CASE STUDY

Total versus Hemi-arthroplasty for Displaced Femoral Neck Fracture

surgicalanalytics

SURGICAL ANALYTICS CASE STUDY

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The prevalence of hip fractures is high worldwide. The numbers of annual new cases of hip fracture are more than 300,000 in the United States and more than 65,000 in the United Kingdom (Ekhtiari et al., 2020; RCP report, 2018). Hip fractures are associated with impaired physical function, pain, poorer health-related quality of life and increased cost to patients and society (Hopley et al., 2010).

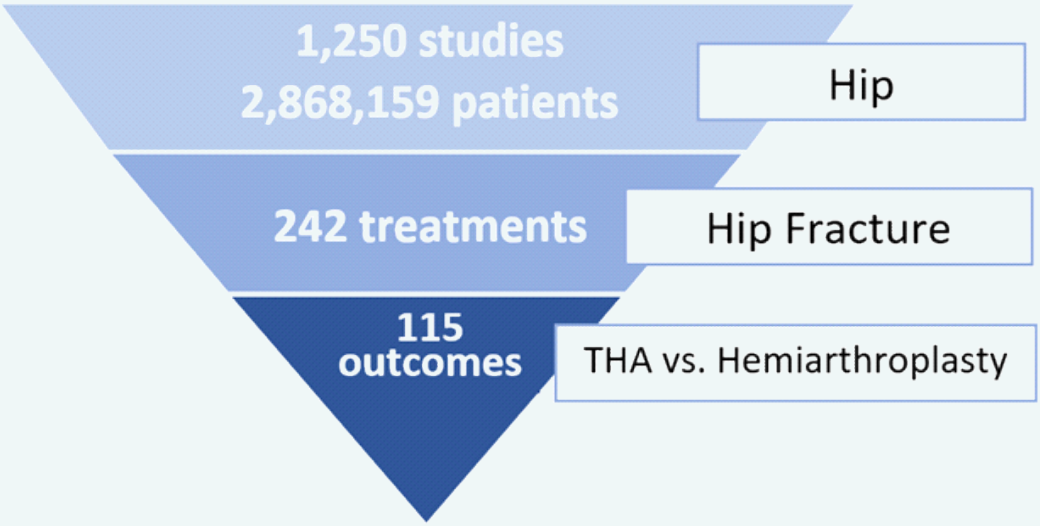
Displaced femoral neck fracture is one of the main types of hip fractures and requires early surgical repair because the condition (especially the Garden III or IV) is at risk of osteonecrosis (Hopley et al., 2010; Lewis et al., 2019). Surgery options include total hip arthroplasty (THA), hemiarthroplasty (HA) and internal fixation. It has been found that in older patients, arthroplasty (either THA or HA) is superior to internal fixation (Lewis et al., 2019). The choice of a specific surgery depends on efficacy in pain relief, adequate mobility and physical function enabling independent living, as well as a low risk of adverse events including secondary operation, dislocation and other general complications.

In this case study, we present analytics using Surgical Analytics, powered by the OE M.I.N.D. database.. All of the data were extracted from randomized controlled trials (RCTs) published in English by experienced medical literature reviewers. OE M.I.N.D. updates data on a daily basis, with new trials and data being constantly added. The results in this review were based on analyses performed on July 18, 2023.

Surgical Analytics Meta Analyzer --- Overview of the available evidence

Over 3 million patients across 1,510 studies were reported for hip conditions. There are 316 treatments that were studied for hip fractures, and 2,053 outcome measures were reported at various followup durations evaluating effectiveness and adverse events of THA compared to hemiarthroplasty (Figure 1).

Figure 1. Summary data of research topic according to anatomical region, condition and treatment



Surgical Analytics Meta Analyzer Tool — Effectiveness of treatments

We identified 22 articles that reported 17 RCTs with 3162 patients comparing the effectiveness of THA to HA for patients with dislocated femoral neck fractures (Table 1). The longest follow-up was 13 years post surgery (Skinner et al., 1989 and Ravikumar et al., 2000).

Table 1. Characteristics of RCTs included in meta-analysis

Author Year	Country	Number of patients analyzed	Patients	THA details	HA details
Baker 2006 & Avery 2011	The United Kingdom	81	Displaced intracapsular fracture of the femoral neck; aged > 60 years.	Cemented collarless polished tapered femoral component; transgluteal lateral approach.	Endo Femoral Head; cemented collarless polished tapered femoral component; transgluteal lateral approach.
Bhandari 2019	Ten countries*	1441	Low-energy displaced fracture of the femoral neck; aged ≥ 50 years.	Minimally invasive total hip arthroplasty and hinged prostheses or capture cups. Other aspects were not standardized.	Modern implants (not standardized); Excluded non-modular, non-canal filling unipolar implants.
Soderqvist 2007 & Hedbeck 2011	Sweden	120	Displaced intracapsular fractures of the femoral neck in elderly patients; aged ≥ 70 years.	Modified Hardinge anterolateral approach; cemented.	Bipolar; cemented.
Chammout 2019	Sweden	120	Acute displaced femoral neck fracture; aged ≥ 80 years.	A cemented highly cross-linked polyethylene acetabular component; direct lateral approach.	Unipolar; cemented; direct lateral approach.
Dorr 1986	The United States	89	Displaced (Garden type 3 or 4) femoral neck fractures with a prosthesis	Cemented; posterior approach.	Bipolar; cemented or uncemented; posterior approach.
Giannini 2011 & Cadossi 2013	Italy	96	Displaced intracapsular fractures of the femoral neck; aged > 70 years.	A novel THR comprising a polycarbonate–urethane (PCU) acetabular component coupled with a large-diameter metal femoral head; uncemented; straight lateral approach.	Bipolar; cemented or uncemented stem; straight lateral approach.
Iorio 2019	Italy	60	Elderly patients with displaced femoral neck fracture (Garden 3 or 4), and a diagnosis of dementia.	Dual mobility cup with cementless femoral stem; direct lateral approach.	Excia cementless femoral stem with bipolar head; direct lateral approach.
Grant 2006	The United Kingdom	138	Displaced intracapsular fractures of the hip	Cemented; lateral or posterior approach.	Bipolar; cemented; lateral or posterior approach.
Li 2023	China	132	Traumatic femoral neck fracture	Lateral approach	Lateral approach
Macaulay 2008	The United States	40	Displaced femoral neck fractures	Cemented or uncemented; posterolateral or modified Hardinge/anterolateral approach.	Unipolar or bipolar; cemented or uncemented; posterolateral or modified Hardinge/anterolateral approach.
Mouzopoulos 2008	Greece	86	Displaced subcapital hip fracture	Cemented	Bipolar
Parker 2019	The United Kingdom	105	Displaced intracapsular fracture; aged ≥ 60 years.	Cemented; anterolateral approach.	Unipolar; cemented; anterolateral approach.
Ren 2016	China	100	Femoral neck fracture; aged > 60 years.	Cemented; posterior approach.	Cemented
Sharma 2016	India	80	Displaced femoral neck fracture (Garden 3 and 4); aged > 60 years.	Modified Gibson approach	Modified Gibson approach
Skinner 1989 & Ravikumar 2000	The United Kingdom	180	Displaced subcapital fractures of the femur; aged > 65 years.	Posterolateral approach; cemented Howse II prosthesis using a semi captive cup and a 32 mm head.	Posterolateral approach; uncemented Austin Moore prosthesis.
Sonaje 2018	India	42	Closed intracapsular femoral neck fracture; aged > 60 years.	Cemented	Bipolar; cemented.
van den Bekerom 2010 & Tol 2007	The Netherlands	252	Displaced intracapsular fracture of the femoral neck; aged > 70 years.	Cemented acetabular and femoral component; anterolateral, straight lateral or posterolateral approach.	Bipolar; cemented; anterolateral, straight lateral or posterolateral approach.

