p.190 per hour
Cost of lost productivity		
Days off work (per day)	101.2	Office for National Statistics - April 2012 median grossly week earning for full-time employees - £506[23]

PSSRU, personal social services research unit

Table III. Mean EQ-5D index scores at the baseline and follow-ups and annual quality-adjusted life years (QALYs) of distal fracture fixation by treatment arms

	K-wire n = 141	Locking-plate n = 137	Difference
	Mean (SD)	Mean (SD)	Incremental (SEM)
Retrospective pre-injury	0.919 (0.169)	0.936 (0.154)	0.075 (0.005)
Baseline	0.358 (0.305)	0.363 (0.323)	0.070 (0.009)
3 mths	0.725 (0.210)	0.739 (0.224)	0.014 (0.026)
6 mths	0.787 (0.193)	0.807 (0.183)	0.020 (0.023)
12 mths	0.842 (0.188)	0.845 (0.184)	0.002 (0.022)
Total QALYs (non-imputed)	0.734 (0.166)	0.742 (0.159)	0.014 (0.020)
Total QALYs (imputed)	0.734 (0.167)	0.744 (0.156)	0.013 (0.005)

K-wire, Kirschner wire; SD, standard deviation; SEM, standard error of the mean

the results. The reported cost effectiveness results were calculated based on all imputed datasets.

Cost effectiveness analysis. The 'within-trial' analysis aimed to determine which intervention would maximise the QALYs within a limited NHS budget and within a societal perspective over the 12 month trial follow-up. This is called a 'cost-utility analysis' because the primary outcome of the cost effectiveness analysis is the cost per QALY gained for all patients. It adopted an intention-to-treat perspective. Descriptive statistics of costs and EQ-5D scores were initially undertaken and parametric *t*-tests conducted to evaluate any important differences at the end points within the time frame of the trial. Incremental cost effectiveness ratios (ICER) were then calculated by dividing the mean difference in cost between the two arms by the mean difference in QALYs.

The ICER represents the additional cost per one unit of QALY gained. This indicates the trade-off between total costs and effectiveness when choosing between volar locking-plate fixation and percutaneous K-wire fixation. When compared with the marginal trade-off for the NHS as a whole, this gives an indication of whether spending additional money on volar locking-plate fixation appears cost efficient. As a rule, NICE considers an intervention with an ICER of less than £20 000 per QALY to be cost effective and generally considers that an intervention which costs more than £30 000 per QALY is not cost effective.

The non-parametric bootstrapping approach with replacement[27] was used to determine the level of sampling uncertainty around the ICER; the bootstrap consists of resampling from the original sample, to create multiple random samples and generate 10 000 estimates of incremental costs and benefits. The uncertainty in the ICER was presented using cost effectiveness acceptability curves (CEACs) which show the probability that each treatment is cost effective in relation to the comparator intervention, as a function of the willingness to pay.[28]

A number of univariate sensitivity analyses[27] were undertaken. To evaluate the impact of missing data, a complete case analysis was conducted where only those participants with complete data were analysed. We then separated the analysis according to age (above or below 50 years), as age was used as a stratification factor in the trial

Table IV. Costs of resources (£) used in relation to distal fracture fixation by treatment arms

	K-wire n = 230	Locking-plate n = 230	Difference
	Mean (SD)	**Mean (SD)**	**p-value (*t*-test)**
NHS resource use costs*	1524.84 (1840.14)	1590.19 (2216.07)	0.789
Social care costs	13.01 (105.37)	8.18 (57.97)	0.637
Private cost	9.74 (66.51)	22.05 (149.05)	0.372
Cost of lost productivity	394.26 (1704.29)	249.16 (1128.92)	0.405
	Mean (SD)	**Mean (SD)**	**Difference (95% CI)**
Total costs (NHS PSS perspective)†	3440 (2539)	4145 (2203)	714 (588 to 864)
Total costs (Societal perspective)†	3832 (3142)	4413 (2927)	581 (401 to 761)

* The costs do not include the cost of the initial operation/care
† The costs include the cost of the initial operation/care.SD, standard deviation; NHS, National Health Service; CI, confidence interval; PSS, personal social services

to balance differences in bone density between younger and older patients; the two age groups were assumed to present different types of fractures (high and low energy) so the impact of the fixation was expected to differ by age. Finally, adjusted cost-effectiveness analyses were also undertaken using baseline covariates which included age, gender, and EQ-5D score.

