"COMPARATIVE OUTCOMES OF INTRAMEDULLARY NAILING AND CEMENTED PLATING FOR METASTATIC PATHOLOGICAL FRACTURES IN THE PROXIMAL HUMERUS"

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Abstract

BackgroundPathological fractures of the proximal humerus due to metastatic bone disease cause severe pain, limited upper limb functionality, and reduced quality of life. This study aimed to compare the outcomes of intramedullary (IM) nailing and cemented plating in the surgical treatment of these fractures.

MethodsA retrospective analysis was conducted on 45 patients treated surgically between 2011 and 2022. The cohort included 17 patients who underwent IM nailing with cement augmentation and 28 patients who underwent cemented plating. Outcomes evaluated included pain relief, functional recovery, perioperative parameters (blood loss, surgical time, hospital stay), complications, and survival status. Statistical analyses were performed to compare the two surgical approaches.

ResultsThe IM nailing group exhibited significantly lower blood loss (100 ml vs. 500 ml, $p < 0.001$) and shorter hospital stays (8.4 days vs. 12.3 days, $p < 0.001$) compared to the plating group. Pain relief, as measured by the reduction in Visual Analog Scale (VAS) scores, was significantly greater in the nailing group (7.0 vs. 6.0, $p = 0.01$). Functional outcomes, assessed by Musculoskeletal Tumor Society (MSTS) and Karnofsky performance scores, were comparable between the groups. Complication rates were low in both groups, with no significant differences. Survival outcomes were also similar, with no statistical difference in overall survival (log-rank $p = 0.215$).

Conclusions

IM nailing with cement augmentation is a viable option for treating metastatic pathological fractures of the proximal humerus, offering reduced blood loss, shorter hospital stays, and better pain relief compared to cemented plating. However, both techniques provide effective stabilization and comparable functional outcomes. Further studies are needed to validate these findings in larger patient populations.

Keywords: Intramedullary nailing**;** Cemented plating**;** Proximal humerus**;** Pathological fracture**;** Metastatic bone disease**;** Pain relief**;** Functional outcomes**;** Surgical stabilization

Introduction:

Metastatic bone disease frequently complicates advanced cancer, often resulting in painful and debilitating pathological fractures. The proximal humerus, as the second most common long bone affected by metastatic lesions after the femur, is a critical site due to its role in upper limb functionality (Frassica & Frassica, 2003). Pathological fractures in this region lead to severe pain, reduced mobility, and a decreased quality of life, necessitating surgical intervention to restore limb stability and optimize functional outcomes (Scolaro & Lackman, 2014).

The management of metastatic pathological fractures of the proximal humerus requires careful consideration of tumor characteristics, bone quality, and patient prognosis. Among the available surgical techniques, intramedullary (IM) nailing and cemented plating are commonly employed(1,2). Cemented plating has long been the standard, offering reliable stabilization for contained metaphyseal lesions. However, IM nailing, with recent advancements in interlocking nail designs, has emerged as a minimally invasive alternative, reducing blood loss and hospital stays while providing immediate stability (Choi et al., 2016; Karataglis et al., 2011). Despite these advantages, concerns remain regarding IM nailing's ability to achieve sufficient fixation in cases with poor bone quality or extensive tumor involvement(3,4).

Comparative studies between these two surgical methods remain limited, particularly concerning outcomes such as pain relief, functional recovery, complication rates, and overall patient survival. To address this gap, the present study evaluates and contrasts the effectiveness of intramedullary nailing and cemented plating in treating metastatic pathological fractures of the proximal humerus. This retrospective analysis incorporates data from 45 cases treated between 2011 and 2022, offering valuable insights into the clinical applications of these techniques. Additionally, a literature review is included to provide a broader context for the findings(5,6).

The results of this study aim to inform evidence-based surgical decision-making, optimizing care for patients with metastatic bone disease in the proximal humerus.

Materials and Methods

Study Design and Setting

This retrospective comparative study was conducted to evaluate the outcomes of intramedullary (IM) nailing versus cemented plating in the management of metastatic pathological fractures of the proximal humerus. The study included patients treated surgically at a single institution between January 2011 and January 2022. Ethical approval for this research was granted by the Institutional Review Board, and informed consent was waived due to the retrospective nature of the study.

Inclusion and Exclusion Criteria

Patients were eligible for inclusion if they had:

1. Symptomatic impending or complete pathological fractures of the proximal humerus.
2. A life expectancy of more than three months as determined by an oncologist.
3. Underwent surgical intervention with either IM nailing or cemented plating.