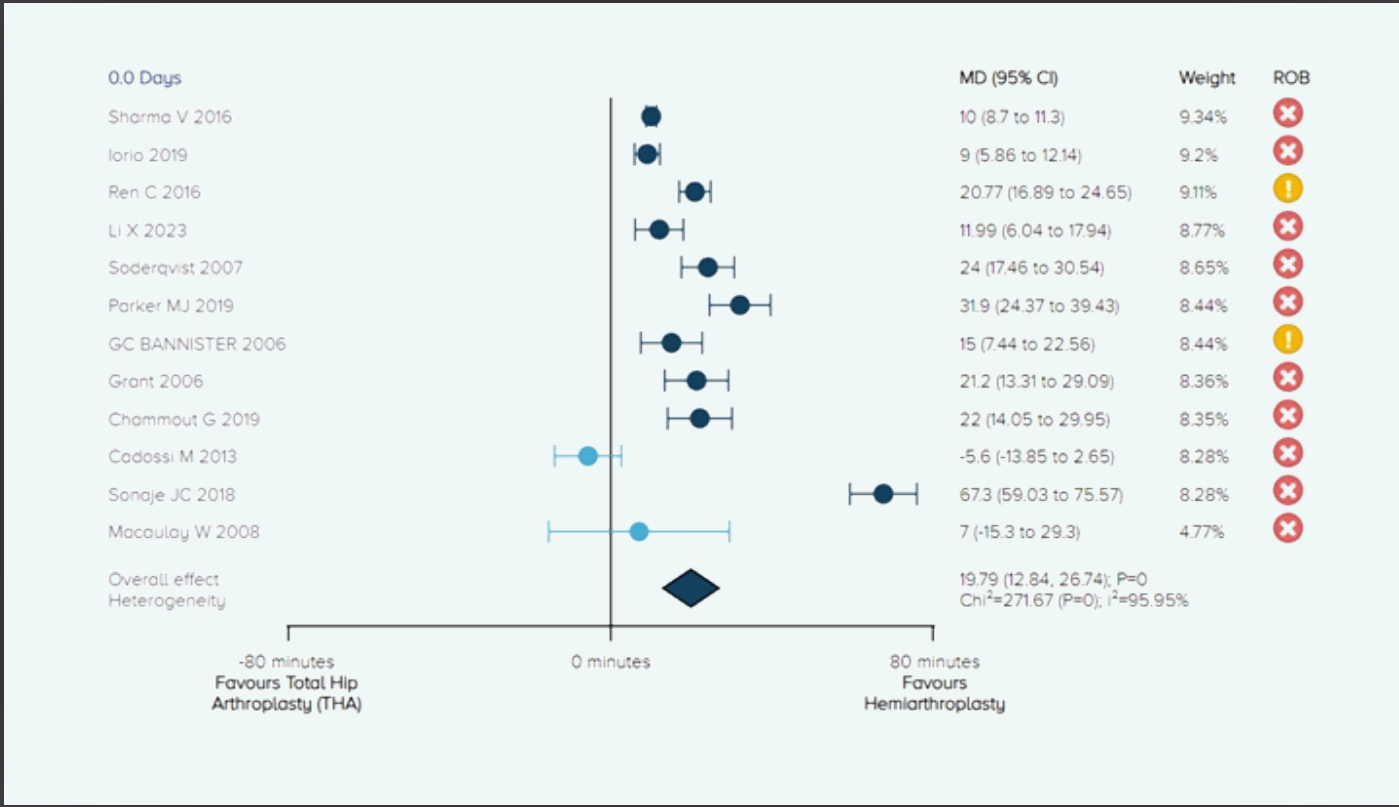
Note: THA = total hip arthroplasty; HA = hemiarthroplasty.
* Canada, the United States, Spain, the United Kingdom, the Netherlands, Norway, Finland, Australia, New Zealand, and South Africa.

We are presenting the meta-analysis results of operative time and blood loss, as well as incidence of revision surgery, dislocation, adverse events, mortality, composite clinical outcomes, function and pain within three time frames of follow-up: up to 1 year, 1 to 5 years, and beyond 5 years post surgery.

2.1 Operative time

In the comparison of THA versus HA for the outcome of operative time, a total of 1,099 patients from 12 studies published between 2006 to 2023 are included in the analysis. Ten studies favour HA, and 2 studies show no difference between surgeries. The overall effect demonstrates a shorter operative time with HA over THA [mean difference (MD), 19.79 minutes shorter; 95% confidence interval (CI), 12.84 minutes shorter to 26.74 minutes shorter]. The certainty of the evidence by GRADE assessment was rated as low due to serious risk of bias and inconsistency (Figure 2).

Figure 2. Forest plot of operative time (minutes)

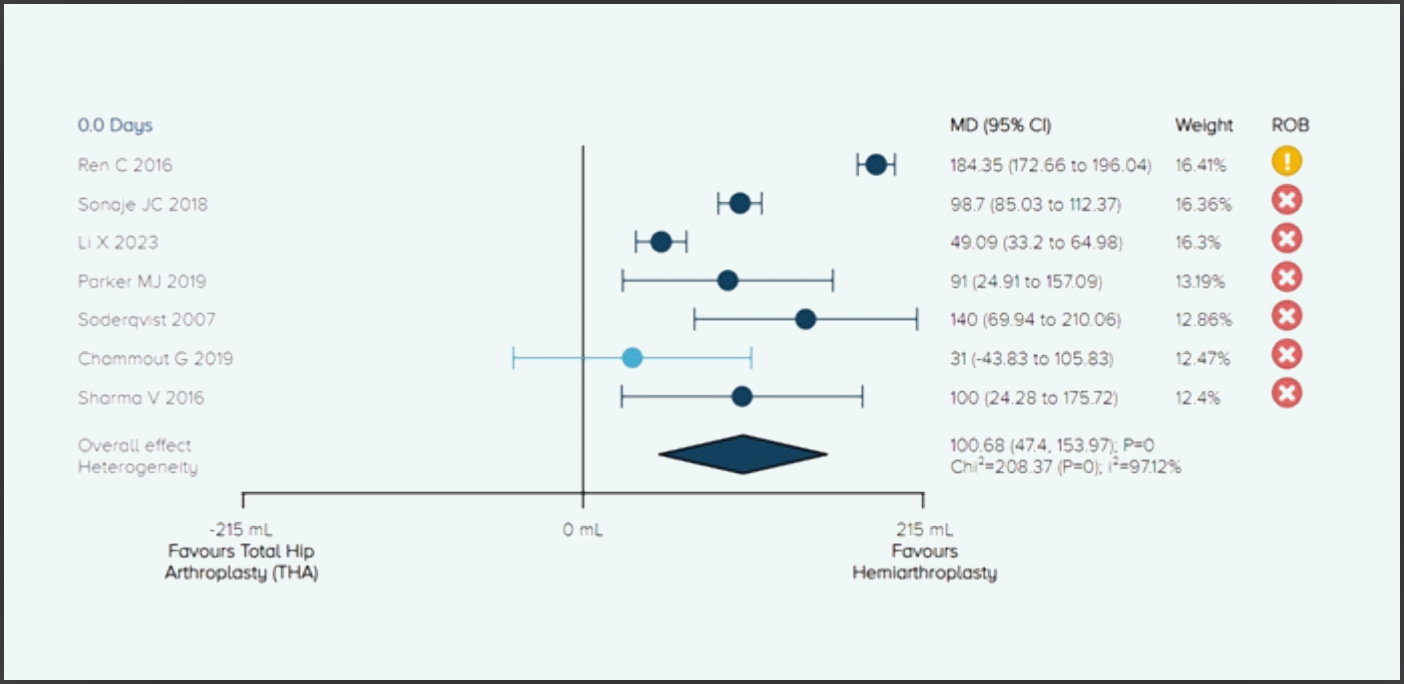


Notes: ROB = risk of bias; red circle with a cross mark, at high risk of bias; yellow circle with an exclamation mark, have some concerns based on the Revised Cochrane risk-of-bias tool for randomized trials (RoB 2).

2.2 Intraoperative blood loss

In the comparison of THA versus HA for blood loss, a total of 697 patients from 7 studies published between 2007 to 2023 are included in the analysis. Six studies favour HA, and 1 study shows no difference between treatments. The overall effect demonstrates less intraoperative blood loss with HA over THA [MD, 100.68 millimeters (mL) less blood loss; 95% CI, 47.4 mL less to 153.97 mL less], with low certainty of the evidence (Figure 3).

