

# Clinical and functional comparison of dynamic hip screws and intramedullary nails for treating proximal femur metastases in older individuals

Hua Gao, Xiaodong Bai, Wentao Chen, Yadong Li, Liang Zhao, Changgui Liu, Zhenyu Liu, Baojun Wang

Department of Orthopaedics, Beijing Friendship Hospital, Capital Medical University, Beijing 100050, China

*Correspondence to:* Zhenyu Liu. Department of Orthopaedics, Beijing Friendship Hospital, Capital Medical University, No. 95 Yong'an Road, Xicheng District, Beijing 100050, China. Email: liuzhenyu\_orthop@163.com; Baojun Wang. Department of Orthopaedics, Beijing Friendship Hospital, Capital Medical University, No. 95 Yong'an Road, Xicheng District, Beijing 100050, China. Email: wangbaojun\_orthop@163.com.

## Abstract

**Objective:** To compare the outcomes of dynamic hip screws (DHS) and intramedullary nailing (IMN) in the treatment of extra-capsular metastatic carcinoma of the proximal femur.

**Methods:** A retrospective case analysis method was used to examine data of patients with proximal metastatic cancer of the femur who were treated with internal fixation in Department of Orthopaedics, Beijing Friendship Hospital, from January 2007 to December 2018. Blood loss, postoperative pain, functional score, length of stay, and survival rates were compared, and postoperative complications were assessed.

**Results:** Complete follow-up data were available for 33 patients. The mean follow-up period was  $12.2\pm 3.6$  (range: 9–32) months and the average age was  $72.3\pm 4.7$  (range: 59–83) years old. There were 20 females and 13 males. Twenty-three patients had undergone IMN and 10 DHS, according to bone defects and the patient's overall condition. The median survival time was 10 months in the IMN group and 11 months in the DHS group. Duration of surgery ( $t=-7.366$ ,  $P<0.001$ ) and length of hospital stay ( $t=-3.509$ ,  $P<0.001$ ) differed significantly between the two groups. There was one case of breakage of internal fixation in the IMN group.

**Conclusions:** There was no significant difference between DHS and IMN in terms of surgical efficacy. IMN and DHS were different in terms of surgical time and hospital stay. However, due to the limited number of cases in this study, multi-factor analysis has not been performed and needs to be further verified in future analysis. When developing a surgical plan, it is recommended to consider the patient's condition and the surgeon's experience.

**Keywords:** Proximal femur; bone metastatic cancer; dynamic hip screw (DHS); intramedullary nail (IMN); bone cements

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## Introduction

Bone is the third most common site of malignant tumor metastasis, after lung and liver (1). With advances in the treatment of malignant tumors, patients with cancer are surviving longer and the rates of both bone metastases and pathological fractures are therefore increasing (2). Breast cancer is the most common primary tumor causing

pathological fractures (about 60%), followed by lung cancer. Most metastases that result in pathological fractures are osteolytic (3), and osteolysis seriously affects the strength of the affected bone (4). The incidence of pathological fracture associated with metastatic bone cancer in the limbs ranges from 10% to 30%, with the proximal femur being the most common site of fractures associated

with metastases in long limb bones (1). Because of the high-intensity biomechanical load transmitted in this area, there is a high incidence of fractures of the proximal femur in older individuals. Fractures occurrence has a great impact on the patient's subsequent quality of life (5). Fifty percent of proximal pathological fractures of the femur are located in the femoral neck, 30% in the femoral subtrochanteric, and 20% in the femoral trochanter (6,7). The aims of internal fixation of pathological fractures are to reduce pain, restore function, and improve quality of life as rapidly as possible (8,9). Both intramedullary nailing (IMN) and dynamic hip screws (DHS) can achieve reliable fixation of brittle fractures of the proximal femur (10); however, there are few reports on their relative efficacy for pathological fractures of the proximal femur (11). In this study, we compared the efficacies of DHS and IMN.

