



Retrospective Study

Health economics for intra-capsular hip fractures undertaking fixation

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Abstract

BACKGROUND

Hip fracture is a common musculoskeletal injury in the elderly requiring surgery worldwide. The operative mainstay of intra-capsular hip fractures is arthroplasty with a smaller proportion for fixation.

AIM

To determine the most beneficial method of fixation for patients with intra-capsular hip fractures.

METHODS

A registered audit from 2012-2018 was conducted on all intra-capsular hip fractures treated with 2 commonly used fixation methods. Patient notes, electronic records and clinical codes for cost benefit were evaluated. A validated quality of life measure was collected at least 1 year after surgery.

RESULTS

A total of 83 patients were identified with intra-capsular fractures undergoing fixation during the retrospective period. There were 47 cannulated cancellous screw and 36 sliding hip screw fixations with the case mix comparable for age, gender, co-morbidities and fracture configuration. There was no significant difference in blood loss, tip apex distance, radiation exposure, length of stay, radiological union time, collapse, avascular necrosis or re-operation between fixation methods. Logistic regression analysis demonstrated displaced intracapsular hip fractures correlated significantly with an undesirable outcome conferring a relative odds ratio of 7.25. There were 9 (19%) and 4 (11%) patients respectively, who required re-operation. There was no significant difference in health resource group tariff and implant cost with comparable EQ-5D and visual

analogue scores.

CONCLUSION

No significant advantage was identified with differing fixation type, but irrespective there were a high number of patients requiring re-operation. This was predicted by initial fracture displacement and patient age. Arthroplasty may need to be carefully considered for health economics and patient benefit.

Key Words: Hip fracture; Fixation; Patient reported outcome measure; Cost

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Core Tip: Both sliding and cannulated hip screws had undesirable outcomes in older patients with displaced fractures. More predictable methods of treatment such as hip arthroplasty should be considered for older patients with displaced fractures.

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INTRODUCTION

Hip fracture is the commonest musculoskeletal injury requiring surgery in the United Kingdom[1,2]. In 2017 alone, the national hip fracture database reported 65958 admissions with a 1 mo mortality of 6.9% and the disability leaving only half of patients returning to their pre-morbid state[3]. The total cost and burden to health and social services is over £1 billion per year along with 1.5 million National Health Service beds occupied annually[3-5]. A number that is set to rise with an aging population making health resource and provision allocation more important than ever[6].

Almost all hip fractures are managed surgically to enable early mobilisation, reducing complications associated with prolonged recumbency[7-9]. Surgical management is primarily dictated by fracture configuration and level, whilst also considering patient-specific factors such as physiological age, co-morbidities and pre-morbid function[10,11]. Specifically, operative management of intra-capsular fractures, which accounts for roughly 60% of all hip fractures, include a range of fixation and arthroplasty procedures[3,12]. Hip fixation whilst less successful than arthroplasty still comes as an attraction in order to maintain native anatomy and hip geometry whilst always having arthroplasty as a backup if it fails [12-14]. The evidence to date is equivocal for which fixation type is superior but a recent international multi-centre randomised controlled trial (FAITH) comparing standard cancellous and sliding hip screws found trends favouring sliding hip screws in certain subgroups of patients for reoperation rate[15]. With the cost implication to society of these fractures, health economics may play an important role in the decision making of fixation type to best manage them. This study therefore set out to determine the best fixation method routinely used for intra-capsular neck of femur fractures incorporating patient, surgeon and hospital metrics. The primary aim of this clinical practice study is to determine the most effective and beneficial way of treating these patients. The secondary aim is to determine which factors predispose to an undesirable fixation result. The null hypothesis was that no difference would be determined between fixation methods.

