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ORIGINAL PAPER

Prevalence and risk factors for intra-operative periprosthetic fractures in one thousand eight hundred and seventy two patients undergoing total hip arthroplasty: a cross-sectional study

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Abstract
Purpose The purpose of this study was to identify the frequency and type of intra-operative periprosthetic fractures and to describe risk factors in a single tertiary, public hospital, so that these events could be prevented, even among less experienced surgeons.
Methods This is a cross-sectional study, based on medical records and imaging exams from the archives of a public, tertiary hospital, from April 1998 to October 2013. All consecutive patients submitted to total hip arthroplasty (THA) in the study period were evaluated, excluding unipolar or bipolar arthroplasty, surgery for the osteosynthesis of periprosthetic fractures, surgical procedure to clean infection site without component substitution and not arthroplastic surgery. Data were analyzed with chi-squared test and multivariate Cox regression.
Results In the study period, 1,872 THA (1,728 patients) were performed and analyzed, with 144 bilateral cases. In 173 cases, patients had undergone surgical procedures other than THA previously, and in only 260 the surgery consisted of revision THA. There were only two cases of resection THA. Among all patients 101 intra-operative periprosthetic fractures occurred. The univariate analysis revealed a significantly higher risk of intra-operative fractures in female patients, aged more than 65 years, with indication of primary THA and the presence of a previous hip surgery. It indicated also that revision surgeries were associated with a 2.8-fold higher risk of intra-operative fracture, 2.18-fold risk in a previously operated hip and 3.9-fold in cases of resection THA or revision surgery in two stages.
Conclusions Intraoperative periprosthetic fracture is a rare event, and it is associated with revision type surgery and THA in a previously operated hip.

Keywords Periprosthetic fractures · Risk factors · Arthroplasty · Replacement · Hip · Hip prosthesis · Hip fractures

Introduction

Total hip arthroplasty (THA) is an efficient, long-lasting and safe solution for pain and movement restrictions. It was previously restricted to a group of patients, especially the elderly with arthrosis, but clinical success widened the spectrum of individuals who benefit from the procedure, including young patients that require future revisions. Complications are rare, but can compromise function, satisfaction and the prosthesis longevity [1–3]. With population ageing, a larger number of primary and revision THA is expected [4], and consequently the complications of these procedures [5].

Post-operative periprosthetic (femoral and acetabular) fractures are rare, with the literature pointing to an elevation of the number of events with the increase in the number of procedures [4], and treatment of post-operative periprosthetic fractures and prognosis are already defined [6]. However, little is known about intra-operative periprosthetic fractures and their consequences [7, 8].

The objective of the present study was to identify the frequency and type of intra-operative periprosthetic fractures and to describe risk factors in a single tertiary, public hospital, so

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that these events can be prevented even among less experienced surgeons.

Materials and methods

This is a cross-sectional study, based on medical records and imaging exams from archives of a public tertiary hospital, a referral centre for orthopaedics in a large city of Brazil. This study followed all Helsinki Declaration guidelines, and informed consent was obtained from patients for surgical procedures and inclusion of data in studies. Analysis by the Ethics Committee was waived, since this was a retrospective study based on archival material, with no current contact with patients whatsoever. The period of study was April 1998 to October 2013.

All patients submitted to primary or revision THA, component revision or resection arthroplasties in the study period were included in this analysis, but the following cases were excluded: unipolar or bipolar arthroplasty, surgery for the osteosynthesis of periprosthetic fractures, surgical procedure to clean infection site without component substitution and not arthroplastic surgery.

The variables analysed were sex, age, operated size, indication for primary THA, previous surgeries, type of THA (primary, revision or arthroplastic resection), type of fixation (cemented or not) and type of implant. Surgical findings and technical details noted in the medical charts were also recorded. The primary outcome was the occurrence of accidents during surgery (intraoperative incidents), with the number of fractures registered for analysis. Problems such as infections of intra-operative nerve or vascular lesions were excluded. The type of fracture was a secondary outcome.

