SYSTEMATIC REVIEW

Cephalomedullary Nailing has a Higher Reoperation Rate Compared to Sliding Hip Screw Fixation in the Treatment of Intertrochanteric Femur Fractures: A Systematic Literature Review and Meta-analysis

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Abstract

Objectives: Intertrochanteric hip fractures are a common orthopaedic injury in the United States. Complications of surgical treatment include nonunion, lag screw cutout, implant failure, post-operative pain, risk of refracture or reoperation, and infection. The purpose of this study was to compare the rate of complications of sliding hip screw fixation (SHS) compared to cephalomedullary nailing (CMN) for the treatment of closed intertrochanteric femur fractures in adult patients.

Methods: PubMed, CINAHL, and Cochrane Library databases were searched for studies comparing SHS to CMN in the treatment of closed intertrochanteric femur fractures in adults. Data were compiled to observe the rate of nonunion, cutout failure, infection, refracture, perioperative blood loss, reoperation, postoperative pain, pulmonary embolism/deep venous thrombosis (DVT), length of hospital stay, and mortality.

Results: Seventeen studies were included comprising 1,500 patients treated with SHS and 1,890 patients treated with CMN. Treatment of intertrochanteric femur fractures with SHS demonstrated significantly fewer refractures and reoperations. There was no significant difference in other variables between SHS and CMN treated groups.

Conclusion: This meta-analysis shows that the only notable difference in outcomes is patients treated with CMN have a higher rate of refracture and reoperation. With new advances in the development of both CMNs and SHS, further studies will be required to see if these differences persist in the coming years.

Level of evidence: II

Keywords: Fracture fixation, Hip fracture, Outcomes, Systematic review

Introduction

Hip fractures are one of the most common major orthopaedic injuries in the United States. The incidence is reported at 957 per 100,000 in women and 414 per 100,000 in men, along with high rates of mortality within a year of injury. Additionally, post-surgical complications are a major public health concern.[1-3] Although hip fracture fixation is common, it is not without considerable morbidity and complications, such as screw cut-out, nonunion, avascular necrosis, and implant failure.[4] Surgical complication rates have been reported between 9-31%.[4,5] With the aging United States population and the inevitable burden on the United States healthcare system, there is an unprecedented need for high quality trials investigating the optimal fixation method for these injuries.[6]

"Hip fracture" is a term that encompasses a variety of injuries referring to any fracture of the proximal femur extending from the distal extent of the femoral head to the proximal aspect of the femoral shaft. The fractures referred to in this anatomic region are classically divided into

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femoral neck (FN), intertrochanteric (IT), and subtrochanteric (ST) fractures, from proximal to distal, respectively. Proper diagnosis is an essential first step in understanding treatment options because they vary regionally depending on what portion of the hip is fractured.

Over the past 50 years, a wide variety of implants and fixation strategies have been utilized for the surgical stabilization of intertrochanteric hip fractures. The two most common implants used for stabilizing intertrochanteric fractures are a cephalomedullary nail (CMN) or a sliding hip screw (SHS). The choice of implant is dependent on clinicopathologic variables, chiefly the fracture's orientation.[7,8] Stable fracture patterns are those that course inferomedially from the greater trochanter toward the lesser trochanter without disruption of the posteromedial cortex, the lesser trochanter, and the lateral wall.[9] Fractures that extend to the medial cortex, result in a compromised lateral wall, extend into the subtrochanteric region, or have a reverse obliquity pattern are considered unstable.[9] Traditionally, stable fractures are treated with SHSs while unstable fractures are treated with CMNs.

The majority of available data supports this algorithm, but there is still no consensus among surgeons.[10,11] Indeed, several studies have reported no significant differences in outcomes, mortality rates, surgical site infections, urinary tract infections, reoperations, and hospital stays between intramedullary and extramedullary fixation.[12] Many of these studies are limited due to their retrospective nature, small sample sizes, and single institution studies, necessitating further investigation.[11,13] The aim of this meta-analysis is to evaluate the difference in outcomes between SHS and CMN in the treatment of intertrochanteric fractures utilizing randomized, controlled trials.

Materials and Methods

The search was performed using the following MeSH and "Title, Abstract" search designations in PubMed, CINAHL, and Cochrane Databases: "((Intertrochanteric OR intertrochanteric[tiab] OR intertroch OR intertroch[tiab] OR femur OR femur[tiab]) AND (surg* OR surg*[tiab] OR treat* OR treat*[tiab] OR fixation OR fixation[tiab] OR oper* OR oper*[tiab]) AND (sliding hip screw OR sliding hip screw[tiab] OR SHS[tiab] OR dynamic hip screw[tiab] OR DHS[tiab] OR hip screw OR hip screw[tiab] OR compression hip screw OR compression hip screw[tiab] OR screw plate OR screw plate[tiab] OR gliding screw OR gliding screw*[tiab]) AND (cephalomedullary nail OR cephalomedullary nail[tiab] OR CMN[tiab] OR intertrochanteric medullary nail[tiab] OR IMN[tiab] OR gamma nail OR gamma nail[tiab] OR trochanteric nail OR trochanteric nail[tiab] OR intramedullary nail* OR intramedullary nail[tiab] OR gamma locking nail OR gamma locking nail[tiab] OR gamma3 nail[tiab]))

