Open Journal of Orthopedics, 2014, 4, 70-76
Published Online March 2014 in SciRes. http://www.scirp.org/journal/ojo
http://dx.doi.org/10.4236/ojo.2014.43012

Scientific Research

Intraoperative Fracture of the Femur in Revision Total Hip Arthroplasty with a Fully HA-Coated Stem

David E. Rothem[1,2,3*], Lilah Rothem[1], Alexander Lerner[2,3], Tal Salamon[2,3], Richard Hiscock[1], Neil Bergman[1]

[1]Warringal Private Hospital, Heidelberg, Australia
[2]Ziv Medical Center, Zefad, Israel
[3]Faculty of Medicine in the Galilee, Bar-Ilan University, Ramat Gan, Israel
Email: [*]davidrothem@gmail.com

Received 9 February 2014; revised 10 March 2014; accepted 17 March 2014

Abstract

A retrospective review was made of intraoperative femoral fracture prevalence in seventy nine consecutive, cementless, fully HA-coated stems used for revision hip arthroplasty. Three patients were lost to follow up. Intraoperative fracture occurred in 15 (20%) femurs. Fractures occurred during cement removal (3/15) or insertion of the implant (12/15). All fractures were identified using intraoperative biplane X-ray, and were treated during the same operation. The clinical outcome of both groups (with or without fractures) was similar. The risk of intraoperative fracture was not statistically related to any demographic features or operative technique. Intraoperative radiographs are therefore mandatory in revision hip arthroplasty in order to diagnose and treat the common complication of femur fracture appropriately.

Keywords

Revision Hip Arthroplasty; Intraoperative Fracture; Fully Coated HA Stem; Femoral Periprosthetic Fracture

1. Introduction

The increased number of total hip replacements performed during the last two decades has inevitably made revision surgery more common. Revision hip arthroplasty has a higher rate of complication than primary surgery [1].

[*]Corresponding author.

How to cite this paper: Rothem, D.E., Rothem, L., Lerner, A., Salamon, T., Hiscock, R. and Bergman, N. (2014) Intraoperative Fracture of the Femur in Revision Total Hip Arthroplasty with a Fully HA-Coated Stem. *Open Journal of Orthopedics*, **4**, 70-76. http://dx.doi.org/10.4236/ojo.2014.43012

Femoral reconstruction can be extremely challenging. The goal in femoral reconstruction during revision hip arthroplasty is to achieve good implant fixation despite bone defects, poor bone quality and variable canal size. In order to overcome these obstacles for fixation, several options are available. This includes modular stems and bodies with a variety of lengths and diameters, degree and type of coating, plus geometries of the stem. Intraoperative fracture during revision hip arthroplasty is a well-recognized complication. Contributing patient features and technical factors has been identified [2]-[8]. The incidence of intraoperative fracture, using cementless revision implants, is 1% to 46% (**Table 1**) [9]-[15].

The aim of this study was to assess the prevalence of intraoperative femur fracture using a cementless fully coated HA stem utilizing intraoperative radiographs taken in two planes after insertion of the stem. Additionally, we retrospectively reviewed the patients' chart and radiographs in order to correlate risk factors associated with intraoperative fractures and the effect of the fracture on the outcomes.

2. Material and Methods

79 consecutive revision hip arthroplasties in which an uncemented stem was used in 70 patients, performed between October 1995 and August 2009, were reviewed. In each case the Restoration Hip Stem (Stryker, Mahwah, NJ), was implanted. The cylindrical plasma HA fully coated stem was used. Three patients were excluded as they were lost to follow-up or their radiographs were not available, leaving 67 patients with 76 hips in the study group. 69 stems, 91%, were straight. 7 stems (9%) were bowed. Forty four out of 76 (58%) revision hip arthroplasties received non-modular Restoration stems and 34 (42%) received modular Restoration stems. All cases were performed by the senior author at one institution (Warringal Private Hospital, Heidelberg, Australia) (**Table 2**). The 76 revision hip arthroplasties were in 67 patients (34 female, 33 male). The mean follow-up time was 6.3 years (range of 1.8 - 15.2 years). All cases were included to determine the prevalence of an intraoperative fracture.

