

Clinical Paper

Mortality and complications after total hip arthroplasty via the posterior approach for displaced intracapsular hip fracture: Results from a regional trauma centre

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Abstract

Introduction

Total hip arthroplasty (THA) for displaced intracapsular hip fracture is increasingly common. The aim of this project was to determine all-cause mortality rates, rates of significant complications and functional outcomes following THA for fractures.

Methods

An inpatient database search identified all patients undergoing THA for displaced intracapsular fracture in Northern Ireland's regional trauma centre from 2010-2017. Regional electronic healthcare systems were reviewed for evidence of complications.

Results

After exclusions, 345 cases were identified. The median age was 70 years (31 – 91 years).

Median follow-up was 4.3 years (1.6 – 9.3 years). The all-cause mortality rate was 0.3% at 30 days, 3.2% at one year, and 5.5% at two years.

Seven patients (2.0%) experienced dislocations. Most occurred within 60 days; five patients underwent revision.

Radiographic evidence of heterotopic ossification (HO) was seen in 48 patients (13.8%).

Re-operation was required for 16 patients (4.6%). This included 5 dislocations, eight cases of periprosthetic fractures (in seven patients), two cases of infection, and one case of symptomatic HO.

Pre-injury, 96.2% (332/345) were independently mobile, and after one year 78.9% (262/332) of those patients remained so. Pre-injury, 96.2% obtained the maximum functional score (Barthel Index, maximum score of 20), and after one year 78.9% (262/332) of these continued to report a maximum Barthel Index score.

Conclusion

THA for hip fracture holds a 2.0% risk of dislocation and a

4.6% risk of re-operation. HO is common but seldom requires re-operation. All-cause mortality rates and functional levels compared favourably with current literature.

Key words

Hip fracture, total hip arthroplasty

Introduction

Hip fractures are a common and increasing global challenge¹ associated with an increased risk of mortality, particularly in the first six months post-injury.² In the United Kingdom (UK), the National Hip Fracture Database (NHFD) reported that 30-day mortality rates remain substantial at 6.1%.³

Intracapsular hip fractures affect the region of the femur which is enveloped by the ligamentous hip joint capsule.⁴ Following such an injury, the femoral head is at risk of avascular necrosis due to disruption of the branches of the medial and lateral circumflex arteries supplying the femoral head.⁵ Thus, intracapsular hip fractures, particularly if displaced, are typically managed with arthroplasty. This may be in the form of a hemiarthroplasty (femoral side only) or a total hip arthroplasty (THA), where both the femoral head and acetabulum are replaced.^{4,6} Both approaches endeavour to relieve pain and facilitate early weight-bearing and mobilisation.

THA has been associated with superior post-operative function and lower re-operation rates, compared with hemiarthroplasty.⁷ This may be due to erosion of the patient's native acetabular cartilage by the femoral prosthesis⁸, and disruption of hip abductor function due to the anterolateral approach typically employed for hemiarthroplasty.⁹ However, THA has also been associated with greater risk of dislocation as well as operative time and intra-operative blood loss.¹⁰ Thus, consideration of the patient's pre-

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morbid function and overall health status is paramount when planning management.

In 2011, the UK National Institute of Health and Care Excellence (NICE) introduced guidelines regarding the use of THA for intracapsular hip fractures.¹¹ These recommended offering THA to patients with a displaced intracapsular femoral neck fracture who can walk independently outdoors with no more than the use of a stick, are not cognitively impaired, and are medically fit for anaesthesia and the procedure.

Northern Ireland's regional trauma centre, the Royal Victoria Hospital (RVH), is one of the highest-volume centres in the UK NHFD, with low 30-day hip fracture mortality rates and relatively high usage of THA for hip fractures.¹² Northern Ireland also has a relatively 'captive' population due to its geographical location, whereby patients rarely travel to healthcare providers outside the region, and regional healthcare systems record all emergency department and inpatient episodes, and all radiological investigations performed in Northern Ireland.

