

REVIEW

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Review of patient-reported outcomes in periprosthetic distal femur fractures after total knee arthroplasty: a plate or intramedullary nail?

Dustin Rinehart* , Tyler Youngman, Junho Ahn and Michael Huo

Abstract

Purpose: This study reviewed the literature regarding the patient-reported treatment outcomes of using either open reduction and internal fixation (ORIF) with a plate and screw system or intramedullary nail (IMN) fixation for periprosthetic distal femur fractures around a total knee arthroplasty.

Methods: A total of 13 studies published in the last 20 years met the inclusion criteria. The studies included 347 patients who were allocated to ORIF ($n = 249$) and IMN ($n = 98$) groups according to the implants used. The primary outcome measures were the Knee Society Score or the Western Ontario and McMaster Universities osteoarthritis index. The secondary outcome measures included knee range of motion and the rates of complications, including non-union, malunion, infection, revision total knee arthroplasty, and reoperation. Statistical significance was set at $P < 0.05$.

Results: The mean Knee Society Scores of ORIF and IMN groups were 83 and 84, respectively; the mean postoperative range of motion of the knee were 99° and 100° , respectively ($P < 0.05$); the non-union rates were 9.4 and 3.8%, respectively ($P > 0.05$); the malunion rates were 1.8 and 7.5%, respectively ($P < 0.05$); surgical site infection rates were 2 and 1.3%, respectively ($P > 0.05$); the reoperation rates were 9.6 and 5.1%, respectively ($P > 0.05$); and revision rates of total knee arthroplasty were 2 and 1%, respectively ($P > 0.05$).

Conclusion: Based on the patient-reported outcome assessments, both ORIF with a plate and screw system and IMN fixation are well-accepted techniques for periprosthetic distal femur fractures around a TKA, and they produce similar functional outcomes.

Keywords: Distal femur periprosthetic fracture, Patient-reported outcomes, Open reduction and internal fixation, Intramedullary nail

Introduction

The incidences of periprosthetic fractures (PPFs) are on the rise around the globe. The reported incidence of PPFs around a total knee arthroplasty (TKA) stand at somewhere between 0.3 and 2.5% [1–3]. The risk factors include advanced age, diabetes, elevated body mass

index, female gender, and anterior femoral notching during the index procedure [4]. The incidence is expected to increase as more TKAs are being performed annually, and the patients continue to live longer with their TKAs [5]. In addition to the cost associated with the management of PPFs, increased morbidity and mortality also pose challenges [6].

The management of PPFs around a TKA demands significant resource input and incurs high healthcare costs [7]. Moreover, most PPFs require surgical intervention

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[8]. The surgical options include external fixation, open reduction and internal fixation (ORIF) with a plate and screw system, retrograde or antegrade intramedullary nail (IMN) fixation, and the use of a distal femur replacement (DFR) [9]. Currently, there is no consensus regarding the most effective and safest treatment alternatives. The goals of the treatment include early full-weight bearing, independent ambulation, regaining of adequate range of motion of the knee, and minimal morbidities and complications [10].

Currently, there are no physician-directed or patient-focused outcome measurement scale or instruments specifically designed or validated for PPFs around a TKA. In fact, many published reports did not include the functional outcome assessment [11–13]. In TKA, the commonly used assessments include the Knee Society Score (KSS) and the Western Ontario and McMaster Universities (WOMAC) osteoarthritis index. Both scores can be used for assessing the success or failure of TKAs [14, 15].

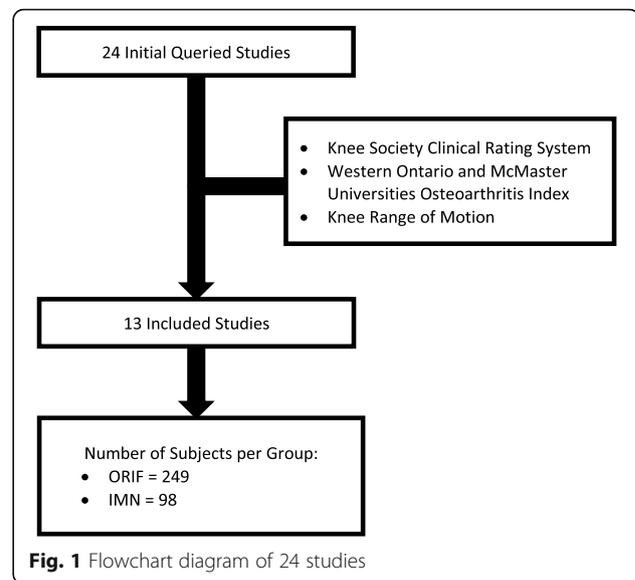
The purpose of this study was to review the available publications over the past two decades, which included the patient-reported treatment outcomes of distal femoral PPFs around a TKA. The aim of the study was to determine if there were differences between ORIF with a plate and screw system and IMN for periprosthetic fractures around a total knee arthroplasty.

