Periprosthetic Femoral Fractures in Total Hip Arthroplasty (THA): Comparison Between Osteosynthesis and Revision

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Abstract

Background Periprosthetic fractures are challenging complication of hip arthroplasty and a rare injury, but their incidence is increasing. The surgical treatment is demanding to achieve early mobilization and avoid the complications of prolonged recumbency. The aim of this study is to evaluate the clinical outcomes of surgical treatment in periprosthetic femoral fractures of hip arthroplasty, making a comparison between implant revision and reduction and internal fixation of the fracture.

Methods Authors retrospectively reviewed a series of 117 patients with total hip arthroplasty treated for periprosthetic femur fractures in the period between January 2013 and March 2018 at a single tertiary referral center. We collected the data of 70 patients who satisfied inclusion criteria. The fractures were classified according to the Unified Classification System (UCS) and randomized in two groups: reduction and internal fixation (G1) or revision arthroplasty (G2). Clinical outcomes were assessed with Oxford Hip Score post and pre-surgery, Barthel Score in relation to CIRS score (Cumulative illness rating scale), the type of fracture and post-operative complications with a minimum follow up of one year.

Results Nominal univariable statistical analysis revealed significantly results concerning the difference between the post and pre-operative Oxford Hip Score (D Oxford) with type of treatment ($p=0,008$) and with the CIRS score ($p=0,048$). Moreover, we observed a strong significant relationship between type of treatment and type of fracture ($P=0,0001$). Multivariable analyses revealed that CIRS score was independently associated with Oxford Score improvement after surgery ($P=0,024$).

Conclusions Authors reported how the surgical revision has a better functional outcome in B2 type of fracture than B1 or C, but the chosen treatment should be related to surgeon's experience and patient's comorbidities and a multidisciplinary team.

Background

Periprosthetic femoral fractures (PPFx) are challenging complications of hip arthroplasty for orthopedic surgeons. The increasing incidence is related to larger numbers of prosthetic replacement per year and higher life expectancy (1). PPFx are going to involve a significant amount of operating time, bed and cost days and are associated with both high mortality and morbidity. (2)(3) (Fig. 1)

According to current available literature and the Annual Report 2019 of the National Joint Replacement Registry (Australian Orthopedic Association), there has been a 124.9% increase in primary total conventional hip replacement procedures performed since 2003. Among these high numbers most frequent complications after primary total hip replacement are loosening (24.6%), dislocation (20.8%) and fracture as 20.7%. Reports from single centers show a lower incidence. (4)(5)

Surgical treatment is turned to achieve early mobilization and avoid complications of prolonged bed rest. Achieving a stable fixation is demanding for to the interference of femoral stem with synthesis devices, osteoporotic bone quality and altered anatomy. PPFx result in severe morbidity for patients. Undergoing

revision surgery for periprosthetic fractures results in a worse survival outcome than the general population at one year and that bias persists for several years after surgery. (6)(7)(8). Non-operative management is not practicable as for complications from long-lasting period of immobilization and potential fracture non-union when there is a cemented stem (9). Main features implicated are location of the fracture, type of prosthetic fixation, cemented or cementless and adequacy of bone stock and supporting the implant.

In the present study we assessed the surgical and clinical postoperative outcomes of patients, treated for periprosthetic fractures after total hip arthroplasty comparing open reduction and internal fixation (ORIF) or revision arthroplasty (RA) of the femoral stem.

Methods

The Authors retrospectively reviewed a series of 117 patients with total hip arthroplasty treated for PPFx between January 2013 and March 2018, who presented to our hospital (single tertiary referral center). The patients who had associated fractures, the fracture pattern and the injury's severity score were considered specifically.

The exclusion criteria were conservative management, minimum available follow-up lower than 12 months, undetectable and incomplete clinical or radiological records for cases referred from other hospital, intraoperative fractures, fractures related to tumoral lesions and concomitant infection. This left 68 cases, but 70 fractures because two patients presented with bilateral fractures.