MATERIALS AND METHODS

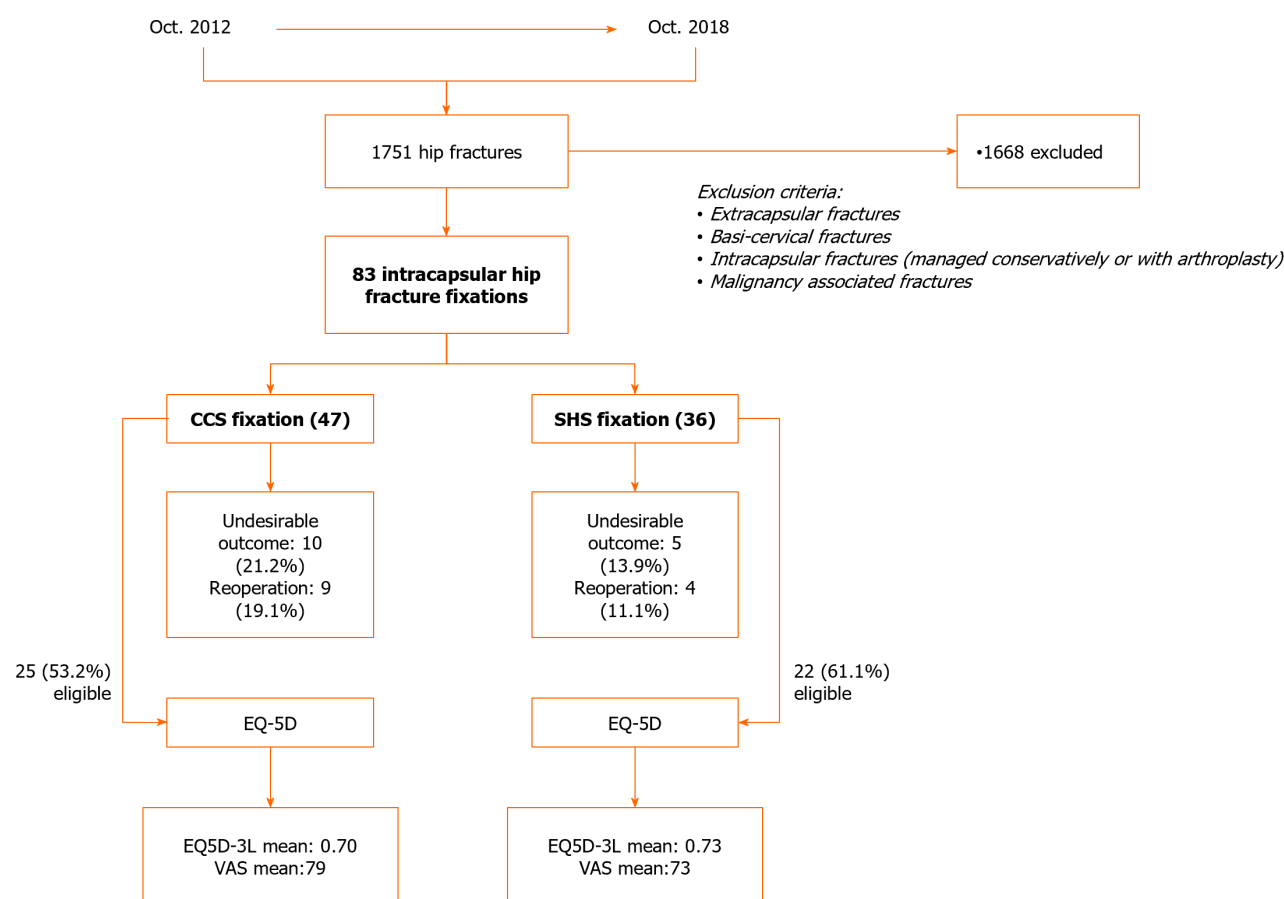
A retrospective analysis was conducted on all skeletally mature patients who sustained a closed intra-capsular hip fracture treated with either cannulated cancellous screws (CCS) or 2-hole sliding hip screw (SHS) fixation during the period from October 2012 to October 2018 (Figure 1). The study was conducted at a single district general hospital which regularly treats hip fractures using both fixation types and having no preference for either, with the requirement to proceed having achieved good-closed reduction in all planes intraoperatively. Patients with malignancy associated, basi-cervical or intertrochanteric fractures were excluded. The service improvement project was registered locally to follow good clinical governance practice guidelines.

