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Original Article

Curettage of lesion combined with reconstruction of intramedullary nail and bone cement for the treatment of subtrochanteric metastatic tumors of the femur

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Abstract: This study investigated subtrochanteric femoral metastases using a retrospective approach by analyzing data from 109 patients with bone metastases (2015-2019). Surgical methods were compared: curettage with intramedullary nail and bone cement versus prosthetic reconstruction. Post-surgical assessments included joint function, bone metastasis-related serum markers, and complications. Univariate and multivariate logistic regression analysis was used to screen independent risk factors affecting patients' prognosis. R language was used to construct a nomogram model for predicting patients' 1- and 2-year survival, which was validated through ROC curves and the calibration chart. Patients treated with curettage showed superior postoperative outcomes, exhibiting significantly higher Karnofsky Performance Status (KPS) scores (80.00 *vs.* 70.00, $P < 0.001$) and Musculoskeletal Tumor Society Scores (MSTS) (23.86 ± 2.57 *vs.* 21.67 ± 3.24, $P < 0.001$). Both methods demonstrated comparable efficacy in pain control (VAS: 3.00 *vs.* 3.00, $P > 0.05$) and bone metabolism impact (ALP: 85.93 ± 14.44 *vs.* 83.19 ± 21.19; CTX-I: 3.03 ± 1.56 *vs.* 3.15 ± 1.75; PINP: 10.30 ± 4.41 *vs.* 11.57 ± 3.90; all $P > 0.05$). Cox regression identified treatment regimen, age, diabetes, and pre-treatment KPS score as significant survival factors (all $P < 0.05$). The nomogram model demonstrated high accuracy in predicting one-year and two-year survival (AUC: 0.821 and 0.790, respectively). In conclusion, curettage with intramedullary nail and bone cement enhances postoperative functional recovery and quality of life for subtrochanteric femoral metastases patients, representing a promising treatment method.

Keywords: Curettage of the lesion, intramedullary nail, bone cement, metastatic tumor in the subtrochanteric region of the femur, prognosis analysis

Introduction

Malignant tumors frequently metastasize to distant sites, with bone ranking third after lung and liver [1]. Prevalent malignant tumors in China, including lung, esophageal, breast, prostate, and liver cancers, exhibit the propensity to metastasize to bone tissues [2]. Bone metastases often give rise to complications such as pain, pathological fractures, hypercalcemia, and bone marrow compression, significantly diminishing patients' quality of life and daily functioning [3]. Consequently, there is an urgent need for effective treatments that can alleviate these bone-related complications, thereby enhancing patients' quality of life and extending their survival.

In cases of bone metastasis affecting the long bones of the limbs, the femur stands out as the most frequently affected site, accounting for approximately 65.1% of such cases [4]. About half of these femoral metastases occur in the femoral neck, and another 30% occurr in the subcapital region [5]. The subcapital region, spanning from the lesser trochanter to the nar-

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rowest part of the femoral medullary cavity, typically situated 5 cm below the lesser trochanter, bears the highest mechanical stress on the femur [6]. Osteolytic lesions commonly manifest in bone metastases, and when they occur in specific femoral regions, they may precipitate pathological fractures [7]. These fractures not only inflict severe pain and impose significant limitations on limb function but also detrimentally affect patients' quality of life and potentially reduce their life expectancy [8]. Moreover, such fractures can lead to impaired mobility and prolonged bed rest, fostering serious complications like aspiration pneumonia, pressure ulcers, and lower limb deep vein thrombosis, imposing a substantial burden on patients and their families [9].

While nonsurgical treatments may partially remove tumors, they often fail to provide adequate internal support [10]. In contrast, surgical intervention not only enables complete excision of local lesions but also offers robust support to the affected limb through internal fixation [11]. However, due to the intricate anatomy of the femoral subcapital region, surgical procedures involving lesion clearance, bone cement filling, and internal fixation using plates and screws carry a heightened risk of failure, rendering them less prevalent in clinical practice [12]. Presently, the primary surgical options for subtrochanteric metastatic femoral tumors comprise intramedullary nail reconstruction combined with bone cement filling after lesion curettage, as well as prosthetic reconstruction following tumor segment resection. There exists considerable debate regarding the optimal surgical approach for achieving favorable treatment outcomes [13-15].

This study adopts a retrospective approach to analyze the treatment outcomes of lesion curettage combined with intramedullary nail reconstruction and bone cement in patients with subtrochanteric metastatic femoral tumors. The objective is to furnish clinical practitioners with additional insights and guidance, aiding them in selecting the most suitable treatment strategies for patients afflicted with subtrochanteric metastatic femoral tumors.

Methods and data

Ethical statement

This study was approved by the Medical Ethics Committee of Dongying People's Hospital.

Sample source

A retrospective analysis was conducted on data from patients treated at Dongying People's Hospital for bone metastases involving the femoral sub capital region between January 2015 and January 2019.

