Open Reduction Internal Fixation Versus Distal Femoral Replacement (DFR) for Treatment of OTA/AO 33C Fractures in the Elderly: A Review of Functional Outcomes and Cost Analysis

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Objectives: To determine the economic cost associated with the treatment of OTA/AO 33C fractures in patients older than 65 years of age using open reduction internal fixation (ORIF) or DFR and to assess the perioperative outcomes of elderly patients treated surgically following OTA/AO 33C fractures.

Design: Retrospective cohort over a 10-year period.

Setting: A single level-1 trauma center.

Participants and Intervention: Thirty-nine patients 65 or older with OTA/AO 33C fractures who underwent treatment with ORIF (n = 27) or DFR (n = 12) were included.

Main Outcome Measurements: Direct cost associated with surgical treatment along with LOS, functional outcomes, patient-reported outcomes, and all-cause reoperation.

Results: Index procedure costs were as follows: DFR: $ 61,259 vs. ORIF: $44,490 ($P$ = 0.056). Five (20%) ORIF patients required revision versus one (8%) in the DFR group. Total cost when including reoperation resulted in DFR being $14,805 more costly, which was not significant. Hospital LOS was similar between groups; however, convalescent LOS was longer in ORIF patients (43.2 vs. 23.1 days, P = 0.02).

Conclusion: This study demonstrates that there is no significant difference in overall cost between ORIF and DFR when all costs are considered. A larger portion of DFR patients were able to mobilize postoperatively, with subacute length of stay being longer in ORIF patients. A multicenter trial is warranted to determine optimal treatment for this complex problem.

Level of Evidence: Economic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Distal femur fractures account for 3%–6% of all femur fractures, with increasing rates observed in the aging population.[1] These injuries occur in a bimodal distribution, with 50% occurring in elderly individuals with the osteoporotic bone as a result of low-energy trauma.[2,3] These injuries carry substantial mortality in this patient population, with rates as high as 22% at 1 year. Furthermore, 40% of these patients experience perioperative complications, most commonly in the form of respiratory issues, thromboembolic events, infection, and changes in cognition.[4,5]

There have been many advances over time in fixation strategies of distal femur fractures. Despite these improvements, nonunion rates continue to be as high as 20 percent.[6] Nonunion or delayed union can lead to further surgical intervention and hospitalization, with a significant portion of these patients never regaining previous ambulatory function.[7] This carries substantial quality of life implications for this patient population as well as noteworthy cost for the health care system.

Distal femoral replacement (DFR) has emerged as a viable treatment option for elderly distal femur fractures. When used as an index treatment, the literature has demonstrated improved ambulatory status when compared with open reduction internal fixation (ORIF), along with the maintenance of knee range of motion.[7,8] In addition, patients who undergo DFR have not been found to have higher complication rates, whereas reoperation rates have not been significantly different.[7,9,10] Despite these findings, a common criticism of DFR has been the added implant cost.[11] However, recent findings in the use of DFR for periprosthetic fractures have demonstrated that the decreased complication rate and shorter length of stay may offset the added implant cost.[9,12] To the best of our knowledge, a cost comparison between DRF and ORIF for treatment of geriatric fractures of the distal femur in the native knee has not been performed.

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MATERIALS AND METHODS

Objectives

1. .Perform an economic analysis of the total cost associated with ORIF compared with DFR in the treatment of OTA/AO 33C fractures in patients older than 65 years of age.
2. .Assess the LOS, functional outcomes, patient-reported outcomes (PROMs), and all-cause reoperation in patients older than 65 years of age with OTA/AO 33C fractures treated with either ORIF or DFR.

Design

This is a retrospective, consecutive, multisurgeon, cohort study of patients older than or equal to 65 years of age who underwent either DFR or ORIF for OTA/AO 33C fractures between 2009 and 2019, with a minimum follow-up of 12 months.

Setting

This study was completed at a single academic level-1 trauma center in Ontario, Canada.

Patients

During the study period, there were 421 distal femur fractures in ambulatory patients 65 or older that were treated surgically at our institution. After radiographic review and classification based on the OTA/AO system, 337 type A or B were excluded, along with 39 periprosthetic fractures and 6 pathological fractures. Furthermore, the exclusion criteria during review included those who were nonambulatory at the time of the injury or underwent prior intervention outside of our institution, which did not result in any further exclusions. This resulted in 39 total fractures that were included in the cohort. Of the 39 fractures of interest, 12 underwent DFR whereas 27 underwent ORIF as the index procedure.

Demographic data including ASA score, time to operation, length of stay, and discharge disposition were collected. The mean patient age for the DFR cohort was 83.0 (range, 65–101) and 80.1 (range, 66–98) for the ORIF cohort which was not significantly different. All 12 (100%) patients in the DFR group were female compared with 22 of 27 (81.5%) in the ORIF group. The patients were not significantly different about the ASA score or timing to OR. All demographic data are summarized in Table 1.