Patients and procedure

Over the audit period, 1751 patients were admitted with a hip fracture, of which 83 had intra-capsular hip fracture fixation (Table 1) which met the study criteria. Fixation was achieved with either three partially threaded cancellous screws (6.5 mm diameter with 16 mm thread length) arranged in a reverse triangular configuration or with a single 13 mm sliding hip screw with a 47 mm barrelled two hole side plate affixed with two 4.5 mm cortical screws +/- 6.5 mm anti-rotational screw. The time of surgery was defined as time from admission to the emergency department to the time

Table 1 Fracture configuration, *n* (%)

	Cannulated cancellous screw fixation	2-hole sliding hip screw fixation
Fixation group	47 (56.6)	36 (43.4)
Laterality		
Left	25 (53.2)	18 (50)
Right	22 (46.8)	18 (50)
Garden classification		
I	24 (51.1)	13 (36.1)
II	8 (17)	11 (30.6)
III	10 (21.3)	7 (19.4)
IV	5 (10.6)	5 (13.9)
Pauwels classification		
I	7 (14.9)	1 (2.8)
II	32 (68.1)	24 (66.7)
III	8 (17)	11 (30.6)



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Figure 1 Audit period flowchart for hip fractures. CCS: Cannulated cancellous screws; SHS: Sliding hip screw; VAS: Visual analogue score.

of surgery in theatres. All procedures were conducted by specialty trainee registrars with minimum 3 years' experience under the supervision of a consultant. The patient setup was identical for both using a standard hip traction table using routine manoeuvres such as gentle traction with internal rotation. All patients before having closed reduction with fixation under fluoroscopy guidance had a single dose of intravenous antibiotic. All patients had hospital guided prophylaxis low molecular weight heparin peri-operatively unless contra-indicated. Patients were all seen by physio-

therapy department day 1 post-operatively with a standardised protocol encouraging early mobilisation.

Operative and post operative parameters

All clinical records were reviewed to determine age, sex, date of injury, date of surgery, pre-to-post operative haemoglobin count, post-operative weight bearing status and length of stay. Pre-operative imaging studies were reviewed to assess fracture configuration and displacement, classified according to the Pauwel and Garden classification systems, respectively with a simple modification (undisplaced or displaced) to the Garden classification for improved reliability[16,17]. Intra-operative imaging studies were reviewed to assess fixation type, reduction adequacy, fixation accuracy on the centre of the femoral head (tip-apex index) along with the radiation exposure time report, a surrogate for procedural complexity and radiation exposure. All available post-operative patient imaging studies were reviewed to assess fracture union time and the event of an undesirable outcome including significant collapse (> 5 mm), non-union, avascular necrosis (AVN) or implant failure. All images were accessed through the hospital electronic picture archiving and communication system and were reviewed by a senior surgeon. Follow up clinic letters were accessed using the electronic clinic letter system and reviewed further for an undesirable outcome.

Patient reported outcome measure

Patients not flagged as deceased by hospital records were contacted by a trauma coordinator a minimum of 1 year after surgery. Patients were asked if they were satisfied with their outcome and if further operations following hip fixation was required. A validated quality of life measure, the EuroQol-5 dimensions 3-level (EQ-5D- 3L) index score and visual analogue scale score were collected to provide a single index value for health status[18].

Cost analysis

Clinical coding data corresponding to the patients hip fracture hospital spell was obtained from the hospital clinical coding department. Data included international classification disease (ICD- version 10) diagnostic codes, OPCS-4 procedural codes and health resource group (HRG) coding records. Patient co-morbidity data was extracted and recorded based on number of chronic end-organ co-morbidities. HRG Codes were then converted into monetary tariffs based on service level agreements.

The current standard implants used for CCS and SHS fixation are the Stryker Asnis III and Omega 3 systems respectively (Mahwah, NJ, United States). The implant cost price for each procedure was obtained from the local procurement officer.

Statistical analysis

Statistical analysis was performed using SPSS (IBM SPSS Statistics, version 21) software. Normality was assessed using a Kolmogorov-Smirnov test. A Student-*t* and Mann-Whitney *U* test were used for parametric and non-parametric data. Fisher's exact test was used for categorical variables. Logistical regression analysis was conducted to analyse factors affecting an undesirable result. Significance was set at 0.05 throughout. Results are reported as mean (range) and number (percentage).

