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Case Report
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Modified Hackethal's Technique with Bone Grafting and Plate Fixation: A Case Report of Treatment for Pathological Humeral Shaft Fracture

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Abstract

Background: Pathological Humeral Shaft Fracture (PHSF) is a common clinical manifestation of multiple myeloma, and surgical intervention is indicated for symptom relief and function restoration. However, the most effective surgical technique for PHSF remains uncertain. Conventional nailing has several disadvantages, including potential loss of fixation, local tumor progression, risk of radial nerve injury, and shoulder complications. We employed a modified version of Hackethal's technique that involves intramedullary K-wire combined with bone grafting and plate fixation; such a technique has not yet been widely reported. This novel technique offers immediate rigidity, restores function, decreases tumor burden, and causes fewer shoulder complications than other techniques.

Case Report: A 74-year-old man who lives in the Marshall Islands presented to our orthopedic outpatient department in Taiwan with left arm pain and a swelling sensation that had persisted for a month. Laboratory evaluations revealed normocytic anemia, hypercalcemia, hypoalbuminemia, and hyperglobulinemia. Plain films of the left arm showed a 10-cm osteolytic lesion on the left humeral shaft and multiple small lesions. Magnetic resonance imaging revealed a soft mass on the humeral shaft. To restore function and determine the origin of the shaft lesion, we used a novel, modified version of Hackethal's technique.

Discussion: We discuss the differences among intramedullary nailing, plating, and prosthesis insertion and describe the advantages of our novel technique. We review the literature and suggest various surgical techniques for PHSF.

Take-home message: The combination of allogenic bone grafting, intramedullary K-wire fixation, plate fixation, and bone cement augmentation in the novel technique we describe may serve an alternative treatment for PHSF involving large lesions. Our technique offers broader lesion excision, fewer shoulder complications, and greater rigidity than other techniques offer.

Keywords: Cement augmentation; Hackethal's technique; Metastatic lesion; Multiple myeloma; Pathological humeral shaft fracture; Plate fixation

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Abbreviations

CPF: Cement-augmented Plate Fixation; IMN: Intramedullary Nailing; PHSF: Pathological Humeral Shaft Fracture; SP: Segmental Prosthesis

Introduction

Surgical treatment of Pathological Humeral Shaft Fracture (PHSF) is indicated for improving quality of life and the functional stability of the limb and relieving pain [1-3]. However, the surgery most appropriate for the treatment of PHSF caused by Multiple Myeloma (MM) remains unknown

[4]. Conventionally, the preferred technique for stabilizing a PHSF is intramedullary nailing; however, fixation loss and local tumor progression can occur [5]. Cement-augmented plating was recently shown to have positive effects on patients with PHSF [4]; however, plating is not effective for the fixation of the entire bone. Hackethal's technique is a minimally invasive method developed in 1961 that uses multiple stacked flexible intramedullary nails to treat PHSF. However, to our knowledge, plating combined with Hackethal's technique has not been used in the treatment of MM-induced PHSF. Few studies have described the different surgical approaches available for treating PHSF. In this report, we describe the case of a 74-year-old man with MM-induced PHSF who underwent a novel surgical procedure, and we herein present our recommendations for the surgical approaches to use for different types of lesions in PHSF.

Case Presentation

A 74-year-old man from the Marshall Islands presented to our orthopedic outpatient department in Taiwan with left arm pain and a swelling sensation that had persisted for a month. The patient did not have a history of major trauma. Physical examination revealed swelling of the left arm, localized tenderness, and limited range of motion in the shoulder. A laboratory evaluation revealed normocytic anemia, hypercalcemia, hypoalbuminemia, and hyperglobulinemia. Serum electrophoresis revealed the presence of M protein, a reversal of the albumin–globulin ratio, and elevated β2 microglobulin (3628 μg/L).

Plain films of the left arm revealed a 10-cm lytic lesion on the left humeral shaft, accompanied by multiple small lesions (Figure 1). Moreover, magnetic resonance imaging revealed a soft mass on the humeral shaft that was assumed to be associated with pathological fracture (Figure 2).

To determine the origin of the tumor, further examinations were conducted. Chest and abdominal computed tomography scans revealed multiple suspected malignant lesions throughout the body, including in the left upper lobe of the lung, the liver, and the left costovertebral angle. In addition, high 18-F-fluorodeoxyglucose metabolism was observed in several ribs, several thoracic vertebrae, and the distal humerus.

