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A cost analysis of treating postoperative periprosthetic femoral fractures following hip replacement surgery in a UK tertiary referral centre

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Abstract

Aim

This study aims to evaluate costs associated with periprosthetic femoral fracture (PFF) treatment at a UK tertiary referral centre.

Methods

This study included 128 consecutive PFFs admitted from 02/04/2014-19/05/2020. Financial data were provided by Patient Level Information and Costing Systems. Primary outcomes were median cost and margin. Secondary outcomes were length of stay, blood transfusion, critical care, 30-day readmission, 2-year local complication, 2-year systemic complication, 2-year reoperation and 30-day mortality rates. Statistical comparisons were made between treatment type. Statistical significance was set at $p<0.05$.

Results

Across the cohort, median cost was £15,644.00 (IQR £11,031.00-£22,255.00) and median loss was £3757.50 (£599.20-£8296.20). The highest costs were ward stay (£3994.00, IQR £1,765.00-£7,013.00), theatre utilisation (£2962.00, IQR £0.00-£4,286.00) and overheads (£1705.10, IQR £896.70-£2432.20). Cost (£17,455.00 [IQR, £13,194.00-£23,308.00] versus £7697.00 [IQR £3871.00-£10,847.00], $p<0.001$) and loss (£4890.00 [IQR £1308.00-£10,009.00] versus £1882.00 [IQR £313.00-£3851.00], $p=0.02$) were greater in the operative versus the nonoperative group. There was no difference in cost (£17,634.00 [IQR £12,965.00-£22,958.00] versus £17,399.00 [IQR £13,394.00-£23,404.00], $p=0.98$) or loss (£5374.00 [IQR £1950.00-£10,143.00] versus £3860.00 [IQR -£95.50-£7601.00], $p=0.21$) between the open reduction and internal fixation (ORIF) and revision groups. More patients required blood transfusion in the operative versus the nonoperative group (17 [17.9%] versus 0 [0.0%], $p=0.009$). There was no difference in any clinical outcome between the ORIF and revision groups ($p>0.05$).

Conclusion

PFF treatment costs are high with inadequate reimbursement from NHS tariff. Work is needed to address this disparity and reduce hospital costs. Cost should not be used to decide between ORIF and revision surgery.

Highlights

1. Treatment costs of periprosthetic femoral fracture (PFF) are high and there is inadequate reimbursement through NHS tariff.
2. The highest costs are associated with ward stay, theatre utilisation and overheads.
3. In our unit there was no difference in cost between open reduction and internal fixation and revision surgery.

Keywords

1. Periprosthetic fracture
2. Cost analysis
3. Internal fixation

Introduction

Postoperative periprosthetic femoral fracture (PFF) is a serious complication following hip replacement surgery with unsatisfactory outcomes and complication rates.[1-4] PFF incidence is estimated at 3.5% but this is rising.[5,6] PFF treatment has high costs which represent a significant burden to healthcare providers.[7-10]

PFFs can be manged nonoperatively or operatively. Nonoperative management is reserved for stable fractures around well-fixed stems or for patients who are unfit for surgery. More commonly, operative treatment is undertaken to allow mobilisation and reduce risks associated with prolonged incumbency. This is guided by the Unified Classification System (UCS) which suggests open reduction and internal fixation (ORIF) for PFFs around well-fixed stems and revision hip replacement surgery (+/- ORIF) for PFFs around loose stems or severe bone loss.[11] However, it does not consider fracture pattern with many surgeons offering revision surgery for unstable and comminuted fractures.[12] Comparative studies are sparse but recent evidence suggests that the outcomes of ORIF and revision are equivalent, even in the presence of loose stems, provided that stable anatomic reduction can be achieved to allow immediate and unrestricted weight bearing.[13-15]

The UK Getting It Right First Time (GIRFT) programme aims to improve the clinical and cost-effectiveness of services delivered by the NHS. It promotes regional networks for treating complex pathologies, such as PFFs, within a multidisciplinary team lead by a tertiary referral centre. Advantages include reduced variation in practice, fewer complications, improved team working and lower treatment costs.[16] However, this may also lead to increased referrals for specialist centre care which carries a significant financial burden. The cost of treating PFFs has not recently been investigated in the UK and given potential changes in service delivery, it is imperative that an updated financial assessment is performed. Given that the outcomes of ORIF and revision surgery may be equivalent, it is necessary to compare the costs of treatment as this may provide additional information when considering surgical options.

The study aims to evaluate treatment costs and margins associated with treating PFFs around hip replacement stems at a large UK tertiary referral centre.

Methods

A consecutive series of adult patients presenting to Leeds Teaching Hospitals NHS Trust, UK from 02/04/2014-19/5/2020 with an acute PFF around a hip replacement stem were identified. Local institutional approval was obtained.