Ethical statement

Ethical approval was not sought nor required as it was part of a service evaluation project for the trauma and orthopaedic department. The service evaluation was registered (SUR.NP.19.003) with the local clinical governance team before the audit commencement to ensure hospital standard operating procedure adherence.

RESULTS

A total of 83 patients meeting the inclusion/exclusion criteria were evaluated. CCS fixation was utilised in 47 (57%) patients with 36 (43%) patients undergoing 2-hole SHS fixation. Fracture configuration was comparable between CCS and SHS groups, with undisplaced fractures (Garden I/II) 68.1% *vs* 66.7%, respectively and Pauwel type II the most common type representing 68.1% and 66.7% respectively. Fracture configuration for each fixation group is detailed in Table 1. The case mix was similar for age (65.7 *vs* 70.9 year), gender (66% *vs* 58.3% female) and end-organ co-morbidities (1.47 *vs* 1.42 mean). Patient demographics are summarised in Table 2.

Operative and post operative parameters

There was no significant difference in blood loss (1.8 *vs* 1.5 g/dL), blood transfusions (2 in each group), tip apex distance (20 mm *vs* 23 mm, length of stay (15 *vs* 17 d), total radiation exposure time (53 *vs* 47 sec.) or union time (5.1 *vs* 5.8 mo) respectively for CCS and SHS (Table 3). There was a clear difference in post operative weight bearing instructions following the fixation types (Table 3). Partial weight bearing was most common advice, 45% of the time, in CCS fixation and fully weight bearing, 44% of the time for the SHS fixation.

Complications

In total there were 15 undesirable events with no statistical difference between groups for avascular necrosis, significant collapse, non-union, and cut-out (Table 4). Furthermore there was no statistical difference in re-operation rate between the groups with 9 (19.1%) and 4 (11.1%) for the CCS and SHS groups respectively. Most reoperations were metal work

Table 2 Patient demographics, *n* (%)

	Cannulated cancellous screw fixation	2-hole sliding hip screw fixation
Mean age, yr (range)	66 (18-91)	71 (28-100)
Group by age		
< 50	7	6
> 50	40	30
Gender		
Male	16 (34)	15 (41.7)
Female	31 (66)	21 (58.3)
Number of organ co-morbidities		
0	13 (27.7)	11 (30.6)
1	13 (27.7)	9 (25)
2	11 (23.4)	8 (22.2)
3	6 (12.8)	6 (16.7)
4	4 (8.5)	2 (5.6)
Mean	1.5	1.4

Table 3 Peri-operative parameters, *n* (%)

	Cannulated cancellous screw fixation	2-hole sliding hip screw fixation
Time to surgery, h (range)	39 (6-168)	43 (7-408)
Tip-apex, mm (range)	20 (10-45)	23 (15-35)
Hb drop pre-op to post op, g/dL (range)	1.8 (0.1-5.0)	1.4 (0.3-4.2)
Radiation time, sec (range)	53 (7-127)	47 (35-75)
Length of stay, d (range)	15 (3-69)	17 (4-62)
Weight bearing status		
NWB	5 (10)	2 (6)
PWB	21 (45)	7 (19)
FWB	3 (6)	16 (44)
Unclear	18 (39)	11 (31)
Union time, mo (range)	5.1 (1-16)	5.8 (1-12)
Health resource group, £ (range)	5979 (517-11117)	6862 (639-14323)

NWB: Non weight bearing, PWB: Partial weight bearing, FWB: Full weight bearing; Hb: Haemoglobin.

removal due to significant collapse causing soft tissue irritation. Each group had 3 patients having undergone revision total hip replacement.

Subanalysis and regression analysis of all patients

In total there were 56 patients with undisplaced fractures and 27 with displaced fractures. With the undisplaced fractures only 9% ($n = 5$) resulted in an unsatisfactory outcome in comparison to 37% ($n = 10$) in the displaced group. When subdividing the patient by age, there were a total of 13 patients under the age of 50 with 5 having an undisplaced fracture and 8 having a displaced fracture. There were zero unsatisfactory results in the less than 50 years undisplaced fracture patients but 25% ($n = 2$) in the displaced fractures. When analysing patients over the age of 50 years, there were in total 70 patients with 51 undisplaced and 19 displaced fractures. Of the greater than 50 group with an undisplaced fracture, only 10% ($n = 5$) resulted in an unsatisfactory outcome as compared to 42% ($n = 8$) in the displaced group.