Clinical and demographic data (gender, age, body mass index, side of fracture) were retrospectively gathered from clinical records. The highlighted data, model of femoral component and/or plate used, type of surgical technique used, number of cerclage wires and blood transfusion are collected in clinical records (digitally stored). Moreover, Authors used the CIRS score (Cumulative illness rating scale) to assess the comorbidity level of the patients before surgery. This scoring system measures the chronic medical illness taking into consideration the severity of chronic disease in 14 items. Each item has a 0–4 score, where 0 represent “no problem affecting that system” and 4 “extremely severe problem and/or immediate treatment required and /or organ failure and/or severe functional impairment”. The cumulative final score can vary from 0 to 56. (10)

The Unified Classification System (UCS) for PPFx, based on the Vancouver Classification relating to the femur fractures and described by Duncan and Masri in 1995 (11) was employed in the study (14) and it was confirmed on the intra-operative evaluation performed during surgical procedures.

The patients were randomized to two groups (G1 and G2) depending on the surgical treatment, ORIF vs RA. Clinical features and overall post-operative complications (infection, hardware failure, dislocations, non-union, deep venous thrombosis, heart failure and pneumonia) were analyzed in relation to fracture classification and type of surgical management (ORIF or RA) with a minimum follow up of one year. Pre-

and post- surgical clinical outcomes and disability of patients were evaluated respectively with Oxford Hip score and Barthel score.

Different surgical procedures have been performed considering the type of fracture, the quality of the bone stock, the general conditions of the patient before the fracture with adequate functional and cognitive assessment and the associated comorbidities. (Fig. 2)

When the prosthetic implants were considered stable (Duncan Classification type B1 or C) ORIF was performed; the bone stock should be adequate for synthesis and clinical conditions of the patients should allow a longer recovery and rehabilitation times. Prosthetic revision was used in case of loosening of prosthesis stability (type B2), inadequate bone stock (type B3) or when general conditions of the patient required a rapid mobilization and ambulation. Cerclage wires were added to RA procedures to provide adequate support for revision stem and avoid new fractures during revision procedures. We routinely used the postero-lateral access to the hip with lateral extension to proximal femur, which in our experience allows a good exposure of the fracture pattern and facilitates a direct reduction. In every case surgery was performed by a senior surgeon with adequate experience in trauma or revision surgery.

Descriptive statistics were obtained reporting medians and interquartile ranges (IQR) for continuous variables and frequencies and proportions for categorical variables, as appropriate. Continuous variables were compared by the Student Independent T test or the Mann-Whitney U test based on their normal or not-normal distribution, respectively. Normality of variables' distribution was tested by the Kolmogorov-Smirnov test. Categorical variables were tested with the Chi-square and Kruskal-Wallis tests. Differences between pre- and post-treatment variables were assessed using paired T test. Univariable and multivariable ANOVA (MANOVA) with post hoc analysis was adapted to compare clinical and surgical variables between different types of treatment. Multivariable analysis was performed to explore predictors of Δ Oxford, after adjusting for age, preoperative Barthel and CIRS score. Statistical significance was set as $p < 0.05$. All tests were two-sided. Analyses were carried out using SPSS v. 24 (IBM SPSS Statistics for Mac, Armonk, NY, IBM Corp)

Results

The study cohort included 70 considered eligible from 117 patients evaluated. The mean age of patients at the time of fracture was 88 years (IQR, 83-96 years) and the median age 90 years (SD ± 10.21). 55 patients were female (78.6%) and 15 males (21.4%). In 41 cases the affected side was right (58.6%) and in 29 left (41.4%). The median of Oxford Score Pre-Surgery was 36 (IQR 22-43, SD ± 12.21) and the median of Barthel Pre-Surgery score was 87.5 (IQR, 65-100; SD ± 22.35). Moreover, the comorbidity median score of the series, evaluated with CIRS score, was eight (IQR, 5-11; SD ± 4.35). Preoperative data are reported in Table 1.