## Materials and methods

### Patients

Patients who had pathological fractures of the proximal femoral underwent surgical procedures of IMN or DHS in Beijing Friendship Hospital from January 2007 to December 2018. Eligibility criteria were as follows: 1) pathological fracture of the proximal femur detected on imaging (intertrochanteric and subtrochanteric bone destruction at the fracture site, but femoral head and neck intact); 2) histopathologic diagnosis of metastatic cancer in samples from the fracture site; and 3) history of malignant tumor. Exclusion criteria were as follows: 1) no other surgical procedures performed; 2) primary tumor of the femur; or 3) life expectancy of less than 3 months. Data meeting the requirements were collected on preoperative patient characteristics and preoperative preparation. This study was approved by the Ethics Committee of Beijing Friendship Hospital and all the patients signed informed consent. The serologic examination and X-ray were taken at 1 month, 3 months, 6 months, 12 months and annually thereafter postoperatively to evaluate the clinical results and internal fixation status.

### Treatment methods

In the IMN group, curettage of the lesion under spinal or general anesthesia, intramedullary nail fixation (proximal femoral nail antirotation; Johnson & Johnson, New Brunswick, NJ, USA), and augmentation with bone cements [polymethyl methacrylic (PMMA); Depuy,

Warsaw, IN, USA] were performed. In the DHS group, the lesions were removed under spinal or general anesthesia, and hip screw internal fixation (DHS; Johnson & Johnson) with bone cements augmentation was performed. The choice of surgical method depends on the local and overall conditions of the patient and the operator's experience. Perioperative symptomatic treatment, such as blood transfusion and anti-inflammatory medications, was administered as indicated. The primary tumor was then treated with chemotherapy, hormone therapy and bisphosphonate treatment as indicated.

### Outcome measures

The main indicators of efficacy assessed in this study were visual analogue score (VAS), Harris hip score, Karnofsky performance score (KPS), survival time, survival rate, and perioperative complications. Secondary efficacy indicators included preoperative acute physiology and chronic health evaluation score (APACHE II score) (12), operation time, bleeding volume, length of hospital stay, and so on.

### Statistical analysis

The significance of correlations was analyzed with IBM SPSS Statistics (Version 22.0; IBM Corp., New York, USA). The description of the continuous data in the two groups was in the form of  $\bar{x} \pm s$ , using the *t* test; if the normal distribution was not satisfied or the variance was uneven, the description was in the form of median [interquartile range (IQR)], Wilcoxon rank sum test was used for comparison between groups. The Kaplan-Meier method was used to calculate the survival rate of the two groups. The log-rank test was used to compare the two survival curves, and the influence of covariates was corrected by Cox regression.

## Results

### Clinical and tumor characteristics

The study cohort comprised 33 patients with proximal femoral metastases who had undergone internal fixation (13 males and 20 females; age range: 59–83 years old). The average follow-up period was  $12.2 \pm 3.6$  (range: 9–32) months. There were 23 patients in the IMN group; their average age was 72.3 years old whereas the average age of the 10 patients in the DHS group was 66.6 years old (difference not significant;  $P=0.062$ ). Primary tumors

included six gastric cancers, six colorectal cancers, five liver cancers, five lung cancers, three kidney cancer, two esophageal cancers, two breast cancers, one prostate cancer, one bladder cancer, one bile duct cancer, and one fallopian tube cancer.

**Surgery-related variables**

Table 1 shows APACHE II score, operation time, bleeding volume, amount of bone cements, blood transfusion volume, VAS scores (preoperative and postoperative), Harris hip score, KPS, and length of hospital stay according to groups. There were significant differences between the two groups in gender (P=0.026), operation time (t=-7.366, P<0.001), and hospitalization time (t=-3.509, P<0.001).

**Survival data and Cox regression analysis results**

Kaplan-Meier survival curve analysis was performed, as shown in Figure 1. The one-year survival rate of the IMN group was 43.4% and of the DHS group 50.0% (P=0.554). The median survival time was 10 months in the IMN

group and 11 months in the DHS group (log-rank,  $\chi^2=0.0104$ , P=0.9198). The result of Cox regression with hazard ratio (HR) was shown in Table 2, although there factors were found statistically different between the two groups, considering the obvious positive correlation between operation time and hospitalization time (the longer the operation time, the longer the hospitalization time), and the small number of samples, we adjusted for the variables of gender and operation time, and there was no statistically significant difference in the risk of death between the two groups (P=0.8022).

