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REVIEW ARTICLE

Total knee arthroplasty for distal femoral fractures in osteoporotic bone: a systematic literature review

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Abstract

Purpose Distal femoral fractures in the elderly are associated with high morbidity and mortality and their incidence is increasing with an ageing population. Management of these fractures has evolved over recent decades and there is now an accepted recognition of the important role that acute arthroplasty may have in treatment of these fractures. Our purpose was to systematically review the evidence available in the literature for arthroplasty as a treatment option for distal femoral fractures.

Methods This systematic review was conducted in accordance with the PRISMA reporting guidelines. We searched CENTRAL, MEDLINE, EMBASE, and Science Citation Index Expanded (until October 2018) for studies and case series. Furthermore, clinical trial registries were searched for ongoing studies. We included all studies or case series that described total knee arthroplasty for distal femoral fractures irrespective of language, publication status, sample size, or follow-up period due to limited studies available in the literature. Exclusion criteria included single patient case reports, isolated tibia fractures, and periprosthetic fractures. Two authors independently identified trials for inclusion and independently extracted the data. Outcome measures included mortality, peri-operative complications (excluding mortality), anaesthetic time, blood loss, time to mobilisation, length of hospital stay, functional scores, radiological loosening, and revision rate.

Results Fourteen papers were included for subsequent quantitative and qualitative synthesis incorporating a total of 181 patients. The highest level of evidence identified was a single cohort study (level III), the remaining 13 papers consisted of multi- or single-centre case series (level IV). The mean mortality rate was 3.34% (range 0–10) at 30 days and 18.4% (range 0–42) at 1 year. The mean revision rate was 3.43% (range 0–25) at 1 year. The mean time to mobilisation was 3.90 days (range 2.5–6) with a mean time to discharge from the acute ward being 16.6 days (range 8–33).

Conclusions Although there is limited evidence in the literature available, our review suggests that there is a role for acute knee arthroplasty in distal femoral fractures. This mode of treatment has satisfactory mortality and revision rates, and may result in faster time to mobilisation and discharge. There is a need for a higher level of evidence to delineate this issue further.

Keywords Total knee arthroplasty · Fracture fixation · Distal femoral fractures · Femoral fractures · Periarticular fractures · Trauma

Introduction

Distal femoral fractures are relatively rare and account for less than 1% of all fractures. There is a bimodal distribution to these injuries—high-energy trauma in younger patients with normal bone and low energy injuries in mainly elderly patients with osteoporotic bone. The incidence of osteoporotic distal femoral fractures is about 4.5 per 100,000 and is rising with the ageing population [1].

Management of distal femoral fractures has evolved with advancement in implant technology. Historically, these fractures were treated non-operatively with bracing and/or traction. Subsequently to this, surgical fixation became more popular with the development of fixed-angle devices, locking plates, and intramedullary devices. However, internal fixation in poor bone stock can still lead to loss of reduction resulting in non-union, mal-union, and stiffness [1, 2]. Elderly patients can struggle to comply with the non-weight bearing status that may be required with internal fixation, and prolonged immobility in this patient subgroup has been

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associated with a 2.5 times increase in mortality [3]. Indeed, the 30 day and 1 year mortality associated with distal femoral fractures in patients over 65 has been shown to be equivalent or higher than that associated with hip fractures [4].

Revision surgery can subsequently be required to manage failed fixation or the development of post-traumatic arthritis with an obvious additional associated morbidity and mortality [5, 6]. Total knee arthroplasty (TKA) allows the early mobilisation to avoid these factors which can provide a potentially viable alternative for some patients in this subgroup.

The purpose of this study was to evaluate and present the evidence for TKA for distal femur fracture by conducting a systematic review of the contemporary literature. As the patient cohort for this procedure has a mortality rate equivalent to hip fracture patients, mortality was the primary focus of our review.

Materials and methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guidelines.

Criteria for considering studies for this review

Types of studies

We included all studies or case series that described TKA for distal femoral fractures irrespective of language, publication status, sample size, or follow-up. Single patient case reports were excluded from the review. Patients with a distal femoral fracture, as defined by the authors of each study, were eligible for inclusion; studies involving proximal tibia fractures in isolation were excluded. Studies describing the management of periprosthetic fractures were excluded. All TKA interventions (including different implant type) were included.