Results

Trial recruitment. Between January 2011 and July 2012, 461 patients were recruited and randomised[11] (K-wire = 230; locking-plate = 231). One patient in the locking-plate arm of the study did not provide any QOL data and was excluded from the analysis.

Quality of life. Details of the EQ-5D scores at pre-injury, baseline, three, six and 12 months when missing values were imputed are shown in Table III. Both groups showed increasing EQ-5D scores from baseline to the last follow-up point. The most important increase was observed between baseline and three months; doubling the baseline EQ-5D scores in both arms of the trial. It was noted that at 12 months, patients EQ-5D score was still lower than their pre-injury EQ-5D score. The mean total QALYs over the 12 months was marginally higher in the locking-plate arm (0.742; standard deviation (SD) 0.156) than in the K-wire arm (0.734, SD 0.167) but the difference was not significant (0.013; SD 0.005; p-value 0.649, *t*-test). There were no significant differences between EQ-5D scores at baseline for the two treatment arms (0.070; SD 0.009; p-value 0.856, *t*-test).

Healthcare resource usage. Resource use was broadly comparable between the two treatments. Patients needed high numbers of physiotherapy outpatient visits (mean 6.9 visits over the 12 months; 6.128; SD 8.255 for K-wire and 7.584; SD 11.212 for locking plate) and reported a mean of 3.6 visits to the orthopaedic department and 3.6 visits for radiographs. Visits to general practitioners and nurses were infrequent. Patients used a wrist brace or splint (0.780; SD 1.076 for K-wire and 0.964; SD 1.239 for locking plate) and paracetamol for pain relief was the most reported medication (2.702; SD 10.11 for K-wire and 1.285; SD 4.618 for locking plate).

Costs. The mean total NHS resource use costs were £3385 (SD 2097.09) for K-wire and £4288 (SD 2244.30) for a volar locking plate, respectively and were significantly higher for volar locking plate (£903, SD 260.43; p-value < 0.001, *t*-test) (Table IV). Lost earnings and productivity losses to employers through sickness absences appeared higher in the K-wire arm, but the difference was not significant (-£120.44; SD 203.16; p-value 0.405, *t*-test). Overall societal costs, excluding hospital costs, were a mean of £48 (SD 360.04) higher in the K-wire arm.

Cost-effectiveness and sensitivity analyses. The results show that volar locking-plate treatment was more expensive than K-wires with a mean incremental cost of £726.46 (95% confidence interval (CI) 558.44 to 864.48) per case and had greater, albeit small, QALY gains. The difference in QALY gains was 0.008 QALYs (which is equivalent to an extra three days of perfect health per year) between groups. We have graphically represented the uncertainty of these estimates in Figure 1, which shows that all the points are above the x-axis, indicating that the volar locking-plate was more costly, and more points are to the right of the y-axis, indicating that volar locking-plates produced more QALYs. The points in the plane lie in the area where there is a trade-off between effect and cost: additional health benefit can be gained but at a higher cost. The ICER of volar locking-plate with respect to K-wires was £89 322 per QALY: under these circumstances, volar locking-plate treatment could not be considered cost-effective, as its ICER was above the NICE range of £20 000 to £30 000 per QALY. The CEAC is presented in Figure 2, with a range of willingness-to-pay (WTP) threshold values. The probability of volar locking-plate fixation being cost effective was very low: at a WTP threshold of £20 000 per QALYs it was zero and only rose to 3% at a threshold of £30 000.

