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Research Article

Risk Factor Analysis of Intraoperative Femoral Metaphyseal Fractures in Cementless Hip Hemiarthroplasty

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Abstract

To investigate the risk factors for intraoperative femoral metaphyseal fractures during primary hip hemiarthroplasty (HHA). A retrospective analysis was conducted on patients who underwent primary HHA at our hospital from February 2013 to February 2023. Patients who sustained intraoperative femoral metaphyseal fractures were included in the study group, while those without fractures were included in the control group. Patient data, including age, sex, body mass index (BMI), surgical indication, Dorr classification of the femoral canal, Singh index, and pre- and postoperative Harris scores, were analyzed to identify risk factors for intraoperative fractures. A total of 2,795 cases were followed up, of which 103 experienced intraoperative femoral metaphyseal fractures, with an incidence rate of 3.6%. The Dorr classification of the femoral canal and the Singh index were identified as risk factors for intraoperative fractures during HHA. Further multivariate logistic regression analysis showed That the Dorr classification was an independent risk factor for intraoperative femoral fractures. For patients with preoperative risk factors undergoing primary HHA, careful preoperative planning and adequate intraoperative exposure are essential to minimize the occurrence of femoral metaphyseal fractures.

Keywords

Hip Hemiarthroplasty, Intraoperative Femoral Metaphyseal Fracture, Logistic Regression Analysis

1. Introduction

With the accelerating aging of the population in China, the incidence of end-stage hip joint diseases is increasing, and problems such as joint pain and functional limitation severely impact patients' quality of life. Hip hemiarthroplasty (HHA), often referred to as "the most successful surgery of the 20th century," can effectively relieve hip pain, improve joint function, and enable patients to return to normal work and daily activities. According to statistics, the number of hip replacements in China exceeded 430,000 in 2018 and is projected to surpass That of the United States within the next decade [1]. However, along with the rising number of procedures, surgery-related complications have also increased. Among them, intraoperative femoral metaphyseal fracture is one of the most common complications during HHA [2]. Such fractures prolong operative time, increase intraoperative blood loss, negatively affect postoperative outcomes, delay ambulation, and raise hospitalization costs. This study aims to conduct a retrospective analysis of patients who underwent HHA in our hospital to evaluate the risk factors for intraoperative femoral metaphyseal fractures and provide evidence to support clinical decision-making.

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2. Materials and Methods

General Information

From February 2013 to February 2023, a total of 2,746 patients (2,795 hips) who underwent hip hemiarthroplasty (HHA) at our hospital were retrospectively analyzed using the electronic medical record system. Collected data included age, sex, body weight, height, surgical indications, Dorr classification of the femoral canal, Singh index, and preoperative and postoperative Harris scores.

3. Inclusion and Exclusion Criteria

Inclusion criteria:

1) Primary hip hemiarthroplasty;
2) Cementless prosthesis fixation;
3) Presence of intraoperative femoral metaphyseal fracture.

Exclusion criteria:

1) Hemiarthroplasty, surface hip arthroplasty, or revision HHA;
2) Cemented HHA;
3) Intraoperative fractures other thann femoral metaphyseal fracture;
4) Congenital or developmental deformities of the femur;
5) History of previous hip or femoral surgery;
6) Presence of systemic or local infection.

4. Radiological Evaluation

Standard anteroposterior X-rays of both hips were obtained preoperatively. Based on the Dorr classification system [3], the morphology of the proximal femoral canal was assessed by measuring the canal width at the level of the lesser trochanter (calcar width, CW) and 10cm distal to the lesser trochanter (femoral canal width, FW). A FW/CW ratio of 0-0.49 was classified as Dorr type A; 0.5-0.75 as Dorr type B; and 0.76-1 as Dorr type C.

According to the Singh index [4], the degree of trabecular bone resorption and the sequence of trabecular disappearance in the proximal femur were evaluated. Osteoporosis was classified into six grades, with grade 6 indicating normal bone and grade 1 indicating severe osteoporosis.