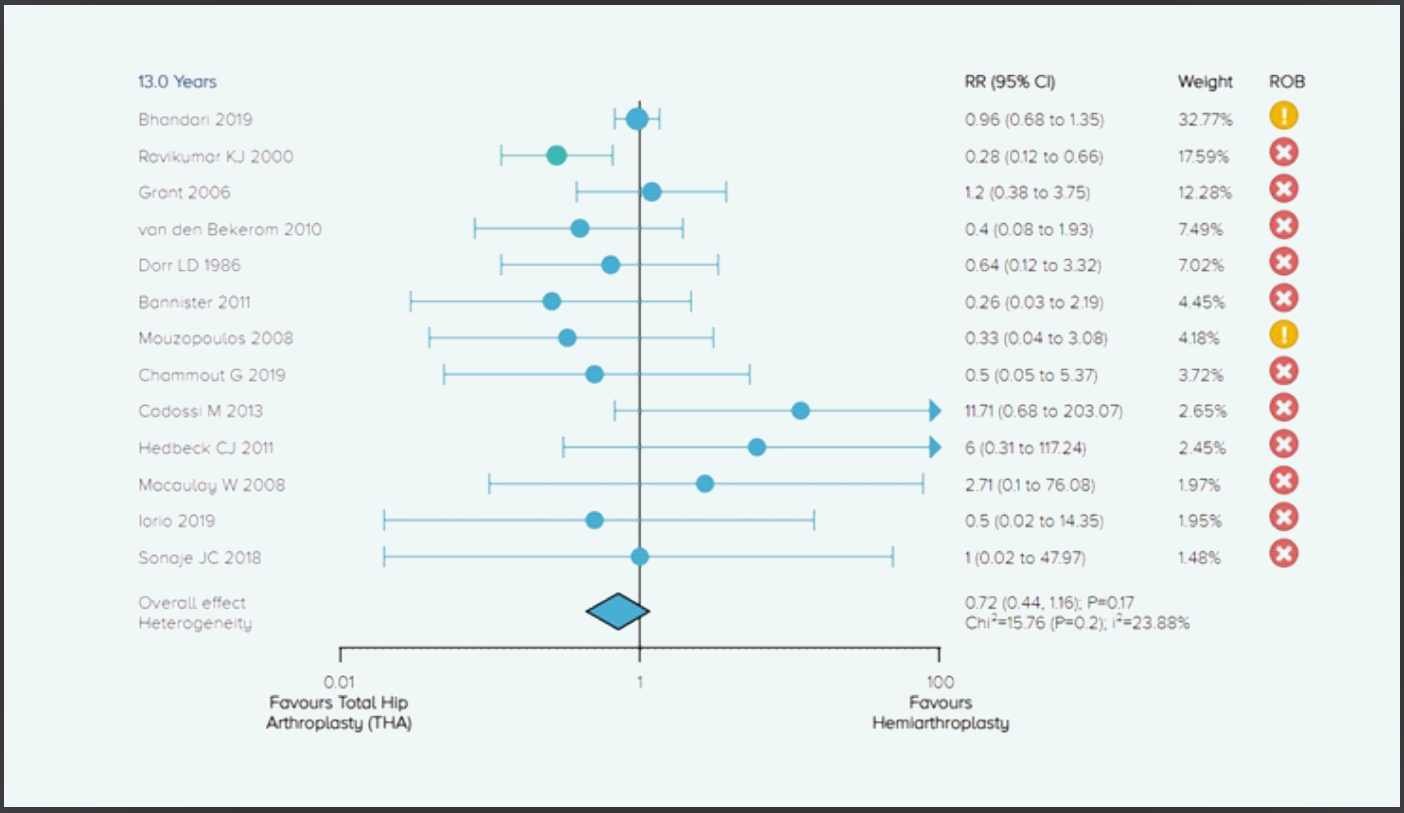
Figure 3. Forest plot of intraoperative blood loss (milliliter)



2.3 Incidence of reoperation (secondary operation)

At the longest follow-up of each study, a total of 2,730 patients from 13 studies published between 1986 to 2019 reported incidence of reoperation that included revisions for loosening of the arthroplasty, osteoarthritis of the acetabulum, deep infection, reduction of a dislocated hip, open reduction of fracture, and other secondary operations. One study favours THA, and 12 studies show no difference between surgeries. There was no significant difference in revision surgery between THA and HA [relative risk (RR), 0.72; 95% CI, 0.44 to 1.16], with low certainty of the evidence (Figure 4).

Figure 4. Forest plot of incidence of reoperation

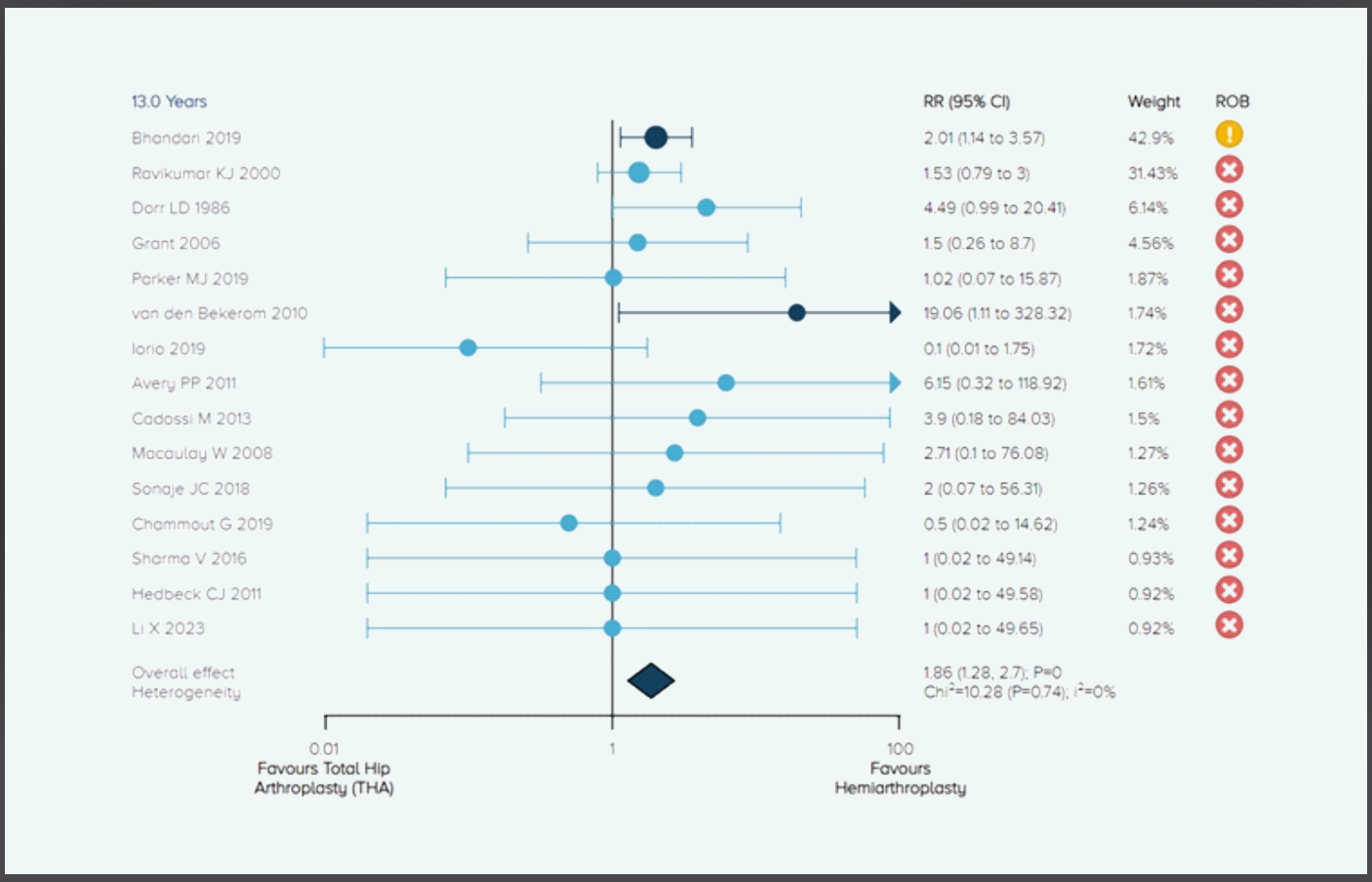


Notes: ROB = risk of bias; red circle with a cross mark = high risk of bias; yellow circle with an exclamation mark = have some concerns.