((Intertrochanteric OR intertroch OR femur) AND (fixation OR treat* OR surg* OR oper*) AND (sliding hip screw OR SHS OR dynamic hip screw OR DHS OR hip screw OR compression hip screw OR screw plate OR gliding screw) AND (cephalomedullary nail OR CMN OR intertrochanteric medullary nail OR IMN OR gamma nail OR trochanteric nail OR intramedullary nail* OR gamma locking nail OR gamma3 nail))."

A total of 645 results were found, and results were subsequently filtered by English language, full text, in human subjects, leaving 321 articles for review. Studies were included if they were randomized or non-randomized controlled trials that compared the outcomes of patients over 18 years old with closed intertrochanteric femur fractures treated with SHS or CMN. In this study, randomized controlled trials, retrospective reviews, case control studies, prospective cohort studies, and prospective matched pair studies were included. We reviewed adults with closed intertrochanteric femur fractures treated with SHS or CMN that reported primary outcomes of mortality, pain, non-union, malunion, fixation failure, pulmonary embolism (PE), re-fracture, reoperation, and infection.

Figure 1 demonstrates the PRISMA diagram for study results. A total of 324 articles were not included in the final analysis for the following reasons: 78 did not use SHS or CMN, 190 did not report primary outcomes, 16 included patients with open fractures, nine included patients with pathologic fractures, and 15 were in children (<18 years old). Therefore, 17 studies were included in the final analysis. Statistical analysis was performed using GraphPad Prism (Graphpad Software, La Jolla, California, USA) and Cochrane RevMan5 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration). Forest plots were created using random-effects and the Mantel-Haenszel model, and the level of statistical significance was set at $P < 0.05$ [Figure 1].

Results

General Results

Seventeen studies met ultimate inclusion criteria and were included in the analysis.[14-30] there was a total of 1,500 patients treated with SHS and 1,890 patients treated with CMN. The average age of patients treated with SHS was 80.5 years and 81.4 years for CMN ($P = 0.48$). The cohort included more female (n = 2,584) than male patients (n = 1,015). Fifteen studies provided information on whether male or female patients were treated with SHS or CMN. In these studies, 415 men and 985 women were treated with SHS and 446 men and 1108 women were treated with CMN ($P = 0.60$). Figure 2 shows the Risk of Bias summary for included studies [Figure 2].

Post-Operative Pain

Seven studies provided categorical data for post-operative pain in patients treated with SHS or CMN.[14-16,19,21,22,26] In the SHS cohort, 149 of 730 patients reported post-operative pain (20.4%) compared to 153 of 722 patients in the CMN cohort (21.2%) ($P = 0.75$). Figure 3 is a forest plot of the risk ratio of post-operative pain after DHS or CMN. The test for overall effect was not statistically significant ($P = 0.93$) and there was moderate statistical heterogeneity ($I^2 = 43\%$) [Figure 3].