Inclusion and exclusion criteria

Inclusion criteria: (1) Patients with confirmed subtrochanteric metastatic femoral tumors through imaging and pathological examination [16]; (2) Patients with pathological fractures or a Mirels score over 8, indicating a higher fracture risk; (3) Patients without skip metastases in the same-side femur; (4) Patients who completed treatment and follow-up with good compliance; (5) Patients with complete medical records and follow-up data; (6) Patients treated with either curettage of lesion + intramedullary nail or artificial prosthesis reconstruction following tumor segment resection.

Exclusion criteria: (1) Patients with overall poor health that unable to tolerate surgery; (2) Patients with an expected lifespan of less than 12 weeks; (3) Patients with a follow-up period of less than 3 months; (4) Patients with complete loss of self-care ability due to metastatic lesions in other parts of the body.

Sample screening and grouping

We initially identified 184 eligible patients based on inclusion criteria. Subsequently, 109 patients meeting the requirements were selected after applying exclusion criteria. Among them, 51 patients who underwent curettage of lesion and intramedullary nail treatment were assigned to the study group, while the remaining 58 patients who underwent artificial prosthesis reconstruction following tumor segment resection were assigned to the control group.

Surgical procedures

In the study group, patients underwent curettage of the lesion and reconstruction with an intramedullary nail and bone cement surgery. The procedure began with excision of the tumor lesion through a lateral linear incision centered on the tumor or fracture area, followed by sequential tissue dissection to expose and remove accumulated blood and tumor tissue at fracture ends, as well as to scrape the affected bone substance. Subsequently, reconstruction with an intramedullary nail and bone cement commenced. With the patient's hip joint flexed and adducted, a longitudinal incision of approximately 5 cm was made at the top of the greater trochanter of the femur to expose the greater trochanter area. An opening was created at the piriformis fossa to extend the medullary cavity entrance. An appropriately sized intramedullary nail was then inserted, and locking screws at both ends were secured with X-ray assistance to ensure proper placement. Following confirmation of satisfactory fluoroscopic results, bone cement was applied to fill bone defects at fracture ends. The incision was meticulously cleaned, hemostasis ensured, and then closed layer by layer with sutures. A drainage tube was inserted. Zoledronic acid concentrated solution (4 mg) dissolved in 100 ml normal saline was administered via slow intravenous drip, with each administration consisting of one vial containing 4 mg zoledronic acid.

In the control group, tumor segment resection and artificial prosthesis reconstruction surgery were performed. After satisfactory anesthesia, the patient was positioned laterally. Routine disinfection was carried out, and sterile drapes, along with sterile film were applied to protect the skin. The main steps were as follows: (1) Tumor excision: The surgery commenced by accessing the hip joint through a posterior-lateral incision. The incision was made on the outer side of the hip joint, followed by dissection of the skin and underlying tissues. The gluteus maximus muscle was then divided at the femur, exposing the posterior area of the buttocks. Subsequently, the external rotators, abductor muscles, and posterior joint capsule were severed. The lateral muscles of the thigh were also cut, and a "T" incision was made to open the joint capsule, exposing the femur. The femur was transected approximately 2 cm away from the distal end of the metastatic tumor, causing dislocate posterior-laterally. (2) Artificial prosthesis reconstruction: The medullary cavity of the femur was enlarged, and the sizes of the resected femoral end and the femur were measured. The prosthesis was then trial-fitted, and compatibility with the acetabulum was verified. Following the trial fitting, the prosthesis was wrapped with the hip joint capsule, and the joint motion range was examined to ensure prosthesis stability in various positions. Subsequently, the prosthesis was fixed using bone cement, with the prosthetic femoral neck tilted 20 degrees anteriorly. The length and mobility of the lower limb were checked before cement hardened, and the prosthesis position was reconfirmed. (3) Soft tissue reconstruction: Soft tissue reconstruction involved suturing the hip joint capsule and securing it to the prosthetic neck to ensure complete closure and prevent dislocation. The gluteus maximus, gluteus medius, lateral thigh muscles, iliacus, and external rotator muscles were then attached and secured to the metal strut and graft to ensure joint stability. Finally, the surgical site was irrigated, hemostasis was ensured, and the incision was closed layer by layer with sutures. A drainage tube was placed. Zoledronic acid concentrated solution (4 mg, China Resources Double-Crane Pharmaceutical Co., Ltd.) dissolved in 100 ml normal saline was administered via a slow intravenous drip, with each administration consisting of one vial containing 4 mg zoledronic acid.

Detection of bone turnover markers

Fasting peripheral blood (6 ml) were collected from each patient both before and after treatment, with each tube containing 3 ml of blood. After allowing them to stand for 20 minutes, the tubes were centrifuged at 3000 rpm for 15 minutes to obtain serum. The serum was then transferred to EP tubes and stored at -80°C for further testing. The C-terminal telopeptide of type I collagen (CTX-I, J20436), procollagen type I N-terminal propeptide (PINP, J21817), and alkaline phosphatase (ALP, J21011) markers were assessed using enzyme-linked immunosorbent assay (ELISA, P0205S, Beyotime, China), with reagent kits procured from Wuhan Jilide Biotechnology Co., Ltd. This experiment was conducted at our hospital.