Materials and methods

We conducted a literature review by using the key terms “periprosthetic”, “distal femur”, “total knee arthroplasty”, “plate”, and “intramedullary” in PubMed. A total of 24 articles published between January 1, 2000 and January 1, 2020 were retrieved and reviewed for selection. We excluded the systematic reviews and meta-analyses ($n = 11$). We finally included 13 studies for extraction of the relevant primary and secondary outcome measures (Fig. 1). The primary outcome measures were the post-operative patient-reported data consisting of either the Knee Society clinical rating system (KSS) or the Western Ontario and McMaster Universities osteoarthritis index (WOMAC) [16, 17]. The secondary outcome measures included knee range of motion (KROM) and the postoperative complications requiring a reoperation.

The fracture patterns were classified as Rorabeck-Lewis Type 1/2, AO/OTA 33-A1/2/3, Su Type 1/2/3, or Neer Type 2/3 [18]. The type of fracture against each classification system represented a displaced fracture around a stable femoral component of the knee. Because of possible individual variations, the fractures were fixed with either a locked plate and screw system (ORIF group) or an IMN (IMN group).

Descriptive statistics were used to represent the patients' demographics and outcome variables using the



average for continuous variables and frequencies. Percentage values were used for the categorical variables. Pooled averages of the continuous variables were calculated by summing the product values of the means and the study populations from each study. Frequency of the complications was presented as percentages cited in each study. P values were calculated on the categorical data utilizing the chi-squared and the Fisher tests. A $P < 0.05$ was considered statistically significant. The P values could not be calculated on the continuous variables such as KSS scores and the knee ROM given the insufficient data in the literature.

Results

The population data are summarized in Table 1. The pooled patient variables of ORIF and IMN groups are shown in Table 2. The ORIF group consisted of 11 studies (249 patients) [19–21, 23–26, 28–31]. The mean age was 71.7 years, and 84% of the patients were female. The mean follow-up period lasted 3.6 years. The mean KSS score was 83, the mean WOMAC was 49.5, and the mean knee range of motion was 99°. The IMN group contained 6 studies (98 patients) [20, 22–24, 27, 28]. The mean age was 70.6 years, and 78% of the patients were female. The average follow-up period was 3.6 years. The average KSS score was 84, and the mean WOMAC was 37.1. The mean knee range of motion was 100°.

The reported complications in the studies included nonunion, malunion, infection, implant failure, loss of reduction, reoperation, and revision TKA (Fig. 2). The ORIF group had higher rates of nonunion (9.4%), infection (2.0%), loss of reduction (3.8%), and reoperation (9.6%). The complication rates of IMN group were 3.8, 1.3, 0.0, and 5.1%, respectively. There were no significant