According to UCS classification, the most frequent type of fracture was B2 (32 cases, 45.7%) followed by C (22 cases, 31.4%), B1 (13 cases, 18.6%) and B3 (3 cases, 4.3%). Patients were divided in two groups: G1 treated with ORIF (Fig. 3) and G2 treated with RA (Fig. 4). G1 patients (45 cases, 64.3%) were treated with

ORIF with Non-Contact Bridging Periprosthetic Femur Plate System (NCBâ PFP, Zimmer) in 40 patients and Less Invasive Stabilization System plates (LISS, Synthes) in five patients; implant revision Wagner SL Revisionâ Hip Stem (Zimmer) plus ORIF was performed in two cases. In G2 patients (25 cases, 35.7%) RA with revision Wagner SLâ prosthetic stem was performed. Cerclage wires were added in 51 cases (72.9%) to achieve adequate reduction prior to ORIF or RA. Operative procedures are detailed in Table 2.

During hospitalization 40 patients (62.5%) required blood transfusions due to post-surgery anemia. Postoperative venous ultrasound (VUS) based on B-mode, combined with color-Doppler US and power imaging techniques on the fifth post-operative day recorded in seven cases (10.9%) the presence of a deep vein thrombosis of the lower limb. This was the most frequent post-operative complication, along with seven cases of congestive heart failure (10.9%) and five cases of pneumonia (7.8%) treated with intravenous antibiotics. Moreover, in three patients (4.7%) occurred implant aseptic loosening, in two cases (3.1%) an implant prosthetic infection and in one patient (1.6%) a THA posterior dislocation during the follow up. These six patients required an additional treatment and implant revision. Post-operative data are reported in Table 2.

The median Oxford Post-Surgery Score was 32 (IQR, 19-40; SD +- 12.07) and the median of Barthel Post Surgery Score was 77.5 (IQR, 46.25-90; SD +-26.6). (Table 2).

Results of the univariable analyses between pre-operative, operative and post-operative data in relation to the type of treatment, reduction and synthesis or prosthetic revision are reported in the Table 3. Pre-operative, operative and post-operative features, like gender ($p=0.474$), side ($p=0.162$), blood transfusion ($p=0.538$) and using of cerclages ($p=0.717$) were not significantly associated with the type of treatment. As well, the incidence of post-operative complications, deep vein thrombosis, vascular damage, non-unions or consolidation delay and infections, does not statistically significantly correlate with the surgical treatment performed ($p=0.936$), ORIF vs. RA (Table 3). Nominal univariable analyses resulted in significant differences between the post-operative and pre-operative Oxford Hip Score with the type of treatment ($p=0.008$) and with the CIRS score ($p=0.048$); other univariable analyses did not give significant results (Table 3). Moreover, the relationship between the type of treatment and the type of fractures was highly highlighted extremely strong ($p=0.0001$).

MANOVA with post hoc analysis showed a significant difference according to D Oxford between patients undergoing reduction and synthesis or prosthesis revision ($p=0.042$).

At multivariable analysis, after adjusting for age, preoperative Barthel and type of fracture assessed by Duncan classification, the CIRS score was independently associated with Oxford Score improvement after surgery ($p=0.024$), while type of treatment was not.

Discussion

The treatment of periprosthetic femoral fractures (PPFx) is really challenging for orthopaedic surgeon. These fractures require often senior surgeons with competence both in ORIF and RA. Also the patients

itself are challenging for usually present severe comorbidities (12)(13). The treatment of PPFx has been associated with high risk of failure, poor outcomes and worst survival outcome compared to general population at one year and this item persists for five-eight years after surgery (8)(14).