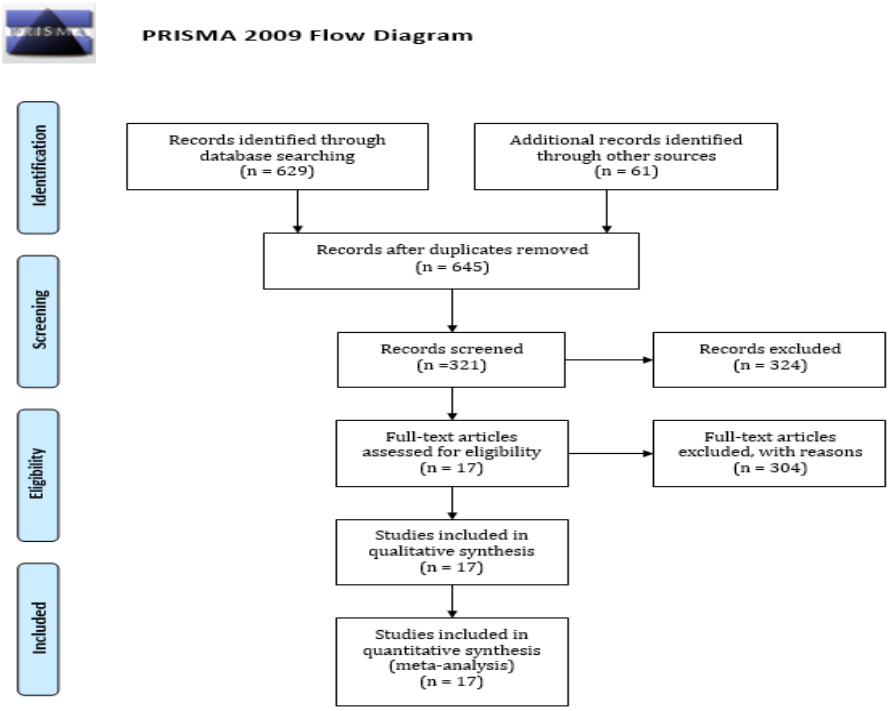

Figure 1. PRISMA Diagram for Included Studies

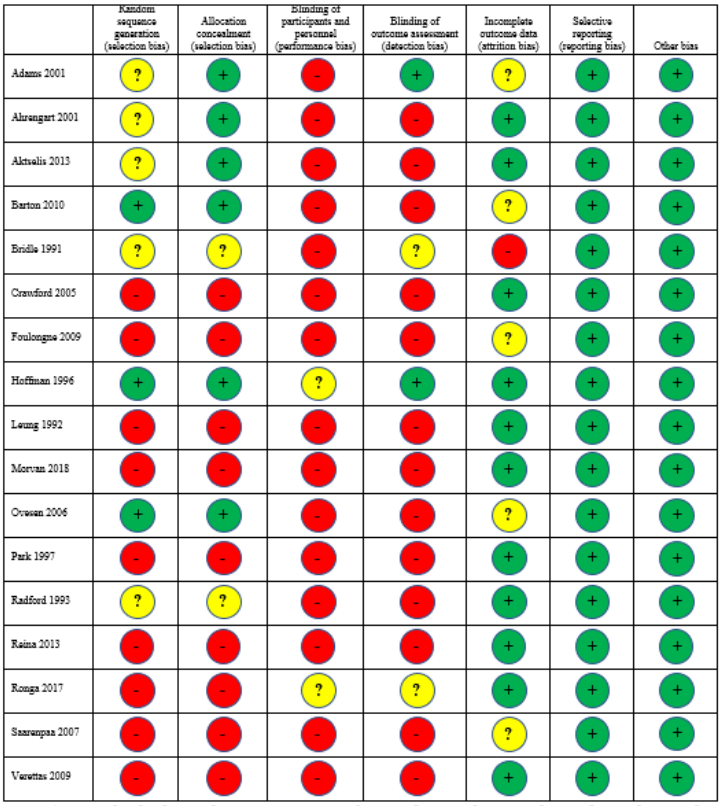

Figure 2. Risk of Bias Summary for Included Studies. Green circles indicate low risk, red circles indicate high risk, and yellow circles indicate unclear risk

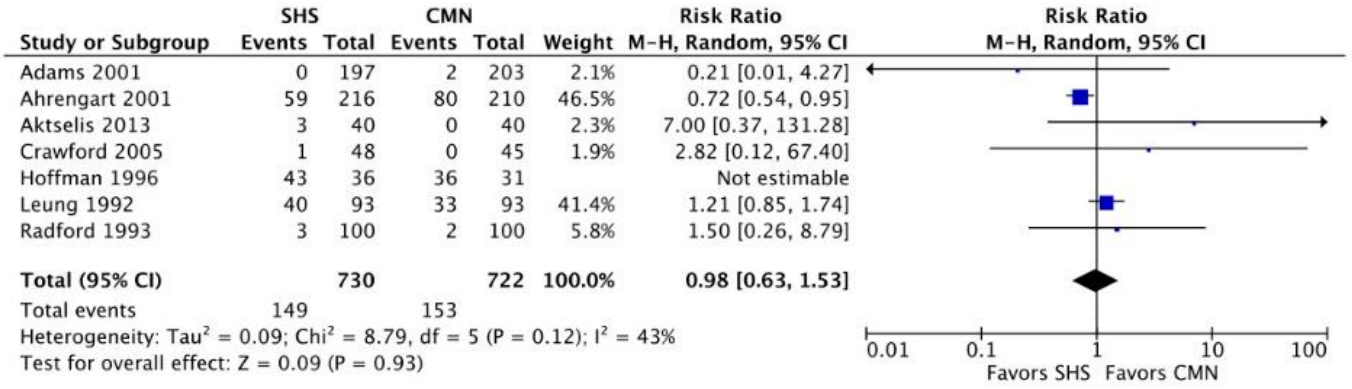

Figure 3. Risk Ratio of Post-operative Pain after SHS or CMN for Intertrochanteric Femur Fractures

Nonunion

Five studies provided categorical data for the incidence of nonunion in SHS and CMN cohorts.[19,21,22,25,26] There were two nonunions recorded in the DHS cohort (n = 307) and three nonunions in the CMN cohort (n = 299) (P = 0.68). The incidence of nonunion was 0.7% and 1.0% respectively. Figure 4 shows the forest plot of relative risk of nonunion after DHS or CMN. The test for overall effect was not statistically significant (P = 0.69) and there was minimal statistical heterogeneity (I^2 = 0%) [Figure 4].

