Distal Femur Replacement Versus Surgical Fixation for the Treatment of Geriatric Distal Femur Fractures: A Systematic Review

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Objectives: The management of geriatric distal femur fractures is controversial, and both primary distal femur replacement (DFR) and surgical fixation (SF) are viable treatment options. The purpose of this study was to compare patient outcomes after these treatment strategies.

Data Sources: PubMed, Embase, and Cochrane databases were searched for English language articles up to April 24, 2020, identifying 2129 papers.

Study Selection: Studies evaluating complications in elderly patients treated for distal femur fractures with either immediate DFR or SF were included. Studies with mean patient age <55 years, nontraumatic indications for DFR, or SF with nonlocking plates were excluded.

Data Extraction: Two studies provided Level II or III evidence, whereas the remaining 28 studies provided Level IV evidence. Studies were formally evaluated for methodological quality using established criteria. Treatment failure between groups was compared using an incidence rate ratio.

Data Synthesis: Treatment failure was defined for both SF and arthroplasty as complications requiring a major reoperation for reasons such as mechanical failure, nonunion, deep infection, aseptic loosening, or extensor mechanism disruption. There were no significant differences in complication rates or knee range of motion between SF and DFR.

Conclusions: SF and DFR for the treatment of geriatric distal femur fractures demonstrate similar overall complication rates. Given the available evidence, no strong conclusions on the comparative effectiveness between the 2 treatments can be definitively made. More rigorous prospective research comparing SF vs. DFR to treat acute geriatric distal femur fractures is warranted.

Key Words: geriatric, fragility fracture, knee, distal femur, arthroplasty, osteosynthesis, trauma

Level of Evidence: Therapeutic Level IV. See instructions for authors for a complete description of levels of evidence.

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INTRODUCTION

Distal femur fractures can be devastating injuries in the elderly, resulting in similar morbidity and mortality to what has been observed in geriatric femoral neck fractures.[1,2] Although surgical fixation (SF) with either a locking plate or retrograde intramedullary nail (RIN) remains the most common treatment strategy, not all surgeons allow immediate postoperative weight bearing, and complications such as nonunion, malunion, knee stiffness and compromised function remain relatively common.[3–6]

In response to the inherent limitations of SF, distal femur replacement (DFR) has emerged as an alternative treatment for these fractures. Potential advantages of DFR include immediate postoperative weight bearing and elimination of the risks of nonunion, malunion, fixation failure, and post-traumatic arthritis. On the other hand, distal femoral replacement has the potential disadvantage of requiring more extensive exposure and has limited salvage options in the event of treatment failure. The role of DFR in the management of geriatric distal femur fracture remains controversial.[7]

There is a paucity of high-quality evidence to guide surgeons who must choose between fixation and replacement of distal femur fractures. The purpose of this systematic review is to compare outcomes and complication rates in geriatric patients with distal femur fractures being treated with either SF or acute DFR.

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MATERIALS AND METHODS

The PubMed, Embase, and the Cochrane Database of Systematic Reviews were queried for articles published up to April 24, 2020. The search used keywords and medical subject headings representing open reduction with internal fixation and distal femoral replacement for distal femur fracture in a geriatric population, such as "fracture fixation, internal," "femoral fractures," "arthroplasty, replacement, knee," "geriatrics," and "aging." An Appendix contains the search strategy details (see **Supplemental Digital Content 1**, http://links.lww.com/JOT/B115).

The search results were downloaded into the Covidence web-based software platform (Melbourne, Australia), and duplicates were removed. All studies were screened in the initial stage by title and abstract and subsequently reviewed by full-text based on the inclusion and exclusion criteria. To be included, studies must have provided at least 5 patients over 60 years old who underwent primary DFR or SF with locked plates or retrograde IM nails after sustaining a native distal femur fracture and disclosed objective outcomes data and/or complication rates. The exclusion criteria were small case series of less than 5 patients, case reports, expert opinions, and review articles or studies with mean patient age <55 years, nontraumatic indications for DFR, SF with nonlocking plates, periprosthetic fractures, revision surgeries, fixation other than locked plate or retrograde nail, or non-English text. The review was conducted by 2 authors independently with discrepancies adjudicated through group discussion. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement was used[8] (Fig. 1).