Data collection and follow-up

Clinical data of patients, including age, sex, body mass index (BMI), smoking history, alcohol abuse history, hypertension history, diabetes history, primary tumor, metastatic tumor size, pathological type, treatment history, surgi-

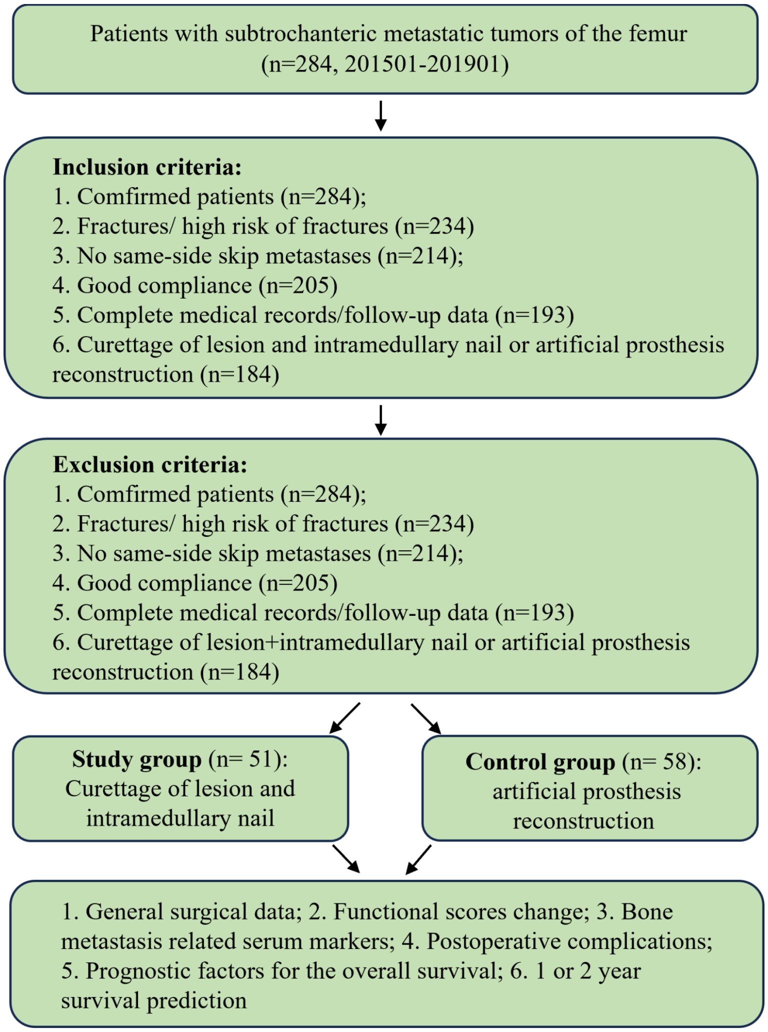

Figure 1. The flowchart of patient sample selection and result observation.

cal time (minutes), intraoperative blood loss (mL), length of hospital stay, visual analogue scale (VAS) score [17], Karnofsky Performance Status (KPS) score [18], musculoskeletal tumor society score (MSTS) [19], ALP, CTX-I, PINP, and incidence of complications, were gathered from the hospital's LIS system and outpatient follow-up records. Following discharge, patients were contacted every 3 months for 2 years, with tumor recurrence, confirmed by imaging and pathological findings as the primary outcome, and all-cause death as the secondary outcome. VAS, KPS, MSTS, ALP, CTX-I, and PINP were measured 3 days before treatment and 3 months after treatment, while complications such as pulmonary infection, incision infection, severe anemia, and lower limb deep venous thrombosis were recorded at the 3rd postoperative month.

Result measurement

1. General surgical data were compared between groups. 2. Changes in functional scores before treatment and at 3 months post-treatment were compared between groups. 3. Changes in serum markers related to bone metastasis before treatment and after treatment were compared between groups. 4. The incidence rate of postoperative complications was compared between groups. 5. Cox regression was employed to analyze prognostic factors affecting overall patient survival. 6. A predictive model was developed using a nomogram to forecast 1-year and 2-year patient survival. The accuracy and clinical utility of the model were assessed using calibration curves and receiver operating characteristic (ROC) curves. The study flow chart is shown in **Figure 1**.

Statistical analyses

Data processing was performed using SPSS 26.0 software. The Shapiro-Wilk method was initially applied for normality testing. Measurement data in a normal distribution (presented as mean ± standard deviation) were compared using the t-test, with inter-group and intra-group comparisons conducted via independent-sample T-test and paired t-test, respectively. Non-normally distributed data were represented using quartiles as P50 [P25, P75], and analyzed using the non-parametric Kruskal Wallis test. Enumeration data were analyzed using the χ^2 test. Cox regression was utilized to analyze prognostic factors affecting overall patient survival, with survival differences among different prognostic factors assessed using Kaplan-Meier survival curves. The nomogram was generated using the RMS package in R language, and the accuracy and clinical efficacy of the model were evaluated using calibration curves and ROC curves. A significance level of $P < 0.05$ indicated a notable difference.