Outcome measures

Primary outcome measure was mortality. Secondary outcome measures included peri-operative complications (excluding mortality), anaesthetic time, blood loss, time to mobilisation, length of hospital stay (LOS), radiological loosening, revision rate, and functional scores [including Oxford Knee Score (OKS) and Knee Society Score (KSS) Hospital for Special Surgery Score (HSS)].

Mean mortality rate was calculated at 30 days and 1 year of follow-up in concordance with the majority of published literature assessing hip fracture mortality. The remaining outcome measures were categorised into short-term (≤ 30 days) or long-term (> 30 days) outcomes. A time period of under 30 days was used for short-term outcome measures to align with the calculated 30 day mortality rate, and because this period covers the peri-operative period and likely inpatient stay. All outcomes of greater duration than this were classified as long-term outcomes.

Search methods for identification of studies

Search strategy

The Cochrane Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, and Web of Science were searched on 5th October 2018 for relevant studies and case series. The search strategy for each database is presented in "Appendix". A search of the US National Institutes for Health Clinical Trials Registry, ClinicalTrials.gov (http://www.ClinicalTrials.gov) and the WHO International Clinical Trials Registry Platform (http://www.who.int/ictrp/en/) was conducted for ongoing studies. The search strategy for clinical trial registries is presented in the appendix. All databases were searched from their inception to 5th October 2018. No restrictions on the language of publication were imposed. Reference lists of all primary studies and review articles were searched for additional references; no further studies were identified from this method. Included studies published in full text on PubMed (http://www.ncbi.nlm.nih.gov/pubmed) were searched for errata or retractions.

Data collection and analysis

Selection of studies

Duplicates were identified and excluded. Two review authors (SS and IR) independently screened titles and abstracts of all the studies identified by the above-mentioned search strategies and excluded studies that did not meet the inclusion criteria. The same two review authors (SS and IR) independently screened the full text of the study reports of the remaining studies. Studies for inclusion were identified and reasons for any exclusion of the ineligible studies recorded. Any disagreement of studies eligible for inclusion was resolved through discussion and consulting with a third author (IS). A PRISMA flow diagram (Fig. 1) was completed and the characteristics of excluded studies recorded.

Data extraction

Two review authors (SS and IR) independently extracted data from included studies using a standardised pre-designed data extraction form for study characteristics and outcome data. Data extraction forms included information on setting, population, inclusion and exclusion criteria, interventions,