2.4 Incidence of dislocation

At the longest follow-up of each study, a total of 2,959 patients from 15 studies published between 1986 to 2023 reported the outcome of dislocation. Two studies favour HA, and 13 studies show no difference between treatments.The overall effect demonstrates that risk of dislocation is significantly higher with THA than with HA (RR, 1.86; 95% CI, 1.28 to 2.7), with moderate certainty of evidence (Figure 5).

Figure 5. Forest plot of incidence of dislocation

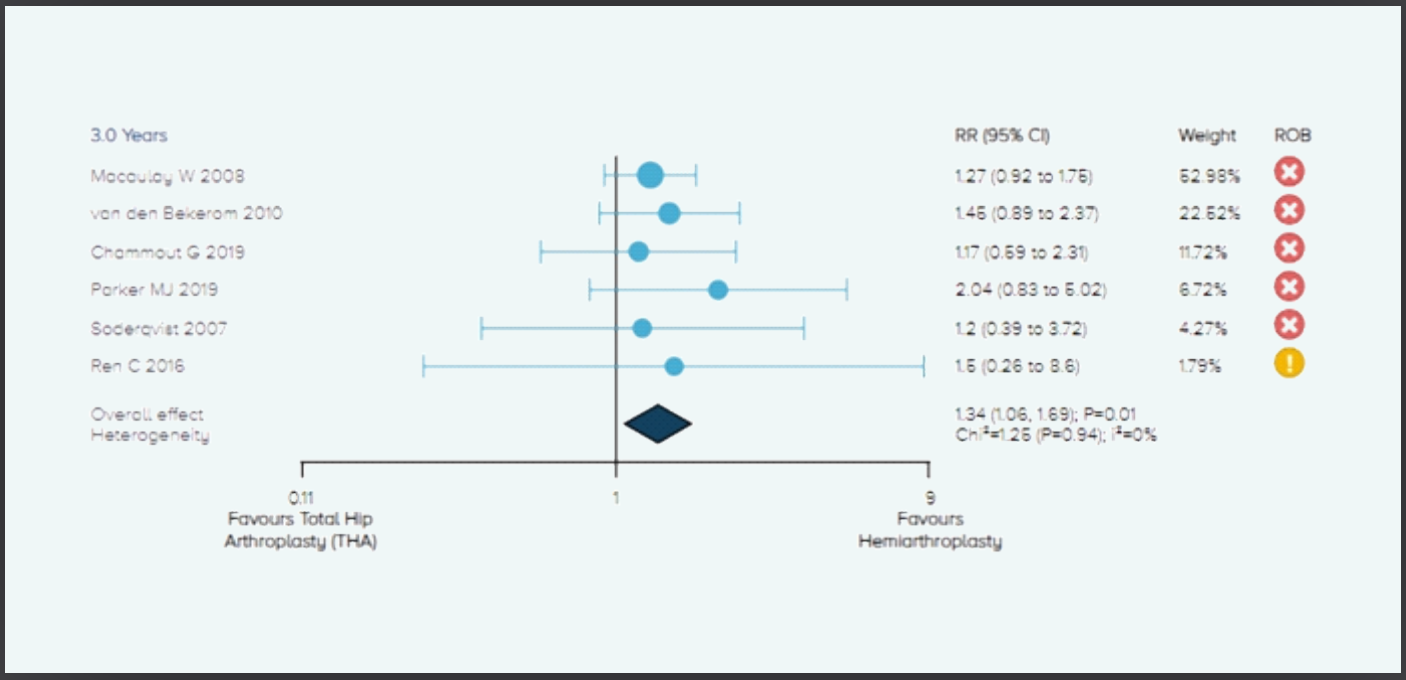


2.5 Incidence of adverse events (general complications)

Six RCTs reported the outcome of adverse events including cardiovascular, neurological, respiratory, gastrointestinal events, general complications of pressure ulcer, allergic reaction, as well as local complications of haematomas, superficial or deep infection, wound dehiscences and gluteal palsy (Figure 6).

The overall effect demonstrates that risk of adverse events is significantly higher with THA than with HA at the longest follow-up of each study (737 patients from 6 studies; RR, 1.34; 95% CI, 1.06 to 1.69), with moderate certainty of evidence. To note, the statistical difference is at borderline significance as the lower bound of the 95% CI is close to the RR of 1 for both results (Figure 6).

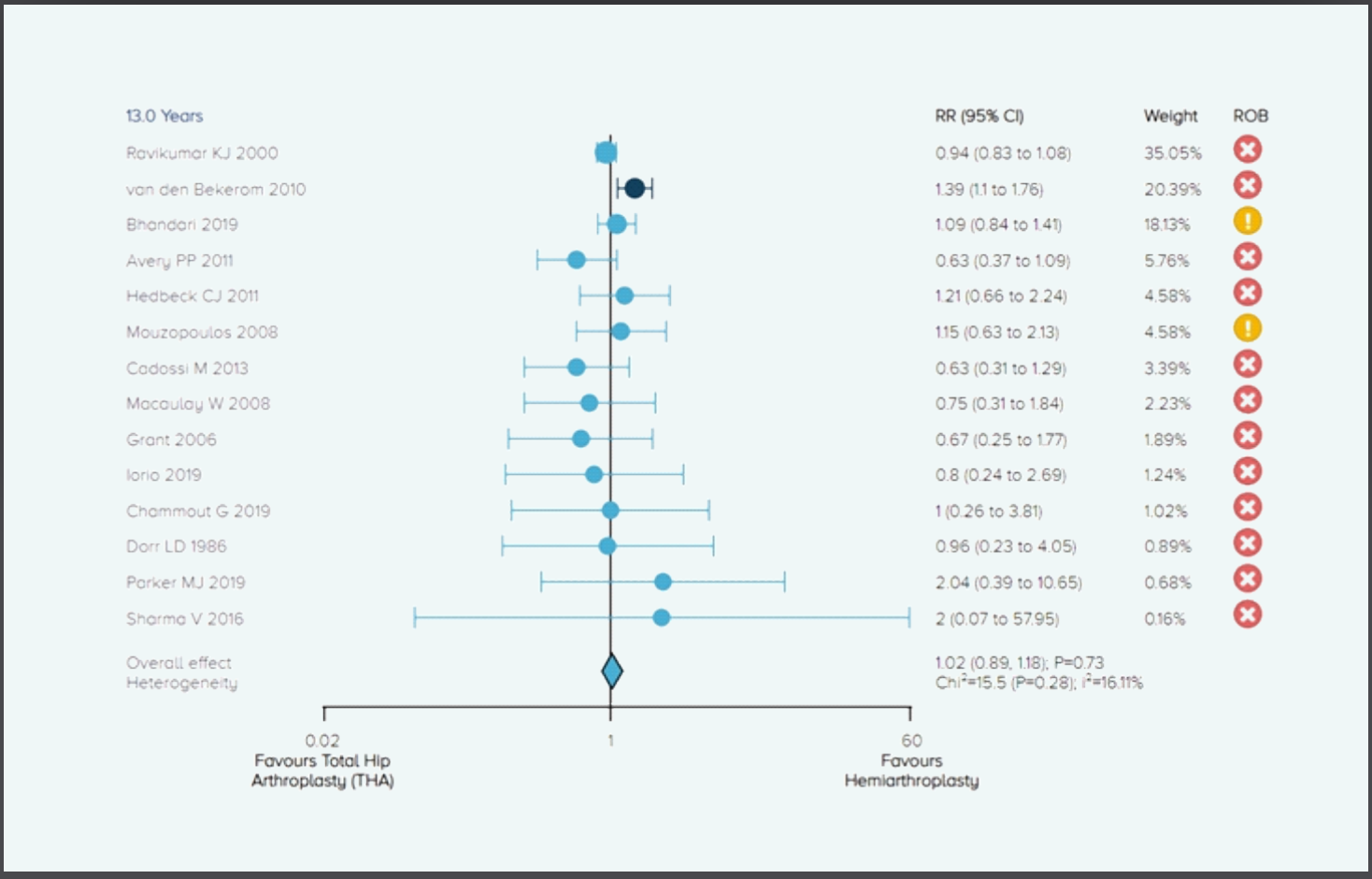
Figure 6. Forest plot of incidence of adverse events



2.6 Incidence of mortality

There was no significant difference in mortality rate between THA and HA at the longest follow-up of each study (2,875 patients from 14 studies; RR, 1.02; 95% CI, 0.89 to 1.18), with low certainty of evidence (Figure 7). One study favoured hemiarthroplasty while 13 studies showed no difference between the groups.