The indication for femoral revision was aseptic loosening in 60 hips, second stage reimplantation for infection in 10 hips, non-union or malunion of an intertrochanteric fracture in 3 hips, periprosthetic fracture in 2 hips and short leg post primary hip arthroplasty in 1 hip (**Table 2**). There was a mean of 1.3 previous surgeries (range 1 - 5) (**Table 2**). Forty of the stems revised were cemented, 33 were uncemented stems and 3 required removal of a sliding hip screw (**Table 2**). All Cases were templated preoperatively to determine the stem diameter that would achieve the best fit. The final stem diameter was decided during canal preparation. A posterolateral approach without femoral osteotomy was used in 26 hips, and in 50 hips a femoral osteotomy was incorporated to facilitate removal of the stem and cement. The femoral canals were under-reamed by 0.5 mm.

Patient charts and postoperative radiographs were reviewed by an independent observer (D.R.) who did not participate in any of the operative procedures.

Descriptive data is presented as mean (SD), median [25^{th} - 75^{th} percentile] or count (%), according to type & distribution. Eight covariates were transformed prior to regression modeling, with the baseline for BMI set at 20 $kg \cdot m^{-2}$ whilst age, blood loss, surgical time, intramedullary reaming diameter, stem diameter, length and shape were set at their respective means or values close to the mean. The unit of change for odds ratio is as presented except for age (5 year), BMI (5 unit), blood loss (250 ml) and surgical time (60 minutes). Whilst improving model stability and allowing meaningful interpretation of regression coefficients, these transformations do not

Table 1. Prevalence of intraoperative fracture.

Author	Hips	Intraoperative Fractures	Stem Type
Egan *et al*. [7]	135	27 (20%)	Fully porous-coated straight stem
Malkani *et al*. [12]	175	34 (46%)	Proximally coated, bowed long stem
Paprosky *et al*. [18]	170	15 (9%)	Fully porous-coated straight stem
Zalzal *et al*. [19]	45	7 (17.5%)	Straight, 205-mm fully coated
Meek *et al*. [20]	211	64 (30%)	Fully porous-coated stem (135 bowed, 76 straight)
Chappell *et al*. [21]	54	8 (15%)	Fully porous-coated stem (50 bowed, 4 straight)
Present study	76	15 (20%)	Cylindrical plasma HA fully coated (7 bowed, 69 straight)

Table 2. Patient demographics and preoperative data.

Patient Demographics (Patient No. = 67, Hips No. = 76)	Number of Patients or Average (Range)
Age (Years)	72 (20 - 91)
Gender	
Male	33
Female	34
BMI (kg/m^2)	29.8 (20.3 - 42.8)
Diagnosis	
Aseptic Loosening	60
Infected Total Hip	10
Non-Union and/or Malunion of Intertrochanteric Fracture	3
Periprosthetic Fracture	2
Short Leg Post THR	1
Previous Surgeries	1.3 (1 - 5)
Revised Stem Type (Cemented/Cementless/DHS)	40/33/3
Follow Up (Years)	6.3 (1.8 - 15.2)

change statistical inference. For the dichotomous variables stem length, stem shape and stem type the categories are 167 mm/205 mm, straight/bowed and HA modular/HA non-modular respectively.

Univariable logistic regression was used to assess association between intraoperative femoral fracture and measured covariates. Multivariable logistic regression was then performed and included all covariates where likelihood ratio chi-squared in the univariable logistic regression had p-values ≤ 0.2. Regression diagnostics were performed. Significance level was set at 0.05. Analysis was performed using Stata v11 software (StataCorp. 2009. Stata Statistical Software: Release 11. College Station, TX: StataCorp LP).

3. Results

The prevalence of intraoperative fracture of the femur was fifteen (20%) of the seventy-six femoral component revisions. The remaining sixty-one (80%) had no fracture (control group). There was no significant differences in age (p = 0.89), gender (p = 0.95), BMI (p = 0.18), previous surgeries (p = 0.26), revised stem type (p = 0.99) (**Table 2**). Likewise, unvariable logistic regression of operative data variables (*i.e.* operation time, blood loss, approach) (**Table 3**) against the occurrence of femoral fracture was performed with the odds ratio and associated p-value. No statistical significance was found. In addition, there was no association among the prevalence of fracture and intraoperative reaming diameter, stem size, diameter or length (p > 0.1) (**Tables 3** and **4**).