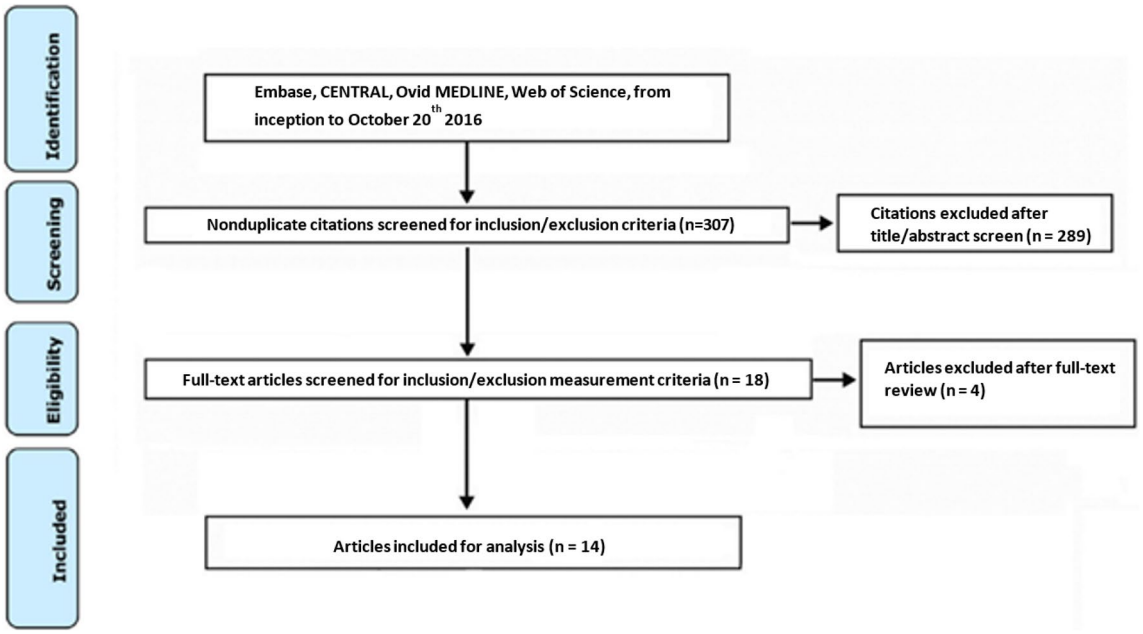

Fig. 1 Flowchart of study selection

and outcomes. Notes were also included reporting information on funding, baseline differences, and any notable conflicts of interest of study authors. Any disagreement was resolved through discussion or, if required, through consult with a third author (IS).

Statistical analysis

SPSS (IBM SPSS Statistic 24, 2016) was used to perform data analysis. We pooled results of studies with similar characteristics (participants, outcome measures, and timing of outcome measures) to provide mean outcomes across studies. Where we could not combine data, we presented a narrative synthesis of results. Clinical heterogeneity was assessed by comparing the participants' characteristics and the methodology across studies. Sensitivity analysis was performed to assess for incomplete outcome data. A Chi-squared test was used to analyse demographic data and fracture configuration. We intended to perform subgroup analyses for age, sex, and fracture configuration; however, sufficient information was not available for these subgroup analyses.

Results

The search resulted in 307 studies. Following the removal of duplications and citations excluded after title and abstract screen by both authors, 18 relevant papers were identified. After full-text review, 4 case reports were excluded.

The highest level of evidence was provided by a retrospective cohort study carried out by Pearse et al. [7]. They compared six medically fit active patients who had Stanmore TKA with four patients who had internal fixation (dynamic condylar screws or intramedullary nail).

All other studies included were case series. The largest of these was described by Appleton et al. [8], who looked at 54 distal femoral fractures in 52 patients over a 17-year period. The remaining 12 [9–20] studies included in our analysis are smaller case series ranging in size from 26 patients to 3 patients. Mean follow-up ranged from 5 to 38.8 months (Table 1).

Demographics

Low clinical heterogeneity was found amongst the study populations with a little variation across inclusion criteria or patient demographics. There were 181 patients with a mean age of 77.7 years (range 55–98). The studies spanned over 29 years from 1987 to 2016. There were significantly more women than men, 4.52:1 ($p < 0.001$). The mean follow-up period was 29.3 months (range 5–120 months) and there were significantly more type C fractures (AO Classification) [21] ($p < 0.001$). Figure 2 describes the distribution of fracture types. One study did not specify the fracture patterns. Wide variety of implants were used within and between studies, both cemented and uncemented. It was not often explicitly stated whether the implant was cemented or not.

Table 1 General characteristics of the studies

	Country	Level of evidence	Fracture type	Patient number[a]	Age (years)	Mean follow-up period (months)	No. of types of implants/surgeons
Pearse EO et al. [7]	United Kingdom	III	Femur	6	85	33	1/NS
Appleton et al. [8]	United Kingdom	IV	Femur	54	82	120	3/6
Bell et al. [9]	United Kingdom	IV	Femur	14	84	5	3/NS
Benazzo et al. [12]	Italy	IV	Femur + tibia	6 (4)	62	12	1/1
Boureau et al. [13]	France	IV	Femur + tibia	21 (10)	79	31	3/1
Choi et al. [14]	South Korea	IV	Femur	8	76.8	49	1/NS
Jun et al. [15]	China	IV	Femur	13	70.5	14.3	1/NS
Malviya et al. [16]	United Kingdom	IV	Femur + tibia	26 (11)	80	38.8	2/NS
Nau et al. [17]	Austria	IV	Femur + tibia	6 (3)	79	24.4	2/1
Parratte et al. [18]	France	IV	Femur + tibia	26 (10)	80.5	16.2	> 4/multiple
Rosen et al. [10]	United States	IV	Femur	24	76	11	2/1
Yoshino et al. [18]	Japan	IV	Femur	3	88	14.6	1/NS
In et al. [19]	South Korea	IV	Femur	3	68.3	12	1/NS
Bettin CC et al. [20]	United States	IV	Femur	18	77.1	30	1/NS