Because of the perioperative risks, life expectancy of the patient, and medical environment of the Marshall Islands, a novel surgical technique was used for fixation and the excision of the local tumor. An extended anterolateral incision was made to approach the lesion site. The biceps brachii and brachialis were separated to expose the tumor. Malignancy was intraoperatively confirmed through frozen biopsy. We then performed segmental resection of the tumor. The bone defect was 12 cm in length. For reconstruction, an allograft was applied to the defect, with intramedullary K-wire augmentation. Dual-plate fixation was used with the assistance of a C-arm intensifier. Cortical screws were inserted into the plate, starting from the center and moving toward the periphery, and then augmented with bone cement (Figure 3).

Pain severity decreased and range of motion improved postoperatively. After 2 weeks, the patient had minimal pain and improved range of movement and grip strength. MM was confirmed through serological examination and bone marrow biopsy. The patient was then transferred to a hematologist. The patient received regular dexamethasone at the Department of Hematology 3 weeks after surgery. After consulting with the patient's family and a medical consultant in the Marshall Islands, we decided to send the patient back to the Marshall Islands for further MM treatment at 1 month after surgery. At a 6-month follow-up, the patient had further improved

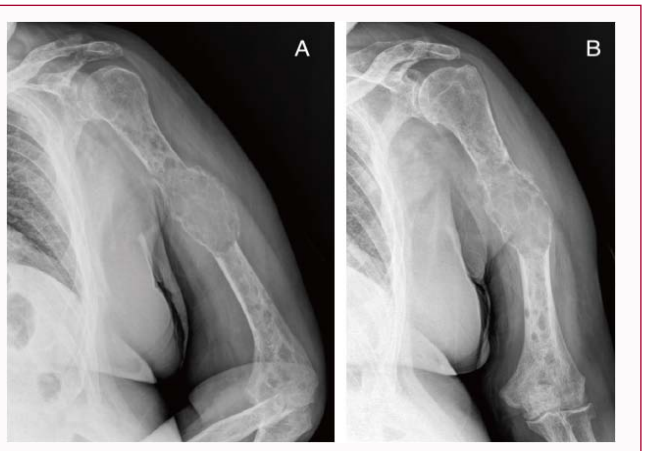

Figure 1: Preoperative X-ray images of left humerus.
(A) Lateral (B) and anteroposterior view of 10-cm lytic lesion on the left humeral shaft and multiple 1-cm lytic lesions over the left humerus.

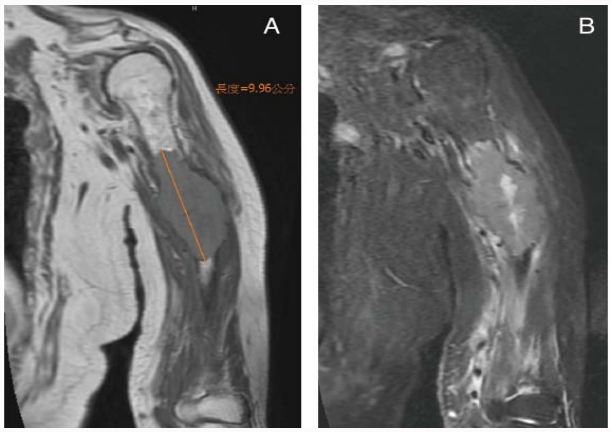

Figure 2: Preoperative magnetic resonance imaging.
Soft mass in the humeral shaft associated with pathological fracture presented as (A) hypointensity and isointensity on T1-weighted image and as (B) heterogenous hyperintensity on T2-weighted image. Several small metastatic-like lesions were also detected at the distal humeral shaft and scapula.

Figure 3: Postoperative X-ray images.
(A) Postoperative anteroposterior and (B) lateral view of the left humerus, showing reduction and fixation with plate and K-wire augmentation.

Table 1: Surgical approach according to features of pathological fractures of humeral shaft.

Features of PHSF	Short term	Long term
Large solitary lesion	CPF (+ our technique)	CPF (+ our technique) or SP
Impending fracture or multiple lesions	IMN	IMN or SP

range of motion and reported no pain. We will continue to follow up on the patient's rehabilitation and fracture healing.