Exclusion criteria included:

1. Life expectancy of less than three months.
2. Preoperative American Society of Anesthesiology (ASA) grade 4.
3. Extensive lesions involving the articular surface.

Patient Population

A total of 45 patients were included in the study, comprising 22 males and 23 females with a mean age of 61.7 ± 9.7 years. Among the cohort:

- 17 patients underwent IM nailing with cement augmentation.
- 28 patients received cemented plating with a locking plate.

The choice of surgical procedure was determined based on physician judgment, availability of equipment, and the stage of experience with the respective techniques. All procedures were performed under similar surgical protocols.

Surgical Procedures

Intramedullary Nailing with Cement Augmentation

The IM nailing procedure was conducted under general anesthesia with the patient in a semi-sitting position. A limited anterolateral approach was used to access the fracture site. After meticulous tumor curettage, local adjuvant therapy with 95% alcohol was applied to the lesion.

An interlocking humeral nail (DePuy Synthes, MultiLoc Humeral Nails, Raynham, MA, USA) was inserted in an antegrade manner, ensuring the nail was long enough to stabilize the entire humerus. The distal and proximal ends of the nail were secured with interlocking screws. The bone defect was filled with poly(methyl methacrylate) (PMMA) cement after fixation. Early postoperative mobilization and rehabilitation were encouraged.

Cemented Plating with a Locking Plate

The plating procedure followed the same preoperative and perioperative principles. A proximal humerus locking plate (DePuy Synthes, Philos® System, Raynham, MA, USA) was used for fixation. Tumor curettage and local adjuvant therapy were performed, followed by cement augmentation to fill the bone defect. The plate was secured with appropriately sized screws to ensure stabilization.

Postoperative Care and Rehabilitation

All patients received adjuvant external beam radiation therapy (3000–3500 Gy) as part of their treatment protocol to reduce the risk of local recurrence. Rehabilitation protocols, including passive stretching and gravity-resistant exercises, were initiated within one week post-surgery.

Outcome Measures

The primary outcomes were:

1. Pain relief, assessed using the Visual Analog Scale (VAS).
2. Functional outcomes, measured by the Musculoskeletal Tumor Society (MSTS) score and the Karnofsky performance status scale.

Secondary outcomes included:

1. Perioperative parameters, such as blood loss, surgical time, and hospital length of stay.
2. Postoperative complications, including implant failure, infection, nerve injury, and revision surgery.

Data Collection

Data were collected retrospectively from medical records, including patient demographics, primary tumor characteristics, surgical details, and follow-up outcomes. Pain scores and functional assessments were recorded preoperatively, at one week post-surgery, and at three months postoperatively.

Statistical Analysis

Continuous variables were presented as mean ± standard deviation (SD) or median and interquartile range (IQR), depending on data distribution. Categorical variables were expressed as counts and percentages. Comparisons between groups were performed using:

- Student’s t-test for normally distributed continuous variables.
- Wilcoxon rank-sum test for non-normally distributed data.
- Chi-square or Fisher’s exact test for categorical variables.

Kaplan–Meier survival analysis was conducted to evaluate overall survival, with statistical significance set at $p < 0.05$. All analyses were performed using SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA).

Results

Patient Demographics and Surgical Outcomes

A total of 45 patients with proximal humerus metastatic pathological fractures were included in this study. The mean age of the intramedullary nailing group was significantly higher than that of the cemented plating group (66.6 vs. 58.7 years, p = 0.006). The nailing group experienced significantly lower intraoperative blood loss (100 ml vs. 500 ml, p < 0.001) and shorter hospital stays (8.4 days vs. 12.3 days, p < 0.001) compared to the plating group. Pain relief, as assessed by the reduction in Visual Analog Scale (VAS) scores, was significantly greater in the nailing group (7.0 vs. 6.0, p = 0.01), indicating better pain management in this cohort (Table 1, Figure 1).