Data were collected from electronic healthcare records. Demographic details included age, gender, body mass index (BMI) and Charlson Comorbidity Index (CCI). Implant details included hip replacement type (total hip replacement [THR] or hemiarthroplasty), cemented stem type (polished taper-slip or composite beam), cementless stem type (fully or partially coated, collared or uncollared), primary cup type (standard, dual mobility or fully constrained) and bearing type (metal-on-polyethylene, ceramic-on-polyethylene, ceramic-on-ceramic or metal-on-metal). PFF details included laterality, UCS grade and Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) fracture type[17] for UCS grade B and C fractures (transverse, oblique, spiral or wedge) including an additional category specific to PFFs around polished taper-slip stems, the metaphyseal split (or log-splitter) fracture, where there is bone and cement comminution but an intact bone-cement interface.[18] Surgical details included operating time, ORIF type (cerclage only, plate only, plate and cerclage or plate and nail combination), use of a PFF-specific locking plate, revision stem type (cementless, cemented or proximal femur replacement) and revision cup type (standard, dual mobility, fully constrained or posterior lip augmentation device [PLAD]). ORIF was defined as using any fixation device to stabilise the fracture without removal, exchange or modification or any component of the original hip replacement construct (**Figures 1A and 1B**). Revision was defined by removal, exchange or modification of any component of the original hip replacement construct +/- additional fixation (**Figures 2A and 2B**). Clinical outcomes included length of stay (LOS), postoperative critical care requirement, postoperative blood transfusion within 72 hours, 30-day readmission rates, 2-year local and systemic complication rates, 2-year reoperation rates and 30-day mortality rates.

Financial data was provided by our Patient Level Information Costing System (PLICS) including all episodic costs relating to treatment, inpatient stay and outpatient follow-up. Costs associated with specific clinical areas (consultant, surgeon, ward, theatre, drugs, pathology, radiology, consumables and overheads) were all individually reported, contributing to the total cost for each episode. Consumables, such as surgical implants, were identified to individual patients using barcode technology. Overhead costs included the costs of support services such as ancillary staff, heat and lighting. The total clinical revenue generated through reimbursement was also collected and the margin associated with each episode subsequently calculated.

Statistical analysis

Statistical analysis was undertaken using R (version 4 .1.1). The primary outcome measures were total cost and margin. Data was tested for normality using histogram models. Normally distributed continuous variables were summarized as mean values with standard deviations (SDs) and non-normally distributed variables as median values with interquartile ranges (IQRs). Comparison of ordinal and nominal variables were performed with the Chi-squared test but where assumptions for this were not met, Fisher's exact test was used. The Wilcox-Mann-Whitney test was used to compare independent non-normal continuous populations, and the two-sample t-test was used to compare independent normal continuous populations. Statistical significance was set to $p < 0.05$.

Results

135 PFF episodes were identified. Five were excluded due to incomplete costing data and two were excluded as they did not fit the eligibility criteria (an infected nonunion of a previous PFF and a PFF around a fracture fixation implant). 128 PFF episodes were therefore included. Median age was 84.0 (IQR 77.0-89.0) years, 75 (58.6%) patients were female, median BMI was 24.0 (IQR 20.0-29.0), mean CCI was 5.1 (SD 1.7) and median follow-up was 287.5 (IQR 88.8-585.5) days.

Comparison of groups

Baseline demographic and clinical information stratified by treatment type (nonoperative versus operative) is presented in **Table 1**. Of the 128 PFF episodes, 33 were managed nonoperatively and 95 were treated operatively. Compared to the nonoperative group, the operative group had a significantly higher BMI (26.0 [22.0-29.0] versus 20.0 [18.5-22.0], p=0.004), fewer hemiarthroplasties (8 [8.4%] versus 10 [30.3%], p=0.005), more uncollared cementless stems (20 [58.8%] versus 4 [21.1%], p=0.02) and more UCS grade B2 (38 [40.0%] versus 3 [9.1%]), B3 (10 [10.5%] versus 0 [0.0%]) and C (14 [14.7%] versus 0 [0.0%], p<0.001) fractures. There were fewer oblique (4 [4.3%] versus 10 [71.4%]) fractures but more transverse (8 [8.6%] versus 0 [0.0%]), spiral (72 [77.4%] versus 3 [21.4%]) and metaphyseal split (6 [6.5%] versus 0 [0.0%], p<0.001) fractures in the operative group. More patients required blood transfusion in the operative group (17 [17.9%] versus 0 [0.0%], p=0.009). There was no difference in any other clinical outcome (p>0.05).