Data Extraction and Statistical Analysis

Surgical outcomes were extracted from the eligible studies. Recorded outcomes were mechanical failure, nonunion, aseptic loosening, periprosthetic or peri-implant fracture, infection, malunion, and shortening (leg length discrepancy). All additional reported complications were extracted and pooled. There was some heterogeneity in how studies defined malalignment and shortening, but all studies reporting these complications used a threshold of at least 5 degrees of angulation or 5 mm of shortening. Patient comorbidities were not routinely reported and therefore were not included in the analysis. Descriptive statistics including weighted mean and SD were calculated for demographic and objective outcome data using the number of fractures in each study as frequency weights (RStudio, Boston, MA). Treatment failure was defined for both SF and arthroplasty as complications requiring a major reoperation for reasons such as fixation failure, nonunion, deep infection, mechanical failure, aseptic loosening, or extensor mechanism disruption. An incidence rate ratio was calculated for complications affected by the follow-up time, including treatment failures or revisions requiring a secondary surgery (nonunion, deep

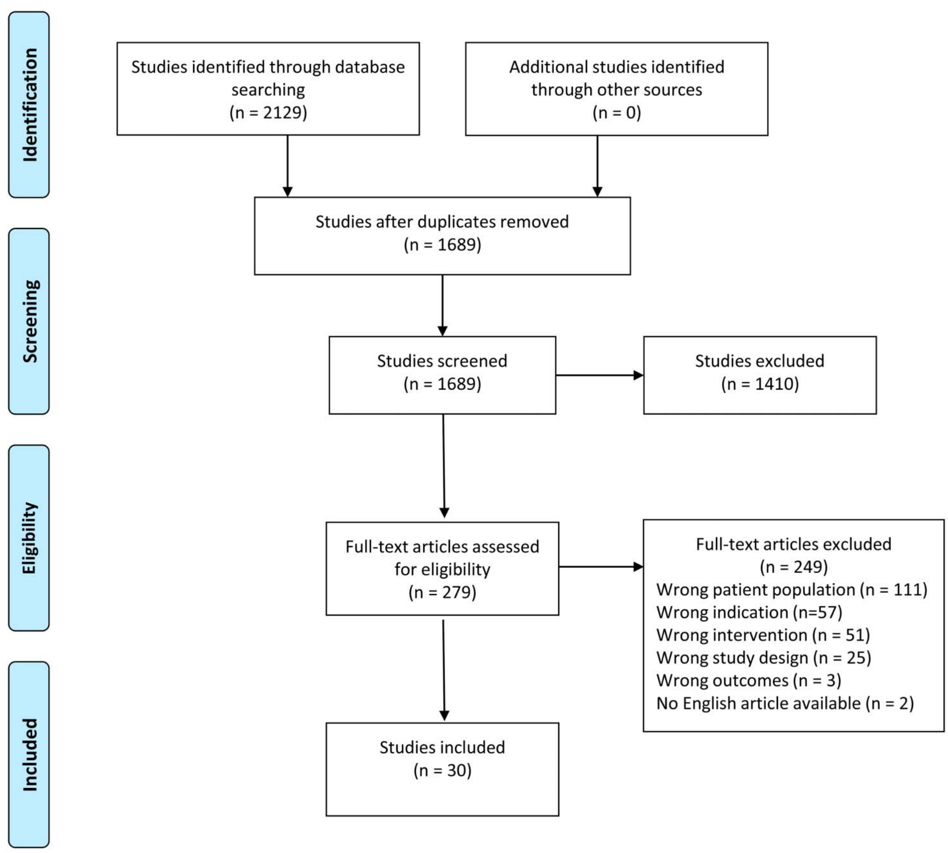

FIGURE 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram illustrating the selection process for articles. **Editor's Note**: A color image accompanies the online version of this article.