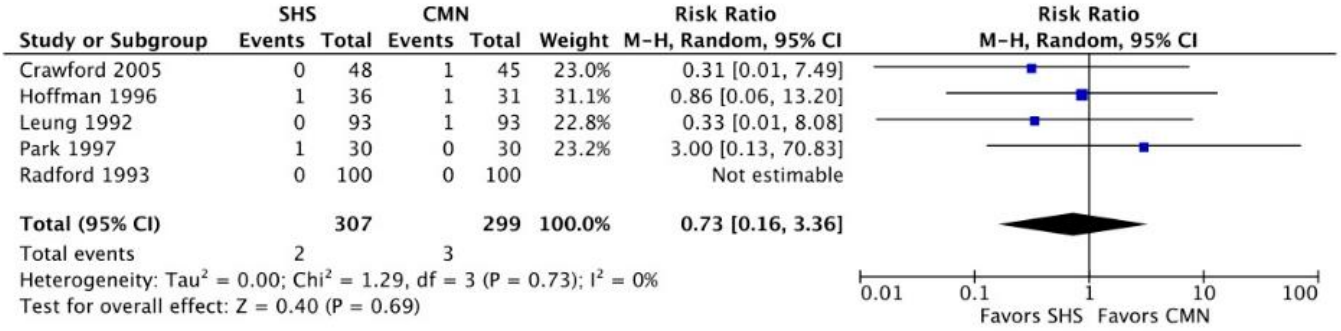

Figure 4. Risk Ratio of Nonunion after SHS or CMN for Intertrochanteric Femur Fractures

Screw Cutout Failure

Fourteen studies provided categorical data on the incidence of screw cutout or hardware failure.[14-27] There were 1,207 patients in the SHS subgroup and 1,380 patients in the CMN subgroup. Cutout or hardware failure was reported in 39 patients (3.2%) treated with DHS and 61 patients (4.4%) treated with CMN (P = 0.13). Figure 5 shows the forest plot of risk ratio of hardware failure after SHS or CMN. The test for overall effect was not statistically significant (P = 0.42) and there was minimal statistical heterogeneity (I^2 = 8%) [Figure 5].

Perioperative Blood Loss

Ten studies reported information on perioperative blood loss in milliliters after SHS or CMN.[15,14,18,22,24-28,30] The mean of means was 492.3 mL (95% CI 246.5 to 738.1mL) for SHS patients and 507.2 mL (95% CI 189.6 to 824.8mL) for CMN patients, and the difference was not significant (P = 0.94) by unpaired t-test. Three studies reported both mean and standard deviation for perioperative blood loss and could be included in a mean difference analysis.[24,28,27] The overall mean difference was -337.97 mL (95% CI -712.52 to 44.57 mL) with less blood loss seen for SHS as compared to CMN (P = 0.08, [Figure 6]). There was significant statistical heterogeneity in this analysis (I^2 = 98%, P = 0.00001).

Mortality

Twelve studies reported information on patient mortality for SHS and CMN cohorts during follow-up.[14,16-22,24,26,29,30] The cohort consisted of 971 patients treated with SHS and 957 patients treated with CMN. There were 193 deaths (19.9%) in the DHS cohort and 221 deaths (23.1%) in the CMN cohort (P = 0.09). Figure 7 shows the forest plot for risk ratio of mortality after DHS or CMN. The test for overall effect was not statistically significant (P = 0.07) and there was minimal statistical heterogeneity (I^2 = 1%) [Figure 7].