Statistical analysis was performed considering the number of surgical procedures, and not the number of patients, because many patients underwent more than one or even more than two procedures. Chi-squared test was used to identify the factors associated with risk for intra-operative periprosthetic fractures, and multivariate logistic regression analysis was also used, considering $p<0.05$ as a significant value, 0.05 hazard ration and 95 % confidence intervals. Univariate and Cox univariate regression were used to analyzed the risk factors (the variable of interest) [9] with the outcome (intra-operative fracture), progressing to adjusted Cox multivariate analysis when $p<0.05$. Microsoft SSP 500 software was used in the analysis.

Results

During the study period in our reference centre 1,872 THA from 1,728 patients were performed and analysed. The right side in 1,001 and the left in 871. Among the patients, 144 cases were bilateral, and three patients underwent three surgeries each.

In 173 cases, the surgeries were THA in patients with other previous surgical procedures other than THA, with only 260 consisting of revision THA cases. There were only two cases of resection arthroplasty.

Gender distribution was 42.6 % male and 57.4 % female. Other demographic and clinical data are described in Figs. 1 and 2. The age range was from 12 to 97 years old, so for better analysis patients were divided in two groups: below and above 65 years.

We observe 101 intra-operative periprosthetic fractures in 101 patients. Acetabular and femoral implants used in THA were classified as with or without cement.

The risk factors were gathered to become a more consistent group for new statistical univariate analysis. A strong association was observed with sex, age, indication of the primary surgery, previous surgery and the type of surgery. The data with relevant risk factors are compiled in Table 1.

No difference was observed between cemented or uncemented implants in fractures, nor with specific types of stems (Table 2).

The univariate analysis revealed a significantly higher risk of intra-operative fractures in female patients, aged more than 65 years, with indication of primary THA and with the history of a previous hip surgery, but at multivariate analysis, type of surgery was more relevant than the other variables. It indicated also that revision surgeries were associated with a 2.8-fold higher risk of intraoperative fracture, 2.18-fold risk in a previously operated hip and 3.9-fold in cases of resection THA or revision surgery in two stages (Table 3).

Discussion

Due to the high complication and morbi-mortality rates associated with intra-operative periprosthetic fractures [10], and considering the expected increase in the number of these incidents, it is necessary to study the risk factors in order to prevent or minimize the number of fractures. Periprosthetic fractures can be classified into intra-operative and post-operative. Post-operative fractures can be further divided into early or late events. The early post-operative periprosthetic fractures are identified immediately after surgery in imaging exams; they are stable, have a minimum deviation and few complications. They are in fact intra-operative fractures that were not diagnosed during surgery [11]. Late fractures occur years after THA and are secondary to trauma events or associated with osteolysis or component loosening [12].

Post-operative periprosthetic fractures are frequent with non-cemented prosthesis, especially in cases of early fractures [13–17]. However, scarce literature is available concerning intra-operative periprosthetic fractures.

PREVIOUS SURGERY	NO	TYPE OF SURGERY	R>4	INDICATION	FEMORAL NECK FRACTURE
	OSTEOSYNTHESIS		R1		PRIMARY ARTHROSIS
	THA		R2		AVASCULAR NECROSIS
	FEMORAL OSTEOTOMY		R3		SEQUELAE OF PERTHES
	PARTIAL ARTHROPLASTY		R4		SEQUELAE OF SCFE
	TREATMENT OF PERIPROSTHETIC FRATURE		THA		ANKYLOSING SPONDYLITIS
	OTHERS		PSB THA		ACETABULAR DYSPLASIA
	RESURFACING		R 2TIMES		ACETABULAR FRACTURE
	PELVIC OSTEOTOMY		GIRLDESTONE		SYSTEMIC LUPUS ERYTHEMATOSUS

	RHEUMATOID ARTHRITIS
	OTHERS
	SEQUELAE OF PIOARTHRITIS
	EPIPHISEAL DYSPLASIA
	FEMORAL ACETABULAR IMPINGEMENT
	TRANSTROCHANTERIC FRACTURE

LEGEND: R1: FIRST REVISION; R2: SECOND REVISION; R3: THIRD REVISION; R4: FOURTH REVISION; R>4: MORE THAN FOUR REVISIONS; THA: TOTAL HIP REPLACEMENT; PSB THA: PREVIOUS SURGERY (NOT A ARTHROPLASTY) BEFORE THA ; R 2TIMES: REVISION IN TWO TIMES; INDICATION: INDICATION OF FIRST SURGERY .