Within most of the sensitivity analyses undertaken, the ICER appeared to remain above the range of £20 000 to £30 000 per QALY (Table V), even with the adjusted analysis which showed a lower incremental cost for a similar incremental QALYs gain, from both the NHS and societal perspectives. In the sample of patients over the age of 50, the evaluation suggested that patients who were treated with

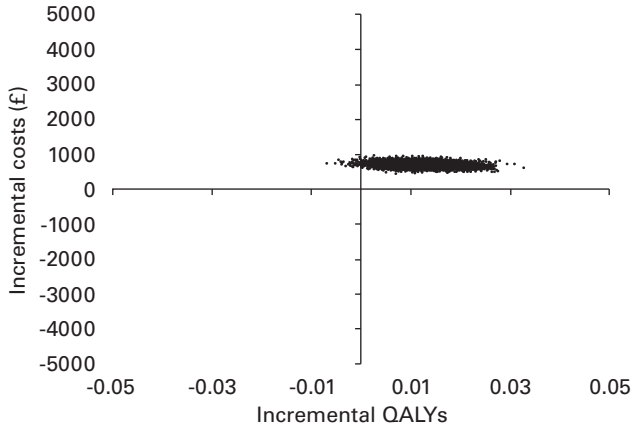

Fig. 1

Graph showing the cost effectiveness plane generated from bootstrapped mean cost and quality adjusted life years (QALYs) differences over 12 months (National Health Service perspective, all patients).

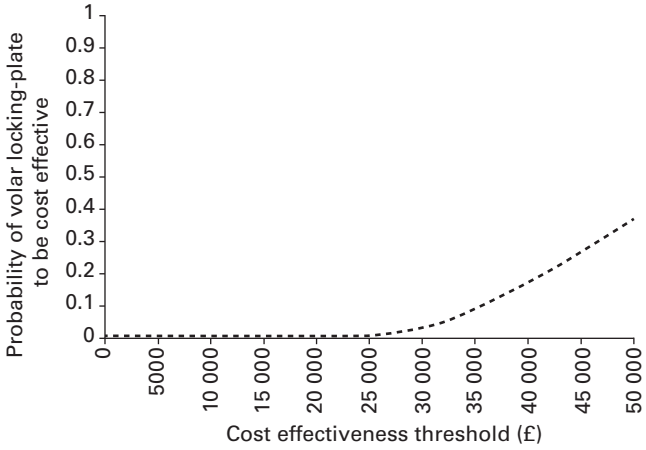

Fig. 2

Graph showing the cost effectiveness acceptability curves at 12 months (National Health Service perspective, all patients).

Table V. Incremental cost effectiveness results

Scenario	Mean incremental costs (£) (95% CI)	Mean incremental QALYs (95% CI)	ICER (Cost (£) per QALY)
NHS PSS perspective			
Base case (imputed)	726 (588 to 864)	0.008 (-0.001 to 0.018)	89 322
Complete case	903 (392 to 1414)	0.014 (-0.025 to 0.053)	64 026
Adjusted (imputed)	286 (171 to 400)	0.009 (-0.018 to 0.032)	32 731
Above 50 yrs old (imputed)	752 (539 to 921)	0.014 (0.002 to 0.025)	54 218
Below 50 yrs old (imputed)	653 (425 to 880)	-0.008 (-0.024 to 0.008)	K-wire dominates
Societal perspective			
Base case (imputed)	581 (401 to 761)	0.010 (0.001 to 0.019)	58 852
Complete case	791 (60 to 1521)	0.014 (-0.025 to 0.053)	56 020
Adjusted (imputed)	300 (158 to 442)	0.010 (-0.013 to 0.033)	30 385
Above 50 yrs old (imputed)	629 (412 to 845)	0.018 (0.007 to 0.029)	35 323
Below 50 yrs old (imputed)	446 (172 to 720)	-0.013 (-0.028 to 0.003)	K-wire dominates

CI, confidence interval; QALYs, quality-adjusted life years; ICER, incremental cost effectiveness ratios; K-wire, Kirschner wire; PSS, personal social services

a volar locking-plate fixation gained 0.018 QALYs more than those treated with a K-wire fixation, at an increased cost of £629 per patient, yielding an ICER of £35 323 per QALY. In the sample of patients under the age of 50, volar locking-plate fixation was associated with lower benefits and higher costs than K-wire fixation, and so locking-plate fixation would not be cost effective at all for this subgroup of individuals.