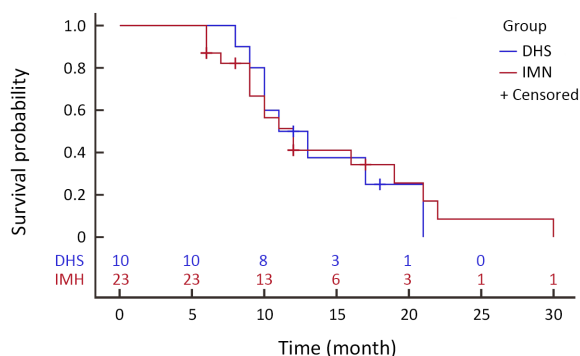
**Deaths and complications**

There were no deaths during the perioperative period in either group. In the IMN group, seven patients developed deep venous thrombosis of the lower extremities and one developed skin and soft tissue infection. In the long term, there was one breakage of internal fixation in this group. In the DHS group, venous thrombosis of the lower extremities occurred in two patients and pulmonary infection in one. There were no failures of internal fixation,

**Table 1** Clinically related data of IMN and DHS group

Variables	IMN (N=23)	DHS (N=10)	t	P
Gender (male) (n)	6	7		0.026*
Age (year) ( $\bar{x}\pm s$ )	72.3±6.9	66.6±9.5	1.937	0.062
ASA grade (n)				0.999*
I	14	7	-	-
II	8	3	-	-
III	1	0	-	-
IV	0	0	-	-
APACHE II score ( $\bar{x}\pm s$ )	12.9±2.6	14.9±2.7	-3.585	0.081
Operation time (min) ( $\bar{x}\pm s$ )	51.1±8.1	73.5±7.8	-7.366	<0.001
Amount of bleeding (mL) ( $\bar{x}\pm s$ )	524.7±60.0	556.0±55.9	-1.406	0.170*
Volume of transfusion (RBC, mL) [median (IQR)]	200 (200-400)	200 (200-400)	0.222	0.824**
Amount of bone cements (g) [median (IQR)]	40 (40-40)	40 (40-80)	-1.607	0.108**
VAS preoperation [median (IQR)]	9 (8.0-9.0)	9 (9.0-9.2)	-1.087	0.277**
VAS postoperation [median (IQR)]	3 (2.0-3.0)	3 (2.8-3.0)	-0.424	0.672**
KPS [median (IQR)]	60 (60-70)	60 (60-63)	0.883	0.377**
Harris hip score ( $\bar{x}\pm s$ )	70.8±4.2	69.7±4.7	0.686	0.498
Length of stay (d) [median (IQR)]	11 (10-16)	18 (13-20)	-3.509	<0.001**
DVT cases	7	2	0.383	0.686*

IMN, intramedullary nailing; DHS, dynamic hip screws; ASA, American Society of Anesthesiologists; APACHE, acute physiology and chronic health evaluation score; RBC, red blood cell; VAS, visual analogue score; KPS, Karnofsky performance score; DVT, deep vein thrombosis; \*, Fisher's exact test; \*\*, Wilcoxon test.



**Figure 1** Kaplan-Meier survival rate analysis of IMN (red) and DHS (blue) groups. There was no statistical significance between two groups (Log-rank test,  $\chi^2=0.0104$ ,  $P=0.9198$ ). IMN, intramedullary nailing; DHS, dynamic hip screws.

rupture, withdrawal or puncture.

As to prognosis, the 1-year survival rate and median survival time did not differ significantly between the two treatment groups.

## Discussion

The treatment strategy for proximal femoral metastatic cancer with fracture is to improve the quality of life, including achieving pain relief (13). Selection of treatment requires consideration of 1) the overall condition of the patients and how likely they will benefit from the surgery; 2) options for reducing pain caused by metastatic cancer and pathological fractures; and 3) life expectancy of patients with metastatic cancer with osteolytic destruction or defects, ability to achieve bone healing, and means of achieving internal stability (11,14,15).