The primary aim of this study was to determine the rate of all-cause mortality in patients undergoing THA for displaced intracapsular hip fracture in this unit. Secondary aims included assessing the rate of significant post-operative complications, and the impact on patient mobility and functional status.

Methods

This retrospective cohort study considered all patients undergoing THA for displaced intracapsular hip fractures in a single regional trauma centre (the Royal Victoria Hospital) between 8 February 2010 and 8 August 2017 as identified from the Fracture Outcomes Research Department (FORD) inpatient database. Telephone follow-up to one year was performed by specialist nurses. Regional electronic systems for healthcare notes and imaging provided information regarding further hospital presentations, complications, and re-operation.

Pre-operatively, patients were medically optimised by a consultant-led ortho-geriatric medical team. All patients underwent a THA with a cemented Exeter (Stryker) femoral stem and an acetabular component with highly cross-linked polyethylene liner, either cemented or uncemented as per surgeon preference. Stainless steel and ceramic femoral heads were utilised at surgeon discretion. Femoral head sized ranged from 22mm to 36 mm. All THAs were inserted via a posterior approach with repair of the joint capsule and short external rotator muscles, either by, or under the close supervision of an experienced arthroplasty surgeon. Antibiotic-impregnated cement and antibiotic prophylaxis were used in all patients. Patients underwent an inpatient post-operative radiograph and were routinely mobilised fully weight-bearing under the supervision of physiotherapists. Patients received mechanical and chemical thrombo-

embolic prophylaxis (typically enoxaparin for 28 days post-operatively unless contraindicated, or until resumption of pre-injury anticoagulants if applicable).

Details of the admission, demographics and telephone follow-up were retrieved from the FORD database. Of the 390 patients identified from the database, 45 cases were excluded due to incorrect coding (n=8), duplicate entries (n=5), indications other than acute intracapsular fractures (n=22), THA for pathological lesions (n=4), or patients normally resident outside Northern Ireland who did not receive local follow-up.

Regional electronic systems of medical records and radiology images and reports were reviewed to obtain details regarding all-cause mortality, dislocation, periprosthetic fracture, infection, and heterotopic ossification (HO). Telephone follow-up ascertained details of mobility, use of walking aids and functional status (using the Barthel Index).

Descriptive statistics were calculated using Microsoft Excel (Microsoft Office Excel 2016, Washington, USA). Categorical variables were analysed using Fisher's exact tests) depending upon sample sizes, using GraphPad QuickCalcs (available at <https://www.graphpad.com/quickcalcs/contingency1.cfm>).

Results

Demographic information

From the database, 345 patients who underwent THA for acute displaced intracapsular hip fracture were identified. This represents 8.6% of the 4005 patients with displaced intracapsular hip fractures admitted to the unit during this period. Usage of THA for this indication rose from 2.3% (9/399) in the period from 8 Feb 2010 to 31 December 2010, to 14.3% (74/516) in 2016, and 15.8% (54/341) of those treated from 1 January 2017 to 8 August 2018. Most patients were female (77.7%), were aged over 65 years (median age 70 years, range 31 – 91 years, interquartile range 64 – 75 years) and were of American Society of Anaesthesiologists (ASA) grade 2 (55.7%, 192/345). A further 37.4% (129/345) were ASA grade 3. Pre-injury, 96.2% (332/345) of patients mobilised without assistance. In addition, 90.7% (313/345) of patients mobilised without walking aids, 7.8% (27/345) mobilised with the use of a stick, and 1.4% (5/345) required the use of a walking frame/ rollator. Pre-injury, 96.2% (332/345) achieved the maximum functional score of 20 on the Barthel Index.

All-cause mortality

At the time of data collection, 306 (88.7%) of the patients were alive (median 4.3 years post-operatively, range 1.6 to 9.3 years), of whom 277 had at least two years of follow-up. Of the 39 patients who were deceased at the time of data collection, 20 patients had two years of follow. Two-year follow-up information was therefore available for 297 (86.1%) of the original 345 patients.