Fig. 1 Demographic data: previous surgery, type of surgery and surgery indication

The prevalence of intra-operative periprosthetic fractures in our centre was 5.39 %, in accordance with the prevalence reported in the literature, which varies from 0.1 to 27.8 % (0.3–18 % in primary and 0.3–17.6 % in revision THA) [13]. It was not possible to investigate, in our study, the already evidenced cementless periprosthetic fractures [14], because most patients in our centre had been treated with cemented implants.

Exeter Stem is our most common prosthesis (1,852 cases), either for primary or for revision, and although there are studies indicating the Exeter prosthesis can be associated with periprosthetic post-operative fractures [15] (with the wedge shape implicated in fractures after trauma), we could not find significant associations of intra-operative fractures with this type of prosthesis. Maybe the earlier cases in our centre were due to the lack of experience of our team with posterior approach for the prosthesis implantation.

Female sex is identified as a risk factor in many studies [13, 16, 18]. Nowak et al. [7] explain that the finding of the female sex as a risk factor for periprosthetic fractures is probably due to the fact the women were the majority of their patients (68 %). In our sample, however, women comprised 57.4 % of patients. Probably the higher risk of intra-operative fractures in our female patients, aged more than 65 years, was due to osteoporosis secondary to menopause. In fact, femoral neck fractures and developmental hip dysplasia are relevant risk factors for a THA indication [2, 13]. Femoral neck fractures are a predisposing factor to periprosthetic fracture after THA, increasing the risk by 4.4-fold [19]. They are a frequent event among older women, and this might explain our finding of significantly higher risk of intra-operative fractures in female patients, aged more than 65 years.

In the study by Nowak et al. [7], young patients were more susceptible to fractures, and the authors suggest that these were sequelae of childhood and adolescence diseases that change bone morphology. Besides, in that study, many patients had previous hip surgery. In contrast, in our study, the higher risk for periprosthetic fractures was concentrated in patients above 65 years. In these patients, the incidence was similar for primary and revision THA, while in the literature, there is much controversy about the type of surgery [13] or patient age [18, 20, 21]. A previous surgery, which modifies anatomy, can make it difficult to find the femoral canal and its drilling, and also cause areas of weakness during implant removal that may cause fractures. Post-operative fibrosis also complicates the limb positioning and luxation and reduction