Binary logistic regression analysis of all characterisable variables showed that only a displaced (Garden 1-2 *vs* Garden 3-4) intracapsular hip fracture was a significant ($P = 0.016$) independent predictor of an unsatisfactory result. Hosmer-Lemeshow goodness of fit was $P = 0.566$ for the model and Nagelkerke R-Square was 0.287 with a classification accuracy

Table 4 Complications, n (%)

Undesirable outcomes	Cannulated cancellous screw fixation	2-hole SHS fixation
Avascular necrosis	1 (2.1)	3 (8.3)
Significant collapse	5 (10.6)	1 (2.7)
Non-union	3 (6.4)	0 (0)
Cut-out	1 (2.1)	1 (2.7)
Reoperation	9 (19.1)	4 (11.1)

SHS: Sliding hip screw.

of 82% and an odds ratio of 7.25 (CI: 1.45-36.31).

Patient related outcome measures

Of the 83 patients having undergone fixation only 47 (57%) were contactable or able to coherently converse for psychometric analysis. A breakdown of those included and reasons for exclusion are detailed in Table 5. Fixation groups were similar for the proportion valid to be included (74% *vs* 79%). There was no significant difference in EQ 5D-3L or VAS scores between fixation groups (0.70 *vs* 0.73 and 79 *vs* 73, respectively). Sub-analysis of all requiring revision total hip arthroplasty demonstrated a score of 0.62 and 69.

Cost analysis

Clinical coding demonstrated no significant difference in the actual tariff received with a mean value of £5979 and £6862 respectively. Total CCS implant cost was £259.35 incorporating Asnis III 6.5 mm cannulated cancellous screws (×3), washers (×3), guidewire and drill bit. Total SHS implant cost was £146.13 assimilating SHS plate, 13 mm lag screw, cortex screws (×2), guidewire and drill bit.

DISCUSSION

Whilst much research has focused on the clinical outcomes of intra-capsular hip fracture fixation considerably less work has examined the health economics on the quality of life and financial effect of differing fixation methods[19,20]. This retrospective study found no significant cost-saving difference between CCS and SHS fixation methods. Both groups had similar lengths of stay and intra-operative radiation exposure, a surrogate for the cost of time. The mean HRG, which is the currency that each patient event attracts, were not statistically dissimilar but favouring the SHS with a mean of £6862 when compared to the CCS with a mean of £5979. Additionally both fixation types had comparative quality of life indices with a mean EQ-5D score of 0.70 and 0.73 and EQ-VAS of 79 and 73 for CCS and SHS respectively. These quality of life findings for economical appraisal terms signifies reasonable return of everyday health and function considering the average index and visual analogue score without injury in the United Kingdom is 0.78 and 77 for individuals greater than 65[21].

In terms of the health impact to the patient, both methods had relatively high rates of undesirable outcomes (21.2% CCS *vs* 13.9% SHS group) resulting in reoperation rates of 19.1% and 11.1% respectively. With greater failures predicted by fracture displacement and patient age over 50 years which is consistent with a recent study looking at displaced fractures treated with fixation[22]. The reoperation rates, demonstrating a non-significant trend favouring SHS, are comparable with those demonstrated in the FAITH study, a multi-centre randomised controlled trial comparing CCS and SHS fixation in an elderly with low impact fractures[15]. As found in the FAITH trial, the rates of AVN also appear to be more frequent in the SHS group. This is contrary to a previous systematic review which suggested CCS were more likely to develop AVN than SHS[23]. Non-union on the contrary was found to be more common for the CCS group but not statistically dissimilar and were identical to the FAITH trial at 6%[15]. The latter observation may be accounted by a recent biomechanical cadaveric study that found significant superiority for prevention of implant migration, varus tilt, femoral neck and leg shortening with a SHS when compared to CCS[24].