Mortality rates were 0.3% at 30 days (one patient of ASA grade 3), 3.2% at one year (11 patients including three of ASA grade 2 and eight of ASA grade 3) and 5.5% at two years (19 patients including five patients of ASA grade 2 and 14 of ASA grade 3).

Among the 192 patients of ASA grade 2, none had died by 30 days post-operatively, three (1.6%) died by one year, and five (2.6%) died by two years. Among the 129 patients of ASA grade 3, one died by 30 days post-operatively (0.8%), eight (6.2%) died by one year, and 14 (10.9%) died by two years post-operatively.

Of the 39 (11.3%) deceased patients, causes of death were available on regional electronic medical for 19 patients, as outlined in **Table 1**. Only one death occurred within 30 days

of surgery, due to a fatal dysrhythmia, having experienced a perioperative non-ST-elevation myocardial infarction.

Major complications

Less than 20% of patients undergoing THA for trauma experienced a major complication, as outlined in **Table 2**.

Dislocation

Seven patients (2.0%) had a hip dislocation during the study period. Of these, four patients experienced two dislocations and three patients experienced three or more dislocations. The median time from arthroplasty to first dislocation was 33 days, with six of these dislocations occurring within 60 days post-operatively (6, 8, 20, 33, 43 and 43 days post-

Table 1: The causes of death as indicated on regional electronic medical records.

Cause of death	Number (Percentage overall cohort) deceased at 30-days post-operatively	Number (Percentage overall cohort) deceased at two-years post-operatively	Number (Percentage overall cohort) deceased during available follow-up period
Cardiac event	1 (0.3%)	1 (0.3%)	2 (0.6%)
Chest infection or chronic obstructive pulmonary disease	0 (0%)	2 (0.6%)	11 (3.1%)
Metastatic or recurrent malignancy	0 (0%)	4 (1.2%)	8 (2.3%)
Single or multi-organ failure	0 (0%)	2 (0.6%)	4 (1.2%)
Intracranial event	0 (0%)	1 (0.3%)	2 (0.6%)
Cause of death unavailable	0 (0%)	9 (2.9%)	12 (3.5%)
Total	1 (0.3%)	19 (5.5%)	39 (11.3%)

Table 2: The incidence of major post-operative complications.

Complication	Number of patients (%)
Dislocation	Total 7 (2.0%)
	Two dislocations 4 (1.2%)
	Three or more dislocations 3 (0.9%)
Periprosthetic fracture	Total 8 (2.3%)
	Femur 7 (2.0%)
	Acetabulum 1 (0.3%)
Infection requiring washout	Total 2 (0.6%)
	Infected wound 1(0.3%)
	Infected haematoma 1 (0.3%)
Heterotopic ossification	48 (13.9%)
Nil known	282 (81.7%)
Total	345



operatively) and one dislocation occurring 30 months post-operatively.

Two patients required only closed reduction. Five patients underwent open procedures, including one open reduction, one exchange of the acetabular liner and femoral head, and three cases of acetabular component revision.

Almost all femoral heads were diameters of either 28mm (72.2%, 249/345) or 36mm (27.0%, 93/345). None of the three patients with smaller femoral heads (0.9%) (one 22mm head and two 26 mm heads) had dislocations. The rate of dislocation ostensibly was around twice as likely after use of a 28mm head (2.4%, 6/249) than 36mm (1.1%, 1/93), although this did not reach statistical significance ($p=0.68$).

Periprosthetic fracture

Eight periprosthetic fractures (2.3%) occurred, including seven (2.0%) femoral fractures in six patients, and one (0.3%) acetabular fracture. All resulted from falls (i.e., none sustained intra-operatively).

All femoral periprosthetic fractures were treated operatively. Two such injuries underwent revision of their femoral component plus cable plating, and four underwent cable plating, with one of the latter sustaining a second periprosthetic fracture one month later, which was subsequently treated with internal fixation. The acetabular fracture was managed non-operatively.