The treatment goals are restoring stem stability and limb alignment, recovery of pre-fracture functional mobility and early mobilization. In B1 and C fracture types advocated standard treatment is ORIF, but in older patients it could be demanding due to weakened bone quality and potential bone loss (6)(15). Recommended treatment of B2 and B3 fractures is femoral stem revision, eventually reinforced with plating or isolated cerclage wires, using long stems with diaphyseal fixation to achieve a more stable construct. (1)(16)

In this study, a strong statistic correlation was found between the type of fracture, according to UCS Periprosthetic Fractures classification, and the surgical treatment used, conforming the main indications of treatment.

Authors evaluated the clinical outcome based on difference of Oxford Score post and pre-surgery, after RA compared to ORIF of the periprosthetic fractures. The univariate analysis showed a better clinical post-operative outcome of patients treated with prosthetic revision (B2) instead of those treated with ORIF (B1 or C); these data disagree with current literature that did not demonstrated a different functional outcome depending on treatment modality (17). To better address this topic, we performed a statistical analysis between functional outcome of ORIF in B1 or C fracture cases, with relatively similar groups, and found no significant differences ($p = 0,143$). Therefore, RA better outcomes are not related to abnormal indications to ORIF but relates to better functional postoperative status of patients treated with revision stems, underlying that revision, when indicated, can predict a better outcome in these fragile patients. These results are not completely aligned to literature data but are not related to ORIF technique or stem stability. (18)

Although the functional outcome is closely related with the type of surgical treatment, the multivariable analysis of this study reveals also that is influenced by the patient's age, pre-operative Barthel Score and the CIRS score.

The level of clinical outcome, based on the Delta Oxford Score (post- and pre-operative), has a statistical relation with CIRS score, even if this correlation is not linear. The CIRS score is a questionnaire based on the various comorbidities of the patient that have a different influence on the post-operative rehabilitation and functional outcome, such as the respiratory disease compared to gastrointestinal disorders, but they all result in the same score. Consequently, Authors recorded different Delta Oxford Score in patients with same CIRS score. The association between CIRS score and Delta Oxford score is also related to the age, pre-operative Barthel score and type of fractures but does not correlate with the surgical treatment.

In literature data survival after PPFx is worse than any other cause of revision THA, like infection, aseptic loosening and dislocation. Cnudde et al (8) found that survival in the repeated surgery after THA is influenced by the reason for re-operation, and PPFx have a five-year survival rate of 54%, worse than the

rates of RA for different complications. (19) Young et al. (20) analysed the functional outcome of revision for periprosthetic fractures and found that patients had poorer outcome and higher death rates compared to those undergoing revision THA for aseptic loosening. On the same side Young underline also the lower mortality rate in patient who had been operated by experienced surgeons and at larger centers.

According to literature, the patient mortality rates at one year remain high (13–17%) despite improvements in surgical and fixation techniques (15)(21). However, Bhattacharyya et al. (22) reported that one year mortality rate in patients treated for type B fractures with internal fixation was 33% while those treated with femoral stem revision experienced a 12% mortality rate. Tucker et al reported that Vancouver classification is an accurate system to choose the surgical treatment but is not correlated with the 12 months mortality rates, nor was the length of surgical procedure (23).

Stoffel et al. (18) compared the functional outcomes of patients undergoing ORIF or RA in Vancouver type B2 and B3 PPFx. Their study highlighted that ORIF could be a viable treatment option considering the type of prosthetic stem, anatomical reduction of fracture and intact cement mantle.

Conclusions

This retrospective study collects a large series of patients treated in a single high-volume center both for trauma and arthroplasty surgeries. Every case was treated by a senior surgeon with large experience both in RA and ORIF. Authors did not find differences between internal fixation and revision arthroplasty in terms of blood loss and reported how the RA revision has a better functional outcome in B2 type of fractures than the B1 or C, but the chosen treatment needs to be related to surgeon's experience and the patient's compliance. In accordance with our study, it underlines the importance of suitable surgical treatment in relation to the type of fracture and it opens new considerations regarding new surgical options compared to the usual treatment algorithm.