Figure 7. Forest plot of incidence of mortality



2.7 Composite clinical outcomes (0 to 100, a higher score indicates better recovery)

Harris Hip Score (HHS), modified HHS, Hip Rating Questionnaire (HRQ), Oxford Hip Score, and the Western Ontario and McMaster Universities (WOMAC) index are normalized on a 0 to 100 scale to assess patient recovery post surgery (Velentgas et al., 2010).

In the comparison of THA versus HA for the composite clinical outcomes at 1 year, a total of 981 patients from 9 studies published between 2006 to 2023 are included in the analysis. The overall effect demonstrates that THA results in a significant improvement with patients experiencing, on average, a 3.88 (95% CI, 0.74 to 7.02) point improvement, with low certainty of evidence (Figure 8).

During 1 to 5 years post surgery, a total of 792 patients from 9 studies published between 2006 to 2019 are included in the analysis. The overall effect demonstrates that THA results in a significant improvement with patients experiencing, on average, a 4.36 (95% CI, 1.59 to 16.33) point improvement, with low certainty of evidence (Figure 8).

Nevertheless, the effect and 95% CI at 1 year and between 1 and 5 years of follow-up did not exceed the recommended minimal clinically important difference (MCID) of a change thresholds of 10 points on the 0 to 100 HHS for patients undergoing hip arthroplasty (Van Den Bekerom et al., 2010).

Beyond 5 years post surgery, a total of 114 patients from 3 studies published between 2000 to 2017 are included in the analysis. There was no significant difference in the composite clinical outcomes between THA and HA (MD, -7.4; 95% CI, -23.89 to 9.1), with low certainty of evidence (Figure 8).

Figure 8. Forest plot of composite clinical outcomes (0-100 scale)

2.8 Function (0 to 100, a higher score indicates better function)

Barthel Index, HHS and modified HHS function subscale, HRQ function, mobility scale, the 36-Item Short Form Health Survey (SF-36) physical functioning subscale and WOMAC function subscale are normalized on a 0 to 100 scale to assess patient function post surgery.

In the comparison of THA versus HA for the outcome of function at 1 year, a total of 853 patients from 8 studies published between 2006 to 2019 are included in the analysis. There was no significant difference in function between THA and HA (MD, -1.39; 95% CI, -3.44 to 0.65), with low certainty of evidence (Figure 9).

During 1 to 5 years post surgery, a total of 778 patients from 9 studies published between 2006 to 2018 are included in the analysis. There was no significant difference in function between THA and HA 0.2 (MD, 0.2; 95% CI, -6.75 to 7.16 , with low certainty of evidence (Figure 9).

We did not find a recommended MCID for function measurement that we can use to compare the pooled results of our analyses.

Figure 9. Forest plot of patient-reported function (0-100 scale)

2.9 Pain (0 to 100, a higher score indicates worse pain)

The pain subscale of HHS, modified HHS, HRQ, SF-36 and WOMAC, pain numeric rating scale, and hip pain score are normalized on a 0 to 100 scale to assess patient pain post surgery.

In the comparison of THA versus HA for the outcome of pain at 1 year, a total of 1,28 patients from 9 studies published between 2006 to 2023 are included in the analysis. There was no significant difference in pain between THA and HA (MD, -0.47; 95% CI, -4.47 to 3.52), with low certainty of evidence (Figure 9).

During 1 to 5 years post surgery, a total of 769 patients from 8 studies published between 1986 to 2019 are included in the analysis. There was no significant difference in pain between THA and HA (MD, -1.75; 95% CI, -8.61 to 5.11), with low certainty of evidence (Figure 9).

The effect and 95% CI at 1 year and between 1 and 5 years of follow-up did not exceed the MCID of 10 points on the 0 to 100 pain scale (Busse et al., 2015) (Figure 10).

Only one study with 252 patients reported pain outcome beyond 5 years post surgery (Tol et al., 2017), and indicates no significant difference in pain between THA and HA (MD, 5.91; 95% CI, -6.8 to 18.62),

Figure 10. Forest plot of patient-reported pain (0-100 scale)

We present a summary of the nine outcome measures at three follow-up durations in Table 2.

Table 2. Summary and certainty of the evidence

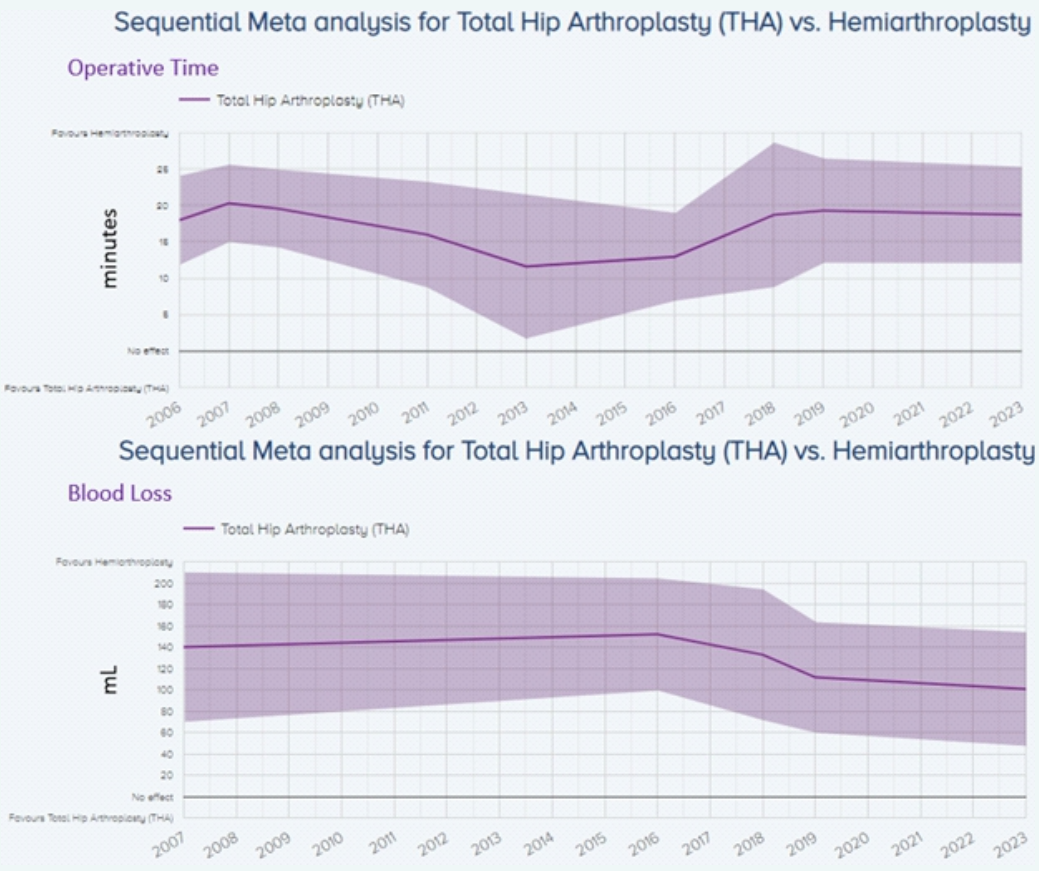
Outcome	Overall	≤ 1 year	> 1 to 5 years	> 5 years
Operative time	Favors HA^	--	--	--
Blood loss	Favors HA^	--	--	--
Reoperation	No difference^	--	--	--
Dislocation	Favors HA^^	--	--	--
Adverse events	Favors HA^^ (borderline)*	--	--	--
Mortality	No difference^	--	--	--
Composite clinical outcomes	--	Favors THA^	Favors THA^	No difference^
Function	--	No difference^	No difference^	No difference^
Pain	--	No difference^	No difference^	No difference^

3. Surgical Analytics Sequential Meta-Analysis Research Tool

The trends of treatment effects over time show that, when new RCTs are reported and more patients are included in the studies, precision of effects increased for all the outcomes at their longest follow-up (narrower 95% CI over time) (Figures 11-13).