Infection

Two patients (0.6%) required re-operation for surgical site infection, one as a wound washout six days post-operatively and one as a washout of an infected haematoma one-month post-operatively. No patients required revision or prosthesis removal due to infection.

Heterotopic ossification

Radiographic evidence of heterotopic ossification (HO) was seen in 48 patients (13.9%), including two patients who had dislocations. Only one patient with HO (0.3%) required surgical excision due to pain.

Mobility and functional outcomes

Almost all patients (96.2%, 332/345) were independently mobile pre-injury. Of these 332 patients, one-year follow-up found that 262 (78.9%) remained independently mobile, 26 (7.8%) required assistance to walk, one was immobile, 11 were deceased, and the mobility of 32 patients was unknown. Amongst the 13 patients who had required assistance to walk pre-injury, one-year follow-up found that eight patients (61.5%) were able to walk without assistance, four (30.8%) continued to mobilise with assistance, and the mobility status of one patient was unknown.

Therefore 79.7% (275/345) of all patients has similar or better independence at one year compared to pre-injury.

Most patients (90.7%, 313/345) also required no walking aids pre-injury. Of these, 195 (62.3%) still required no walking aids at one year post-operatively.

At one year, 65.2% of all patients (225/345) had either similar use of walking aids or less dependence on walking aids, and 22.0% (76/345) required additional walking aids compared to pre-injury. Eleven patients (3.2%) were deceased at one year and the walking aids of 33 (9.6%) were unknown.

Of the 332 patients who achieved the maximum possible functional score pre-injury (Barthel index score of 20 out of 20), 262 (78.9%) maintained a Barthel Index score of 20 at one year, 22 (6.6%) had a decrease in functional score. Functional scores for 39 patients were unavailable and nine (2.7%) were deceased.

Thirteen patients had pre-injury Barthel Index scores less than 20 (range 14-19). At one year, eleven patients reported similar or better Barthel Index scores to pre-injury, and two were deceased.

Therefore, 79.1% of all patients (273/345) demonstrated similar or improved functional scores as compared to pre-injury.

Discussion

As compared to patients undergoing elective THA, patients undergoing THA for trauma have higher risks of mortality and major complications,¹³ may be more frail, and be less likely to have pre-operative optimisation.¹⁴ THA has been associated with greater operative time and physiological burden on the patient than hemiarthroplasty.^{15,16}

All-cause mortality

Whilst the considered hospital has been noted for low mortality rates among hip fracture patients,¹² the 30-day mortality rate for THA patients in this study was notably low at 0.3%. In this cohort, most patients had only mild systemic disease (ASA grades 1-2), but 37.4% had severe comorbidities (ASA grade 3).

The one-year mortality rate of 3.2% compares favourably with rates of up to 13% reported in the literature.¹⁷ This remains higher than the one-year mortality rate for elective THA,¹⁸ however this may reflect different baseline characteristics and pre-operative optimisation.

Patients undergoing THA are expected to represent a healthier and more active subgroup of hip fracture patients, as per the NICE guidelines.⁴ Nevertheless, the low mortality rates suggest that unsuitable patients are not being subjected to undue risks in THA, and that patients are appropriate optimised pre-operatively.

Major complications

Dislocation

Several meta-analyses have reported higher dislocation rates after THA for trauma than after hemiarthroplasty.^{17,18}

The dislocation rate of 2.0% in this study compares favourably with rates of up to 7.5% in recent literature^{19,20,21,22,23} and 3.9% in a recent meta-analysis. This may reflect the local system where high-volume elective arthroplasty surgeons also perform trauma and provide training under supervision. Of note, another United Kingdom regional database, the Scottish Arthroplasty Register, reported one-year dislocation rates (2.1%) comparable to the present study.²⁴

In elective THA, larger head sizes reduce the risk of dislocation,²⁵ but in the present study the increased risk of dislocation with smaller femoral heads did not reach statistical significance.