Baseline demographic and clinical information stratified by surgery type (ORIF versus revision) is presented in **Table 2**. Of the 95 operative cases, 52 had ORIF and 43 had revision surgery. Compared to the revision group, the ORIF group had a more females (34 [65.4%] versus 17 [39.5%], p=0.02), more UCS grade B1 (27 [51.9%] versus 4 [9.3%]), fewer B2 (9 [17.3%] versus 29 [67.4%]), fewer B3 (1 [1.9%] versus 9 [20.9%]) and more C (14 [26.9%] versus 0 [0.0%], p<0.001) fractures. In the ORIF group, there were more spiral (43 [84.3%] versus 29 [69.0%]) and wedge (3 [5.9%] versus 0 [0.0%])

fractures but fewer metaphyseal split (0 [0.0%] versus 6 [14.3%], p=0.01) fractures. Operating time was greater in the revision group (201.0 [159.0-228.5] versus 131.5 [114.2-177.5], p=0.001) minutes. In the ORIF group, more PFFs were treated with plates only (11 [21.2%] versus 0 [0.0%]) or a combination of plates and cerclage fixation (38 [73.1%] versus 10 [26.3%] but fewer with cerclage fixation only (2 [3.8%] versus 28 [73.7%], p<0.001). PFF-specific locking plates were more prevalent in the ORIF group (48 [92.3%] versus 8 [34.8%], p<0.001). There was no difference in any clinical outcome (p>0.05).

Cost analysis

Across the entire cohort, total cost was £2,373,948.00, total revenue was £1,691,194.00 and total loss was £682,769.00 (**Table 3**). Median cost was £15,644.00 (IQR £11,031.00-£22,255.00). The highest costs (**Figure 3**) were associated with ward stay (£3994.00, IQR £1765.00-£7013.00), theatre utilisation (£2962.00, IQR £0.00-£4286.00) and overheads (£1705.10, IQR £896.70-£2432.20). Median loss was £3757.50 (IQR £599.20-£8296.20).

Nonoperative versus operative

Median cost was £7,697.00 (IQR £3871.00- £10,847.00) and £17,455.00 (IQR £13,194.00-£23,308.00, p<0.001) in the nonoperative and operative cohorts, respectively (**Table 4**). Median cost, revenue and loss were all significantly greater in the operative group (p<0.05). In the nonoperative cohort, the highest costs were ward stay (£2553.00, IQR £0.00-£4745.00), overheads (£1078.00, IQR 0.00-£1909.00), and consultant costs (£243.00, IQR £0.00-£675.70). In the operative cohort, the highest costs were ward stay (£4515.00, IQR £1984.00-£7643.00), theatre utilisation (£3557.00, IQR £2745.00-£4767.00) and overheads (£1924.00, IQR £1130.00-£2571.00). Operatively treated PFFs had significantly increased costs across all clinical areas compared to nonoperative cases (p<0.05).

ORIF vs revision surgery

Within the operative cohort, median cost was £17,634.00 (IQR £12,965.00-£22,958.00) in the ORIF group and £17,399.00 (IQR £13,394.00-£23,404.00, p=0.98) in the revision group (**Table 5**). No significant difference between median cost or loss was observed between the ORIF and revision groups (p>0.05). However, there was a significantly higher revenue in the revision group (£13,925.00, IQR £11,294.00-£17,037.00) compared to the ORIF group (£12,164.00, IQR £8682.00-£14,451.00, p=0.03). Except for surgeon costs, no significant difference in cost was noted across different clinical areas between the groups.

Discussion

This study provides a contemporary financial assessment of treating postoperative periprosthetic femoral fractures in a large UK tertiary referral centre. Under the current NHS tariff payment system, treating these injuries is associated with a median cost of £15,644 and a median loss of £3,757.50 per patient. The highest costs are associated with ward stay, theatre utilisation and overheads. As expected, cost and loss for operative treatment are significantly greater than for nonoperative treatment. Although length of stay was similar for both the groups, costs relating to theatre time, critical care requirements, blood transfusion requirements, implant costs and overheads were predictably higher in the operative group. When comparing ORIF to revision surgery, there was no significant difference in median cost or lost revenue. However, revision surgery had a greater median revenue via NHS tariff.