Table 1. Comparison of baseline data

Factors		Control group (n=58)	Study group (n=51)	x^2/T	*P* value
Age					
	≥ 60 years old	31	24	0.443	0.506
	< 60 years old	27	27		
Sex					
	Male	38	26	2.713	0.100
	Female	20	26		
BMI					
	≥ 25 kg/m^2	9	11	0.663	0.415
	< 25 kg/m^2	49	40		
History of Smoking					
	Yes	26	21	0.147	0.701
	No	32	30		
History of alcohol abuse					
	Yes	5	5	0.046	0.831
	No	53	46		
History of hypertension					
	Yes	10	8	0.048	0.827
	No	48	43		
History of diabetes					
	Yes	7	8	0.299	0.584
	No	51	43		
Primary tumor					
	Breast cancer	2	19		
	Lung cancer	15	14	0.221	0.895
	Others	23	18		
Metastatic tumor size		0.53 ± 0.24	0.54 ± 0.21	0.819	1.982
Pathological type	Invasive ductal carcinoma	18	15	0.042	0.098
	Invasive lobular carcinoma	8	6		
	Adenocarcinoma	14	12		
	Squamous carcinoma	6	5		
	others	12	13		
Treatment history	Primary tumor disection	52	47	0.918	0.632
	Chemoradiotherapy without surgery	5	4		
	Others	1	0		

Note: BMI: Body mass index.

Results

Comparison of baseline data

Comparisons of baseline characteristics between the control group and study group revealed no notable differences in age, sex, BMI, history of smoking, history of alcohol abuse, history of hypertension, history of diabetes, and primary tumor (all P > 0.05, **Table 1**).

Comparison of general surgical data

The comparison of general surgical data between the control and study groups revealed that the control group exhibited significantly shorter surgical time and lower intraoperative blood loss compared to the study group (all P < 0.001). However, the control group had a significantly longer postoperative hospital stay compared to the study group (P < 0.001) (**Table 2**).

Table 2. Comparison of general surgical data between the two groups

Factors	Control group (n=58)	Study group (n=51)	T/Z	*P* value
Surgical time (min)	156.95 ± 21.74	203.10 ± 37.02	7.799	< 0.001
Intraoperative blood loss (mL)	626.50 ± 217.53	826.27 ± 241.09	4.518	< 0.001
Length of hospital stay (d)	8.00 [7.00, 9.00]	6.00 [5.00, 7.00]	-6.416	< 0.001

Table 3. Comparison of the changes in functional scores between the two groups

Group	KPS		MSTS		VAS	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Control group (n=58)	50.00 [40.00, 60.00]	70.00 [70.00, 70.00]*	15.74 ± 1.76	21.67 ± 3.24*	8.00 [7.00, 9.00]	3.00 [3.00, 4.00]*
Study group (n=51)	50.00 [40.00, 60.00]	80.00 [75.00, 80.00]*	16.08 ± 2.70	23.86 ± 2.57*	8.00 [7.00, 8.00]	3.00 [3.00, 4.00]*
T/Z	0.802	5.906	0.761	3.93	-1.215	1.388
P value	0.416	< 0.001	0.449	< 0.001	0.185	0.112

Notes: * indicates P < 0.05 *vs.* Before treatment; VAS: visual analogue scale; KPS: Karnofsky performance status; MSTS: musculoskeletal tumor society score.

Table 4. Comparison of the changes in functional scores between the two groups

Group	ALP (IU/L)		CTX-I (ng/mL)		PINP (pg/mL)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Control group (n=58)	125.23 [68.69, 152.37]	83.19 ± 21.19*	5.26 ± 2.08	3.15 ± 1.75*	14.70 ± 4.69	11.57 ± 3.90*
Study group (n=51)	108.07 [91.34, 135.67]	85.93 ± 14.44*	5.41 ± 2.62	3.03 ± 1.56*	15.64 ± 4.28	10.30 ± 4.41*
T/Z	0.121	0.797	0.309	-0.381	1.093	-1.575
P value	0.906	0.427	0.758	0.704	0.277	0.118

Notes: * indicates P < 0.05 *vs.* Before treatment; CTX-I: C-Terminal Telopeptide of Type I Collagen; PINP: Procollagen Type I N-Terminal Propeptide; ALP: Alkaline Phosphatase.

Changes in functional scores

Comparisons of functional scores between the control and study groups before and after treatment revealed no significant differences in KPS, MSTS, and VAS scores before treatment (P > 0.05). However, after treatment, both groups demonstrated significant improvements in KPS and MSTS scores, along with a significant decrease in VAS scores (all P < 0.05). Further analysis showed that the study group exhibited significantly higher KPS and MSTS scores after treatment compared to the control group (all P < 0.001). Nevertheless, there was no significant difference in VAS scores after treatment between the study and control groups (P > 0.05) (**Table 3**).