In elective THA, dislocation rates are higher after posterior approach than other approaches.^{26,27} There is limited evidence regarding the influence of approach on dislocation rates in the trauma setting. However, repair of the posterior capsule in THA for trauma (as is standard practice in this unit) has been associated with decreased dislocation rates.²⁷

Re-operation for fracture or infection

In the present study, sixteen cases (4.6%) required re-operation including five (1.4%) for dislocation, eight cases (2.0%) for periprosthetic fractures, two (0.6%) for infection and one (0.3%) for excision of heterotopic ossification.

Ravi et al reported lower one-year re-operation rates after THA for displaced intracapsular hip fractures as compared to hemiarthroplasty (0.2% vs 1.8%, $p < 0.001$), after matching for demographics and co-morbidities.²⁸

The present study's re-operation rates are comparable to published re-operation rates of 3.3% for periprosthetic fractures²⁰, and 3.1% revision in the Swedish Hip Arthroplasty Register,²¹ but lower than those reported by a recent RCT (7.9% at two years)²⁹ and the American College of Surgeons National Surgical Quality Improvement Program database (5.3%).¹⁶ Re-operation rates for infection following THA for fracture have been reported to be as high as 8.7%³⁰ but were only 0.6% in the present study, although selected patients' demographics may affect this.

Heterotopic ossification

In the present study, HO was seen in 13.2% of patients, of whom only one patient required surgical excision. Similarly, Comeau-Gauthier et al, identified HO in 19.9% of patients at 24 months following either THA or hemiarthroplasty for fracture, none of whom required excision.³¹ These rates are higher than those reported in other studies,^{20,29} possibly due to inclusion of radiologically-identified HO rather than

symptomatic HO.

Functional and mobility outcomes

In the present study, most patients mobilised independently with few/no walking aids and high functional scores pre-injury, and the majority maintained these levels at one-year. Maintenance of functional scores compared favourably with published reports of deterioration in functional scores,¹⁹ and reduced ability to mobilise and perform activities of daily living,²⁰ although the latter study's population involved fewer patients and a higher average age than the present study.

Bhandari, et al compared clinical outcomes following THA and hemiarthroplasty for fracture²⁹ and concluded that improved results after THA fell below the threshold for a minimal clinically important difference. However, the scoring systems used were designed for primary hip OA and not validated for hip fractures, and post-operative scores were not considered in light of pre-injury ambulatory ability.

The findings in the present study are favourable compared with reported rates of ambulation following hemiarthroplasty described in the literature. Following hemiarthroplasty, non-ambulation has been reported in 4% of patients.³² being housebound in 23.3%,³³ a reduction in pre-fracture ambulatory ability at one year in 84.8%,³⁴ and requirement for a walking frame in 42.4%.³⁴ Comparing THA and hemiarthroplasty, Mariconda et al described a trend (non-significant) for a greater independent ambulation following THA at 12 months, and also found walking aid requirement was significantly lower at four months.²⁰ Similarly, a recent cohort study reported greater walking support and shorter walking distances following hemiarthroplasty.³⁵

Considering Barthel index, one study has reported superior scores following THA than following hemiarthroplasty,³⁶ however the authors acknowledge the findings should be interpreted with caution given the inherent selection bias. Similarly, a study found 53% of patients undergoing hemiarthroplasty to have a normal-near normal rating (19-20/20) at 12 months,³⁷ in contrast to 78.8% in the present study. Furthermore, the minimum clinically important difference at 12 months after hip fracture surgery was found to be 2/20.³⁸ thus, the differences reported in the literature may not be notable to the patient, and we believe this warrants further investigation.

Limitations

Limitations to the present study include its retrospective, single-centre design. Furthermore, whilst the use of regional electronic systems allowed access to details of all inpatient or emergency department activity, ensuring recording of attendance to any hospital with complications, causes of death were only specified for inpatient deaths, resulting in incomplete data for deaths outside hospital.