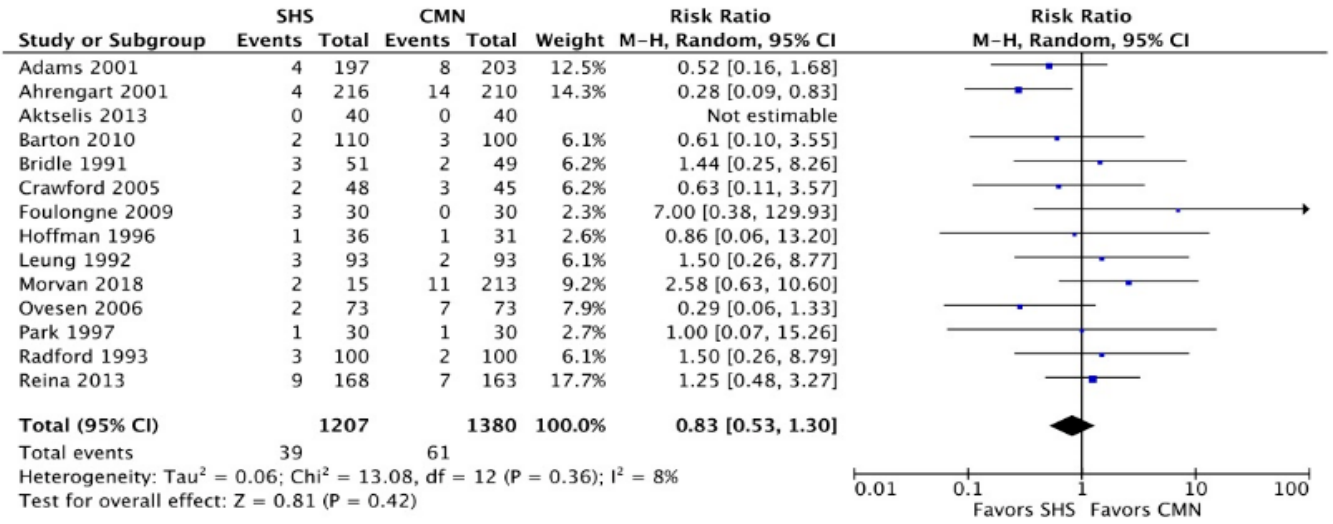

Figure 5.Risk Ratio of Cutout Failure after SHS or CMN for Intertrochanteric Femur Fractures

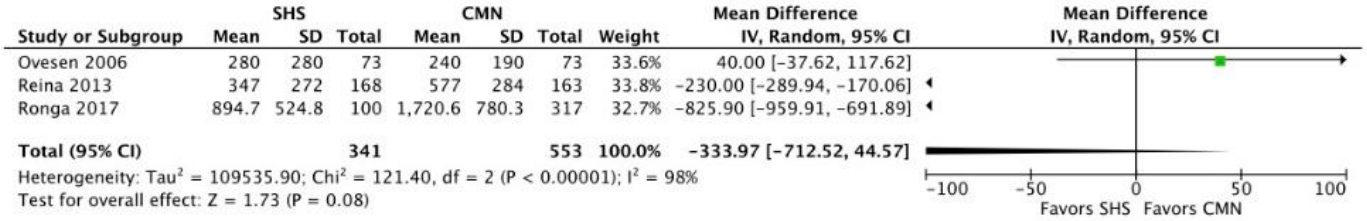

Figure 6.Mean Difference of Perioperative Blood Loss after SHS or CMN for Intertrochanteric Femur Fractures

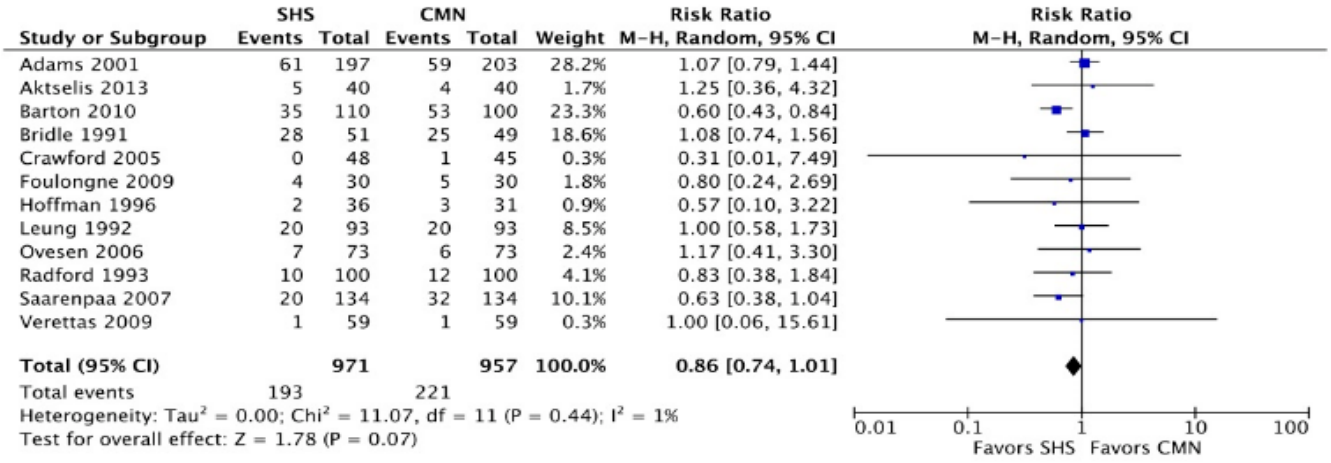

Figure 7. Risk Ratio of Mortality after SHS or CMN for Intertrochanteric Femur Fractures

Post-operative Infection Risk

Twelve studies reported the incidence of postoperative infection in SHS and CMN cohorts.[14,16,18-22,24-26,29,30] The subgroup contained 891 patients treated by SHS and 887 patients treated by CMN. Twenty-five patients in the SHS group (2.8%) and 21 patients in the CMN group (2.4%) developed post-operative infections (P = 0.65). Figure 8 shows the forest plot of risk ratio for post-operative infection after DHS or CMN. The test for overall effect was not statistically significant (P = 0.68) and there was minimal statistical heterogeneity (I^2 = 0%) [Figure 8].