Either IMN or DHS internal fixation can be selected for pathological extracapsular fractures of the proximal femur (5,16). The degree of osteolytic destruction in the bone is critical to the choice of reconstruction method. The selected treatment method must achieve stable fixation and the patient's tolerance to surgical trauma and technical expertise of the surgical team must be considered. Which of these surgical procedures is better has not yet been

conclusively determined.

### *Surgical trauma of internal fixation*

Meta-analyses have shown that there was no significant difference in trauma between the DHS and IMN. However, DHS has fewer complications than IMN in patients with non-pathological extracapsular proximal femoral fracture (17). There are some local differences between simple and pathological fractures of the proximal femur. The latter are accompanied by bone destruction and defects, which lead to greater instability at the fracture site, and abnormalities in local blood flow, such as vascular hyperplasia, tissue erosion, congestion and edema of surrounding soft tissue, and increased bleeding compared with non-pathological fractures (18). Because of the above characteristics, procedures for reduction and internal fixation differ between pathological and non-pathological fractures, the former requires minimally invasive techniques combined with bone cements reinforcement to achieve stable fixation and facilitate early resumption of normal activities and weight-bearing postoperatively.

Most pathological hip fractures are classified as unstable. The application of DHS with bone cements has been supported (19,20). When DHS or IMN is used to treat pathological fractures of the hip, trauma-related factors such as blood loss and operation time are key indicators for judging the effect of treatment. In our study, operation time was shorter in the IMN than in the DHS group (51.1 mins vs. 73.5 mins, respectively;  $P<0.001$ ); this difference is related to the steps involved in each procedure. Patients in the IMN group underwent closed reduction and insertion of the main nail for fixation, and then the lesions were scraped out and filled with bone cements. Two patients underwent only IMN for compression without cement (*Figure 2*). In contrast, in the DHS group, internal fixation was performed after the lesions had been scraped out and filled with cement, possibly accounting for the longer operation time. In this study, more bone cements were used in the DHS than in the IMN group; however, this difference was not statistically significant ( $P=0.108$ ). There

**Table 2** Analysis results of Cox regression

Variables	Parameter estimates	Standard error	$\chi^2$	P	HR (95% CI)
Group	0.18315	0.73104	0.0628	0.8022	1.201 (0.287–5.033)
Operation time	-0.00704	0.03009	0.0547	0.8151	0.993 (0.936–1.053)
Gender	0.06749	0.48523	0.0193	0.8894	1.070 (0.413–2.769)

HR, hazard ratio; 95% CI, 95% confidence interval.



**Figure 2** X-ray showed IMN in a 69-year-old female with bone metastasis of lung cancer. IMN, intramedullary nailing.

appeared to be more overt intraoperative blood loss in the DHS than in the IMN group; however, the difference was not statistically significant (556.0 mL vs. 524.7 mL,  $P=0.170$ ). According to a published report, there is more hidden blood loss during intramedullary than extramedullary fixation (21). However, there was no significant difference in overall blood transfusion volume between the two groups in the present study. Despite the lack of statistical significant differences in operation time and intraoperative blood loss between the two groups, the length of hospitalization of patients was longer in the DHS group (11 d vs. 18 d,  $P<0.001$ ). We therefore believe that the degree of trauma was slightly greater in the DHS group.

### *Surgical outcomes and complications*

As with primary bone tumor fractures (22), the primary goal of treating pathological fractures of the proximal femur is to relieve pain. Before the pathological fracture occurs, most patients have varying degrees of localized pain; this is characteristically more severe after the fracture. Bone cement increases the stability of internal fixation. Additionally, its chemical toxicity and thermal effects during polymerization can cause necrosis of nerve endings in the tumor and surrounding tissues that may have certain analgesic effects (8). In this study, the postoperative VAS was lower than before surgery in both groups; these differences were significant ( $P=0.001$  for IMN,  $P<0.001$  for DHS). Although it is difficult to distinguish cancerous pain from fracture pain, performing internal fixation with bone cements was effective in achieving control of pain in our study.