The present study also lacks a control (hemiarthroplasty)



group, making it difficult to fully evaluate the risks and benefits of THA at this centre, and this represents an area for future work. Subgroup analysis may also wish to consider the merit of using strategies proposed to improve function following hemiarthroplasty, including bipolar components³⁹ or via a modified abductor-sparing surgical approach,⁴⁰ particularly in active, older (>80 years) adults.

Conclusion

In this retrospective cohort study, the one-year all-cause mortality rate following THA for acute displaced intracapsular hip fracture was 3.2%. THA, performed via the posterior approach, was associated with a 2.0% risk of dislocation and 4.6% re-operation rate (1.4% for dislocation, 3.2% for other causes). HO occurred in 13.8% of patients but seldom required re-operation. Overall, a good maintenance of mobility and activities of daily living was seen at one year post-operatively. Therefore, we propose that THA for trauma via the posterior approach with posterior structure repair can be used in suitable patients without putting them at undue risk of major complications or need for revision.

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REFERENCES

- Cooper C, Campion G, Melton LJ. Hip fractures in the elderly: a world-wide projection. *Osteoporos Int*. 1992;2(6):285-9.
- Nemes S, Lind D, Cnudde P, Bülow E, Rolfson O, Rogmark C. Relative survival following hemi- and total hip arthroplasty for hip fractures in Sweden. *BMC Musculoskeletal Disord*. 2018;19(1):407. doi: 10.1186/s12891-018-2321-2.
- Royal College of Physicians. National Hip Fracture Database annual report 2019. London: Royal College of Physician; 2019. [Internet] [cited 2020 May 5] Available from: Accessed 5th May 2020. Available from: <https://www.nhfd.co.uk/20/hipfractureR.nsf/docs/2019Report>
- Sreekanta A, Eardley WGP, Wood H, Glanville JM, Cook J, Griffin XL. Surgical interventions for treating intracapsular hip fractures in adults: a network meta-analysis. CD013404. *Cochrane Database Syst Rev*. [Internet]. 2019;2019(8). doi: 10.1002/14651858.CD013404.pub2
- Barney J, Piuze NS, Akhondi H. Femoral head avascular necrosis. [Internet]. Treasure Island (FL): StatPearls Publishing; 2024. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK546658/>
- Fletcher JW, Sommer C, Eckardt H, Knobe M, Gueorguiev B, Stoffel K. Intracapsular femoral neck fractures-a surgical management. *Algorithm. Medicina (Kaunas)*. 2021;57(8):791. doi: 10.3390/medicina57080791.
- Lewis DP, Wæver D, Thorninger R, Donnelly WJ. Hemiarthroplasty vs total hip arthroplasty for the management of displaced neck of femur fractures: a systematic review and meta-analysis. *J Arthroplasty*. 2019;34(8):1837-43.
- Moon NH, Shin WC, Do MU, Kang SW, Lee S-M, et al. High conversion rate to total hip arthroplasty after hemiarthroplasty in young patients with a minimum 10 years follow-up. *BMC Musculoskeletal Disord*. 2021;22(1):273.
- Gore DR, Murray MP, Sepic SB, Gardner GM. Anterolateral compared to posterior approach in total hip arthroplasty: differences in component positioning, hip strength, and hip motion. *Clin Orthop Relat Res*. 1982(165):180-7.