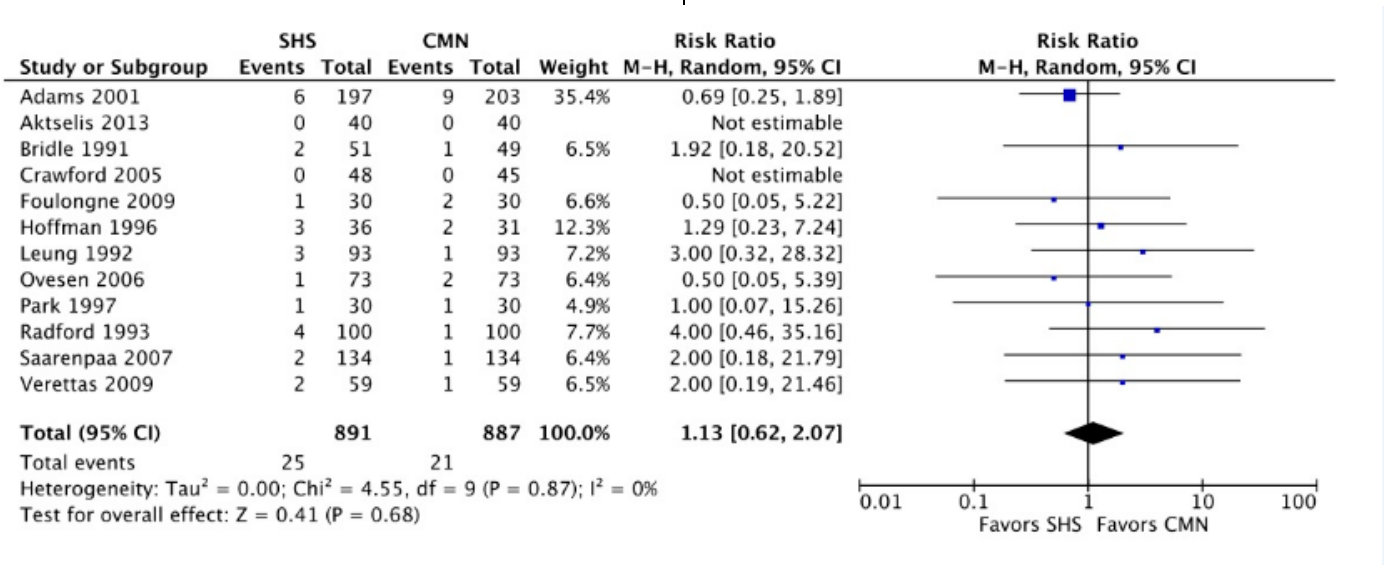

Figure 8. Risk Ratio of Post-operative Infection after SHS or CMN for Intertrochanteric Femur Fractures

Risk of Deep Venous Thrombosis (DVT) or Pulmonary Embolism (PE)

Six studies provided categorical data on the incidence of DVT/PE after SHS or CMN.[14,18,20,21,26,30] The subgroup contained 473 patients treated by SHS and 472 patients treated by CMN. Eight patients in the DHS (1.7%) and ten patients in the CMN group (2.1%) developed DVT/PE (P = 0.64). Figure 9 shows the risk ratio of DVT/PE after SHS or CMN. The test of overall effect was not statistically significant (P = 0.60) and there was minimal statistical heterogeneity (I^2 = 0%) [Figure 9].

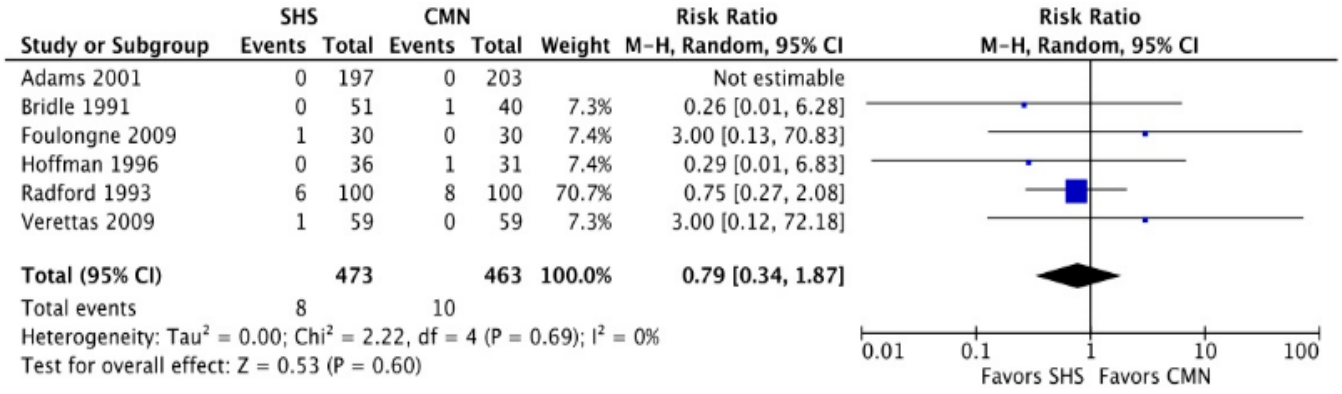

Figure 9. Risk Ratio of Pulmonary Embolism after SHS or CMN for Intertrochanteric Femur Fractures