Table 1: Surgical Outcome Comparison

Variable	Intramedullary Nailing	Cemented Plating	p-Value
Age (years)	66.6	58.7	0.006
Blood loss (ml)	100	500	<0.001
Length of hospital stay (days)	8.4	12.3	<0.001
VAS Score Reduction	7.0	6.0	0.01

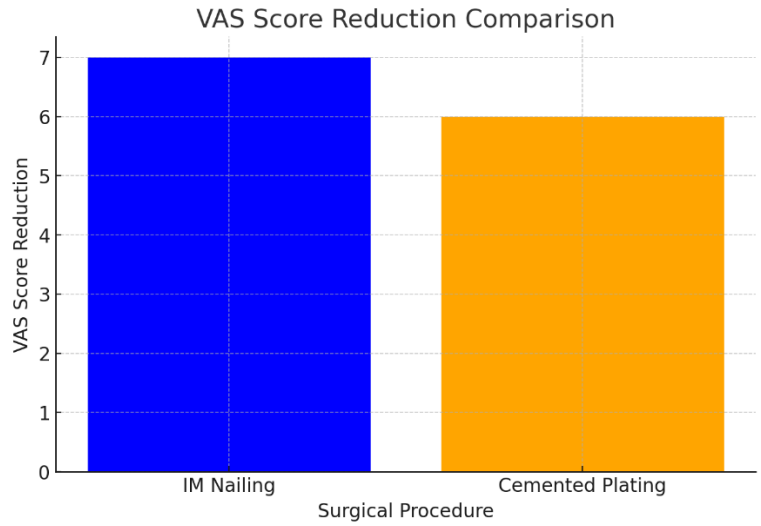

Figure 1: Reduction in Visual Analog Scale (VAS) scores comparing intramedullary nailing and cemented plating groups. Pain relief was significantly greater in the nailing group (p = 0.01)

Complications

The overall complication rate was low in both groups, with no implant failures or infections reported during the follow-up period. Radial nerve injury occurred in one patient in the nailing group compared to three patients in the plating group. Additionally, one patient in the plating group experienced humeral head collapse without the need for revision surgery. No significant differences in complication rates were observed between the two groups (Table 2).

Table 2: Complication Comparison

Complication	Intramedullary Nailing	Cemented Plating	p-Value
Radial nerve injury	1	3	1.0
Humeral head collapse	0	1	N/A
Infection	0	0	N/A
Implant failure	0	0	N/A

Functional and Survival Outcomes

Functional outcomes, as measured by Musculoskeletal Tumor Society (MSTS) and Karnofsky performance scores, were comparable between the two groups ($p > 0.05$). Survival analysis revealed no significant differences in overall survival between the nailing and plating groups (log-rank test $p = 0.215$). At the final follow-up, 7 patients in the nailing group and 17 patients in the plating group were alive, while 10 and 11 patients, respectively, had deceased (Table 3, Figure 2).