- van den Bekerom MP, Hilverdink EF, Sierevelt IN, Reuling EM, Schnater JM, Bonke H, et al. A comparison of hemiarthroplasty with total hip replacement for displaced intracapsular fracture of the femoral neck: a randomised controlled multicentre trial in patients aged 70 years and over. *J Bone Joint Surg Br*. 2010;92(10):1422-8.
- National Institute for Health and Care Excellence. Hip fracture: management [Internet]. Manchester: NICE; 2023. [cited 2020 May 5]. Available from: <https://www.nice.org.uk/guidance/cg124>.
- Royal College of Physicians. National Hip Fracture Database annual report 2017; [Online] =, [cited 2020 May 5]. Available from: <https://www.data.gov.uk/dataset/2045eb71-0820-49fc-9599-80dca17ff1e6/national-hip-fracture-database-annual-report-2017>.
- Le Manach Y, Collins G, Bhandari M, Bessissow A, Boddart J, Khiami F, et al. Outcomes after hip fracture surgery compared with elective total hip replacement. *JAMA*. 2015;314(11):1159-66.
- Coomber R, Porteous M, Hubble MJ, Parker MJ. Total hip replacement for hip fracture: Surgical techniques and concepts. *Injury*. 2016;47(10):2060-4.
- Sharma V, Awasthi B, Kumar K, Kohli N, Katoch P. Outcome analysis of hemiarthroplasty vs. total hip replacement in displaced femoral neck fractures in the elderly. *J Clin Diagn Res*. 2016;10(5):RC11-3. doi: 10.7860/JCDR/2016/18638.7877
- Liodakis E, Antoniou J, Zukor DJ, Huk OL, Epure LM, Bergeron SG. Major complications and transfusion rates after hemiarthroplasty and total hip arthroplasty for femoral neck fractures. *J Arthroplasty*. 2016;31(9):2008-12.
- Burgers PT, Van Geene AR, Van den Bekerom MP, Van Lieshout EM, Blom B, Aleem IS, et al. Total hip arthroplasty versus hemiarthroplasty for displaced femoral neck fractures in the healthy elderly: a meta-analysis and systematic review of randomized trials. *Int Orthop*. 2012;36(8):1549-60.
- Inacio MC, Dillon MT, Miric A, Navarro RA, Paxton EW. Mortality after total knee and total hip arthroplasty in a large integrated health care system. *Perm J*. 2017;21:16-171.
- Dawson D, Milligan D, Callachand F, Cusick L. Hip hemi-arthroplasty vs total hip replacement for displaced intra-capsular hip fractures: retrospective age and sex matched cohort study. *Ulster Med J*. 2018;87(1):17-21.
- Mariconda M, Costa G, Misasi M, Recano P, Balato G, Rizzo M. Ambulatory Ability and Personal Independence After Hemiarthroplasty and Total Arthroplasty for Intracapsular Hip Fracture: A Prospective Comparative Study. *J Arthroplasty*. 2017;32(2):447-52.
- Hansson S, Nemes S, Kärrholm J, Rogmark C. Reduced risk of reoperation after treatment of femoral neck fractures with total hip arthroplasty. *Acta Orthop*. 2017;88(5):500-4.
- Blomfeldt R, Törnkvist H, Eriksson K, Söderqvist A, Ponzer S, Tidermark J. A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. *J Bone Joint Surg Br*. 2007;89(2):160-5.
- Chammout G, Kelly-Pettersson P, Hedbeck CJ, Stark A, Mukka S, Sköldenberg O. HOPE-trial: hemiarthroplasty compared with total hip arthroplasty for displaced femoral neck fractures in octogenarians: a randomized controlled trial. *JBJS Open Access*. 2019;4(2):e0059. doi: 10.2106/JBJS.OA.18.00059.