Risk of Refracture

Eight studies reported the incidence of refracture after SHS or CMN for intertrochanteric femur fractures.[14,15,21,22,24-26,29] The subgroup analysis was comprised of 879 patients treated with SHS and 874 patients treated with CMN. Eight patients treated with DHS (0.9%) and 36 patients treated by CMN (4.1%) developed periprosthetic fractures (P < 0.0001). Figure 10 shows the risk ratio of refracture after SHS or CMN. The test of overall effect was statistically significant (P = 0.0010) and there was minimal statistical heterogeneity (I^2 = 0%) [Figure 10].

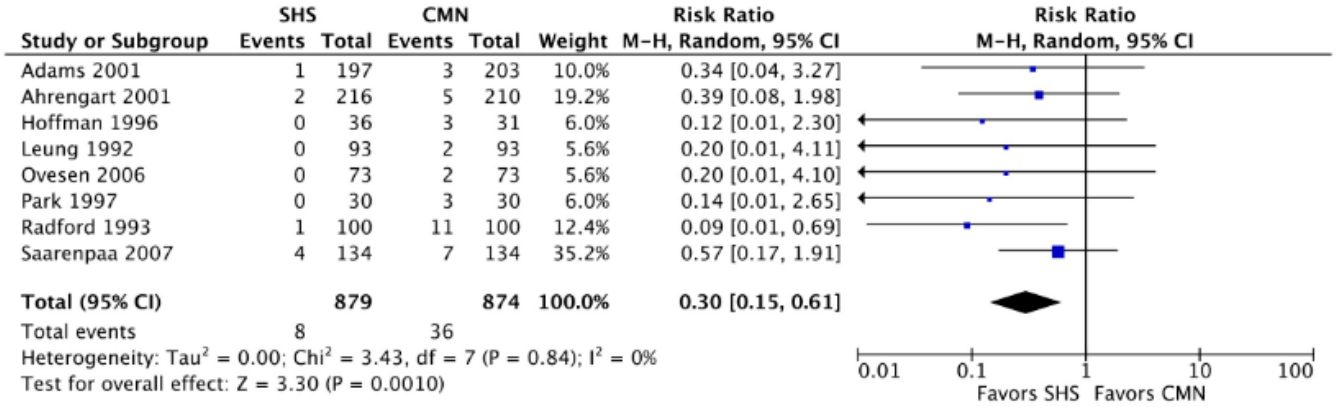

Figure 10. Risk Ratio of Refracture after SHS or CMN for Intertrochanteric Femur Fractures

Risk of Reoperation

Nine studies reported the incidence of secondary surgical procedures after SHS or CMN.[14,17-21,24,26,29] The subgroup analysis was comprised of 779 patients treated with SHS and 765 patients treated with CMN. Thirty-three patients in the SHS group (4.2%) and 54 patients (7.1%) in the CMN group required secondary surgical procedures (P = 0.02). Figure 11 shows the risk ratio of reoperation after SHS or CMN. The test for overall effect was statistically significant (P = 0.02) and there was minimal statistical heterogeneity (I^2 = 0%) [Figure 11].

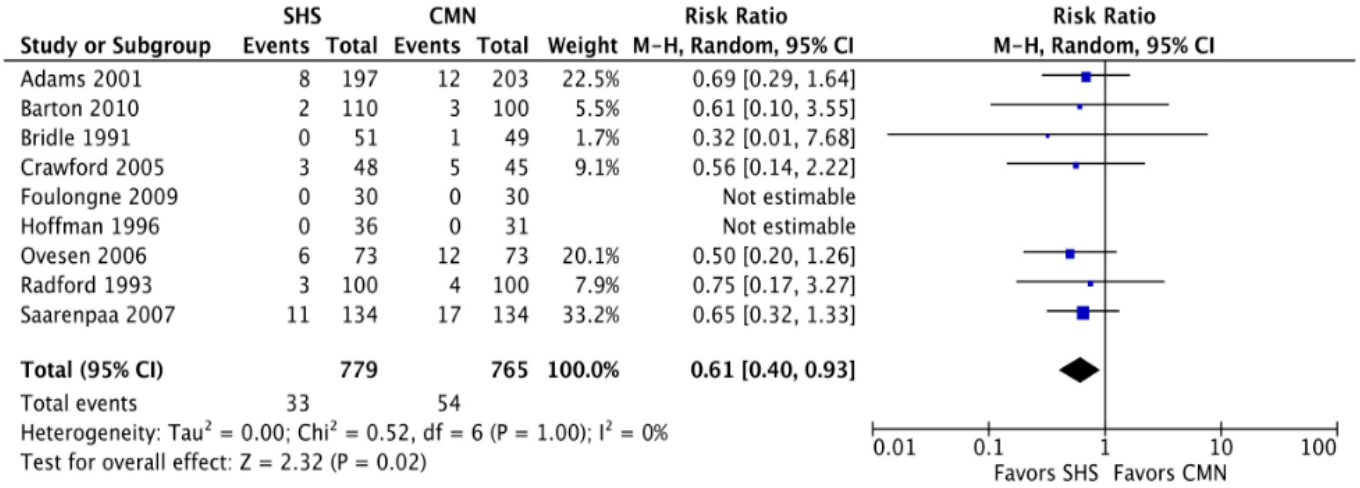

Figure 11.Risk Ratio of Reoperation after SHS or CMN for Intertrochanteric Femur Fractures

Length of Hospital Stay

Seven studies reported information on the length of hospital stay after the index surgery.[17,18,21,22,24,16,30] The average length of stay was 23.9 days for SHS (95% CI 13.87 to 33.93 days) and 23.8 days (95% CI 13.89 to 33.74 days) for CMN (P = 0.99). Measures of variance were not provided for hospital length of stay in these studies which precluded the production of forest plots and evaluation of the overall mean difference.

Discussion

Hip fractures are an increasing epidemic in the United States. With the aging population, the incidence of these fractures is anticipated to exceed 500,000 per year by 2040.[31] SHS have traditionally been the preferred implant in the treatment of intertrochanteric hip fractures, but CMN offer the theoretical advantage of being less invasive and biomechanically superior, providing a buttress to limit fracture collapse.[8,32] Despite extensive research and debate, there no consensus on the superiority of one construct over the other. This meta-analysis demonstrates that there is a higher rate of refracture and reoperation among patients receiving treatment with a CMN compared to those treated with a SHS.

Our finding that there is no difference in rates of post-operative pain, nonunion, cutout failure, infection, PE, length of stay, or mortality corroborates with a previous meta-analyses.[33,34] Many randomized controlled trials and meta-analyses have found no difference in mortality between CMN and SHS.[34-36] Numerous risk factors for mortality have been identified in these populations, including liver disease, time to surgery, diabetes, pulmonary disease, and cardiovascular disease, but these do not appear to play a role in the decision to choose a CMN or SHS.[37-39]

Previous studies have shown no difference in length of stay between patients undergoing CMN and SHS.[30,36,40] An increased length of stay predisposes patients to higher risks of nosocomial complications such as infections, thrombotic events, and decreased mobility. A recent meta-analysis of six studies involving 909 patients found that patients undergoing treatment with a CMN experienced significantly less operative blood loss, leg shortening, wound infections, and length of hospital stay.[41] Our data do not demonstrate a decreased rate of infection or a shorter hospital stay. The authors of the previous study postulate that the use of minimally invasive techniques in CMNs may minimize short tissue dissection, thereby reducing blood loss, infections, and wound complications, but acknowledge that these results should be interpreted with caution due to notable heterogeneity in the analysis of blood loss in the five studies included. Our results, which include 12 studies, found no statistically significant difference.

A Cochrane Database Systematic Review concluded that the Gamma Nail (Stryker; Mahwah, NJ) was associated with a significantly increased risk of reoperation, which was attributed to poor nail design and/or insertion technique. Other studies have demonstrated higher rates of repeat operation and failures in patients treated with CMN using data from five studies.[41] Our data, which include nine recent studies, do not show any statistically significant difference in these complications between implants. This may be due, in part, to advances in technology and greater familiarity with the implants amongst surgeons as its use becomes more ubiquitous.

There are several limitations to this study. Fracture characteristics, such as obliquity and stability, were not assessed in our analysis. These fracture characteristics may provide relevant variables that can affect different outcomes, such as implant failure and screw cutout. While there is minimal heterogeneity in most outcomes assessed, there is the risk of bias due to differences in reporting metrics and patient data collection. Various preoperative factors were not assessed, such as patient comorbidities and fracture patterns, as well as the implant manufacturer utilized in each case.

Conclusion

In summary, this meta-analysis reports on clinically relevant outcomes SHS vs. CMN in the treatment of intertrochanteric hip fractures. Using the most recently published data, we found that the only notable difference is patients treated with CMN have a higher refracture and reoperation rate. With new advances in the development of both CMNs and SHS, further studies will be required to see if these differences persist in the coming years.

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Not applicable

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