Avakian (23) *et al.* found no significant differences in terms of functional scores and length of stay between IMN and DHS for non-pathological intertrochanteric fractures. Ma (18) *et al.* conducted a meta-analysis of the outcomes of these two types of internal fixation on intertrochanteric fractures and found that the IMN group had less intraoperative blood loss and a lower rate of failure of internal fixation than the DHS group; however, the IMN group had longer radiation exposure and the DHS group more bleeding. There were no significant differences in surgical time, infection rate, incidence of pneumonia, or incidence of thrombosis between the two internal fixation methods in that study. The patients' function was also effectively improved after surgery in that study; however, Harris hip scores and KPS did not differ significantly between the two groups in our study ( $P=0.498$  and  $P=0.377$ ). There was no significant difference in preoperative APACHE scores between the two groups ( $P=0.081$ ). However, the length of stay was longer in the DHS than in the IMN group ( $P<0.001$ ). We considered that this difference was related to the longer operation time and greater amount of intraoperative bleeding in the DHS group.

Common complications of proximal femoral metastatic cancer include lower extremity venous thrombosis, soft tissue infections, and pneumonia (24). In a study by Piccioli *et al.* (25), the incidence of lower extremity venous thrombosis was 13.75% when IMN was used to treat proximal femoral metastatic cancer (average age, 61.2 years old). In our study, nine patients were found to have venous

thrombosis of the lower extremities (incidence 27.3%; average age, 72.3 years old). We attribute this difference to the older average age of our patients (26). In addition to age factors, patients with cancer reportedly have blood coagulation abnormalities, more surgical trauma, and longer time of staying in bed than those with non-pathological hip fractures, which together result in a higher incidence of lower extremity thrombosis in those with pathological fractures (27).

In this study, no failure of internal fixation occurred in the DHS group (Figure 3). A screw broke in the IMN group (Figure 4), the broken screw was an interlocking nail in the femoral head, not the main nail. Because of its thin diameter, the patient began to bear weight after surgery. The breakage occurred in the third month after surgery, however, this did not significantly affect function. The stability achieved was basically the same with both types of internal fixation combined with bone cements.

#### Survival analysis and treatment strategy

Some scholars believe that the survival rate of patients with femoral metastases is related to sex, type of primary tumor, number and location of metastases, pathological fractures, and surgical methods (28-30). In this study, Kaplan-Meier survival curve analysis was performed and showed that the

1-year survival rate was 43.4% in the IMN group and 50.0% in the DHS group ( $P=0.554$ ). Median survival times were 10 months in the IMN group and 11 months in the DHS group ( $\chi^2=0.0104$ ,  $P=0.9198$ ). Thus, these differences between the two groups are not significant. Piccioli *et al.* treated 80 patients with metastatic cancer of the proximal femur with IMN and found that the 1-year and 3-year survival rates were 40% and 15%, respectively, which are very close to the results of this study (25).

The following factors need to be considered when formulating a surgical strategy: 1) the general condition of the patient; 2) the local lesions, estimated operation time and amount of bleeding; 3) the patient's life expectancy; and 4) the timing of the operation. On the basis of our experience, we prefer DHS fixation and bone cements for patients with bone defects (axial length) greater than 5 cm and IMN compression for defects less than 3 cm. Between 3 cm and 5 cm, provided their general situation is better, we treat younger patients with DHS and bone cements and older patients with more complications with IMN and bone cements. This study is limited by the small number of cases and requires further validation.

#### Conclusions

There was no significant difference between DHS and



**Figure 3** X-ray showed DHS in a 62-year-old male with bone metastasis of clear cell carcinoma of kidney. DHS, dynamic hip screws.



**Figure 4** X-ray showed IMN in a 64-year-old male with bone metastasis of liver cancer and one breakage of an interlocking nail occurred 3 months after operation. IMN, intramedullary nailing.

IMN in terms of surgical efficacy. IMN and DHS were different in terms of surgical time and hospital stay. However, due to the limited number of cases in this study, multi-factor analysis has not been performed and needs to be further verified in future analysis. When developing a surgical plan, it is recommended to consider the patient's condition and the surgeon's experience.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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