Changes in serum markers related to bone metastasis

Comparisons of ALP, CTX-I, and PINP between the two groups before and after treatment revealed no significant differences in these markers before treatment (all P > 0.05). However, after treatment, both groups exhibited a significant decrease in ALP, CTX-I, and PINP levels (all P < 0.05). Further analysis showed no significant differences in ALP, CTX-I, and PINP levels between the study and control groups after treatment (P > 0.05) (**Table 4**).

Incidence of complications

Statistical analysis of postoperative complications in the two groups indicated no significant differences in the occurrence of pulmonary infection, surgical site infection, postoperative severe anemia, and lower limb deep vein thrombosis (all P > 0.05). Furthermore, there was no significant difference in the overall incidence of postoperative complications between the two groups (P > 0.05) (**Table 5**).

Analysis of postoperative survival factors

All patients were followed up for a period ranging from 4 to 25 months, with an average survival time of 15.23 months. Cox regression analysis was conducted to assess the overall postoperative survival of the patients. Initially, values were assigned to relevant indicators,

Table 5. Comparison of the incidence of complications between the two groups

Factors	Pulmonary infection	Incision infection	Postoperative severe anemia	Deep venous thrombosis of lower limbs	Total incidence rate
Control group (n=58)	1	2	2	0	5
Study group (n=51)	2	4	2	2	10
x^2	0.489	1.008	0.017	2.317	2.760
P value	0.484	0.316	0.895	0.128	0.096

Table 6. Associated risk factors leading to poor patient prognosis and their assignments

Risk factors	Variable	Assignment
Treatment regimen	X1	Study group, 0; control group, 1
Age	X2	< 60 years old, 0; ≥ 60 years old, 1
Sex	X3	Female, 0; Male, 1
BMI (Kg/m^2)	X4	< 25, 0; ≥ 25, 1
Smoking history	X5	No, 0; Yes, 1
History of alcoholism	X6	No, 0; Yes, 1
History of hypertension	X7	No, 0; Yes, 1
History of diabetes	X8	No, 0; Yes, 1
Primary tumor	X9	Lung cancer, 0; Breast cancer, 1; other, 2
Surgical time (min)	X10	< 180, 0; ≥ 180, 1
Intraoperative blood loss (mL)	X11	< 700, 0; ≥ 700, 1
Hospitalization time (d)	X12	< 7, 0; ≥ 7, 1
VAS before treatment (score)	X13	< 8, 0; ≥ 8, 1
KPS before treatment (score)	X14	≥ 40, 0; < 40, 1
MSTS before treatment (score)	X15	≥ 15, 0; < 15, 1
CTX-I before treatment (ng/mL)	X16	< 5, 0; ≥ 5, 1
PINP before treatment (pg/mL)	X17	< 15, 0; ≥ 15, 1
ALP before treatment (IU/L)	X18	< 100, 0; ≥ 100, 1

and the cut-offs were determined by X-tile software (**Table 6**), followed by univariate and multivariate Cox regression analyses, which identified treatment regimen, age, history of diabetes, and pre-treatment KPS score as independent risk factors influencing overall postoperative survival (all $P < 0.05$) (**Table 7**). Kaplan-Meier survival curves were also plotted for each independent factor (**Figure 2**).

Construction of nomogram model

Based on the provided data, we developed a prognostic nomogram model incorporating treatment regimen, age, diabetes status, and KPS score as predictive factors to estimate one-year and two-year survival probabilities post-treatment. The model's diagnostic performance was assessed using ROC curves, yielding high accuracy with AUC values of 0.821 and 0.790 for one-year and two-year survival predictions, respectively. Calibration curve analysis further demonstrated strong agreement between predicted and observed survival rates, particularly in the low-risk prediction range. These findings underscore the potential clinical utility of the model for prognostic assessment (**Figure 3**).

Discussion

Surgical intervention is a common approach for subtrochanteric fractures of the femur [20]. The Mirels scoring system guides decision-making in these cases, with scores exceeding 8 points indicating a high risk of pathological fracture, warranting preventive fixation measures [21]. While a score of 8 points suggests a decreased risk, surgical fixation may still be considered, given the associated 15% risk of fracture [21]. Conversely, scores below 8 points may not necessitate immediate treatment.

Table 7. Cox regression analysis

Factor	Univariate Cox regression			Multivariate Cox regression		
	P value	HR	95% CI	*P* value	HR	95% CI
Treatment regimen	< 0.001	1.812	1.212-2.710	< 0.001	2.23	1.448-3.435
Age	< 0.001	2.5	1.695-3.687	< 0.001	2.686	1.788-4.036
Sex	0.958	1.01	0.689-1.481			
BMI	0.396	0.809	0.496-1.319			
Smoking history	0.882	1.029	0.702-1.509			
History of alcoholism	0.625	1.178	0.610-2.274			
History of hypertension	0.096	1.545	0.926-2.580			
History of diabetes	0.028	1.853	1.069-3.210	0.018	2.02	1.13-3.612
Primary tumor	0.326	1.119	0.894-1.402			
Surgical time	0.100	0.996	0.991-1.001			
Intraoperative blood loss	0.107	0.999	0.999-1.000			
Hospitalization time (d)	0.755	1.018	0.909-1.14			
VAS before treatment	0.723	1.049	0.804-1.37			
KPS before treatment	< 0.001	0.963	0.949-0.977	< 0.001	0.963	0.948-0.978
MSTS before treatment	0.113	0.941	0.874-1.014			
CTX-I before treatment (ng/mL)	0.436	1.035	0.950-1.127			
PINP before treatment (pg/mL)	0.441	0.984	0.943-1.026			
ALP before treatment (IU/L)	0.062	0.996	0.992-1.000			