Discussion

Compared with percutaneous K-wires, volar locking-plate fixation incurred greater cost (£726 in the base-case analysis) and a very small gain in QALY (0.008) within the first 12 months of surgery. The cost of that improvement was equivalent to £89 322 for one additional QALY, which was substantially above the NICE's range of £20 000 to £30 000 per QALY.

Furthermore, the CIs around this marginal QALY difference of 0.008 (95% CI -0.001 to 0.018) excluded the possibility that volar locking-plate fixation was a cost-effective intervention. A simple calculation based on these results shows that a net QALY gain of at least 0.036 would be needed, for an incremental cost of £726, to provide an ICER that meets NICE's maximum willingness-to-pay of £30 000 per QALY. Therefore, volar locking-plates would have had to provide much greater QALY gains for the NHS to consider paying the extra cost of this treatment. The high ICER and the low probability of locking-plate fixation being cost effective and meeting the £20 000 to £30 000 willingness-to-pay threshold, demonstrates that volar locking-plate treatment is not cost effective. This result is robust to several sensitivity analysis scenarios.

The results have shown EQ-5D score is a suitable measure of health assessment for this population and is sensitive

to both the effects of the distal radius fracture and the method of fixation. There were important changes in the scores over the follow-up period. Patients receiving a K-wire fixation (volar locking plate) showed a utility score increasing from 0.358 at baseline (0.373) to 0.824 after 12 month follow-up (0.841).

The main limitation of this study is that we used a 'conservative' estimate of the total cost of the surgical treatment. This was based on the NHS tariffs and we did not take into account the extra theatre operating time required for locking-plate fixation; the surgical time for the K-wire fixation was less than for the locking plate; with a median difference of 31 minutes (95% CI 28 to 35) and a p-value of < 0.001 (Mann–Whitney U test). Although the exact cost of theatre time is difficult to calculate, it is clear that including the cost of theatre operating time would lead to even higher costs for locking plate fixation.

Previous cost analyses have focused on comparing the cost of surgical fixation with non-surgical treatment.[29-35] These studies have concluded that surgery has a higher initial cost, and can be associated with increased costs in cases of post-surgical complications. However, few studies have provided a comparative cost analysis of different types of surgical fixation. Shyamalan et al,[36] in a retrospective study, undertook a micro-costing analysis of percutaneous K-wire fixation and locked volar-plate fixation, with a sample of ten patients in each group. They found a difference of £1549 and 65 minutes of operating time between percutaneous K-wire fixation and the use of a volar locked-plate. The choice of implants appears to influence the overall cost considerably as has been shown in other studies.[37,38] However, the cost effectiveness of distal fracture fixations within a randomised control trial had never been fully explored. Our study provides a comprehensive assessment of the cost effectiveness of two commonly undertaken treatments for distal radial fractures with obvious implications for the surgical community.

In conclusion, percutaneous K-wire fixation is a 'cost saving' intervention and is substantially less expensive than volar locking-plate fixation, which provides minimal, if any, advantage in health outcome over K-wire fixation. We therefore recommend a change in current practice in favour of K-wires when treating fractures of the distal radius

Supplementary material

Tables presenting the associated unit costs as well as the use of healthcare resources related to distal fracture fixation by each follow-up period and treatment arm (complete case) are available alongside the online version of this article at www.bjj.boneandjoint.org.uk.

Author contributions:
S. Tubeuf: Economic evaluation study design, Supervision of data analysis, Writing the paper.
G. Yu: Data analysis.
J. Achten: DRAFFT trial design, Writing the paper.
N. Parsons: DRAFFT trial design, Statistical analysis, Writing the paper.
A. Rangan: Co-applicant and co-investigator, Performed surgeries, Contributed to trial management.
S. E. Lamb: DRAFFT trial design, Member of the TMG, Writing the paper.
M. L. Costa: Data analysis, Writing the paper.

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