Table 1 Overview of study population of each included study

| Study | ORIF | IMN | DFR | ORIF ROM° | IMN ROM° | DFR ROM° | ORIF KSS | IMN KSS | DFR KSS | ORIF WOMAC | IMN WOMAC | DFR WOMAC |
|----------------|------|-----|-----|-----------|----------|----------|----------|---------|---------|------------|-----------|-----------|
| Agarwal [19] | 11 | - | - | 98.5 | - | - | 85 | - | - | - | - | - |
| Bezwada [20] | 12 | 18 | - | 90.0 | 95.0 | - | 82 | 84 | - | - | - | - |
| Gavaskar [21] | 20 | - | - | 106.0 | - | - | - | - | - | 75.8 | - | - |
| Gliatis [22] | - | 10 | - | - | - | - | - | - | - | - | 58.5 | - |
| Gondalia [23] | 24 | 18 | - | 96.5 | 105.7 | - | 77.2 | 81.8 | - | - | - | - |
| Kilicoglu [24] | 9 | 7 | - | 82 | 82 | - | 78.8 | 72.7 | - | - | - | - |
| Kolb [25] | 23 | - | - | 102 | - | - | 78 | - | - | 30.2 | - | - |
| Bae [26] | 33 | - | - | 98.9 | - | - | 84.6 | - | - | - | - | - |
| Lee [27] | - | 25 | - | - | 111 | - | - | 81.5 | - | - | 30.2 | - |
| Park [28] | 21 | 20 | - | 104 | 100 | - | - | - | - | 24.4 | 27.4 | - |
| Kim [29] | 32 | - | - | 103.6 | - | - | 85.8 | - | - | - | - | - |
| Ha, C [30] | 14 | - | - | 107.3 | - | - | 78.9 | - | - | - | - | - |
| Darrith [31] | 50 | - | 22 | - | - | - | 86 | - | 84 | - | - | - |

ORIF Open-Reduction Internal Fixation, IMN Intramedullary Nail, DFR Distal Femoral Replacement

differences in the rates of nonunion, infection, loss of reduction, and reoperation (Fig. 2). IMN group had a significantly higher malunion rate (7.5% vs. 1.8%, $P = 0.005$) and implant failure rate (5.0% vs. 0.6%, $P = 0.04$), compared to ORIF group.

Discussion

For fixing periprosthetic fractures around a total knee arthroplasty, both open reduction internal fixation with a plate and screw system and intramedullary nail fixation produce similar results in terms of Knee Society Scores, Western Ontario and McMaster Universities Osteoarthritis Index, and knee range of motion, as well as the complication rates and functional outcomes of the knee.

The patient-reported outcome assessments are important factors for determining the success and limitations of an intervention. These outcomes are routinely

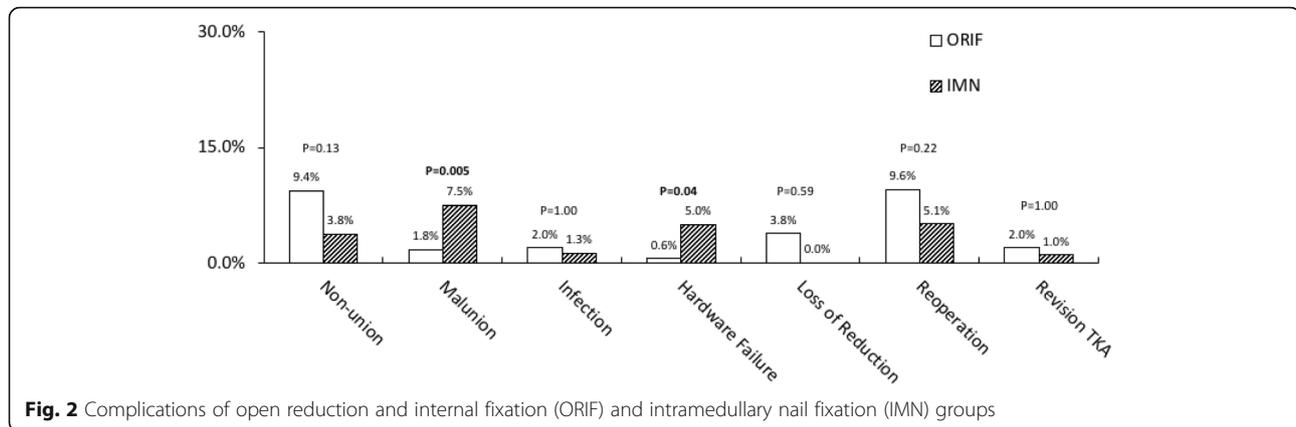
assessed by the patients who have undergone TKAs. The KSS and WOMAC scores are among the most commonly used instruments before and after TKAs. The KSS has previously been validated in total knee arthroplasty patients [15, 32]. It combines both patient-reported responses and surgeon-administered assessments. Higher KSS scores indicate better outcomes [33, 34]. The Western Ontario and McMaster Universities Osteoarthritis index is also validated for assessing pain, stiffness, and the physical function. Higher WOMAC scores are indicative of worse outcomes [35]. Miner et al. [36] demonstrated significantly worse WOMAC scores 1 year after TKA, and the knee movement was less than 95° of flexion, compared to the knees with greater flexion.