TABLE 1. Demographic Data

Article	Year	Treatment	Intervention	Level of Evidence	Design	Fractures, n	Age, Mean	FU, mo, Mean
Abdelgaid et al[28]	2013	SF	SF (locked plate)	Therapeutic Level IV	Prospective, case series	5	70.0	42
Christodoulou et al[18]	2005	SF	SF (RIN)	Therapeutic Level IV	Prospective, case series	35	>60*	>18*
Chung et al[29]	2016	SF	SF (locked plate)	Therapeutic Level IV	Retrospective, case series	80	74.2	14.4
D'sa et al[19]	2019	SF	SF (RIN)	Therapeutic Level IV	Retrospective, case series	41	80.0	9
Danziger et al[20]	1995	SF	SF (RIN)	Therapeutic Level IV	Retrospective, case series	7	68.7	12.6
Doshi et al[30]	2013	SF	SF (LISS)	Therapeutic Level IV	Retrospective, case series	24	72.8	15.3
Dunlop and Brenkel[21]	1999	SF	SF (RIN)	Therapeutic Level IV	Prospective, case series	26	84.2	>12*
El-Ganainy et al[31]	2010	SF	SF (locked plate)	Therapeutic Level IV	Retrospective, case series	13	67	22.4
El-Kawy et al[22]	2007	SF	SF (RIN)	Therapeutic Level IV	Retrospective, case series	21	75.0	14.0
Gellman et al[23]	1996	SF	SF (RIN)	Therapeutic Level IV	Retrospective, case series	7	70.7	17.3
Hart et al[15]	2017	SF vs. DFR	SF (locked plate)	Therapeutic Level III	Retrospective, comparative	28	82.0	—
Hull et al[16]	2019	SF vs. DFR	SF (RIN or locked plate)	Therapeutic Level II	Prospective, randomized control trial	11	89.9	9
Janzing et al[24]	1998	SF	SF (RIN)	Therapeutic Level IV	Prospective, case series	24	82.0	19.0
Jennison et al[40]	2019	SF	SF (RIN or locked plate)	Therapeutic Level IV	Retrospective, case series	80	82.4	—
Kanabar et al[32]	2007	SF	SF (LISS)	Therapeutic Level IV	Retrospective, case series	12	75.8	9.4
Karam et al[33]	2019	SF	SF (locked plate)	Therapeutic Level IV	Retrospective, case series	57	70.9	22
Kayali et al[34]	2007	SF	SF (LISS)	Therapeutic Level IV	Prospective, case series	8	70.8	30.3
Khursheed et al[35]	2015	SF	SF (locked plate)	Therapeutic Level IV	Prospective, case series	25	66.5	—
Kim et al[25]	2009	SF	SF (RIN)	Therapeutic Level IV	Retrospective, case series	13	78.5	29.8
Kumar et al[26]	2000	SF	SF (RIN)	Therapeutic Level IV	Retrospective, case series	16	81.9	—
Metwaly et al[36]	2018	SF	SF (locked plate)	Therapeutic Level IV	Prospective, case series	23	69.6	14.1
Shulman et al[41]	2014	SF	SF (RIN or locked plate)	Therapeutic Level IV	Retrospective, case series	30	78.0	25.2
Singh et al[27]	2006	SF	SF (RIN)	Therapeutic Level IV	Retrospective, case series	16	78.4	47.5
Syed et al[37]	2004	SF	SF (LISS)	Therapeutic Level IV	Prospective, case series	11	85.5	—
Toro et al[38]	2015	SF	SF (locked plate)	Therapeutic Level IV	Retrospective, case series	12	68.8	—
Wong et al[39]	2005	SF	SF (LISS)	Therapeutic Level IV	Prospective, case series	16	75.8	22.9
Total		**SF**				**641**		
Weighted mean (SD)							**76.7 (5.8)**	**18.8 (9.0)**
Appleton et al[12]	2006	DFR	DFR	Therapeutic Level IV	Retrospective, case series	54	82.0	—
Bettin et al[13]	2016	DFR	DFR	Therapeutic Level IV	Retrospective, case series	18	77.1	26.4
Choi et al[14]	2013	DFR	DFR	Therapeutic Level IV	Prospective, case series	8	76.9	49.0
Hart et al[15]	2016	SF vs. DFR	DFR	Therapeutic Level III	Retrospective comparative	10	81.8	—
Hull et al[16]	2019	SF vs. DFR	DFR	Therapeutic Level II	Prospective, randomized control trial	11	87.9	9

TABLE 1. (*Continued*) Demographic Data

Article	Year	Treatment	Intervention	Level of Evidence	Design	Fractures, n	Age, Mean	FU, mo, Mean
Wang et al[17]	2018	DFR	DFR	Therapeutic Level IV	Retrospective, case series	24	68.9	38.0
Total		**DFR**				**125**		
Weighted mean (SD)							**79.0 (6.6)**	**30.8 (14.8)**

*Cannot determine due to reporting of the grouped data.

infection, mechanical failure, aseptic loosening, extensor mechanism disruption, or symptomatic implants requiring removal), deep infection, and periprosthetic fracture. For perioperative complications, such as superficial infection, malalignment, and shortening, a Fisher exact test was performed. A weighted Mann–Whitney U test was used to compare continuous data. Analysis of functional outcome measurements was not possible because of the heterogeneity of scoring systems used. Studies included for final analysis were assigned a level of evidence based on commonly accepted criteria.[9,10] Studies were scored independently by 2 authors based on existing guidelines[11] with conflicts resolved by consensus (see **Table**, **Supplemental Digital Content 2**, http://links.lww.com/JOT/B116).