Notes: BMI: body mass index; VAS: visual analogue scale; KPS: Karnofsky performance status; MSTS: musculoskeletal tumor society score; CTX-I: C-terminal telopeptide of type I collagen; PINP: procollagen type I N-terminal propeptide; ALP: alkaline phosphatase. All continuous data were dichotomized using X-tile.

Research suggests that preventive internal fixation offers advantages over post-fracture internal fixation [22].

Recent years have witnessed ongoing debate on the optimal treatment approaches for subtrochanteric metastatic tumors of the femur. Some researchers advocate for the use of intramedullary nails for fixation, highlighting their alignment with the central medullary cavity, which provides a robust fixation effect and facilitates early functional exercises for patients [23]. Additionally, the high temperatures generated during the bone cement polymerization process may contribute to the destruction of residual tumor cells to some extent [24]. Conversely, hip arthroplasty has demonstrated favorable outcomes in treating pathological fractures of this nature. Patients often experience a significant reduction in postoperative pain and satisfactory restoration of hip joint function. Moreover, hip arthroplasty enables more extensive removal of metastatic lesions [25]. However, comparative studies evaluating different treatment methods for subtrochanteric metastatic tumors of the femur remain relatively limited.

In this study, the control group, comprising patients who underwent tumor segment resection and artificial prosthesis reconstruction, exhibited lower surgical time and intraoperative blood loss compared to the study group that received curettage of lesion and intramedullary nail treatment. However, the control group experienced significantly longer postoperative hospital stays compared to the study group. Additionally, post-surgery, the study group showed notably higher KPS and MSTS scores than the control group, while no notable difference was found between the two groups in terms of VAS score. Furthermore, there was no significant difference between the two groups in terms of ALP, CTX-I, and PINP levels, as well as the incidence of complications. Studies by Steenma et al. [26] and Peterson et al. [27] suggest that prosthetic reconstruction may prolong the postoperative rehabilitation period without necessarily providing short-term survival benefits [28]. On the contrary, intramedullary nail treatment can offer more immediate benefits for patients in the short term. However, concerns persist regarding implant failure, instability, and local recurrence, partic-