There was no significant difference in fracture rate between the bowed and straight stems: 4 (7%) of the 61 stems were bowed in the control group compared with 3 (20%) of the 15 stems were bowed in the intraoperative fracture group (p = 0.12) (**Table 4**). A posterior approach was used in all 76 revision hip arthroplasties with or without osteotomy, neither approach was found to be associated with an intraoperative fracture (p = 0.20) (**Table 4**). There was no significant association between the prevalence of intraoperative fracture and preoperative diagnosis.

The most frequent intraoperative fracture occurred during insertion of the component. 12 (16%) out of 15 intraoperative fractures. Three (4%) fractures of the femur occurred during cement removal (**Table 5**). Fracture occurring during cement removal or insertion of the implant was B1, according to the Vancouver classification [16]. All the intraoperative fractures were diagnosed with an intraoperative X-ray (AP and lateral) taken immediately after the insertion of the femoral stem (**Figure 1**). Patients with an intraoperative canal perforation and/or fracture prior to stem insertion (3 out of 15 patients), were treated by allograft strut or morsellized bone and cables. However, the 12 patients with intraoperative fractures that occurred during the insertion of the compo-

Table 3. Patient demographics and preoperative data.

Parameters	Number of Patient or Average (Range or Percentage)			
	Without Femoral Fracture	Femoral Fracture	Odds Ratio* (95% CI OR)	*P*-value
Age (yrs)	73 (±12.6)	72 (±14)	0.99 (0.79 - 1.22)	0.89
Gender (male)	29 (48%)	7 (47%)	0.97 (0.31 - 3.0)	0.95
BMI (kg·m^{-2})	30 (±5.7)	28 (±4.4)	0.64 (0.33 - 1.23)	0.18
Previous Surgery				
1	49 (86%)	10 (67%)	1	0.26
2	5 (9%)	3 (20%)	2.94 [0.6 - 14.34]	NA
3	3 (5%)	2 (13%)	3.27 [0.48 - 22.15]	NA
Revised Stem Type Cementless	26 (43%)	7 (47%)	1	0.99
Cemented	32 (52%)	8 (53%)	0.93 [0.26 - 3.45]	NA
DHS	3 (5%)	0	1.04 [0.0 - 10.68]	NA

Data presented as mean (SD), median [25th - 75th percentile] or count (%). NA—Not Applicable. *Unit of change as presented except for age (5 years), BMI (5 unit).

Table 4. Operative data with or without femoral fracture.

Parameters	Intraoperative without Femoral Fracture (Hip No. 61)	Intraoperative Femoral Fracture (Hip No. 15)	Odds Ratio* (95% CI OR)	*P*-value
Operation Time (min)	281(±77)	260 (±58)	0.78 [0.48 - 1.26]	0.31
Blood Loss (cc)	1200 [800 - 1800]	1000 [700 - 1200]	0.86 [0.68 - 1.09]	0.21
Posterolateral Approach with Osteotomy	20 (33%)	6 (40%)	0.20 [0.03 - 1.18]	0.20
Posterolateral Approach without Osteotomy	41 (67%)	9 (60%)	0.40 [0.07 - 2.31]	0.20
Intramedullary Reaming Diameter	16.5 (13.5 - 22.5)	17 (14 - 19.5)	1.04 [0.80 - 1.36]	0.78
Stem Diameter	17 (14 - 23)	17 (15 - 20)	1.03 [0.79 - 1.34]	0.83
Stem length 167 mm/**205 mm****	27 (44%)/**34 (56%)**	6 (40%)/**9 (60%)**	**1.10 [0.86 - 1.40]**	**0.44**
Stem Shape Bowed/Straight	**4 (6.5%)**/57 (93.5%)	**3 (20%)**/12 (80%)	**3.56 [0.70 - 18.02]**	**0.12**
Stem Type HA modular/non-modular	**25 (43%)**/36 (57.5%)	**7 (58%)**/8 (42%)	**1.85 [0.52 - 6.51]**	**0.34**

Data presented as mean (SD), median [25th - 75th percentile] or count (%). *Unit of change as presented. **In bold-for the dichotomous variables stem length, stem shape and stem type the categories are 167 mm/205 mm, straight/bowed and HA modular/HA non-modular respectively.

nent were treated by cable reinforcement alone and allowed to weight bear as tolerated. All fractures united with good clinical outcome.

For the 61 patients without an intraoperative femoral fracture, there was improvement in the postoperative Harris hip score, from a mean of 45 preoperatively to a mean of 65 points at a minimum of 2.3 years of follow-up. Similarly, the improvement in the Harris hip score for the 15 patients with an intraoperative femoral fracture with a follow-up of 1.8 years or more was from a mean of 45 to 66 points.