RESULTS

The initial search produced 2129 articles. Thirty studies with 766 patients met criteria for inclusion (Fig. 1). One study was a prospective controlled feasibility study (therapeutic Level of evidence II), 1 study was a retrospective comparative study (therapeutic Levelevel of evidence III), and the remaining 28 were case series (therapeutic Level of evidence IV). Based on the methodological quality tool proposed by Murad et al,[11] most of the studies were judged to be of high quality (see **Table**, **Supplemental Digital Content 2**, http://links.lww.com/JOT/B116). Low quality scores were mainly because of inadequate description of the inclusion and exclusion criteria or length of follow-up.

Multiple arthroplasty designs were used in the studies performing DFR.[12–17] For SF, RINs were used in 10 studies,[18–27] locked plates in 13 studies,[15,28–39] and 3 studies used both RIN and locked plates.[16,40,41]

Study and patient demographics are summarized in Table 1. The mean patient age and duration of follow-up were not significantly different between groups.

The consistency and completeness of reporting complications were highly variable across studies. Complication rates are summarized in Table 2. After controlling for follow-up time, there was no significant difference in the rate of treatment failure between the SF group and the DFR group [IRR: 1.35 (0.74–2.47)]. There was no significant difference in the rate of deep infections between the SF group and the DFR group [IRR: 0.37 (0.08–1.65)]. The rates of periprosthetic and peri-implant fracture were similar in the SF compared with the DFR group [IRR: 0.43 (0.15–1.65)]. Incidence of superficial infection, malalignment, and shortening was not significantly different between groups (superficial infection: $P = 0.101$, malalignment: $P = 0.092$, and shortening: $P = 0.228$). Removal of symptomatic implants was an operation unique to SF, occurring in 3.8% ± 4.6% of patients. There were no reports of component loosening after DFR. Of the 14 studies reporting, the postoperative knee range of motion was similar between groups [DFR: 104° ± 7.0°, SF: 107° ± 11.2° ($P = 0.74$)].[13,14,17,20,22,23,25–27,30,32,34,35,41]

DISCUSSION

This study is the first comprehensive quantitative analysis comparing outcomes between SF and DFR for distal femur fractures in the elderly. The data available for analysis were primarily obtained from observational studies. Thus, it is difficult to make strong conclusions about the comparative safety and efficacy of one procedure vs. the other,[12–41] but the pooled outcomes observed in this study were similar. This study highlights the need for higher level evidence to determine indications for DFR in the treatment of acute distal femur fractures.

The decision to proceed with SF vs. DFR for geriatric fractures remains controversial, with each procedure providing a unique set of advantages and disadvantages. Successful SF preserves the patient's native anatomy and can result in a durable knee. Bone stock is preserved so that if arthroplasty is required in the future, a less constrained prosthesis can be used. Fixation strategies have improved over the years to optimize healing and minimize complications. When plating, surgeons are now aware of risk factors for failure and techniques such as optimizing working length and using dynamic locking to optimize callus formation.[42,43] Combining a retrograde nail with a lateral plate may also help facilitate immediate full weight bearing, whereas minimizing the chance of fixation failure.[44] However, SF is technically unforgiving and less generalizable to lower volume surgeons.[45] Failed fixation will expose often frail patients to multiple procedures and severe deconditioning.[46] DFR has the advantages of eliminating the possibilities of fixation failure and nonunion while allowing for immediate unrestricted weight bearing.[47] Fracture healing is not required, and cemented components are immediately stable. However, DFR requires extensive exposure and dissection. If a major complication such as deep infection occurs, there are few salvage options and amputation may be required. Despite the perceived advantage of early mobilization, 15% of DFR patients