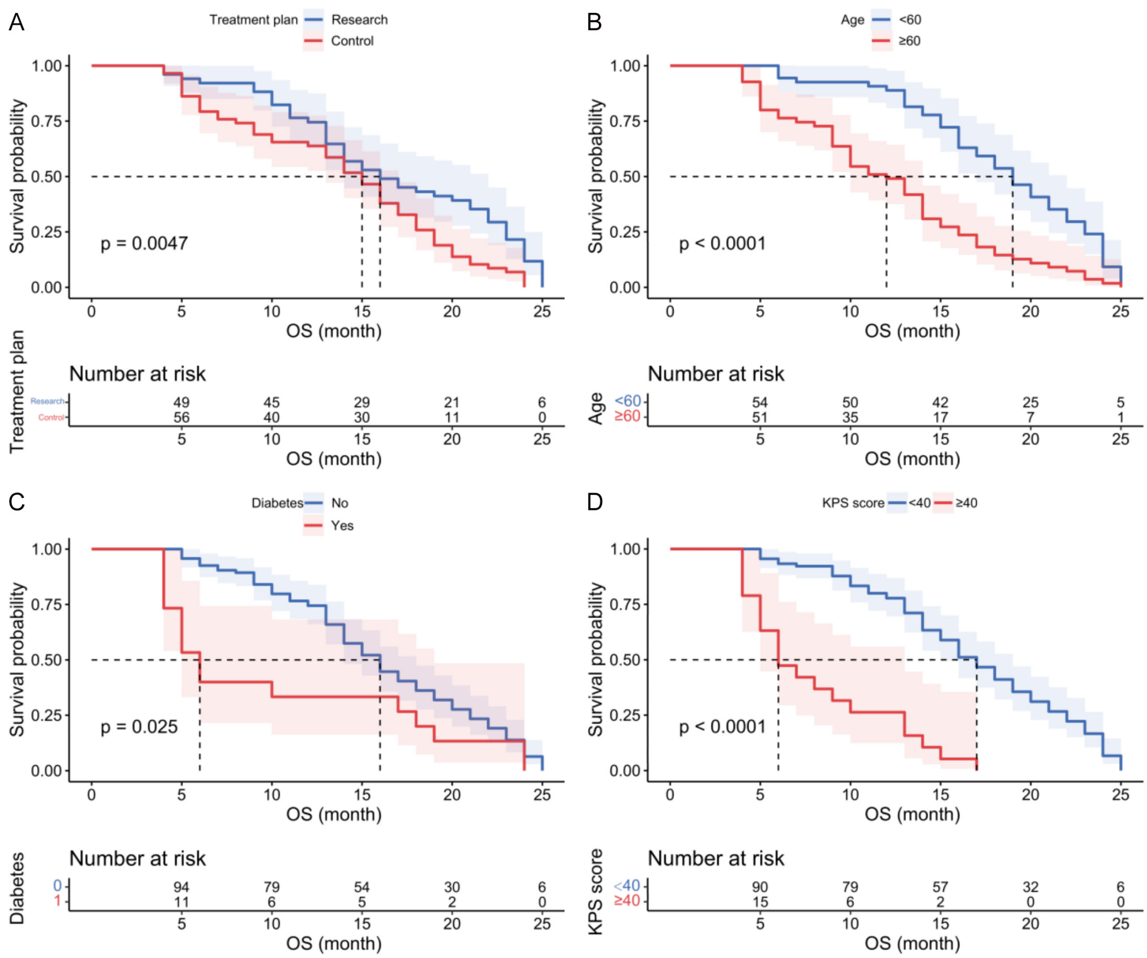

Figure 2. K-M survival curve for prognostic factors. A: K-M survival curve for different treatment regimens. B: K-M survival curve for different age groups. C: K-M survival curve for patients with or without diabetes. D: K-M survival curve for patients with KPS score ≤ 40. Note: KPS: Karnofsky performance status.

ularly for patients with longer survival times. Miller et al. [29] indicated a high risk of intramedullary nail failure and the need for revision surgery in patients with postoperative survival exceeding 3 years. While tumor prosthesis implantation mitigates these concerns, it is also associated with issues such as incision infections and prosthesis dislocation. Postoperatively, patients may require longer bed rest, increasing the risk of thromboembolic complications. Thus, our findings suggest that while curettage of the lesion combined with intramedullary nail treatment contributes to better functional recovery post-surgery, artificial prosthesis reconstruction following tumor segment resection offers advantages in terms of surgical time and blood loss. Both methods demonstrate similar effects in pain control and bone metabolism and do not increase the incidence of complications. Therefore, clinicians must carefully select the most appropriate surgical approach based on each patient's specific circumstances.

In this study, several key factors significantly impacting the overall survival of patients have been identified. These independent prognostic factors include treatment regimen in the control group, age ≥ 60 years, a history of diabetes, and a pre-treatment KPS score below 40. The influence of these factors can be attributed to their close association with the patient's overall health status, disease severity, and response to treatment. Firstly, the choice of treatment regimen directly relates to local disease control and functional recovery, significantly impacting survival. Secondly, age is particularly important as elderly patients often have more comorbidi-