Discussion

Lytic bone lesions are a common clinical manifestation of MM, causing a 9-fold increase in the risk of pathological fracture, which can lead to substantially lower quality of life [5]. Fracture events occur in approximately 60% of MM cases [6]. Other typical clinical manifestations include hypercalcemia, renal failure, anemia, and bone disease [7]. In our case, pathological fracture was the first sign of MM, and the results of the laboratory evaluations were consistent with those of other typical manifestations of MM, further indicating of MM and suggesting the likelihood of a poor prognosis [8].

PHSF is performed to relieve pain, provide immediate rigidity of the humerus to restore shoulder function, and increase quality of life [2,3]. Surgical interventions, including intramedullary nailing, plating, and prosthesis insertion, were proposed to treat PHSF [2]. The technique most often used to stabilize a PHSF is intramedullary nailing [2,3]; however, this technique has several disadvantages, including rotator cuff damage, nail protrusion at the shoulder, and a risk of unstable fixation, especially in low-quality bone [9]. Furthermore, nailing cannot effectively reduce the local tumor burden, meaning the tumor can progress rapidly [10].

We used a novel surgical technique to overcome the aforementioned disadvantages and obtain the maximum benefit for the patient: Dual-plate internal fixation. Dual-plate internal fixation avoids damaging the rotator cuff and eliminates the possibility of nail protrusion [3]. In contrast to intramedullary nailing, dual-plate internal fixation allows extensive curettage and segmental resection, thereby decreasing the risk of tumor progression [4]. After wide excision of the tumor, we used allograft bone with cement augmentation to reconstruct the 12-cm defect. K-wires were inserted into the medulla and allograft bone in a modified version of Hackethal's technique, which involves using multiple stacked flexible intramedullary nails for the treatment of PHSF [11]. Our technique achieves the same stability as intramedullary nailing and allows for immediate rigidity and the restoration of function shortly after surgery; furthermore, our technique is cheaper and involves less blood loss than intramedullary nailing [12-14]. Compared with intercalary prosthesis insertion, dual plating and intramedullary nail fixation with allograft bone and cement augmentation have several advantages. First, more osseous tissue is retained than is typical with other surgical techniques. Retaining osseous tissue is crucial in MM because patients with MM lose bone more rapidly than they experience tumor metastasis [15]. Second, our technique is less complicated than prosthesis insertion, which has a high risk of complications and is associated with increased blood loss [16]. Last, prosthesis insertion has a high risk of requisite reoperation due to prosthesis loosening. In a study by Wilson et al., patients underwent cement-augmented plating; after a mean follow-up of 20 months, the success rate was 100%, and no reoperations were required. We chose to use the new surgical technique in this case after considering the medical environment of the Marshall Islands and comparing the risks and benefits of the technique with those of other techniques.

Conclusion

Early surgical treatment is indicated for PHSF. Surgery improves quality of life and relieves pain. Dual-plate fixation can be performed in cases involving large lesions and wide excision of the tumor. Allogenic bone grafting with intramedullary K-wires and bone cement augmentation was performed in our case to reconstruct the bone defect and restore stability. This technique relieves pain, restores function, and reduces the risk of tumor progression.

Our patient was satisfied with his functional recovery and the effective treatment of his primary disease and consented to the publication of this report with the hope that it benefits the treatment of other patients with the same condition.

Our technique achieved a satisfactory outcome. No other reports have described this method for the treatment of MM-induced PHSF. Studies with large sample sizes and long follow-ups are warranted to identify the surgical indications, related complications, and implant survival rate.

According to review articles and our experience, the most effective surgical approach for treating PHSF depends on the lesion (Table 1) [3]. For cases that involve large solitary lesions, cement-augmented plate fixation provides greater anatomical stability and more complete lesion removal than does intramedullary nailing. Our novel technique could be used to augment rigidity in cases that involve large lesions, thereby overcoming the poor rigidity achieved through traditional cement-augmented plate fixation. By contrast, for cases that involve multiple lesions or impending fractures, we suggest using intramedullary nailing, which causes less perioperative blood loss and takes less time to perform. Finally, segmental prostheses are suitable for long-term implantation. The unique clinical characteristics of each case should be considered in addition to the aforementioned general suggestions.

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