TABLE 2. Complication Rates

Paper	Treatment	Fractures, n	Revision/Failure of Treatment/ Nonunion	Deep Infection	Periprosthetic/Peri-Implant Fractures
Abdelgaid et al[28]	SF	5	20.0%	0.0%	20.0%
Christodoulou et al[18]	SF	35	5.7%	0.0%	0.0%
Chung et al[29]	SF	80	0.0%	0.0%	0.0%
D'sa et al[20]	SF	41	0.0%	0.0%	0.0%
Danziger et al[20]	SF	7	14.3%	0.0%	0.0%
Doshi et al[30]	SF	24	0.0%	0.0%	0.0%
Dunlop and Brenkel[21]	SF	26	7.7%	0.0%	0.0%
El-Ganainy et al[31]	SF	13	0.0%	7.7%	0.0%
El-Kawy et al[22]	SF	21	0.0%	0.0%	0.0%
Gellman et al[23]	SF	7	14.3%	0.0%	0.0%
Hart et al[15]	SF	28	17.9%	3.6%	0.0%
Hull et al[16]	SF	11	9.1%	0.0%	0.0%
Janzing et al[24]	SF	24	20.8%	DNR	0.0%
Jennison et al[40]	SF	80	11.3%	2.5%	3.8%
Kanabar et al[32]	SF	12	8.3%	0.0%	0.0%
Karam et al[33]	SF	57	21.1%	0.0%	1.8%
Kayali et al[34]	SF	8	0.0%	0.0%	0.0%
Khursheed et al[35]	SF	25	4.0%	0.0%	4.0%
Kim et al[25]	SF	13	0.0%	0.0%	0.0%
Kumar et al[26]	SF	16	12.5%	0.0%	12.5%
Metwaly et al[36]	SF	23	17.4%	0.0%	0.0%
Shulman et al[41]	SF	30	10.0%	0.0%	0.0%
Singh et al[27]	SF	16	0.0%	DNR	0.0%
Syed et al[37]	SF	11	0.0%	0.0%	0.0%
Toro et al[38]	SF	12	25.0%	0.0%	0.0%
Wong et al[39]	SF	16	12.5%	0.0%	0.0%
Weighted mean (SD)	**SF**	**641**	**8.6% (8.1%)**	**0.7% (1.6%)**	**1.3% (2.9%)**
Incidence rate			**0.055**	**0.005**	**0.008**
Appleton et al[12]	DFR	54	13.0%	1.9%	7.4%
Bettin et al[13]	DFR	18	22.2%	5.6%	5.6%
Choi et al[14]	DFR	8	0.0%	0.0%	0.0%
Hart et al[15]	DFR	10	10.0%	10.0%	0.0%
Hull et al[16]	DFR	11	9.1%	0.0%	9.1%
Wang et al[17]	DFR	24	0.0%	DNR	0.0%
Weighted mean (SD)	**DFR**	**125**	**10.4%(8.3%)**	**3.0%(3.6%)**	**4.8%(4.1%)**
Incidence rate			**0.041**	**0.013**	**0.019**
Incidence rate ratio (confidence interval)			1.35 (0.74–2.47)	0.37 (0.08–1.65)	0.43 (0.15–1.23)

Paper	Superficial Infection	Malalignment	Shortening	Removal of Implants	Component Loosening
Abdelgaid et al[28]		20.0%	20.0%	DNR	DNR
Christodoulou et al[18]		0.0%	5.7%	DNR	DNR
Chung et al[29]		0.0%	6.3%	0.0%	DNR
D'sa et al[20]		2.4%	0.0%	0.0%	0.0%
Danziger et al[20]		0.0%	DNR	DNR	0.0%
Doshi et al[30]		0.0%	DNR	DNR	DNR
Dunlop and Brenkel[21]		0.0%	7.7%	DNR	3.8%
El-Ganainy et al[31]		7.7%	7.7%	DNR	DNR
El-Kawy et al[22]		4.8%	42.9%	33.3%	DNR
Gellman et al[23]		0.0%	14.3%	DNR	DNR
Hart et al[15]		3.6%	DNR	DNR	DNR
Hull et al[16]		0.0%	DNR	DNR	DNR
Janzing et al[24]		DNR	20.8%	16.7%	12.5%
Jennison et al[40]		DNR	DNR	DNR	DNR
Kanabar et al[32]		0.0%	16.7%	DNR	DNR
Karam et al[33]		0.0%	DNR	DNR	3.5%
Kayali et al[34]		12.5%	0.0%	12.5%	0.0%
Khursheed et al[35]		8.0%	0.0%	0.0%	0.0%
Kim et al[25]		0.0%	DNR	DNR	DNR