5. Surgical Technique

All procedures were performed by the same senior surgical team. After anesthesia, patients were placed in the lateral decubitus position on the contralateral side. A standard posterolateral approach was used, involving sequential dissection of the skin, subcutaneous tissue, and external rotator muscles, preserving 1cm of the femoral calcar during femoral neck osteotomy. The femoral head was removed, and the femoral canal were reamed to appropriate size and depth. Trial components were inserted for reduction and testing. Once satisfactory, final implants matching the trial size were placed. The occurrence of femoral metaphyseal fracture was assessed under direct visualization; in suspicious cases, intraoperative fluoroscopy was used to confirm the presence of fracture. All findings were documented in the electronic medical record system, and postoperative imaging provided further confirmation.

6. Statistical Analysis

Continuous variables were presented as mean ± standard deviation (MD ± SD), and comparisons between groups were performed using the t-test. Categorical variables were expressed as rates (percentages) and compared using the chi-square test. Univariate and multivariate logistic regression models were used to identify risk factors for intraoperative femoral metaphyseal fractures during HHA. A p-value < 0.05 was considered statistically significant.

7. Results

A total of 103 patients were included in the experimental group (intraoperative femoral metaphyseal fracture group), with a mean age of 70.8 years. Among them, 43 were male and 60 were female. The indications for HHA was femoral neck fracture. The control group (no intraoperative femoral fracture) included 2,692 patients. The general characteristics of both groups are shown in Table 1.

Table 1. *Comparison of Baseline Characteristics Between the Two Groups.*

Variable	Fracture Group (n=103)	Control Group (n=2692)	P-value
Age (years)	57.1 (6.8)	55.6 (7.2)	0.08
Female, n (%)	60 (58.3%)	1023 (60.1%)	0.71
Body Mass Index (BMI)	27.1 (2.3)	26.7 (2.8)	0.28
Femoral Canal Dorr Classification			
- Type A	33	442	0.17

Variable	Fracture Group (n=103)	Control Group (n=2692)	P-value
- Type B	12	139	0.21
- Type C	58	1121	0.05*
Femoral Singh Index			
- Grade 1	2	86	0.15
- Grade 2	14	154	0.06
- Grade 3	25	514	0.20
- Grade 4	31	502	0.89
- Grade 5	24	394	0.97
- Grade 6	7	52	0.03*
Preoperative Harris Score	43.2 ±7.3	42.7 ±8.7	0.83
Postoperative Harris Score	89.3 ±9.4	91.5 ±10.1	0.13

*P < 0.05, indicating statistical significance.

The overall incidence of intraoperative femoral metaphyseal fractures during HHA was 3.6% (103/2795). Univariate logistic regression analysis was performed for factors including patient age, sex, body mass index (BMI), Dorr classification of the femoral canal, and Singh index. The results showed that age, Dorr classification, and Singh index were risk factors for intraoperative fractures (see Table 2).

Table 2. *Univariate Logistic Regression Analysis of Risk Factors for Intraoperative Femoral Metaphyseal Fractures During Primary THA.*

Variable	OR	P-value
Age	1.8	0.05*
Female, n (%)	1.2	0.12
Body Mass Index (BMI)	0.5	0.23
Femoral Canal Dorr Classification	0.5	0.01*
Femoral Singh Index	2.1	0.03*

*: P<0.05

Table 3. *Multivariate Logistic Regression Analysis of Risk Factors for Intraoperative Femoral Metaphyseal Fractures During Primary THA.*

Variable	OR	P-value
Age	1.6	0.11
Femoral Canal Dorr Classification	0.6	0.03*
Femoral Singh Index	2.0	0.09

*: P<0.05

Multivariate logistic regression analysis was further conducted for age, Dorr classification, and Singh index. The results indicated that the Dorr classification of the femoral canal was an independent risk factor for intraoperative fractures (see Table 3).