Table 5. Intraoperative femoral fracture.

Hips Number	Cause of Fracture	Preoperative Diagnosis	Classification of Fracture*	Treatment	Weight Bearing	Fracture Outcome
3	Perforation during cement removal	Aseptic Loosening (3/3)	B1	Strut graft and cables	Partial weight bearing (6/52)	Union
12	Insertion of the implant	Aseptic Loosening (11/12) Infection (1/12)	B1	Cables	Weight bearing as tolerated	Union

*According to Vancouver classification.

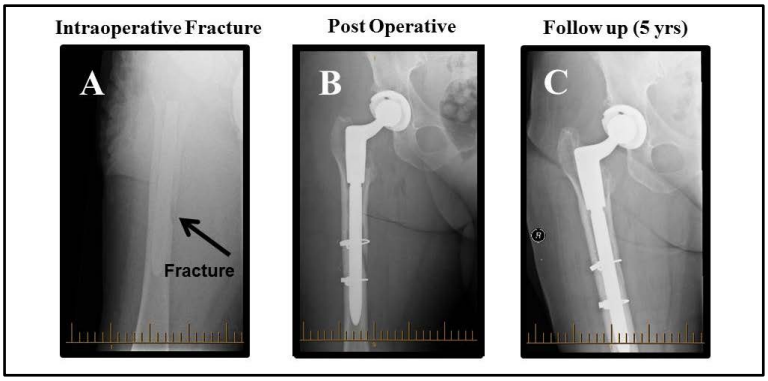

Figure 1. Radiographs of intraoperative fracture during insertion of the stem. A: Intraoperative X-ray after insertion of the stem demonstrates fracture of the femur, B: Postoperative X-ray after treatment of the femoral fracture with cables, C: X-ray after six years follow-up demonstrates united fracture.

4. Discussion

The fixation of the femoral component in revision hip arthroplasty is challenging. Recent reports reflect the common usage of cementless femoral components [10] [12] [15] [17] [18]. Previous studies demonstrated that an intraoperative fracture of the femur occurs with exposure, during cement removal, or while inserting the new femoral component [7] [9] [10] [12] [15] [17]-[19]. The most common time during revision surgery for an intraoperative fracture to occur, with cementless implants, is while obtain a tight "scratch fit" at stem insertion. The prevalence of intraoperative fracture of the femur using cementless revision implants is 1% to 46% in revision arthroplasty. The majority of studies report, however, that the incidence is less that 15% (**Table 1**) [8]-[14]. Malkani *et al*., reported the highest prevalence of intraoperative fracture of the femur with 34 out of 69 intraoperative fractures (46%) [12]. Nineteen of the fractures extended below the lesser trochanter and 15 were proximal to the lesser trochanter. Engh *et al*., reported 3 intraoperative fractures at the tip of the prosthesis out of 21 hips (15%) [13]. Paprosky *et al*., reported 8.8% intraoperative fracture occurring during 187 femoral revisions using straight fully porous-coated stems [18]. These authors stated that there is an association between stem diameter (≥18-mm) and stem length (≥205-mm) with intraoperative fracture [18]. Zalzal *et al*., reported intraoperative fracture of the distal femur in 17.5%. They suggested that a straight 205-mm, press-fit stem should be used with caution, and a bowed stem of that length should be considered [19]. Meek *et al*., showed that 30% of the patients sustained an intraoperative fracture [20]. Their results pointed that the degree of preoperative bone loss and low cortex to canal ratio are risk factors of intraoperative femoral fracture [20].

Intraoperative fractures can occur for a variety of reasons. These include poor preoperative bone quality, length of implant, perforation during cement removal, the reaming technique or during insertion of the component. In the current study we examined the association of multiple preoperative and intraoperative factors with the prevalence of intraoperative fracture. Our results demonstrated that none of the analyzed parameters reached statistical significance. This means that none of the analyzed parameters were a risk factor for intraoperative fracture. This is in contrast to previous studies.

5. Conclusion

In conclusion, the results of the current study suggest that despite preoperative templating and careful insertion of the implant, there is high prevalence of intraoperative fracture. Thus, the senior author always obtains an intraoperative radiograph without breaking sterility. Our results confirm that immediate diagnosis and treatment of the intraoperative fractures leads to the same clinical outcome as those hips without intraoperative fracture.

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