Figure 11 shows that operative time of HA was shorter than THA, at first with 95% CI from 12 to 29 minutes shorter based on studies published in 2006 and over time the 95% CI of difference was from 12 to 25 minutes shorter based on all the studies published up to 2023; and the amount of blood loss of patients who undergoing HA was less than those undergoing THA, at first with 95% CI from 70 to 209 mL less blood loss based on the studies published in 2007 and over time the 95% CI of difference was from 51 to 158 mL less based on all the studies published up to 2019.

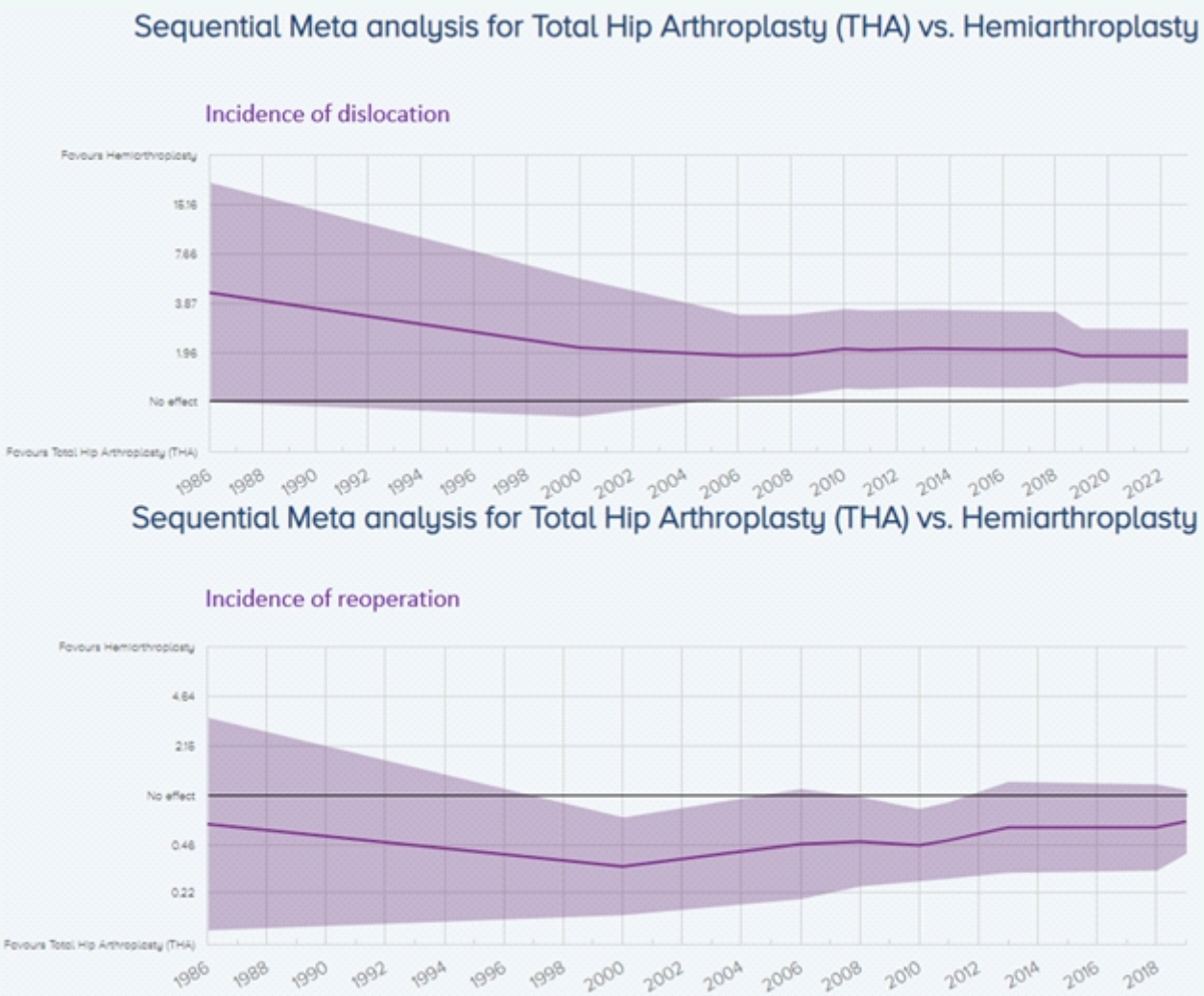
Figure 11. Sequential meta-analysis results for operative time and blood loss



THA = total hip arthroplasty; HA = hemiarthroplasty; 95% CI, the shaded area around the trending solid line in the figure.

We can see from Figure 12 that the overall effect at the first study in 1986 demonstrated no significant difference in incidence of reoperation, was in favour of THA between 1998 and 2012, and afterwards showed no difference between THA and HE up to 2019. For dislocation, the overall effect was in favour of HA but the lower boundary of the 95% CI was very close to the “No effect” line, and the effects have been moving toward the “No effect” threshold after 2018 (Figure 12).

Figure 12. Sequential meta-analysis results for reoperation and dislocation

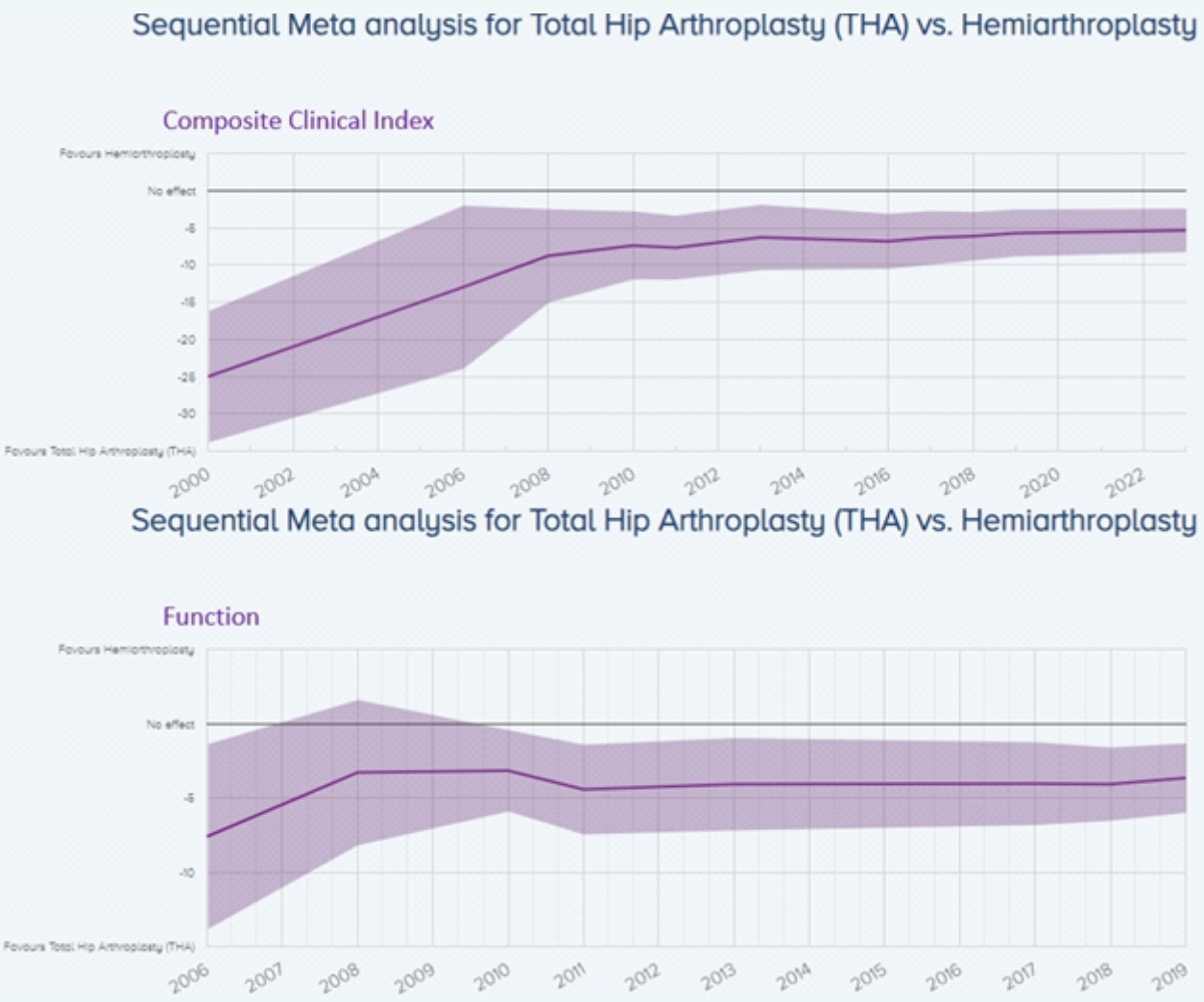


THA = total hip arthroplasty; HA = hemiarthroplasty; 95% CI, the shaded area around the trending solid line in the figure.