24. Jenkinson MRJ AF, Campbell J, Meek RMD. A comparison of THA outcomes between fractured neck of femur and osteoarthritis: a population-based study. Scottish Committee for Orthopaedics and Trauma (SCOT) meeting, Dublane, Scotland, August 2019. *Orthop Procs.* 2020;102-B(Suppl_3):3-3. doi:10.1302/1358-992X.2020.3.003
25. Plate JF, Seyler TM, Stroh DA, Issa K, Akbar M, Mont MA. Risk of dislocation using large- vs. small-diameter femoral heads in total hip arthroplasty. *BMC Res Notes.* 2012;5(1):553. doi: 10.1186/1756-0500-5-553.
26. Tsukada S, Wakui M. Lower dislocation rate following total hip arthroplasty via direct anterior approach than via posterior approach: five-year-average follow-up results. *Open Orthop J.* 2015;9:157-62.
27. Mason JL, Bourne RB. Surgical approach, abductor function, and total hip arthroplasty dislocation. *Clin Orthop Relat Res.* 2002(405):46-53.
28. Ravi B, Pincus D, Khan H, Wasserstein D, Jenkinson R, Kreder HJ. Comparing complications and costs of total hip arthroplasty and hemiarthroplasty for femoral neck fractures: a propensity score-matched, population-based study. *J Bone Joint Surg Am.* 2019;101(7):572-9.
29. Bhandari M, Einhorn TA, Guyatt G, Schemitsch EH, Zura RD, Sprague S, *et al.* Total hip arthroplasty or hemiarthroplasty for hip fracture. *N Engl J Med.* 2019;381(23):2199-208.
30. Moerman S, Mathijssen NMC, Tuinebreijer WE, Vochteloo AJH, Nelissen R. Hemiarthroplasty and total hip arthroplasty in 30,830 patients with hip fractures: data from the Dutch Arthroplasty Register on revision and risk factors for revision. *Acta Orthop.* 2018;89(5):509-14.
31. Comeau-Gauthier M, Zura RD, Bzovsky S, Schemitsch EH, Axelrod D, Avram V, *et al.* Heterotopic ossification following arthroplasty for femoral neck fracture. *J Bone Joint Surg Am.* 2021;103(14):1328-34.
32. Mukka S, Knutsson B, Krupic F, Sayed-Noor AS. The influence of cognitive status on outcome and walking ability after hemiarthroplasty for femoral neck fracture: a prospective cohort study. *Eur J Orthop Surg Traumatol.* 2017;27(5):653-8.
33. Kim JW, Shon HC, Song SH, Lee YK, Koo KH, Ha YC. Reoperation rate, mortality and ambulatory ability after internal fixation versus hemiarthroplasty for unstable intertrochanteric fractures in elderly patients: a study on Korean Hip Fracture Registry. *Arch Orthop Trauma Surg.* 2020;140(11):1611-8.
34. Nilsson LT, Jalovaara P, Franzén H, Niinimäki T, Strömqvist B. Function after primary hemiarthroplasty and secondary total hip arthroplasty in femoral neck fracture. *J Arthroplasty.* 1994;9(4):369-74.
35. Elyahu RB, Khateeb B, Yaacobi E, Palmanovich E, Marom O, Segal D, *et al.* Better short-term outcomes after total hip arthroplasty compared to hemiarthroplasty in active older patients with displaced intracapsular femoral neck fracture. *Isr Med Assoc J.* 2023;25(12):804-8.
36. Craig J, McDonald J, Cassidy R, McDonald S, Barr J, Diamond O. Clinical outcomes for hemiarthroplasty versus total hip arthroplasty in patients with femoral neck fracture who meet published National Criteria for total hip arthroplasty. *J Orthop Trauma.* 2022;36(1):17-22.
37. Frihagen F, Nordsletten L, Madsen JE. Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: randomised controlled trial. *Bmj.* 2007;335(7632):1251-4.
38. Unnanuntana A, Jarusriwanna A, Nepal S. Validity and responsiveness of Barthel index for measuring functional recovery after hemiarthroplasty for femoral neck fracture. *Archives of Orthopaedic and Trauma Surgery.* 2018;138(12):1671-7.
39. Fahad S, Nawaz Khan MZ, Aqueel T, Hashmi P. Comparison of bipolar hemiarthroplasty and total hip arthroplasty with dual mobility cup in the treatment of old active patients with displaced neck of femur fracture: A retrospective cohort study. *Ann Med Surg (Lond).* 2019;45:62-5.
40. Charity J, Ball S, Timperley AJ. The use of a modified posterior approach (SPAIRE) may be associated with an increase in return to pre-injury level of mobility compared to a standard lateral approach in hemiarthroplasty for displaced intracapsular hip fractures: a single-centre study of the first 285 cases over a period of 3.5 years. *Eur J Trauma Emerg Surg.* 2023;49(1):155-63.