The limits of this study are the retrospective form, but it demonstrated some noteworthy data deserving a prospective study. Our results are also influenced by being collected from a single department, both in negative and positive means. Decision making was always reviewed by collegial meeting and choice of treatment was constant throughout the period of study.

List Of Abbreviations

Periprosthetic femoral fractures in Total Hip Arthroplasty (THA)

Unified Classification System (UCS)

Cumulative illness rating scale (CIRS)

Periprosthetic femoral fractures (PPFx)

Open reduction and internal fixation (ORIF)

Revision arthroplasty (RA)

Interquartile ranges (IQR)

Declarations

Ethical approval and consent to participate: This study was approved by our institutional review board; Informed consent was obtained from all patients for being included in the study.

Consent for publication: Informed consent was obtained from all patients for being included in the study.

Availability of data and materials: the datasets generated and/or analyzed during the current study are not publicly available due but are available from the corresponding author on reasonable request, because there are presents private data of the patients.

Competing interests: The authors declare that they have no conflict of interest. Not applicable.

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Author's contributions: GS, DB, LZ and PdB as designers of the study.

GS, DB, LA, FdM for acquisition, analysis and intepretation of data. GS, DB, RB e PdB as revisors of the study.

All Authors have read and approved the manuscript.

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Tables

Table 1. Pre-operative data of patients.

Preoperative Features		
Gender, n. (%)	Male	15 (21,4%)
	Female	55 (78,6%)
Age, median (IQR)		90 (83 – 96)
Side, n. (%)	Right	29 (41,4%)
	Left	41 (58,6%)
Oxford Score Pre-Surgery, median (IQR)		36 (22 – 43)
Barthel Score Pre- Surgery, median (IQR)		87,5 (65- 100)
CIRS Scale, median (IQR)		8 (5-11)
Duncan Classification UCS, n. (%)	B1 (%)	13 (18,6%)
	B2 (%)	32 (45,7%)
	B3 (%)	3 (4,3%)
	C (%)	22 (31,4%)

Table 2. Operative and Post-operative data of patients.

Peri- operative features		
Type of Surgery, n. (%)	Reduction and Synthesis (%)	45 (64,3%)
	Prosthetic revision (%)	25 (35,7%)
Cerclages, n. (%)	Yes (%)	51 (72,9%)
	No (%)	19 (27,1%)

Post- operative features		
Post-operative complications, n. (%)	Absent (%)	39 (60,9%)
	Deep Venous Thrombosis (%)	7 (10,9%)
	Aseptic loosening (%)	3 (4,7%)
	Dislocations (%)	1 (1,6 %)
	Pneumonia (%)	5 (7,8%)
	Vascular injury (%)	7 (10,9%)
	Infection (%)	2 (3,1%)
Blood Transfusion, n. (%)	Yes (%)	40 (62,5%)
	No (%)	24 (37,5%)
Oxford Score Post-Surgery, median (IQR)		32 (19,75 – 40,25)
Barthel Score Post-Surgery, median (IQR)		77,50 (46,25- 90)

Table 3. Univariable statistical analyses on patients' data.

		Reduction and Synthesis	Prosthetic Revision	p value
Pre -operative Features				
· Gender, n	Female	34	21	0,474
	Male	5	10	
· Side, n	Right	15	14	0,162
	Left	30	11	
Peri-operative and Post- operative Features				
· Cerclages, n.	Yes	33	18	0,717
	No	13	7	
· Blood Transfusion, n.	Yes	27	13	0,538
	No	13	8	
	Present	19	2	
· Post-operative complications	Yes	20	13	0,936
	No	25	12	
· Post-operative and Pre-operative Oxford (D Oxford)				0,008
· Duncan Classification				0,0001
Post- Operative and Pre-operative Oxford Hip <u>score</u>				
CIRS SCORE				0,048

Figures

Figure 1

Periprosthetic femoral fracture with stem mobilization.

Figure 2

Distal stem periprosthetic femoral fracture.

Figure 3

open reduction and internal fixation with plate.

Figure 4

Revision arthroplasty.