There have been no significant differences in adverse events (general complications) and mortality between THA and HA, and the results demonstrate a steady trend (no difference) since the first studies in 1986 to 2019.

The overall effects were in favour of THA in composite clinical outcomes like HHS, function and pain and the effects are small (difference was within the MCID for composite clinical outcomes and pain, and within 10 points on a 0-100 scale for function) over time (Figure 13).

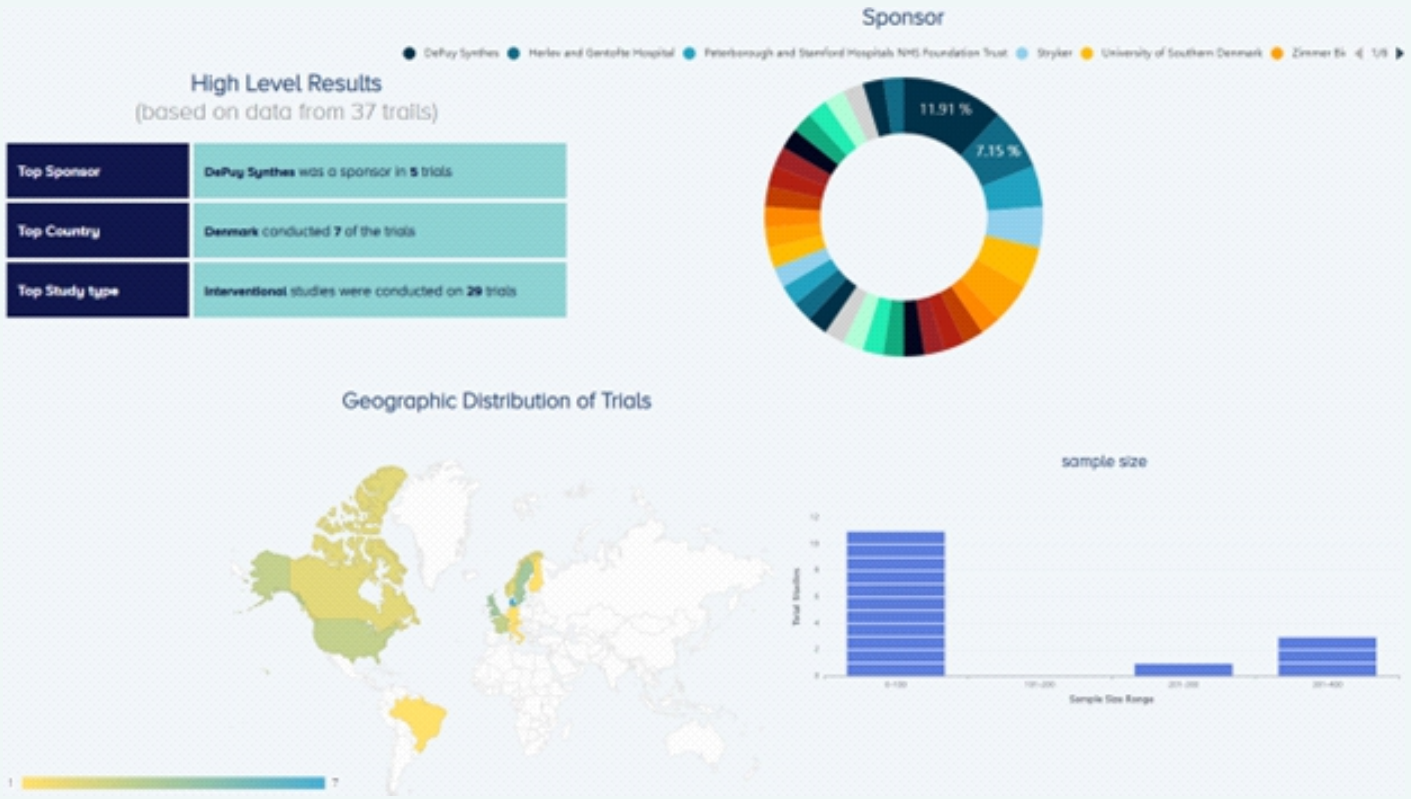
Figure 13. Sequential meta-analysis results for composite clinical outcomes, function and pain



4. Surgical Analytics Ongoing trials report

For intervention comparisons that include either THA or HA, a total of 37 studies were found to be currently ongoing around the world, aiming to recruit over 2,000 patients. Seven of these 37 ongoing studies (18.9%) are being conducted in Denmark. (Figure 14).

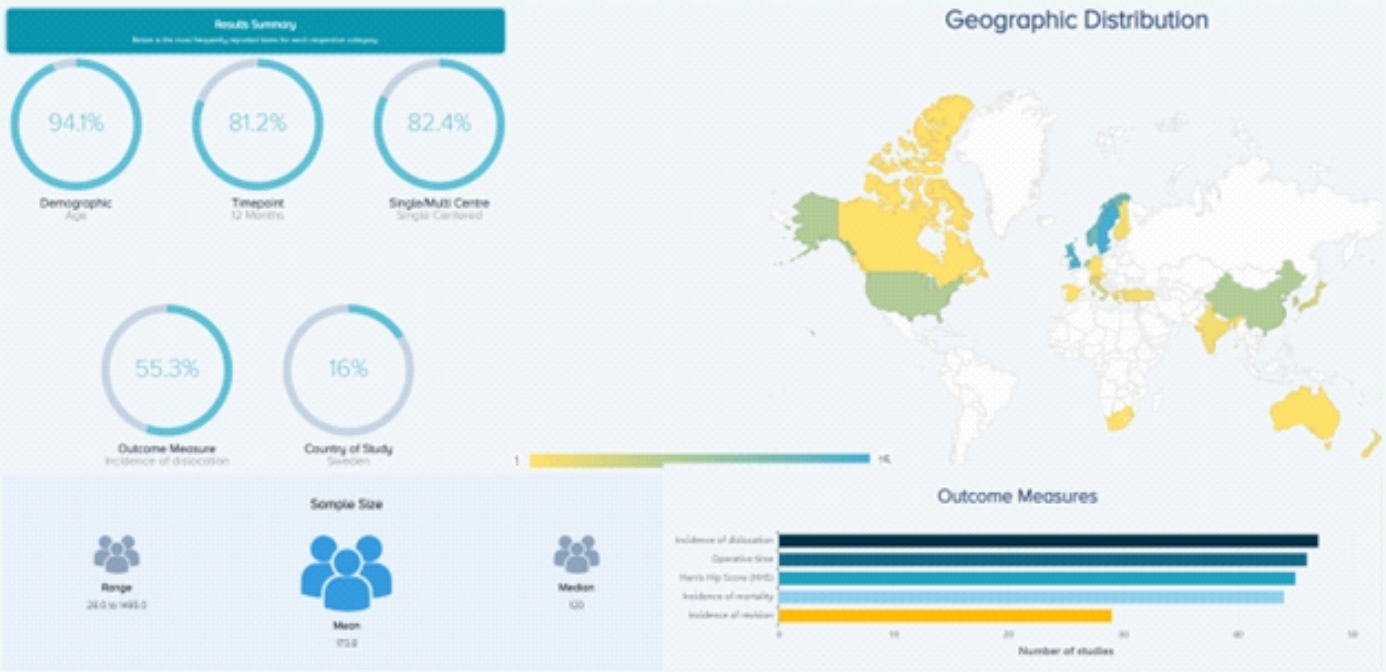
Figure 14. Ongoing trials of THA or HA for hip fractures



5.Surgical Analytics Research Planning Tool

It takes knowledge of completed studies to assist in the planning of our own research. The Surgical Analytics Research Planning Tool provides us with an overview of characteristics of prior RCTs. For studies related to arthroplasty for hip fractures, the most frequently reported characteristics include: patient demographics, age (94.1% studies reported age); follow-up time point, 12 months (81.2% studies reported outcomes at 12 months' follow-up); studies conducted at a single center (82.4%); incidence of dislocation (55.3%); and the country, Sweden (16%) (Figure 15).