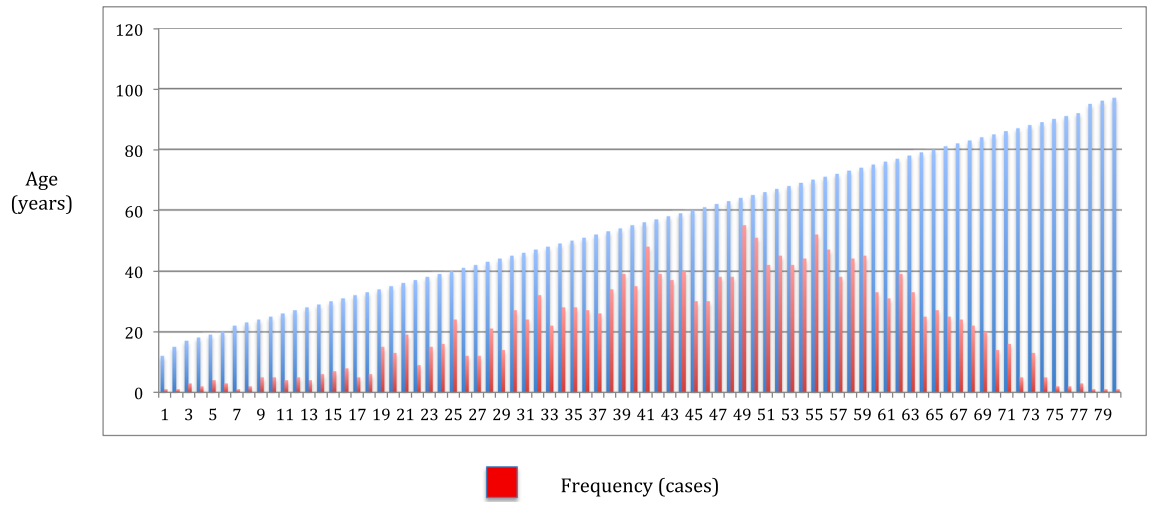

Fig. 2 Frequency of the cases according to age

Table 1 Univariable analysis for positive fractures

Variable			Intra-operative fracture		
			No	Yes	Total
Gender	Male	Count	760	37	797
		%	95.4 %	4.6 %	100.0 %
	Female	Count	1007	68	1075
		%	93.7 %	6.3 %	100.0 %
Age	>65	Count	693	48	741
		%	93.5 %	6.5 %	100.0 %
	<65	Count	925	45	970
		%	95.4 %	4.6 %	100.0 %
Primary surgical indication	Neck fracture	Count	186	20	206
		%	90.3 %	9.7 %	100.0 %
	Arthrosis	Count	1046	45	1091
		%	95.9 %	4.1 %	100.0 %
	AVN	Count	197	11	208
		%	94.7 %	5.3 %	100.0 %
	DDH	Count	83	7	90
		%	92.2 %	7.8 %	100.0 %
	Others	Count	85	3	88
		%	96.6 %	3.4 %	100.0 %
	Secondary arthrosis	Count	174	15	189
		%	92.1 %	7.9 %	100.0 %
Previous surgery	No	Count	1321	61	1382
		%	95.6 %	4.4 %	100.0 %
	Yes	Count	446	44	490
		%	91.0 %	9.0 %	100.0 %
Type of surgery	THA	Count	1381	56	1437
		%	96.1 %	3.9 %	100.0 %
	Revision	Count	227	28	255
		%	89.0 %	11.0 %	100.0 %
	PSB THA	Count	157	16	173
		%	90.8 %	9.2 %	100.0 %
	OUTHERS	Count	6	1	7
		%	85.7 %	14.3 %	100.0 %

PSB THA previous surgery (not arthroplasty) before total hip arthroplasty (THA)

manoeuver [17]. None of these studies, however, addressed intra-operative fractures specifically.

Type of surgery was a relevant risk factor for fracture in this study. The risk for intra-operative periprosthetic fracture was almost three times higher in revision surgery, and two times when the patient had a history of hip surgery (other than THA). Also it was nearly four times higher in two-staged surgery and resection THA. In the latter case, the most logical explanation is infection, whether associated or not to osteoporosis due to disuse osteoporosis, or large osteolysis preventing implants insertion. Bone fragility can cause periprosthetic fractures, as shown by the literature [7].

Table 2 Implants

Fixation			Acetabular fracture		
			No	Yes	Total
Acetabular fixation	Cemented	Count	1,376	86	1,462
		%	94.10 %	5.90 %	100.00 %
	Uncemented	Count	395	15	410
		%	96.30 %	3.70 %	100.00 %
			Femoral fracture		
			No	Yes	Total
Femoral fixation	Cemented	Count	1,757	94	1,851
		%	94.90 %	5.10 %	100 %
	Uncemented	Count	14	2	16
		%	87.50 %	12.50 %	100 %

There are three limitations of this study that should be pointed out: first, the difficulty in comparing cemented versus cementless prosthesis due to the low number of cementless implants and great variety of implant types in our sample; also, the impossibility to identify the exact moment of fracture—if during components removal, drilling, component insertion, luxation or reduction. It was not possible, thus, to identify possible technical errors that could lead to fracture. It was not possible either to analyse the types of revision and the osteolysis or loosening grade.

However, the strengths of our study must also be highlighted: the evaluation of intra-operative fractures in a large sample, and among patients with cemented prostheses and revision surgeries with impacted bone graft, which knowingly is a risk factor for periprosthetic fractures, especially when a short implant is used [22–24].

Conclusions

Intra-operative periprosthetic fracture is a rare event and yet female sex, elderly age, previous surgery and indication of the first surgery are relevant risk factors for it. The type of procedure is the main variable associated with revision type surgery

Table 3 Odds ratio

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Type of surgery			20,860	3	0.000	
Revision	1062	0.251	17,871	1	0.000	2893
Previous THA	0.783	0.313	6263	1	0.012	2189
Others	1383	1089	1612	1	0.204	3987
Constant	−3175	0.142	503,111	1	0.000	0.042

THA total hip arthroplasty

Variable(s) entered on step 1: type of surgery

(2.8-fold increased risk) and THA in a previously operated hip (2.18-fold increased risk).

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