NS not stated

[a]Number of patients with distal femoral fractures in ()

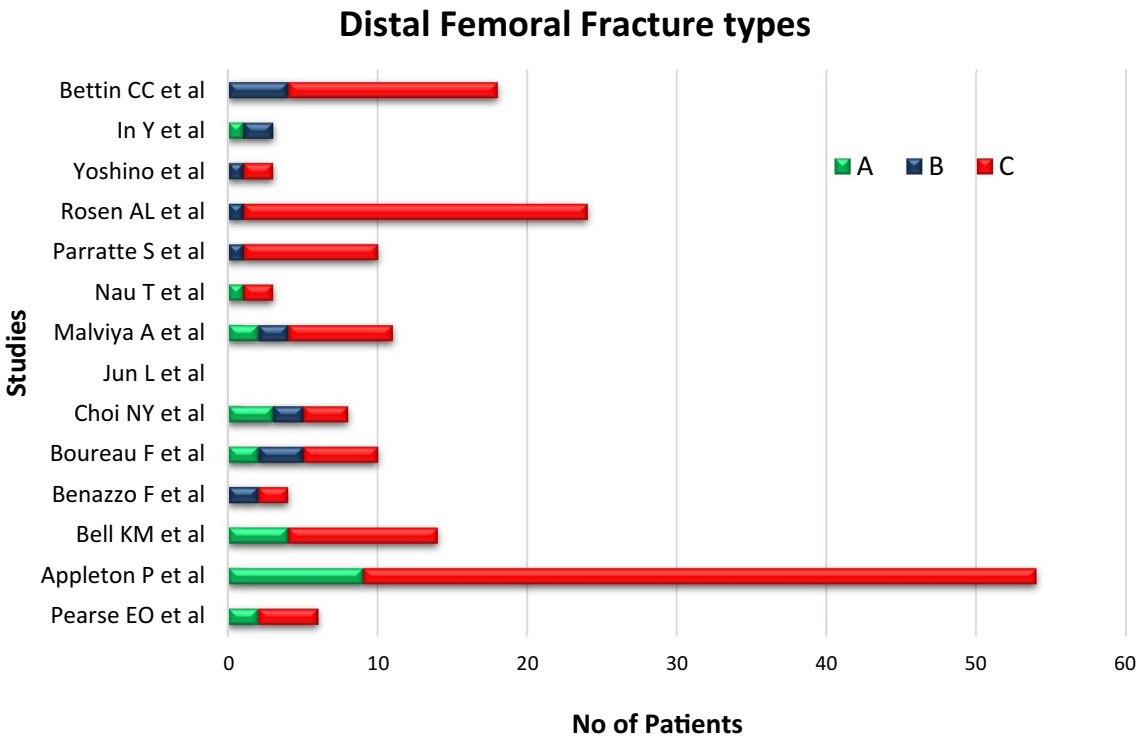

Fig. 2 Distribution of femoral fracture types. **a** Extra-articular. **b** Partial articular. **c** Complete articular (AO Classification[21])

Outcomes

Short-term outcomes are summarised in Table 2 and long-term outcomes are summarised in Table 3.

The mean overall mortality rate was 3.34% (range 0–10) at 30 days and 18.4% (range 0–42) at 1 year. Best- and worst-case sensitivity analysis was performed for 1 year mortality to account for incomplete outcome data (loss to follow-up).