TABLE 2. (*Continued*) Complication Rates

Paper	Superficial Infection	Malalignment	Shortening	Removal of Implants	Component Loosening
Kumar et al[26]		0.0%	0.0%	6.3%	6.3%
Metwaly et al[36]		8.7%	DNR	DNR	0.0%
Shulman et al[41]		DNR	DNR	DNR	3.3%
Singh et al[27]		DNR	DNR	DNR	12.5%
Syed et al[37]		0.0%	DNR	DNR	DNR
Toro et al[38]		DNR	DNR	DNR	DNR
Wong et al[39]		0.0%	DNR	DNR	DNR
Weighted mean (SD)		**2.1% (3.8%)**	**8.9% (11.7%)**	**6.1% (11.9%)**	**3.8% (4.6%)**
Incidence rate					
Appleton et al[12]		DNR	DNR	DNR	—
Bettin et al[13]		5.6%	DNR	DNR	—
Choi et al[14]		0.0%	0.0%	0.0%	—
Hart et al[15]		10.0%	DNR	DNR	—
Hull et al[16]		9.1%	DNR	DNR	
Wang et al[17]		DNR	0.0%	0.0%	—
Weighted mean (SD)		**6.4%(4.0%)**	**0% (−)**	**0% (−)**	**—**
Incidence rate					
Incidence rate ratio (confidence interval)	***P* value**	0.101	0.092	0.228	—

identified in our study were not allowed unrestricted weight bearing immediately after surgery. There is likely a subpopulation of patients and fractures for whom DFR is optimal, but this particular population has yet to be identified.

This study contributes meaningfully to the existing literature examining the roles of internal fixation vs. DFR for the treatment of distal femur fractures. Meluzio et al[48] recently published a systematic review showing DFR to be a viable treatment option in a diverse group of adult patients with native or periprosthetic distal femur fractures and nonunions based on a pooling of 104 patients. We limited the scope of our question to a more uniform and thus more clinically relevant group of geriatric patients with acute fractures of the native distal femur and assessed outcomes in many more patients (125 DFR and 641 SF patients). Our results highlight the distinct complication profiles unique to arthroplasty vs. fixation strategies. Previously, a systematic review reporting on 241 DFRs (mean follow-up 3.3 years) performed largely as revisions documented a 17% failure rate, predominantly because of arthroplasty-related complications such as prosthetic joint infection, aseptic loosening, and periprosthetic fracture.[49] In our study, the DFR group had a lower reported failure rate at 10%, although all included patients were undergoing primary arthroplasty for acute fracture. Similarly, treatment failure after SF in our study (8.6% ± 8.1%) was lower than most studies in the literature where nonunion rates can be as high as 24%.[50]

There are several limitations to this study, primarily related to the inherent bias of the literature analyzed. The included studies are predominantly observational in design and, therefore, subject to inherent selection bias. Comparing treatment failures between 2 fundamentally different operations poses a methodological challenge because some modes of failure after SF are not possible after arthroplasty and vice versa. To address this, we defined overall treatment failure for both SF and arthroplasty to create a broad profile of complications that would capture secondary surgeries for unsuccessful operations. There was less follow-up in patients treated with SF, which is a potential source of bias. Some patients with uncomplicated SF may have been less likely to follow-up after fracture healing, whereas patients successfully treated with DFR continue to follow-up for clinical and radiographic surveillance. To control for different follow-up periods between study groups, we used an incidence rate ratio which allowed us to assign a relative risk of treatment failure. In most studies, fracture severity or baseline functionality of patients was not categorized, both of which likely informed treatment decisions and influenced outcomes. For example, DFR may have been chosen in more complex fracture patterns and/or lower demand patients. Our study also did not differentiate between fixation with lateral locked plates, dual plates, or RINs, although several studies have demonstrated improved outcomes after nailing[51,52] Pooling of these treatment modalities introduced heterogeneity within the SF group. Furthermore, functional outcomes were assessed using multiple measurement tools among studies with minimal overlap, precluding integration with meta-analysis. Previous research has shown the physical function is significantly worse than the general population after both of these surgical interventions.[6,49]

CONCLUSIONS

This systematic review suggests that SF and DFR for the treatment of distal femur fractures in the elderly result in similar functional outcomes and overall complication rates. Given the low level of evidence and the high variability of outcome reporting, no strong conclusions on the comparative effectiveness of the 2 treatments can be made. This systematic review reinforces the potential value of a prospective randomized trial, although the feasibility of such a trial has recently been called into question.[16] Failing an RCT, prospective observational studies with consistent, accurate, and reproducible outcome measures would provide valuable insight into the best treatment for these vulnerable patients.

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