TABLE 1. Demographic Data

	DFR	ORIF	*P*
n =	12	27	
Age	81.3 ± 8.5	79.4 ± 9.2	0.49
Gender (% female)	100	81.5	0.29
ASA score	2.34	3.22	0.61
Time to OR (d)	2.34	1.73	0.99
Time to F/U (y)	**2.20**	**6.26**	**0.001**
Periop mortality	1/12 (8.3%)	1/27 (3.7%)	0.52
1-year mortality	0/11 (0%)	3/26 (11.5%)	0.99

Bold indicates statistical significance.

Intervention

The treatment modality of choice and implants used were at the discretion of the treating surgeon based on training, experience, and comfort. Both patient cohorts were treated by the same group of surgeons. Fracture fixation was performed using a Synthes LCP Locking Distal Femur Plate or bicolumnar plating with the addition of the Synthes 3.5 mm LCP plating system (Synthes, West Chester, PA). Fracture fixation was performed through an anterolateral approach to the distal femur along with a medial subvastus approach for those who underwent bicolumnar plating. Patients who underwent DFR were treated with the Stryker Global Modular Replacement System (Stryker Mahwah, NJ) by a fellowship-trained arthroplasty surgeon. The knee was approached through a midline skin incision and medial parapatellar arthrotomy. Distal femur resection was performed immediately above the proximal extent of the fracture, and the DFR prosthesis was implanted using ether press fit or cemented implants based on surgeon preference.

Outcome Measures

Patient-Reported Outcomes

Postoperative Oxford knee Scores (OKS: 0–48, 48 denoting the best outcome)[13] along with EuroQol 5-dimensional scores[14] were acquired by a telephone interview. At this point of contact, patient survival, ambulatory status, and need for an assistive device was also obtained using standardized scripts. In patients who were not able to be contacted directly because of mortality or cognitive impairment, a subsequent decision maker was contacted to determine survival and ambulatory status. PROMs were not collected for patients who could not be contacted directly because these scores are not validated for use by proxy.

Reoperation

Implant survival for both cohorts was established with all-cause reoperation as a point of interest. This was assessed through chart review and organized telephone calls to verify that their implant(s) had not been revised for any reason at an outside our centre. Admission data as well as costs associated with revision surgery were retrieved and compiled with the existing index cost data.

Economic Analysis

The data set also included the total cost of treatment which was further broken down into total cost of the stay, procedure(s), and implant(s). Costing data include the material and personnel cost of any deliverables directly linked to patient care and consumables. The cost of any subsequent surgery and associated admission was retrieved and included in the analysis. Cost figures were adjusted for inflation using the Bank of Canada Consumer Price Index.[15]

Statistical Analysis

Statistical analysis was conducted using *t* tests for between group comparisons for continuous variables, whereas the Fisher exact and χ^2 tests were used to distinguish differences between categorical variables. The statistical significance was set at $P < 0.05$ for all analysis.

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RESULTS

Demographics

All patients were followed from the time of their index operation to the conclusion of the study period or to the time of their death. Time from index procedure to time of follow-up was significantly different, with an average time since surgery of 2.20 (±1.18) years for the DFR group and 6.54 (±2.97) years for the ORIF group ($P = 0.001$). There was 1 case of perioperative mortality in the DFR group (intraoperative arrest), as well as 1 case in the ORIF group (postoperative pneumonia). These patients were then excluded from further analysis. At the time of study follow-up, 9 of 11 (81%) DFR patients were alive and able to provide PROM data, compared with 16 of 26 (61%) in the ORIF group. One-year mortality rate was 0 of 11 in the DFR group compared with 3 of 26 in the ORIF group which was not significant. Demographic data can be noted in Table 1.

Length of Stay

LOS data are summarized in Table 2. The mean length of stay in acute care hospital was not significantly different between the 2 groups. There was no difference in discharge disposition with 75% of patients in both cohorts requiring discharge to a subacute rehabilitation or convalescence facility. Of those that were discharged to a subacute facility, the mean length of subacute stay was 23.1 days for the DFR group (range, 3–75) and 45.2 days for the ORIF group (range, 6–144), which was significantly different ($P = 0.02$). This did not result in significantly different total LOS when the acute LOS and subacute LOS were surmised ($P = 0.095$).

Patient-Reported Outcomes

There was no difference between the DFR and ORIF cohorts on analysis of PROMs. The mean OKS were 34.8 (range, 20–43) in the DFR group and 28.4 (range, 12–47) in the ORIF group ($P = 0.109$). Similarly, no difference was noted in ED-5D scores, with mean scores of 0.68 (range, 0.25–0.86) in the DFR group and 0.64 (range, 0.23–1.0) in the ORIF group ($P = 0.44$). Of note, all but 1 patient in the DFR group were ambulatory at the time of follow-up or time of their death (91%), whereas only 57% of patients in the ORIF group were able to ambulate at the same time point ($P = 0.11$). There was no significant difference in the use of an assistive device.