8. Discussion

With the advancements in prosthesis design and materials, the use of biological-type hip hemiarthroplasty (HHA) has increased, along with a rising trend in the incidence of intraoperative femoral fractures [5]. According to literature reports, the incidence of femoral fractures during primary hip arthroplasty is approximately 5% [6]. Lamb et al. [7] conducted a 10-year clinical follow-up study and found hip arthroplasty patients who sustained intraoperative femoral fractures had a significantly higher risk of revision after primary hip arthroplasty-up to four times higher within 90 days-compared with those without fractures. Femoral fractures during HHA disrupt anatomical structures, compromise the initial stability of cementless implants, prolong hospital stay and increase financial costs. More importantly, they raise the risk of surgical failure and mortality [8]. Therefore, identifying risk factors for intraoperative femoral metaphyseal fractures during HHA is of great clinical importance, as it can help guide surgeons in minimizing these complications.

Our study showed an intraoperative femoral metaphyseal fracture rate of 3.6%, which is consistent with previously reported rates [6]. We found that age, Dorr classification of the femoral canal, and Singh index were associated with an increased risk of intraoperative fractures. These factors may interact with one another, and multivariate logistic regression analysis revealed that Dorr classification is an independent risk factor. This aligns with findings by James et al., who demonstrated that a lower Dorr ratio correlates with a higher risk of intraoperative fracture, possibly due to circumferential stress exerted on the metaphysis during implantation of larger femoral stems [9]. Although prior studies [10-12] have identified female sex as a risk factor, our results did not support this finding, potentially due to a lower proportion of elderly women (>75 years) in our cohort (125/1083, 11.5%).

The anatomy and developmental morphology of the femoral canal are closely related to the occurrence of femoral metaphyseal fractures during HHA. Preoperative evaluation of canal morphology is crucial. Our study showed that lower Dorr classifications (type C) carry a higher risk of intraoperative fracture. As the Dorr type decreases, the canal becomes more "champagne flute"-shaped, often associated with sclerotic bone and abnormal proximal femoral morphology. This can lead to excessive circumferential compressive stress during canal broaching, resulting in proximal femoral fractures. Prior studies [13, 14] have shown that prophylactic cerclage wiring of the proximal femur can reduce the risk of fracture during reaming. In a biomechanical study, Herzwurm et al. [13] demonstrated that placing a 2-mm titanium cerclage wire around the proximal femur significantly increased microstrain resistance and improved circumferential stress tolerance. Incavo et al. [14] similarly found that prophylactic wiring enhances the load-bearing capacity of proximal bone and effectively reduces the incidence of intraoperative fractures. Based on these findings, we recommend considering prophylactic cerclage wiring in high-risk patients.

For patients with identified preoperative risk factors, special attention should be paid during femoral canal preparation to cortical bone quality in the metaphysis and ensuring adequate exposure to avoid missing occult fractures. Intraoperative fluoroscopy (C-arm) may be employed for assessment. Yun et al. [15] found that 11.5% of HHA procedures involved occult fractures, highlighting the importance of awareness. In the event of metaphyseal fractures, Park et al. [16] recommended using a single wire cerclage proximal to the lesser trochanter, with a reported prosthesis survival rate of 100% at 6 years. Aasis et al. [17] reported similar results; their retrospective study showed no significant difference in prosthetic subsidence between patients with intraoperative fractures treated with cerclage and those without fractures. Thus, cerclage wiring is considered a safe, simple, and reliable technique for managing intraoperative femoral metaphyseal fractures.

This study has several limitations. First, it is a retrospective study and not a randomized controlled trial, which introduces inherent biases. Second, it is a two-center study with a limited sample size and relatively short follow-up duration, which may affect the reliability of the conclusions. Larger-scale studies with longer follow-up periods are needed to validate these findings.

9. Conclusion

In summary, the incidence of intraoperative femoral metaphyseal fractures during HHA was 3.6%. Age, Dorr classification of the femoral canal, and Singh index were identified as risk factors, and further multivariate logistic regression analysis confirmed That the Dorr classification is an independent risk factor for intraoperative femoral fractures.

Abbreviations

HHA	Hip Hemiarthroplasty
FW	Femoral Canal Width
BMI	Body Mass Index
MD ± SD	Mean ± Standard Deviation
CW	Calcar Width

Author Contributions

Haoyan Li: Investigation, Methodology, Writing - original draft, Writing - review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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