Table 3: Survival Status Summary

Survival Status	Intramedullary Nailing	Cemented Plating
Alive	7	17
Dead	10	11

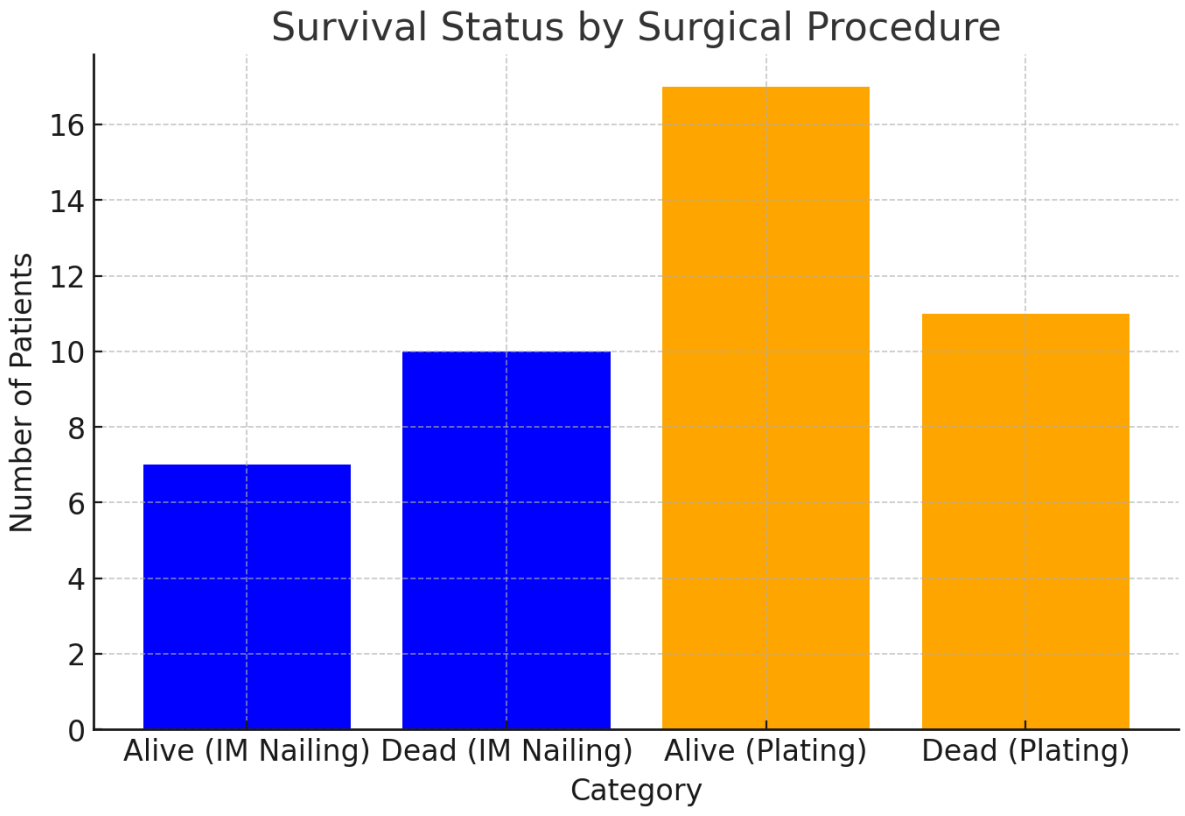

Figure 2: Survival status by surgical procedure, showing the distribution of alive and deceased patients in both groups at the final follow-up.

Discussion

This study compared the outcomes of intramedullary nailing (IM nailing) and cemented plating in managing metastatic pathological fractures of the proximal humerus. The findings highlight that both surgical methods are safe and effective, with specific advantages favoring IM nailing in certain clinical scenarios.

Pain Relief and Functional Outcomes

IM nailing demonstrated superior pain relief compared to cemented plating, as reflected in the significant reduction in Visual Analog Scale (VAS) scores ($p = 0.01$). This can be attributed to the immediate stabilization provided by the nailing technique and its minimally invasive nature, which reduces postoperative trauma. Although functional scores, including the Musculoskeletal Tumor Society (MSTS) and Karnofsky performance scales, were comparable between the groups, the enhanced pain relief in the nailing group suggests a potential benefit in early mobility and rehabilitation(7,).

Perioperative Advantages of IM Nailing

The IM nailing group showed significantly lower blood loss (100 ml vs. 500 ml, $p < 0.001$) and shorter hospital stays (8.4 days vs. 12.3 days, $p < 0.001$) compared to the plating group. These findings align with previous reports highlighting the less invasive nature of IM nailing and its ability to achieve effective stabilization with minimal disruption to surrounding tissues perioperative morbidity associated with IM nailing makes it particularly suitable for patients with compromised health or limited life expectancy(8).

Complications

The overall complication rates were low in both groups. Radial nerve injury, a known risk in proximal humerus surgeries, was observed in both groups but without significant differences. Notably, no implant failures or infections were reported, underscoring the safety and durability of both techniques in this patient population.

While there were no significant differences in overall survival between the two groups, the mortality rate was high due to the advanced metastatic disease in this cohort. The comparable survival outcomes suggest that both IM nailing and cemented plating are equally viable options in terms of life expectancy(9).

study has several limitations. The retrospective design introduces potential selection bias, and the relatively small sample size limits the generalizability of the results. Additionally, the follow-up period was relatively short due to the advanced disease stage of the patients, which may have precluded the detection of long-term complications or outcomes.

Clinical Implications

The findings of this study suggest that IM nailing is a highly effective option for managing proximal humerus metastatic fractures, particularly in patients who require rapid recovery and reduced perioperative morbidity. Cemented plating remains a reliable alternative, particularly in cases where rigid fixation of extensive lesions is required(10).

Conclusion

This study demonstrates that both intramedullary (IM) nailing and cemented plating are effective surgical options for treating metastatic pathological fractures of the proximal humerus. While functional outcomes were comparable between the two techniques, IM nailing offered significant advantages in terms of reduced blood loss, shorter hospital stays, and superior pain relief. These benefits make it a preferable choice for patients with limited life expectancy or those requiring a minimally invasive approach. However, cemented plating remains a reliable alternative, particularly for cases requiring extensive stabilization.

Future prospective studies with larger sample sizes and longer follow-up periods are necessary to validate these findings and provide a more comprehensive understanding of the optimal surgical approach for managing metastatic bone disease in the proximal humerus.

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