TABLE 2. Discharge Location and Length of Stay Data

	DFR	ORIF	*P*
Subacute D/C	9/11	20/26	0.99
Acute stay (d)	29.1	25.9	0.631
Subacute (d)	**23.1**	**45.2**	**0.016**
Total LOS (d)	52.2	71.1	0.09

Bold indicates statistical significance.

Reoperation

The rate of reoperation was not significantly different between the 2 cohorts, with 1 case in the DFR group and 5 in the ORIF group ($P = 0.64$). The case of reoperation in the DFR group was for deep prosthetic joint infection, and this patient underwent a single irrigation and debridement with exchange of modular components and was treated with antibiotics. The total length of stay for this hospitalization was 40 days. Five patients (19%) in the ORIF group required reoperation, with 4 cases of reoperation for nonunion with 1 revision ORIF and 3 revisions to DFR. There was 1 case of deep infection requiring irrigation and debridement. The average time to reoperation in the ORIF group was 350.0 days (range, 89–639 days).

Economic Analysis

Costing data were available for all patients. The direct implant cost was significantly different between the 2 groups, with a mean implant cost of $11,403 in the DFR group and $2066 in the ORIF group ($P = < 0.01$). After all attributable costs of hospitalization were analyzed, the total cost of providing index surgical care was also significantly different, with a mean DFR cost of $ 61,259, compared with $44,491 in the ORIF group ($P = 0.05$). The total cost of the single revision in the DFR group was $66,836, and the mean cost of reoperation in the ORIF group was $50,249. When the cost of revision surgery was included in the total cost analysis, the cost differential between the 2 cohorts was not significantly different, as the total average cost in the DFR group was $67,335 compared with $52,530 ($P = 0.24$). All costing analysis can be noted in Table 3.

CONCLUSIONS

With more than half of distal femur fractures occurring in the elderly population, the expectation is that these injuries will become more common within an aging population.[2,3] These injuries present significant challenges for both patients and surgeons, and the associated economic implications within the health care system cannot be overlooked. To the best of our knowledge, our study is one of the largest cohort comparisons of ORIF versus DFR in the elderly population for distal femur fractures and is the only comprehensive cost analysis comparing these 2 treatments.

Within our cohort, the initial LOS for the 2 groups is not significantly different. Although we noted a significant difference in the subacute or convalescent care LOS, this did not result in a significantly different total LOS. It is important to note that within the ORIF group, there were 2 outliers; both males aged 65 with higher energy fractures and respective LOS of 4 and 5 days. With these 2 patients not necessarily representing the fragility fractures in question, their exclusion would result in a mean LOS of 81 days in the ORIF group. This would have led to a statistically significant difference in overall LOS between the 2 groups when both acute and convalescent care are considered.

No significant difference in patient-reported outcomes was detected between the 2 groups. This is in keeping with the findings of Hull et al as well as Pearse et al who compared

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TABLE 3. Costing Data in Mean CAD [Range]

	DFR	ORIF	P
Primary implant cost	**$11,403** [$9230–$17,672]	**$2066** [$401–$3783]	**<0.001**
Total index cost	**$61,259** [$36,083–$112,252]	**$44,491** [$13,565–$120,849]	**=0.05**
Mean revision cost	$66,836	$50,249 [$27,879–$61,288]	=0.789
Total final cost	$67,335 [$36,083–$147,784]	$52,530 [$13,565v$125,933]	=0.242

Bold indicates statistical significance.

DFR with ORIF in elderly patients and found no significant differences in PROMs at any point in follow-up.[16,17] Like our cohort, these studies also acknowledge limited sample sizes and difficulty with achieving adequate power. Despite this, our cohort did demonstrate a trend toward improved OKS in the DFR group, with a mean difference of 6.4 points. The minimally clinically important difference for the OKS is 5.0 in the knee arthroplasty population,[18] and thus, the trend we have noted may have implications for our cohort favoring patient function after DFR.

It is also relevant to note that 3 (12%) ORIF patients underwent revision to DFR at an average time to revision of 13 months. At the time of revision, all 3 were nonambulatory. After revision, each of these patents were ambulatory with a mean OKS of 43. Given their nonambulatory status at the point of revision, these patients would have likely reported a substantially lower OKS after ORIF when compared with their current DFR, and should we have collected PROMs prospectively, a significant difference in OKS may have been noted. In addition, because of the lack of PROMs in deceased or cognitively impaired patients, the scores reported may not be entirely representative of out cohort. This likely explains the nearly identical EuroQol 5-dimensional scores in our cohort, despite a substantially higher number of DFR patients being ambulatory at the time of follow-up or before their death. These are limitations of collecting PROMs retrospectively in an elderly population.