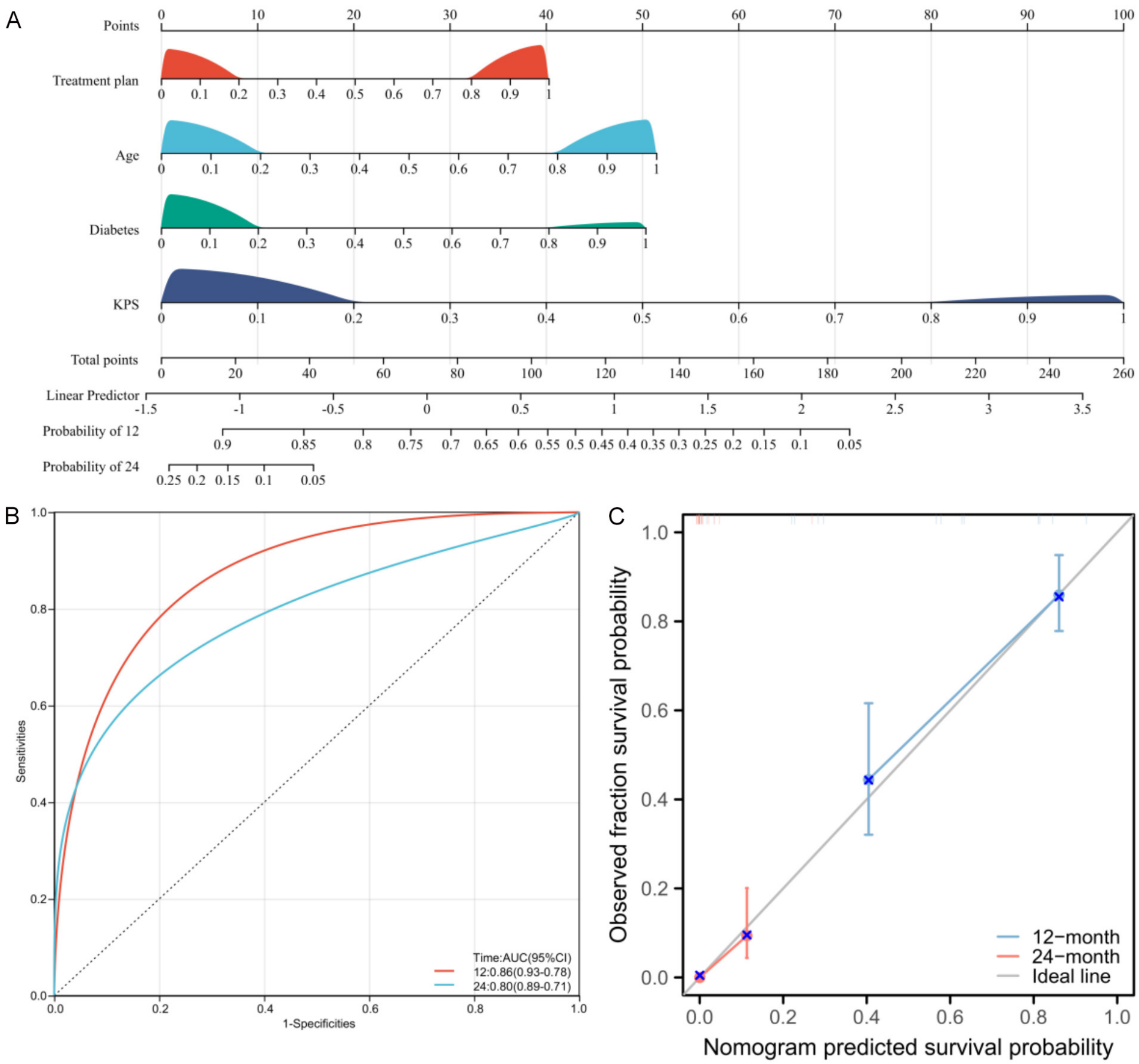

Figure 3. The nomogram model for predicting one-year and two-year survival of patients and internal validation. A: The nomogram model for predicting the one-year and two-year survival of patients. B: ROC curves for evaluating the performance of the nomogram model in predicting one-year and two-year survival of patients. C: Calibration curves for assessing the accuracy of the nomogram model in predicting one-year and two-year survival of patients. Notes: KPS: Karnofsky performance status. In the nomogram, in terms of the treatment regimen variable, 1 indicates the control group and 0 indicates the study group; in the age variable, 1 represents age ≥ 60 years and 0 represents age < 60 years; in the diabetes variable, 1 represents the presence of diabetes and 0 represents the absence of diabetes; in the KPS variable, 1 represents KPS score < 40 and 0 represents KPS score ≥ 40.

ties and weaker physiological reserves, affecting their tolerance to treatment and ability to recover [30]. Diabetes, as a chronic disease affecting multiple body systems, increases the risk of complications, thereby impacting overall patient survival [31]. Lastly, a lower KPS score indicates poorer functional capacity in daily activities, requiring more care and support. The results also reflect the overall poor health status of the patient, indirectly impacting survival rates [32]. Recent studies support these observations. For example, one study found a significant correlation between improved survival rates and KPS scores ranging from 80 to 100 in patients receiving radiation therapy for bone metastases and revealed that age had marginal significance in the study [33]. In another study predicting survival rates in patients receiving radiation therapy for bone metastases, significant predictive value for survival was found in various factors including sex, KPS score, primary tumor characteristics, visceral metastasis, laboratory data, and previous chemotherapy, emphasizing the importance of KPS score in predicting survival prognosis in patients with bone metastases [34]. In summary, the combined effect of these factors plays a crucial role in determining the overall survival of patients. Understanding these prognostic factors is of significant importance in devising personalized treatment regimens and improving patient outcomes.

The limitations of this study primarily include small sample size and low diversity, and its retrospective, single-center design. With a limited sample size and a homogeneous patient population, the study may not sufficiently represent a broader spectrum of patients, thereby restricting the generalizability and applicability of the findings. Moreover, the retrospective design of the study may introduce selection bias and limitations in data collection, potentially impacting the reliability of the results. Additionally, being conducted at a single center, the study's outcomes may not fully encapsulate variations present across different regions or healthcare settings, thereby compromising the external validity of the findings. Therefore, future research endeavors should consider larger-scale, multicenter designs to bolster the reliability and generalizability of the study outcomes.

Conclusion

In the management of subtrochanteric metastatic tumors of the femur, our study suggests that curettage of lesion combined with reconstruction using intramedullary nail and bone cement offers superior outcomes in terms of postoperative functional recovery. This approach significantly improves KPS and MSTS scores compared to artificial prosthesis reconstruction after tumor segment resection. Moreover, treatment regimen, age, history of diabetes, and pre-treatment KPS score can serve as crucial prognostic factors for overall survival. Notably, both treatment methods demonstrate similar efficacy in pain management and bone metabolism modulation, with comparable rates of postoperative complications. Thus, both treatment methods represent viable options for treating subtrochanteric metastatic tumors of the femur.

Disclosure of conflict of interest

None.

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