Yet, the most compelling finding in this study was the significant correlation of the degree of fracture displacement with the risk of an undesirable outcome following any fixation procedure, which is not unsurprising biomechanically and has been previously reported[25-28]. Previous trials have indicated poor outcomes with internal fixation in displaced hip fractures with one study reporting fixation failure rates as high as 44%[29], which was marginally higher than the 42% found in this study for the greater than 50 age group. A meta-analysis comparing internal fixation and arthroplasty in displaced hip fractures found arthroplasty significantly reduces the need for further revision surgery at the expense of greater operative blood loss and surgery time[30]. A subsequent national registry study in patients with displaced hip fractures found that those treated with arthroplasty had significantly less reoperations, reported less pain and had a better quality of life[25,31]. Most literature to date suggest that arthroplasty should be more readily considered in those with displaced fractures, particularly in the elderly[12,32-34].

Table 5 EQ 5D and visual analogue score parameters, *n* (%)

	Cannulated cancellous screw fixation	2-hole sliding hip screw fixation
Successfully contacted patients, <i>n</i> (%)	25 (53.2)	22 (61.1)
Deceased	12 (25.5)	4 (11.1)
Moved abroad	2 (4.3)	1 (2.8)
Dementia	1 (2.1)	4 (11.1)
Unable to contact	7 (14.8)	5 (13.9)
Time from surgery to PROM, months (range)	42 (12-78)	46 (12-98)
Valid (<i>n</i>) to answer questionnaire	25/34 (74%)	22/28 (79%)
EQ 5D 3 level (range)	0.70 (0.07-1)	0.73 (0.22-1)
EQ 5D visual analogue score (range)	79 (40-100)	73 (10-100)

This study is limited by a variety of factors. The basic retrospective analysis intrinsically suffers bias and lends to a fall out rate for data collection. This was seen, as near 20% of patients had deceased before patient reported outcome measures were collected. Surprisingly, this was higher in the CCS group despite being 10% younger. There was also a noticeable difference in the post-operative weight bearing instructions between the two fixations in our study, which is consistent with a multi-national survey studying surgeon preferences for managing femoral neck fractures[35]. In this study, operating surgeons preferred partial or non-weight bearing following CCS fixation whereas SHS fixation was associated with more full weight bearing status. There is evidence to suggest that a restriction in weight bearing status can compromise functional levels up to a year following surgery[36]. In this respect arthroplasty has been shown to be advantageous given the lack of restriction and improved mobility[37]. Finally, the small nature of this series can lead to statistical errors, particularly false negatives, which limit the conclusion, so caution must be taken with these results.

CONCLUSION

In conclusion, no significant benefit was seen with differing fixation types for intra-capsular hip fractures. Nonetheless, younger patients and undisplaced fractures fared better. The significant rates of undesirable outcomes seen in displaced fractures for patients over the age of 50 years suggest hip arthroplasty should be considered.

ARTICLE HIGHLIGHTS

Research background

Hip fractures are common injuries requiring surgery.

Research motivation

Determining if there is an advantage between two common procedures for hip fracture fixation.

Research objectives

Identifying the best fixation method and identifying any patient factors which put them of a less desirable outcome.

Research methods

An audit was conducted to identify patients who had hip fracture fixation during a 6 year period followed by a quality of life questionnaire along with cost analysis of patient having undergone hip fracture fixation.

Research results

Older patients (> 50 years) and displaced fractures were risk factors for undesirable outcomes in hip fracture fixation.

Research conclusions

Alternatives from hip fracture fixation should be considered in displaced hip fractures and older patients requiring surgery.

Research perspectives

Further research should look into fixation constructs along with patient metabolomics.

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FOOTNOTES

Author contributions: Wiik AV designed the study; Wiik AV and Ashdown T collected the clinical data; Wiik AV and Ashdown T analysed the data; Wiik AV, Ashdown T and Holloway I interpreted and wrote the report.

Institutional review board statement: The study was a registered audit so no ethical approval was sought nor required. No individual patient or related identity information have been presented.

Informed consent statement: As a registered audit without any patient or related identity no consent was required.

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Data sharing statement: Raw data is not available freely for use as per National Health Service audit regulations.

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