The ORIF is a well-established surgical technique for the treatment of distal femur fractures caused by either an acute trauma or PPFs around a TKA, but the clinical outcomes are not uniformly satisfactory [37]. Bezwada et al. [20] compared a cohort of patients treated with ORIF to another cohort treated with IMN fixation. They demonstrated that there was no difference between the two cohorts in the KSS score or knee ROM. They, therefore, recommended the treatment should be determined according to the surgeon’s choice and experience. If the femoral component is of the PS design with a closed intercondylar box, most surgeons will choose ORIF rather than IMN fixation. In addition, if there is a pre-existing total hip femoral stem or other implants in the medullary canal, ORIF with a plate and screw system is more likely selected. Bae et al. [26] conducted a sub-

Table 2 Pooled patient variables by treatment group

| Factor | ORIF Value | IMN Value | DFR Value |
|------------------------|------------|-----------|-----------|
| Age, years, mean | 71.7 | 70.6 | 74.5 |
| Female, % | 84% | 78% | 86% |
| Follow-up, years, mean | 3.6 | 3.6 | 4.0 |
| KSS | 83.1 | 84.2 | 78.1 |
| WOMAC | 49.5 | 37.1 | NA |
| ROM, ° | 99.3 | 100.0 | 87.0 |

ORIF Open-Reduction Internal Fixation, IMN Intramedullary Nail, DFR Distal Femoral Replacement, KSS Knee Society Score, WOMAC Western Ontario and McMaster Universities Osteoarthritis Index, ROM Range of Motion



group analysis using either locked plates or non-locked plates to treat PPFs around a TKA. They reported no difference in KSS or knee ROM. The patients treated with non-locked plate had a higher nonunion rate. Our data also showed that the nonunion rate of ORIF was higher than that of IMN fixation, but no statistical significance was found due to a small sample size of patients. The malunion rate of ORIF was lower than that of IMN fixation, because ORIF could achieve a more rigid fixation. The reoperation rates were similar because the small sample size produced a statistical bias.

In TKA, the IMN fixation is partially limited by the femoral component design. In addition, the position of the femoral component may also limit the entry point for a retrograde IMN [38]. Our data demonstrated that the failure rate of IMN fixation was higher. Shin et al. [39] reported that the mismatch between the diameters of the retrograde nail designs and the distal femoral metaphysis of the femur may compromise the stability of fixation, especially in the elderly patients with osteopenic bone quality. The IMN fixation is generally a less invasive procedure, which may be associated with higher KSS scores and knee ROM, compared to ORIF. However, the malunion rate of IMN fixation was higher. Pelfort et al. [40] reported that 23% of patients in their series had more than 10° of extension deformity. A mid-term follow-up showed that the malunion, however, did not adversely affect the clinical outcomes of the patients.

Limitations of this study include the lack of available literature over the past 20 years addressing this topic with inclusion of patient-reported outcome measures. Further study is needed with larger sample size to avoid statistical bias. The study is also limited by the fact that the continuous variable of the pooled analysis could not be statistically compared due to the paucity of the reported data throughout.

Conclusion

Based on the patient-reported outcome assessments, both ORIF with a plate and screw system and IMN fixation are well-accepted techniques for PPFs around a TKA, and they produce similar functional outcomes.

Acknowledgements

None.

Authors' contributions

DR, TY prepared the manuscript. JA analyzed and interpreted the data. MH revised the manuscript and was a major contributor in manuscript writing. All authors read and approved the final version of the manuscript.

Funding

None.

Availability of data and materials

All data derived from previously published studies.

Declarations

Ethics approval and consent to participate

Not required.

Consent for publication

Not required.

Competing interests

Michael Huo is a member of the Editorial Board of *Arthroplasty* and other authors declare that they have no competing interests. All authors were not involved in the journal's review of or decisions related to, this manuscript.

Received: 25 October 2020 Accepted: 20 May 2021

Published online: 11 June 2021

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