Figure 15. The most frequently reported characteristics of relevant studies about arthroplasty for hip fractures

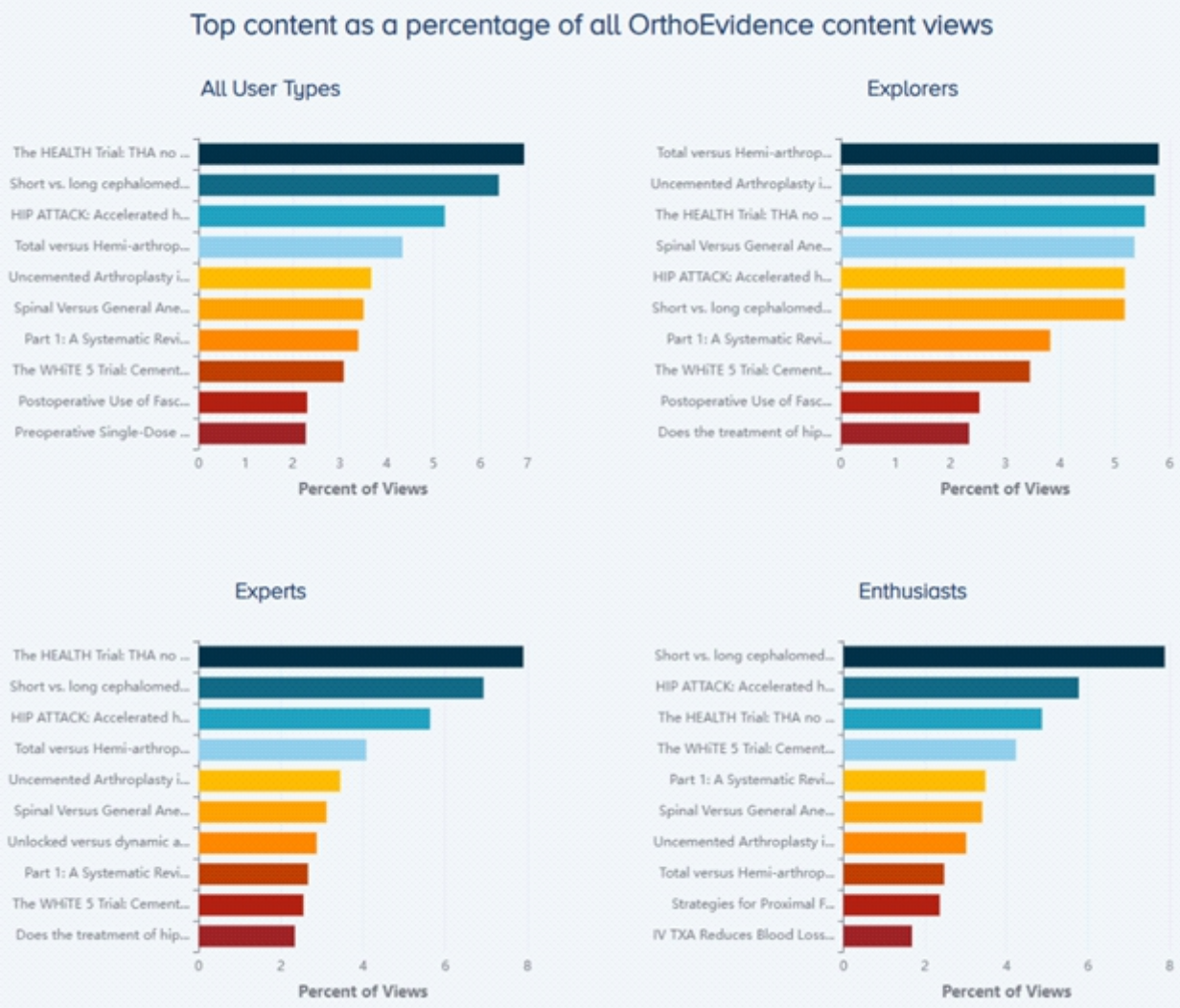


6. OrthoVision

User reading behaviour on OrthoEvidence can help to guide insights into where the interests of the orthopaedic community lie. In the past 5 years, reading on hip fracture has been dominated by arthroplasty research (Figure 16). When examining the top read individual articles, the top read article by all users was the HEALTH trial, comparing THA to HA, with 4 more arthroplasty articles in the top 10 most read. Explorers, or users who identify and consume high impact articles earlier than other users, were especially interested in arthroplasty for hip fracture, with their top 3 most read articles all examining arthroplasty for hip fractures (Figure 17).

Figure 16. The most frequently read interventions from August 2018 to August 2023 for all users, explorers, experts, and enthusiasts

Figure 17. The top read articles from August 2018 to August 2023 for all users, explorers, experts, and enthusiasts



DISCUSSION

Previously published meta-analyses of RCTs and observational studies suggest that THA is beneficial for reoperation rates and functional outcomes, but is associated with longer operation time, higher dislocation rates compared with HA after follow-up periods of 1 to 4 years (Hopley et al., 2010; Burgers et al., 2012; Lewis et al., 2019; Liu et al., 2020). The most recently published meta-analysis identified 16 studies, all included in this analysis, found that the health-related quality of life was significantly in favour of the THA, and there were no significant differences between THA and HA in outcomes of revision rate, dislocation rate, or function (Ekhtiari et al., 2020).

We identified all the RCTs that were included in the previously published systematic reviews. Using the powerful Surgical Analytics meta-analyzer tool, we present the pooled results of 9 prespecified patient-important outcomes at 3 follow-up periods. The Surgical Analytics sequential meta-analysis research tool also demonstrates the trend of a result over time, with more new RCTs' data incorporated into the body of evidence. We use normalized scales to incorporate all the available data in assessment of composite clinical outcomes, physical function and pain, as well as the minimal clinical important difference thresholds, where available, to illustrate magnitude of the efficacy.

By and large, the findings are consistent to previously published systematic reviews on the same topic. THA consistently shows slightly better ratings in composite clinical outcomes, physical function and pain within 1 year and at a longer follow-up period of 1 to 5 years than HA. The effects were statistically significant, but the 95% CI of composite clinical outcomes and pain did not exceed the recommended minimal clinically important difference. No difference was found for these three outcomes beyond 5 years of follow-up. HA is associated with shorter operation time, less intraoperative blood loss, lower risk of dislocation and lower risk of general complications, compared with THA.

We did not find a statistically significant difference in reoperation rate for the overall, within 1 year, and at 1 to 5 years of follow-up. The pooled result of the reoperation rate beyond 5 years of follow-up was significantly in favour of THA.

There is no significant difference between THA and HA in terms of mortality rate and this finding has remained consistent since the first trial published in 1986.

Our concern during the evidence quality assessment was mainly related to serious risk of bias due to lack of blinding to surgeons and participants, and missing outcome data for most of the included studies (Guyatt et al., 2011a; Higgins et al., 2019). Other major concerns were the imprecision and inconsistency. We rated down one level of GRADE assessment for imprecision regarding the outcomes with no statistical difference, as well as for the outcomes showing statistical difference but having the 95% CIs crossed the recommended MCID values. Clinical decisions would differ if the upper boundary versus the lower boundary of the CIs represented the true effect, for patients to achieve a minimal clinical important improvement, therefore the entire 95% CI must be over the MCID (Guyatt et al., 2011b). We rated down one level of GRADE quality of assessment for inconsistency for outcomes when the values of I2 were greater than 40% (Guyatt et al., 2011c).

Data from eligible RCTs are not sufficient for further investigation on factors that may influence the patient outcomes of THA vs. HA such as age, comorbidities, surgical approach, selection of prosthetic components, type of femoral and acetabular fixation, and so on. Future research may consider comparing these factors. More studies with longer than 5 years follow-up are needed to comprehensively evaluate the outcomes of dislocation and revision rates, function, quality of life, and associated cost.

BOTTOM LINE

Meta-analysis of 17 RCTs showed that for patients with displaced femoral neck fractures, THA is associated with small benefits in composite clinical outcomes, physical function and pain than HA at up to 5 years of follow-up. HA is associated with shorter operation time, less intraoperative blood loss, lower risk of dislocation and general complications compared with THA. There is no significant difference between THA and HA in terms of mortality rate.

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