Expected patient, implant and fracture-related differences were observed between the groups. Compared to the operative group, the nonoperative group had a significantly lower BMI and a higher proportion of hemiarthroplasties which is likely due to increased frailty in this group who may have been unfit for surgery. With cementless stems, calcar collars offer a lower risk of PFF as they provide greater rotational stability compared to uncollared stems.[19] Additionally, there is a lower risk of spiral fractures which are commonly treated operatively.[20] These biomechanical observations may explain the lower rate of uncollared stems and spiral fractures in the nonoperative group. As expected, there were more UCS grade B2, B3 and C fractures and a greater proportion of metaphyseal split fractures in the operative group as these are rarely treated nonoperatively. UCS grade A fractures are usually treated nonoperatively as are some undisplaced grade B1 fractures around well-fixed stems.[21] PFFs with loose stems (grade B2 and B3) and metaphyseal split fractures preferentially underwent revision surgery which was associated with increased operating times due to the need for implant removal. More patients in the ORIF group had PFF-specific locking plates than in the revision group. Apart from an increased blood transfusion in the operative versus the nonoperative group, there was no difference in any other clinical outcome in the two subgroup comparisons. However, this finding may be subject to observational bias and requires confirmation in a larger study population.

This study confirms that PFF treatment costs are high and that there is a significant financial loss resulting from inadequate reimbursement through NHS tariff. The majority of costs are attributable to ward stay, theatre costs and overheads. The cost of consumables, including implants, also makes a major contribution to the overall cost. Although UK literature is sparse, similar findings have been reported elsewhere. Phillips et al reported a median cost of treatment of £18,031 in a series of 146 PFFs.[7] Kanakaris et al reported on a series of 28 interprosthetic femoral fractures with a median cost of £15,625 but with a higher median cost for revision compared to ORIF surgery (£20,793 versus

£12,979, respectively).[8] Both of these studies also found that ward and theatre costs were responsible for most of the cost.[7,8] Jones et al reported a mean cost of treatment of £31,370 in series of 90 PFFs although their reported LOS was higher than in the present study.[22] In two studies from Ireland, Fenelon et al reported mean cost of €24,413 per PFF and Lyons et al reported increasing cost depending on complexity of surgical construct but also that cost was directly related to LOS.[23,24] In the present study, there was no cost difference between ORIF and revision surgery which is contrary to previous reports highlighting implant costs as the main reason for this difference.[8,22] This may be due to the high usage of PFF-specific locking plates in our ORIF group. These are more expensive than traditional non-locking plates which may have been used in earlier studies but are equivalent in cost to some revision implants.[8] These plates are more rigid than their earlier counterparts and are designed to allow immediate and unrestricted weight-bearing which may explain the similar LOS observed between ORIF and revision patients in our series. The use of these plates has expanded in recent times but their use is controversial as similar outcomes can be achieved with conventional non-locking plates.[15,25,26]

With the expected rise in PFF incidence and the increased burden on specialist centres, there is likely to be a significant financial shortfall which may put NHS Trusts at risk. Specialist centres could be disincentivised to accommodate tertiary referrals due to the financial risks involved. There should be recognition at national level that NHS Trusts are being inadequately reimbursed for PFF treatment and future modelling for tariff payment systems should commit to appropriate levels of reimbursement. Importantly, work is also required to lower hospital costs associated with PFF treatment and this primarily relates to LOS, theatre utilisation and implant costs. LOS can be reduced through enhanced recovery programmes, reducing waiting times to theatre, early mobilisation and reducing complications.[27,28] As per current hip fracture standards of care, orthogeriatric input within the multidisciplinary team can help reduce surgical waiting times and LOS.[29] Theatre costs are high and are calculated by operating time and therefore efforts must be made to improve efficiency. Dual consultant operating for complex surgical procedures can help lower costs by reducing operating times but can also improve outcomes and prevent complications.[30,31] There must also be concentrated efforts to lowering implant costs through central procurement strategies with a large-scale reduction in loan kit usage for case requiring specialist implants.

Strengths of this study include representation of real-world data as this is a large, consecutive series of patients treated by multiple surgeons with trauma and arthroplasty expertise in a tertiary referral NHS centre. It also uses PLICS data which provides a true cost of an individual patient's treatment pathway. Limitations include a single-centre cohort and a lack of functional outcome data as this is not routinely collected for these patients. A larger multicentre study sample would be needed for generalisable conclusions regarding clinical outcomes. The UCS may also be less reliable for PFFs

around cemented polished taper-slip stems compared to other stem types.[32] Further clinical research comparing expensive PFF-specific locking plates to cheaper alternatives is warranted as this may offer a potential cost-saving strategy.

Conclusion

In summary, this study highlights that the cost of treating PFFs is high and there is inadequate reimbursement from current NHS tariff payment systems. Considerable work is required to ensure adequate financial remuneration and lowering costs associated with treating PFFs. There is no difference in cost between ORIF and revision surgery so this should not be a deciding factor in treatment algorithms.

Figure legends

Figure 1A. UCS grade B1 PFF

Figure 1B. UCS grade B1 PFF treated with ORIF using PFF-specific locking plate

Figure 2A. UCS grade B2 PFF

Figure 2B. UCS grade B2 PFF treated with cementless stem revision

Figure 3. Costs associated with individual clinical areas

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