



Case Report: Modified Arthroplasty and Cement Augmentation for Proximal Humerus Osteosarcoma Reconstruction—Short- Term Functional Outcomes

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ABSTRACT

Introduction : Reconstruction of the proximal humerus after wide tumor excision presents a significant surgical challenge. This case report evaluates the short-term functional outcomes of a modified arthroplasty technique reinforced with bone cement and internal fixation for proximal humerus osteosarcoma.

Case Presentation: A 25-year-old male presented with a progressively painful and enlarging mass on his left shoulder over eight months. Imaging and histopathology confirmed high-grade osteosarcoma of the left proximal humerus, Enneking classification IIB. The patient underwent limb-salvage surgery starting with a wide en bloc tumor excision. Reconstruction was performed using a modified shoulder arthroplasty technique: a size-24 shoulder stem prosthesis was implanted and augmented with polymethyl methacrylate (PMMA) bone cement for enhanced

stability. To provide additional mechanical reinforcement and secure anchor points for soft-tissue reattachment, a 4.5 narrow locking 9-hole plate and screws were secured to the construct. The patient subsequently completed six cycles of adjuvant chemotherapy.

Results: At the 12-month follow-up, the patient achieved an excellent Musculoskeletal Tumor Society (MSTS) score of 80%. Clinical evaluation demonstrated good active range of motion with no signs of local recurrence or distant metastasis.

Discussion: The use of PMMA cement provided immediate rigid fixation for early mobilization, while the supplemental locking plate acted as a critical anchor for reattaching the joint capsule and remaining musculature. Compared to conventional silver-coated or standard modular megaprotheses, which often face challenges regarding soft-tissue integration and high costs in developing regions, this modified approach offers a more accessible and biomechanically stable alternative for restoring shoulder mechanics. This modification effectively addresses the common clinical problem of postoperative shoulder instability caused by the extensive loss of dynamic stabilizers during oncological resection.

Conclusion : The combination of cemented tumor arthroplasty with supplemental plate fixation is a feasible and effective strategy, providing immediate mechanical stability and reliable soft-tissue reattachment for complex proximal humerus reconstruction.

Keyword : bone sarcoma, upper humerus, limb-salvage, arthroplasty

INTRODUCTION

Osteosarcoma is the most common primary malignant bone tumour of non-haematopoietic origin, characterized by malignant osteoid production from primitive mesenchymal cells. It typically presents with localized pain near joints, most often arises in the metaphyseal regions of long bones, including the proximal humerus. Conventional osteosarcoma accounts for 75–80%, further divided into osteoblastic (50%), chondroblastic (25%), and fibroblastic (25%) subtypes¹.

According to the World Health Organization (WHO), the global incidence of osteosarcoma is estimated at approximately 4 to 5 cases per one million individuals per year. This rate increases notably to 8 to 11 cases per one million population annually in adolescents aged 15 to 19 years. In Indonesia, retrospective data from Cipto Mangunkusumo Hospital between 1995 and 2007 revealed a total of 219 osteosarcoma cases, averaging 16.8 cases per year. Osteosarcoma accounted for 70.59% of all primary bone malignancies diagnosed at the institution, with the highest prevalence observed in the second decade of life².

While limb salvage surgery is the preferred modern treatment for osteosarcoma, reconstruction of the proximal humerus following tumour resection remains a complex surgical challenge^{1,2}. This case report details the application and outcomes of a modified shoulder arthroplasty technique for proximal humerus osteosarcoma, reported in line with SCARE criteria³.

Modular megaprotheses are frequently utilized for reconstructing large bone defects; however, this approach is associated with specific complications, including high mechanical failure rates, joint instability due to poor soft-tissue integration, and substantial financial costs. Studies have indicated that proximal humerus megaprotheses often suffer from superior subluxation and dislocation because they lack effective anatomical anchors for the deltoid and rotator cuff muscles.⁴ In contrast, modified techniques using standard shoulder prostheses reinforced with polymethyl methacrylate (PMMA) bone cement and locking plate fixation offer a more cost-effective alternative. This modification provides rigid immediate stability and serves as a reliable anchor for soft-tissue reattachment, which is critical for restoring postoperative limb function.⁵

CASE PRESENTATION

A 25-year-old male patient presented with progressively enlarging and painful mass over his left shoulder. The swelling began eight months prior to admission as a small lump and grew rapidly into the size of football (Fig 1). The pain was severe, often had a burning sensation, worsening at night. There was no history of trauma or systemic symptoms, although he appeared cachectic. No additional masses and family history were noted.

Physical examination revealed a semisolid, circumferential mass measuring approximately 7x7x10 cm, with ill-defined margins and a regular surface. Shoulder movement was restricted but still within functional limits. Distal neurovascular status remained intact.

Radiographs showed a mixed lytic-blastic lesion in the metadiaphyseal region of the proximal humerus (Fig 1). The film demonstrated aggressive features, including a moth-eaten lytic pattern, a wide zone of transition, poorly defined margins, sunburst periosteal reaction, Codman triangle and soft tissue extension. Chest X-ray showed no pulmonary metastases. Magnetic Resonance Imaging (MRI) demonstrated an inhomogeneous hypointense lesion in the proximal left humerus (Fig 2) without neurovascular involvement.

Core needle biopsy confirmed a high-grade Osteosarcoma. The patient diagnosed with Osteosarcoma of the left proximal humerus, Enneking Stage IIB. A multidisciplinary tumour board recommended a limb-salvage surgery with neoadjuvant chemotherapy, wide excision, immediate reconstruction, followed by radical surgery and adjuvant chemotherapy. Surgery was performed using a deltopectoral approach with the patient in the beach-chair position. Dissection through the deltopectoral interval exposed the long head of the biceps brachii and the tumor (Fig 3a-c). The tumour measuring approximately $14 \times 18 \times 8$ cm, was excised *en bloc* with clear margins.

The subsequent reconstruction was executed using a modified shoulder arthroplasty technique:

1. A shoulder stem prosthesis (size-24) was implanted to replace the excised proximal humerus segment.
2. The prosthetic stem was augmented and secured using bone cement (polymethyl methacrylate or PMMA) within the remaining humerus shaft, enhancing long-term stability.

3. Augmentation with additional stability reinforcement was performed by securing the construct with a 4.5 narrow locking 9-hole plate and screws. This internal reinforcement provided crucial mechanical stability and served as critical anchor points for the reattachment of the remaining soft tissues, specifically the joint capsule and muscular remnants (Figure 3e-f).

Postoperative radiographs confirmed correct anatomical placement of prosthesis and fixation construct (Fig 4). The patient completed six cycles of adjuvant chemotherapy. At the twelve months follow-up, surgical and functional outcomes were favourable. Using the Musculoskeletal Tumour Society (MSTS) Score, the patient achieved an excellent score of 80%, with clinical images demonstrated good active range of motion (Fig 5). Serial follow-up confirmed no local recurrence or distant metastasis during this period.

DISCUSSION

Osteosarcoma is the most common non-hematopoietic primary malignant tumor of bone and characterized by aggressive clinical course and a high propensity for metastasis. Conventional osteosarcoma occurs more frequently in males^{6,7}. