

# A Systematic Review of Fixation Methods for Basicervical Femoral Neck Fractures

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## Abstract

**Background:** Basicervical femoral neck fractures (BFNFs), comprising 1.8–7.7% of hip fractures, are biomechanically challenging due to their transitional location. Optimal fixation methods remain debated due to inconsistent classification and limited evidence. This review compared outcomes of sliding hip screw (SHS), Cannulated Cancellous Screws (CCS), and cephalomedullary nails (CMN) for BFNF fixation, with fixation failure as the primary outcome measure.

**Methods:** A PRISMA-compliant systematic review identified 19 studies comprising (989 patients; mean age 73.7 years, 43% male). Fixation methods included SHS (n=610), CCS (n=69), and CMN (n=310). The Newcastle-Ottawa Scale/Rob2 assessed study quality, and statistical analyses compared failure, revision, and non-union rates. This study was registered with PROSPERO on the 11th of November 2020 (PROSPERO 2020 CRD42020209111).

**Results:** Prospective/retrospective studies, case series, and one RCT was included. CMN demonstrated the lowest non-union rate (0.32%) compared to 2.3% for SHS and 2.9% for CCS (p=0.072). Revision rates were significantly lower with CMN (3.54%) compared to SHS (6.39%) and CCS (13.04%) (p=0.011). Fixation failure rates were 6.56% for SHS (CI 4.6% - 8.5%), 21.74% for CCS (CI 12% - 31.5%), and 4.52% for CMN (p<0.00001, CI 2.3% - 7.7%). CMN exhibited the longest time to union (3.6 months).

**Conclusion:** CMN fixation was associated with lower non-union, fixation failure, and revision rates. However, due to limitations in the existing literature, definitive recommendations cannot be made. Randomised controlled trials (RCTs) are needed to validate these results and standardise treatment protocols.

**Keywords:** Basicervical; Neck of femur; Fracture; Open reduction internal fixation; Method of fixation; Intracapsular; Geriatric fracture, Neck of femur fixation

## Background

Annually, over four million individuals worldwide experience hip fractures, with projections that more than 21 million people will live with fracture-related disabilities by 2050 [1,2]. Neck of femur fractures, particularly in the elderly, are associated with high morbidity and mortality. Early surgery and immediate weight-bearing are key to optimising recovery.

Hip fractures are classified as either intracapsular (treated with fixation or arthroplasty) and extracapsular (treated with various fixation methods). Basicervical femoral neck fractures (BFNFs) lie between these classifications, combining biomechanical instability with compromised vascular supply [3].

BFNFs occur at the junction of the femoral neck and intertro-

chanteric region [4,5], accounting for 1.8-7.7% of all hip fractures [5,6]. Their location subjects them to high shear forces, limited vascularity, and reduced cancellous bone interdigitation, predisposing them to mechanical failure [7,8]. The optimal fixation method for BFNs remains uncertain, partly due to classification inconsistencies and limited evidence. The two-part fracture is by far the commonest definition, the fracture line located at the base of femoral neck and medial to intertrochanteric line, exiting above the lesser trochanter [9,10].

Treatment strategies include arthroplasty, or internal fixation (cannulated cancellous screws [CCS], fixed angle devices, sliding hip screw +/- anti-rotation screw [SHS], or cephalomedullary nail [CMN]) [11-14]. Fixation approaches have evolved with a better understanding of the fracture morphology and implant biomechanics.

This systematic review evaluates the most effective fixation method for BFN in adults ( $\geq 18$ ) by comparing union, fixation failures, and revision surgeries across CMN, SHS and CCS constructs. Outcomes were assessed at a minimum follow-up of 12 months. The primary outcome registered was fixation failure, defined as metalwork failure or screw cut-out.

We hypothesised that CMNs would demonstrate the lowest fixation failure rates.

## Methodology

This systematic review was registered with PROSPERO on the 11th of November 2020 (PROSPERO 2020 CRD42020209111), and conducted in accordance with PRISMA guidelines (Figure 1, 2) [15].

### Search strategy and identification of studies (Figure 3)

A comprehensive search of Google Scholar, PubMed, MEDLINE, Cochrane, Web of Science, EMBASE, Scopus, and Ovid was conducted up to July 11, 2021, with an updated search on the 12th of February 2025. MeSH terms included: basicervical, transcervical, hip fracture, femoral neck fracture, femoral neck fractures femur fracture, femur fractures, neck of femur. An experienced librarian assisted in developing the search strategy (Figure 3). The updated search confirmed no new studies that altered conclusions.

### Data extraction and assessment

Two independent reviewers screened titles, abstracts, and full texts using Covidence software. Disagreements were resolved via third-party adjudication. Full-text articles were comprehensively assessed, and data on publication year, study type, patient demographics, fixation methods, and clinical outcomes were extracted. A hand search was completed for additional relevant studies. Only studies exclusively reporting BFN data were included. Studies with mixed fracture types were excluded unless BFN outcomes were separately reported.

### Inclusion criteria

Studies were included if they:

1. Included patients with BFNs.
2. Reported outcomes of internal fixation using CCS, SHS +/- anti-rotation screw, CMN.
3. Reported at least one of the following: time to union, non-union rate, fixation failure, mortality and/or functional outcome score. Failure was defined as metalwork failure or screw cut-out.
4. Were RCTs, non-randomised controlled trials, pro-

spective cohort trials, retrospective comparative studies, or case-series, published in peer reviewed journals.

5. Had  $\geq 12$  months follow-up.

### Exclusion criteria

Studies were excluded if they:

1. Grouped BFNs with other proximal femur fractures without separate reporting.
2. Were non-English publications
3. Were case reports or ongoing/unpublished studies.

### Risk of bias (methodological quality) assessment of individual studies

Given that there are no tools to assess the risk of bias (i.e., methodological quality) of case series', we derived items from the Newcastle-Ottawa scale that were appropriate for this systematic review [16]. We removed the Newcastle-Ottawa scale items that relate to comparability and adjustment and kept items that focused on selection and representativeness of cases, outcome, and exposure. This resulted in five criteria (Table 2) in the form of questions with binary responses to indicate whether the item is suggestive or not of bias. Studies were rated as low risk (5/5 criteria), moderate (4/5), or high risk (<3/5). The sole RCT was assessed using the Cochrane RoB2 tool [17], evaluating randomisation, deviations from the intended interventions, missed outcome data, measurement methods, and reporting bias.

### Statistical analysis

Descriptive statistics were used for demographic and outcome data. Meta-analysis was not performed due to clinical and methodological heterogeneity across studies.

## Results

The search yielded 895 articles, 871 were excluded based on titles and abstracts. Of the 24 full texts, 14 met inclusion criteria. An additional five studies were found through hand search, totalling 19 papers (Figure 2).

### Study characteristics (Table 1)

The review included seven retrospective cohort studies (from Finland, UK, Sweden, South Korea, and China) [7,11,18-22], three prospective cohort studies (from Egypt, South Korea, and India) [3,13,23], and one RCT conducted over multiple hospitals internationally [24]. The remaining eight were case series from six countries (Finland, China, Turkey, USA, Japan, and South Korea) [6,8-10,14,25-27].

### Participant's characteristics (Table 1)

A total of 989 patients were analysed (43% male, 57% female) with a mean age of 73.7 years. Data from 1982 to 2022 showed 610 (62%) patients received SHS fixation, 69 (7%) underwent CCS fixation, and 310 (31%) were treated with various CMN.

### Methodological quality assessment (Table 2, 3)

Risk of bias assessment for the cohort/case series showed 12 papers being at low risk (66.6%), four at moderate risk (22.2%) and two at high risk (11.1%). The single RCT was at a low risk of bias across all five domains of the RoB2 tool.

### Definition of basicervical femoral neck fractures (Table 4)

Definitions varied among studies. The two most common definitions were the Arbeitsgemeinschaft für Osteosynthesefragen B2 and Watson et al's definition; Two-part fracture

Section and Topic	Item #	Checklist item	Location where item is reported
<b>TITLE – A Systematic review of basicervical femoral neck fractures: what is the best of fixation?</b>			
Title	1	Identify the report as a systematic review.	Page 1
<b>ABSTRACT</b>			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 3
<b>INTRODUCTION</b>			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 5, 12
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 5
<b>METHODS</b>			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 7
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Figure 3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 6, 7
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 6, 7
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 9, 10
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 9, 10
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 8
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Page 8, 9, 10
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Page 7
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	N/A
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Tables 1-7
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page, 9, 10, 11, 12
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Page 11
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A

Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Page 12
<b>RESULTS</b>			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 8, 9 Figure 2
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Figure 2
Study characteristics	17	Cite each included study and present its characteristics.	Page 9
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Page 9, Table 2, 3
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Page 9, 10 Table 5
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Page 9
			Table 2, 3
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Page 11, 12
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Pages 8, 9, 10, 11
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Page 11
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Page 9
			Table 2, 3
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Page 10
<b>DISCUSSION</b>			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Page 12-16
	23b	Discuss any limitations of the evidence included in the review.	Page 15
	23c	Discuss any limitations of the review processes used.	Page 15
	23d	Discuss implications of the results for practice, policy, and future research.	Page 12-16
<b>OTHER INFORMATION</b>			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Figure 3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 17
Competing interests	26	Declare any competing interests of review authors.	Page 17
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Figure 2, 3

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. This work is licensed under CC BY 4.0. To view a copy of this license, visit <https://creativecommons.org/licenses/by/4.0/>

Figure 1: PRISMA 2020 Checklist.

at the base of the femoral neck that was medial to the intertrochanteric line and exited above the lesser trochanter but was more lateral than a classic transcervical fracture [10].

**Definition of union, fixation failure and complications (Table 5)**

In total, six papers defined union (four with radiological defini-

tions, two with both radiological and clinical definitions). The most common definitions were ‘evidence/presence of bony trabeculae across the fracture site’ for radiological union, and ‘absence of pain during mobilisation’ for clinical union.

Fixation failure was defined in five papers, the most common of which were screw cut-out (penetration of screw through femoral head) and non-union. The remaining 12 papers did not define fixation failure, but instead defined complications which were non-specific.

**Outcomes by fixation method (Table 6)**

For SHS (610 patients in 11 studies), time to union averaged 3.1 months. Non-union rates averaged 2.3%. Revision rates were 6.39%, and failure rates 6.55%.

For CCS (69 patients in four studies), time to union averaged 3.3 months. Revision rates were 13%, and failure rates 21.7%.

For CMN (310 patients in 12 studies), time to union averaged 3.6 months. Non-union rates were 0.3%. Revision rates were 3.54%, and failure rates 4.51%.

The corresponding 95% confidence intervals were: SHS

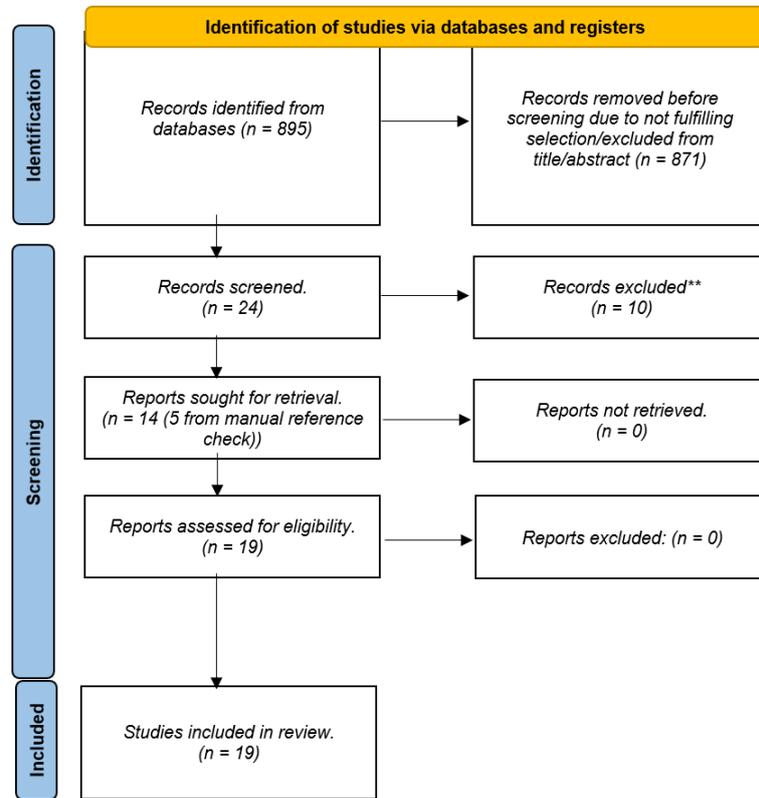


Figure 2: PRISMA Flow Diagram.

1	*"Femoral Neck Fractures"/su [Surgery] 3546 Advanced
2	"Fracture Fixation, Internal"/is [Instrumentation] 9454 Advanced
3	*"Fracture Fixation, Internal"/mt [Methods] 11402 Advanced
4	2 or 3 18010 Advanced
5	1 and 4 735 Advanced
6	(basicervical or basi-cervical or transcervical or trans-cervical).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] 3173 Advanced
7	Hip Fractures/ or hip fracture*.mp. 23277 Advanced
8	Femoral Neck Fractures/ or Femoral neck fracture*.mp. 10649 Advanced
9	Femoral Fractures/ or femur fracture*.mp. 18819 Advanced
10	Neck of femur.mp. 1282 Advanced
11	7 or 8 or 9 or 10 48473 Advanced
12	6 and 11 225 Advanced
13	Fixation.mp. 217751 Advanced
14	12 and 13 148 Advanced
15	5 or 14 853 Advanced
16	Basicervical femoral neck fracture*.mp. 12 Advanced
17	15 and 16 12 Advanced

Figure 3: Example of search strategy.

Table 1: Characteristics of included studies.

Study	Year	Country	Treatment	Sample size	Mean age	Male/Female	Study design	LoE
Bhandari et al [1]	2017	Canada	SHS, CCS	76	72.1	30/46	RCT	I
Chapman et al	2018	USA	CMN	6	83.7	5-Jan	Retrospective cohort study	III
Chen et al	2008	China	SHS	241	73.8		Case series	IV
Enocson et al	2012	Sweden	SHS	93	82.9	41/52	Retrospective cohort study	III
Guo et al [5]	2019	China	CMN	14	67.6	10-Apr	Retrospective cohort study	III
Hu et al	2013	China	CMN	30	47.8	24/6	Case series	IV
Kim et al [7]	2020	South Korea	SHS, CMN	106	77	39/67	Prospective cohort study	II
Koukkanen et al	1991	Finland	SHS	14	74	13/1	Prospective cohort study	II
Kweon et al	2017	South Korea	CMN	15	78	9-Jun	Case series	IV
Lee et al [10]	2018	South Korea	SHS, CMN	69	81.3	17/52	Retrospective cohort study	III
Mallick et al	2004	UK	SHS, CCS	73	80	18/52	Retrospective cohort study	III
Massoud et al [12]	2010	Egypt	SHS	13	68.9	4-Sep	Prospective cohort study	II
Okano et al	2017	Japan	CMN	14	86.9	2-Dec	Case series	IV
Saarenpää et al	2002	Finland	SHS, CMN, CCS	21	75	20-Nov	Case series	IV
Sharma et al	2018	India	SHS, CMN, CCS	88	47.5	56/32	Retrospective cohort study	III
Su et al	2006	USA	SHS	28	79	23-May	Retrospective cohort study	III
Tasyikan et al	2015	Turkey	CMN	28	71	17-Nov	Case series	IV
Wang et al [18]	2019	China	CMN	49	75.1	Nov-38	Case series	IV
Watson et al [19]	2016	USA	CMN	11	79	6-May	Case series	IV

Newcastle Ottawa Scale Questions	
1.	Did the patient(s) represent the whole case(s) of the medical centre?
2.	Was the diagnosis correctly made?
3.	Were other important diagnosis excluded?
4.	Were all important data cited in the report?
5.	Was the outcome correctly ascertained?

Table 2: Risk of bias assessment of cohort/case studies (Newcastle Ottawa Scale).

First Author/Year	Question 1		Question 2		Question 3		Question 4		Question 5		Risk of Bias	LOE	Study Design
	Y	N	Y	N	Y	N	Y	N	Y	N			
Kuokkanen, 1991 [20]	Y		Y		Y		Y		Y		Low	III	Retrospective cohort study
Su, 2006 [7]	Y		Y		Y		Y		Y		Low	III	Retrospective cohort study
Enocson, 2012 [11]	Y		Y		Y	N	Y		Y		Mod	III	Retrospective cohort study
Mallick, 2004 [22]	Y		Y		Y		Y		Y		Low	III	Retrospective cohort study
Chapman, 2018 [18]	Y		Y	N	Y	N	Y	N	Y		High	III	Retrospective cohort study
Lee, 2018 [21]	Y		Y		Y		Y		Y		Low	III	Retrospective cohort study
Guo 2019 [19]	Y		Y		Y		Y		Y		Low	III	Retrospective cohort study
Massoud, 2010 [13]	Y		Y		Y		Y		Y		Low	II	Prospective cohort study
Kim, 2020 [3]	Y		Y		Y		Y	N	Y		Mod	II	Prospective cohort study
Sharma 2018 [23]	Y		Y	N	Y		Y		Y		Mod	II	Prospective cohort study
Saarenpaa, 2002 [6]	Y		Y		Y		Y	N	Y		Mod	IV	Case series
Chen, 2008 [25]	Y		Y		Y		Y		Y		Low	IV	Case series
Hu, 2013 [26]	Y		Y	N	Y	N	Y		Y		High	IV	Case series
Tasyikan, 2015 [8]	Y		Y		Y		Y		Y		Low	IV	Case series
Watson, 2016 [10]	Y		Y		Y		Y		Y		Low	IV	Case series
Okano, 2017 [27]	Y		Y		Y		Y		Y		Low	IV	Case series
Kweon, 2017 [14]	Y		Y		Y		Y		Y		Low	IV	Case series
Wang, 2019 [9]	Y		Y		Y		Y		Y		Low	IV	Case series
<b>Total Studies</b>	18		15	3	15	3	15	3	18				

Table 3: Risk of bias assessment of RCT (Risk of Bias 2 Tool).

Included Study	D1 – Randomisation Process	D2 – Deviations from Intended Interventions	D3 – Missing Outcome Data	D4 – Measurement of the Outcome	D5 – Selection of the Reported Result	Overall
Bhandari 2017 (24)						

Table 4: Definition of basicervical fractures.

First Author/Year	Diagnosis
Kuokkanen, 1991 (20)	Extracapsular fractures of the neck of the femur
Saarenpaa, 2002 (6)	Proximal femoral fracture through the base of the femoral neck at its junction with the intertrochanteric region
Mallick, 2004 (22)	Two-part fracture in which the fracture line runs along the inter-trochanteric line and is immediately proximal to the lesser and greater trochanters
Su, 2006 (7)	Proximal femur fractures through the base of the femoral neck at its junction with the intertrochanteric region as defined by the Arbeitsgemeinschaft fur osteosynthesis and Orthopaedic trauma association (AO/OTA) classification for femoral neck fractures (B2.1)
Chen, 2008 (25)	Extracapsular fractures just proximal to or along the intertrochanteric line
Massoud, 2010 (13)	Extracapsular fracture, through the base of the femoral neck at its junction with the intertrochanteric region corresponding to the AO Type B2.1
Enocson, 2012 (11)	Vertically oriented fracture at the junction between the intertrochanteric region and femoral neck
Hu, 2013 (26)	A particular type of trochanteric fracture in which the fracture line can be seen radiologically to cross close to the base of the femoral neck and its junction with the intertrochanteric region.
Tasyikan, 2015 (8)	Fractures did not extend to the trochanteric site and were at the joint of the femur neck and intertrochanteric site
Chapman, 2018 (18)	Defined used OTA/AO (31-B2) classification.
Watson, 2016 (10)	Two-part fracture at the base of the femoral neck that was medial to the intertrochanteric line and exited above the lesser trochanter but was more lateral than a classic transcervical fracture
Okano, 2017 (27)	Two-part fracture: the proximal fracture line located medial to the intertrochanteric line and did not exceed the midpoint of the intertrochanteric line and the base of the femoral head; the distal fracture line located along the intertrochanteric line and the lesser trochanter was intact
Kweon, 2017 (14)	Two-part fractures between the base of the femoral neck and the intertrochanteric region on computed tomography scans
Bhandari, 2017 (24)	Fracture at the base of the neck
Lee, 2018 (21)	Two-part fracture at the base of the femoral neck that was medial to the intertrochanteric line and exited above the lesser trochanter but was more lateral than a classic transcervical fracture
Sharma 2018 (23)	Represent an intermediate form between femoral neck and intertrochanteric fractures.
Wang, 2019 (9)	Two-part fracture: fracture line located at the base of the femoral neck that was medial to the intertrochanteric line and exited above the lesser trochanter but was more lateral than a classic transcervical fracture
Guo 2019 (19)	Fracture located at the junction between the femoral neck and intertrochanteric region.
Kim, 2020 (3)	Two-part fracture at the base of the femoral neck that was medial to the intertrochanteric line, exiting above the lesser trochanter but was more lateral than a classic transcervical fracture

(4.6%–8.5%), CCS (12.0%–31.5%), and CMN (2.3%–7.7%), reflecting greater precision and reliability with CMN and SHS over CCS.

**Patient reported outcome measures/functional outcome (Table 7)**

Eleven studies reported functional scores. Seven used the Harris Hip Score (mean 83.2, indicating ‘good’ outcomes). Other tools included the Barthel Index, SF-12, SF-36, FRS, Modified criteria of Kyle, WOMAC, and EQ-5D. Heterogeneity limited pool analysis.

**Mortality**

Mortality was inconsistently reported and thus not analysed.

**Analysis**

**Time to union:**

Time to union was similar across fixation methods: SHS (3.1 months), CCS (3.3 months), and CMN (3.6 months). Although CMN had the longest union time, this was not clinically significant, as all patients were permitted to weight-bear as tolerated. This highlights the importance of considering overall recovery and function, not just radiographic union.

**Non-Union rates:**

Non-union occurred in 2.3% of SHS cases, 2.9% of CCS cases, and 0.32% of CMN cases. Although the differences were not statistically significant (p=0.072), CMN showed a clinically meaningful reduction in non-union rates.

**Revision rates:**

Revision surgery was required in 6.39% of SHS, 13.04% of CCS, and 3.54% of CMN cases. The difference was statistically significant (p=0.011), suggesting CMN and SHS were more reliable than CCS, with CMN demonstrating the most favourable profile.

**Failure rates (with or without revision):**

Fixation failure occurred in 6.56% of SHS, 21.74% of CCS, and 4.52% of CMN cases. The differences were highly significant (p<0.00001). Confidence intervals supported this:

SHS (CI 4.6%–8.5%), CCS (CI 12.0%–31.5%), and CMN (CI 2.3%–7.7%). These findings highlight the higher mechanical failure rate and uncertainty associated with CCS compared to the more consistent outcomes seen with SHS and CMN.

**Sensitivity and Heterogeneity:**

Formal sensitivity analyses were not performed due to the descriptive nature of this review and heterogeneity in study design, definitions, and outcomes. Differences in fracture classification, fixation constructs, and follow-up protocols likely contributed to variability in reported outcomes.

Table 5: Union/Failure/Complication definitions.

First author/date	Union	Failure	Complications
Bhandari 2017 (24)	Undefined	Undefined	AVN, non-union, implant failure, infection
Chapman 2018 (18)	Undefined	Non-union, hardware cut-out, need for revision	Undefined
Chen 2008 (25)	Presence of periosteal callus bridging at the fracture site, or trabeculation extending it within 6 months	Screw cut-out	Undefined
Enocson 2012 (11)	Undefined	Undefined	Screw cut-out, lateral pain, non-union, screw penetration, deep infection, AVN, peri-implant fracture, post-traumatic arthritis
Guo 2019 (19)	Evidence of bony trabeculae crossing the fracture interspace	Undefined	Femoral neck shortening, screw protrusion, screw cut-out, non-union
Hu 2013 (26)	Clinical union = absence of local tenderness on palpation or on motion of injured joint, radiographic union = evidence of bony trabeculae crossing the fracture interspace	Undefined	Non-union, AVN
Kim 2020 (3)	Undefined	Undefined	Excess fracture displacement, occurrence of re-operation
Kuokkanen 1991 (20)	Undefined	Undefined	Undefined
Kweon 2017 (14)	Undefined	Undefined	Screw cut-out, excess lag screw sliding, varus deformity, intra-op lateral wall fracture, AVN
Lee 2018 (21)	Undefined	Re-operation	Undefined
Mallick 2004 (22)	Undefined	Undefined	Undefined
Massoud 2010 (13)	Presence of trabeculae across the fracture site	Screw cut-out, excess displacement, implant breakage/loosening, intra or post-op femoral shaft fracture, non-union	Undefined
Okano 2017 (27)	Undefined	Undefined	Screw cut-out, screw cut-through, non-union, loosening of implant, hardware related femoral fracture, any hardware breakage, helical blade movement, excess 'telescoping/fracture collapse over 10mm'
Saarenpaa 2002 (6)	Undefined	Undefined	Undefined
Sharma 2018 (23)	Undefined	Undefined	Infection, screw back-out, superior cut-out, varus collapse, broken screws, joint penetration, non-union, AVN
Su 2006 (7)	Undefined	Undefined	Undefined
Tasyikan 2015 (8)	Clinical union = no pain during mobilisation, radiological union = callus bridging at the fracture line	Undefined	Screw cut-out, femur fracture, wound infection, varus collapse
Wang 2019 (9)	Evidence of bony trabeculae crossing the fracture interspace	Undefined	Screw cut-out, screw cut-through, hardware-related femoral fracture, non-union, lag screw loosening in femoral head, varus collapse
Watson 2016 (10)	Undefined	Collapse at fracture site, movement of lag screw position, non-union	Undefined

Table 6: Outcomes.

	Fixation method	Sample Size	Union time (weeks)	Non-union rate	Failure with Revision	Failure fixation with or without revision
Kuokkanen, 1991 (20)	SHS	14	-	0	0	1
Saarenpaa, 2002 (6)	SHS	10	-	-	1	1
Mallick, 2004 (22)	SHS	71	-	0	1	1
Su, 2006 (7)	SHS	28	-	3.57%	5	5
Chen, 2008 (25)	SHS	241	16.5	1.66%	6	6
Massoud, 2010 (13)	SHS	13	11.5	0	0	0
Enocson, 2012 (11)	SHS	93	-	2.15%	15	15
Bhandari, 2017 (24)	SHS	45	-	-	5	5
Lee, 2018 (21)	SHS	29	-	0	5	5
Kim, 2020 (3)	SHS	39	-	-	1	1
Sharma 2018 (23)	SHS	27	13.9	0	0	0
<b>Total</b>	<b>SHS</b>	<b>610</b>	<b>13.96</b>	<b>14 (2.3%)</b>	<b>39 (6.39%)</b>	<b>40 (6.55%)</b>
Saarenpaa, 2002 (6)	CCS	7	-	-	3	3
Mallick, 2004 (22)	CCS	2	-	0%	1	2
Bhandari, 2017 (24)	CCS	31	-	-	5	5
Sharma 2018 (23)	CCS	29	14.4	6.80%	-	5
<b>Total</b>	<b>CCS</b>	<b>69</b>	<b>14.4</b>	<b>2 (2.9%)</b>	<b>9 (13%)</b>	<b>15 (21.7%)</b>
Saarenpaa, 2002 (6)	CMN	4	-	-	0	0
Hu, 2013 (26)	CMN	30	14.7	0	0	0
Tasyikan, 2015 (8)	CMN	28	10.5	0	0	0
Chapman, 2018 (18)	CMN	6	-	0	2	2
Watson, 2016 (10)	CMN	11	-	1	4	6
Okano, 2017 (27)	CMN	14	-	0	0	0
Kweon, 2017 (14)	CMN	15	20	0	0	0
Lee, 2018 (21)	CMN	40	-	0	1	1
Kim, 2020 (3)	CMN	67	-	-	4	5
Wang, 2019 (9)	CMN	49	19.6	0	0	0
Guo 2019 (19)	CMN	14	-	0	0	0
Sharma 2018 (23)	CMN	32	13.5	0	0	0
<b>Total</b>	<b>CMN</b>	<b>310</b>	<b>15.66</b>	<b>1 (0.32%)</b>	<b>11 (3.54%)</b>	<b>14 (4.51%)</b>

Table 7: Patient reported outcomes.

First author/year	Scoring system	Average Score
<b>Chen 2008 (25)</b>	Harris Hip Score	80
<b>Hu 2013 (26)</b>	Harris Hip Score	86.5
<b>Guo 2019 (19)</b>	Harris Hip Score	85.7
<b>Wang 2019 (9)</b>	Harris Hip Score	84.9
<b>Koukkanen 1991 (20)</b>	Harris Hip Score	Poor
<b>Tasyikan 2015 (8)</b>	Harris Hip Score	81.1
	Barthel Index	50% fully independent, 7.1% slightly dependent, 21.4% mildly, 14.3% severely, 7.1% fully
<b>Sharma 2018 (23)</b>	Harris Hip Score	81.1
<b>Bhandari 2017 (24)</b>	SF-12	Similar between SHS/CCS at 12 months
	WOMAC, EQ-5D	
<b>Massoud 2010 (13)</b>	Modified criteria of Kyle	93.86% excellent, 4.76% good, 2.38% fair

**Discussion**

This review examined fixation strategies for BFNs. Previous similar reviews [28,29] did not include several pertinent studies considered in this analysis [23,24], and one review included arthroplasty as a treatment option, underscoring the novelty and depth of our review as we focused solely on internal fixation methods to maintain methodological consistency. The FAITH trial is a landmark RCT on femoral neck fractures but did not specifically address basicervical fractures, which have distinct biomechanical characteristics. We incorporated its subset data on basicervical fractures to help address this evidence gap in our focused analysis [24].

Finally, a recent meta-analysis by Yoo et al [30] was found to be in-exhaustive in its literature search and included two articles which did not meet our inclusion criteria (one was review-

ing intertrochanteric fractures, one was not yet published in a peer reviewed journal).

Both Yoo et al. and Dekhne et al. highlighted the heterogeneity in defining and managing basicervical fractures, with comparable revision rates reported between CMN and SHS. While Dekhne et al. suggested SHS may have slightly lower reoperation rates, our study found CMN had the lowest failure and revision rates, likely due to stricter inclusion criteria and more consistent definitions. Unlike Yoo et al., who reported variable outcomes with CMNs, our review demonstrated more favourable and reliable results with their use.

BFNs occupy a transitional anatomical zone between intracapsular and extracapsular fractures, rendering them biomechanically unstable due to high shear forces, reduced can-

cellous bone interdigitation, and compromised vascularity [13,29-31]. These factors increase the risk of fixation failure, making optimal surgical management critical.

Our findings suggest that CMNs provide the most reliable fixation for BFNFs. CMNs had the lowest fixation failure (4.52%, CI 2.3%–7.7%), revision (3.54%), and non-union rates (0.32%), despite a slightly longer time to union (3.6 months). This extended healing time did not affect post-operative weight-bearing or functional outcomes, supporting CMN's role as a biomechanically superior construct.

Literature purports that the extended union time in CMN could be due to the internal stabilisation mechanisms that allow for controlled load transfer and potentially better adaptation to the mechanical environment of the hip, especially in osteoporotic bones [32,33]. The inherent stability provided by CMN, especially vital in osteoporotic bone [32,33], underscores its suitability for effectively managing these complex fractures.

Historically, SHS with or without anti-rotation screws were favoured; however, CMN have gained preference due to their biomechanical superiority [3,21]. Unlike SHS, which is prone to complications like cut-out and varus collapse, CMN offers a biomechanically advantageous design. Its shorter lever arm and reduced bending moment allow for controlled impaction and stabilisation of the fracture, thus reducing mechanical stress and enhancing healing [11,17,19,21,27], thereby effectively countering the shear forces that may compromise SHS.

Finite analysis in Kwak et al's paper showed that CMNs distribute stress more effectively across the femoral head, reducing peak stress at the lag screw tip— a major issue of SHS cut-out failures [31].

CMNs also engage the intramedullary canal, reducing axial and cranial migration, whereas SHS relies on lateral fixation, which is more vulnerable to shear forces in BFNFs [31].

CCS limitations include weaker holding capabilities and consequent functional compromise post-operatively, especially in the elderly [34,35]. Comparative studies show that SHS with anti-rotation screws can withstand nearly twice the peak force before failure compared to CCS, and CCS-treated patients exhibit lower ultimate load to failure and lack angular stability leading to higher non-union rates and implant migration [4,5].

### Fracture definitions

Fracture classification remains a significant source of heterogeneity across studies [6]. Older studies employed the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification (B2.1) [7,13,18], while more recent research has adopted the definition by Watson et al. - a two-part fracture at the base of the femoral neck that was medial to the intertrochanteric line and exited above the lesser trochanter but was more lateral than a classic transcervical fracture [3,9,10,21,27]. Consistent use of a standardised definition, such as Watson's, will improve diagnostic accuracy and facilitate inter-study comparisons.

### PROMs

Patient-reported outcome measures (PROMs) varied significantly among studies, hindering direct comparisons. The Harris Hip Score was most reported, but other scoring systems such as SF-12, SF-36, and WOMAC were inconsistently ap-

plied. Future studies should prioritise standardised PROMs to enable robust assessment of functional recovery.

### Limitations

Limitations of this review include the predominance of retrospective cohort studies and case series, small sample sizes, inconsistent follow-up durations, and moderate-to-high risk of bias in several studies. Additionally, some included studies featured younger patients or high-energy trauma mechanisms, which may not represent typical geriatric hip fracture populations. Publication bias and incomplete reporting of post-operative protocols and complications may also influence findings.

### Conclusion

This systematic review provides evidence that CMNs offer a reliable fixation method for BFNFs, with lower failure, revision, and non-union rates compared to SHS and CCS. CMNs demonstrated superior biomechanical stability and resistance to complications such as varus collapse and cut-out. While SHS remains a viable alternative, its biomechanical limitations—particularly in osteoporotic bone—make it less favourable. CCS, associated with the highest failure and revision rates, should be used with caution.

Given the heterogeneity of study designs and the lack of high-quality evidence, definitive recommendations remain limited. Future large, multicentre RCTs are essential to confirm these findings, refine treatment algorithms, and support the development of standardised fracture classifications, fixation protocols, and outcome measures.

### Level of Evidence: Level III

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### Contributions:

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Matthew Ludlow - data collection and literature review, data extraction

Jonathan Quinn – data analysis, manuscript review, supervisor

Tom Walsh – manuscript review, supervisor, editor

Simon Platt – conceptualisation, editor, supervisor

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