A trend was also noted toward maintained ambulatory status in DFR patients. Although this did not reach statistical significance, this finding is in keeping with data presented in previous studies. Of the 3 studies that have reported ambulatory status following DFR for distal femur fractures, a combined 46 of 49 patients have been ambulatory at the time of follow-up.[7,8,19] Hart et al[7] found that 100% of DFR patients in their cohort were ambulatory at 1 year compared with nearly a quarter of ORIF patients requiring a wheelchair for ambulation. Our study further contributes to this trend in the literature; however, a large scale trial is needed to better understand the differences in functional outcomes in these 2 treatments.

Within our cohort, we observed a reoperation rate of 19% (5/26) in the ORIF group and 9% (1/11) in the DFR group. This is consistent with previous findings, with previous reports of nonunion and subsequent reoperation rates in the range of 6%–20% in ORIF patients.[6,20] A recent meta-analysis of distal femur fractures treated with ORIF determined a weighted mean reoperation rate of 10.6%, with failure of treatment and/or nonunion making up most complications.[21] Reoperation data in DFR patents are scarcer with fewer reported outcomes, with reoperation rates ranging from 0% to 22%.[21] Two studies have previously compared reoperation rates between the 2 cohorts and, in keeping with our findings, did not detect a difference between 2 groups.

To the best of our knowledge, this is the largest comparative cost analysis comparing DFR with ORIF in the treatment of elderly distal femur fractures. Hull et al[16] did collect and analyze costing data prospectively; determining the costs in the DFR group was higher than the ORIF group for implant costs, which was not offset by the overall total cost of hospitalization. This, however, was a feasibility study with limited sample size, and patients were followed for a total of 9 months, which may not account for longer term revision rates and the associated cost as evidenced in our cohort. After final costing analysis, as anticipated, we did note a significant difference in implant cost and total cost of index hospitalization. Once revision surgery was accounted for, however, this difference decreased to $14,804, which was no longer significantly different. In addition, this cost differential is likely narrower when costs following discharge are considered, as the average subacute LOS in the 2 cohorts was on average 22 days shorter in the DFR group which was significant. The average cost of subacute care in our province is $350 per day, which would account for a difference of $7700. This was not included in the cost analysis but may certainly have costing implications.

Although the total final cost of providing care was not significantly different, a difference of $14,804 is substantial. A key determinant of cost effectiveness is whether a difference in the effect of 2 treatments justifies additional cost.[22] This can be determined in a quality of life year (QALY) analysis by determining the incremental cost effectiveness ratio.[22] Although our study was considerably underpowered to conduct this analysis, the use of these measures is well demonstrated, with a generally accepted cost effectiveness threshold of US$50,000/QALY.[22–25] Krummeaur et al[26] demonstrated that total knee arthroplasty resulted in annual average of 2.76 QALY gained in patients 70 years of age and older, whereas Konopka et al[27] noted that revision surgery resulted in significantly lower QALY scores. In our DFR cohort, 9 of 11 patients were alive and ambulatory at the time of follow-up with an average time to follow-up of 2.2 years. Only 1 patient required reoperation compared with 5 in the ORIF group. The mean cost of providing care to these patients was $ 67,335, which was $14,804 more than the ORIF group. When considering these data, it is reasonable to believe the use of DFR in elderly distal femur fractures

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could potentially demonstrate an incremental cost effectiveness ratio that is well within the accepted cost effectiveness threshold of $50,000/QALY. Our study further reinforces the need for an appropriately powered prospective trial aimed at determining the optimum treatment for this complex orthopaedic injury.

This study did have several limitations. Owing to the relatively novel use of DFR for elderly distal femur fractures at our institution, there was a notable difference in the time to follow-up between groups. We attempted to account for this in our costing analysis by adjusting for inflation; however, this may have certainly introduced some latency bias about mortality, reoperation, and PROMs between the 2 groups. Furthermore, the use of DFR for these injuries is relatively infrequent in contrast to ORIF which was reflected in the unequal size of the 2 treatment arms despite similar patient and fracture characteristics. This may again have been due to the novel use of DFR for the treatment of these injuries, as it is still somewhat controversial and ORIF is the standard of care. Surgeon preference, training, and experience may influence the type of treatment received; however, all patients were treated by the same group of surgeons, and thus, we do feel the unequal treatment groups may be more an effect of latency rather than selection bias. As a result, and as is the case with many previous studies on this topic, the study is notably underpowered.

We feel these results have important implications in the understanding of the cost effectiveness of these 2 different forms of surgical treatment and contribute to the overall body of knowledge in the use of DFR for the treatment of elderly distal femur fractures. Further large-scale prospective trials are needed to determine the most effective and economic means of managing patients with this complex orthopaedic injury.

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