Table 2 Summary of short-term outcome measures

Study	Anaesthetic time (min)	Blood loss (ml)	Time to mobilisation (days)	Hospital stay (days)	Mortality (inpatient) (%)
Pearse et al. [7]	97	2500	3.3	15	0
Appleton et al. [8]	NS	NS	NS	15	5
Bell et al. [9]	NS	NS	4	8	7
Benazzo et al. [12]	NS	NS	NS	NS	NS
Boureau et al. [13]	NS	NS	NS	NS	10
Choi et al. [14]	76	365	NS	NS	0
Jun L et al[15] [15]	107	413	3.38	15.8	0
Malviya et al. [16]	NS	NS	6	33	3
Nau et al. [11]	NS	NS	NS	31	0
Parratte et al. [17]	124	NS	2.5	NS	3
Rosen et al. [10]	198	NS	NS	NS	0
Yoshino et al. [18]	NS	NS	NS	NS	0
In et al. [19]	NS	NS	NS	NS	0
Bettin et al. [20]	100	344	NS	11	0

NS not stated

Table 3 Summary of long-term outcomes

Study	Functional scores	Radiological loosening (%)	Revision rate (%)	Mortality (%)
Pearse et al. [7]	OKS 32.5	0	0 (3 years)	0
Appleton et al. [8]	Not done	5	4.6 (1 year) 9.1 (10 years)	42 at 1 year
Bell et al. [9]	Not done	0	0	7
Benazzo et al. [10]	KSS	0	25	0
Boureau et al. [13]	OKS, IKS, Parker	0	9.5	30
Choi et al. [14]	HSS	0	0	0
Jun et al. [15]	HSS	0	0	0
Malviya et al. [16]	KSS, OKS, SF36	0	0	19
Nau et al. [11]	KSS	0	0	0
Parratte et al. [17]	KSS, Parker	0	11.5	3
Rosen et al. [10]	Clinical ROM	0	0	4
Yoshino et al. [18]	Clinical ROM	0	0	0
In et al. [19]	Clinical ROM	0	0	0
Bettin et al. [20]	KSS, MSTS, WOMAC	0	0	0% at 1 year 44% at 10 years

NS not stated

Best case analysis revealed a mean 1 year mortality of 16.8%; worst-case analysis revealed a mean 1 year mortality of 20.1%.

The mean anaesthetic time was 117 min (range 76–198) with blood loss only being reported in four studies, varying from 365 to 2500 ml.

All studies allowed patient to weight bear fully on the injured limb following arthroplasty. The mean time to mobilisation was 3.90 days (range 2.5–6) and patients were discharged from the acute ward at a mean of 16.6 days (range 8–33). The majority were discharged back to their previous place of residence, while others were transferred to the other rehabilitation centres.

A wide range of prosthetic joint infection (PJI) rate had been reported in the studies. The largest case series by Appleton of 54 patients reported an infection rate of 1.9% [8]. Benazzo et al. reported an infection rate of 25% in his case series of 4 patients [12]. Among the reported PJI cases, only 3 patients were clearly identified to have had early infection at less than 4 weeks. Timeframe for the majority of PJI cases had not been stated explicitly.

Other surgical complications were decoupling of prosthesis, peroneal nerve palsy, and late patella tendon rupture. There were cases of medical complications such as myocardial infarction, pulmonary embolism and deep vein thrombosis, but incidence had been reported.

Overall, periprosthetic fracture risk was found to be 2.45%. There were four reported cases of periprosthetic fractures in patients who had stemmed TKA [8]. In three of these cases, the patients had an existing hip implant and this created a stress riser between the two implants. Another such complication was reported in the study by Bettin et al. [20]. However, there were no periprosthetic fractures observed in the 40% of the study patients who also had an ipsilateral hip replacement.

The overall revision rate was 3.43% (range 0–25) at 1 year. Appleton [8] reported a rate of 9.1% at 10 years. Apart from this study, the mean follow-up for the remaining studies was under 2 years. Therefore, for these studies, revision rates have been reported as 0% at the last follow-up.

Discussion

The major limitation of our review is that, due to the relative rarity of distal femoral fractures, there are not many studies addressing the use of TKA for their treatment. The majority of studies identified represented level 4 evidence, with only one level 3 retrospective cohort study identified. There have been no prospective cohorts or randomised-controlled trials on this subject.

All the studies in this review were observational retrospective studies with relatively small sample sizes. The follow-up periods between studies were also very variable. Although we are able to make comment on short-term outcome data and 1 year mortality, this variability in follow-up makes meaningful comparison of other long-term outcomes between studies difficult. There were no appropriate controls within the studies and significant heterogeneity within and between them. 50% of the studies used more than 2 implants and 16 different makes of prosthesis were used in total. A mixture of both cemented and uncemented implants were used. We were unable to compare cemented versus uncemented implant for this indication from the data presented in the studies.

A wide variety patient reported tools were used across the studies, and although results were widely positive, this heterogeneity made comparison difficult. Some authors selected patients for TKA on the basis of their fracture pattern rather than selecting patients with pre-existing OA, whilst others argued that TKA should not be performed if there is no pre-existing joint disease.

The major advantage of TKA for distal femoral fracture identified by our review is the allowance early mobilisation without weightbearing restrictions on the injured limb. This is of particular importance in elderly patients who struggle to comply with the restrictions that may be required following distal femoral fracture fixation. On average, across the studies, patients had mobilised by 3.9 days (range 2.5–6). This contrasts to some studies of distal femoral fractures treated using locking plate fixation in which mean time to full weightbearing was as long as 122 days [22]. Early mobilisation is important in reducing risk of developing medical complications, as has been demonstrated in hip hemiarthroplasty for intracapsular neck of femur fractures [11].

The average mortality rate after arthroplasty treatment across the studies was 3.34% (range 0–10) at 30 days and 18.4% (range 0–42) at 1 year. This compares favourably with the mortality rates of between 22 and 30% [22, 23] at 1 year after any treatment of distal femur fracture described in the literature. The largest study (Appleton et al. [8]) had a substantially higher 1-year mortality of 42% in this study, but most of the subjects had significant comorbidities and poor mobility prior to their injury.

It is difficult to make comment on anaesthetic time, blood loss, periprosthetic fracture, infection rates, and revision rates in our review due to variable follow-up and recording of these outcomes by the studies included. However, the studies included have not identified these as major problems. The mean anaesthetic time and blood losses described in the review are equivalent to those described in the literature for distal femoral fracture locking fixation [24]. The mean revision rate of 3.43% at 1 year compares favourably with the 12% 1 year revision rate following distal femoral fixation described by Moloney et al. [25]. The infection rate of 25% described by Benazzo [12] is higher than the infection rate of 7.2% described in the literature following locking plate fixation for distal femoral fracture [26], but the much larger study of TKA for fracture by Appleton describes an infection rate of 1.9% [8].

Although the is a need for more studies providing a higher level of evidence, the literature included in our review demonstrates that there is a role for TKA in the management of distal femoral fractures. In our opinion, the patients who will benefit from arthroplasty are those with osteoporosis and type C fractures, and those who cannot comply with weightbearing instructions. Disadvantages of TKA for femoral fracture that must be borne in mind include the cost of modular implants and technical difficulty of the procedure. The surgeon embarking upon treating these injuries in this fashion should be appropriately skilled and have all the necessary equipments available to counter any unexpected peri-operative findings.

Conclusion

Distal femoral fractures in the elderly are a serious injury, and carry an associated with a high mortality and morbidity. There is increasing interest in the orthopaedic community in managing these patients with TKA to reduce the significant risks associated with prolonged immobility. Although there is a paucity of evidence in the literature, our literature review demonstrates a role for acute knee arthroplasty in distal femoral fractures, allowing the early mobilisation and providing a satisfactory mortality rate. There is a need for further research investigating TKA for distal femoral fracture to clarify which patients would benefit from TKA and the outcomes of this treatment.

Compliance with ethical standards

Conflict of interest Sriskandarsara Senthilkumaran declares that he has no conflict of interest. David R. W. MacDonald declares that he has no conflict of interest. Iain Rankin declares that he has no conflict of interest. Iain Stevenson declares that he has no conflict of interest.

Ethical Standards No human or animal subjects were involved in this study.

Appendix 1

Electronic search strategy

#1 Arthroplasty [MeSH terms]
#2 Knee [MeSH terms]
#3 #1 and #2
#4 Acute
#5 Primary
#6 Total
#7 #4 or #5 or #6
#8 #3 and #7
#9 Femoral fractures [MeSH terms]
#10 Periarticular knee fractures
#11 Intra-articular fractures
#12 #9 or #10 or #11
#13 #8 and #12.

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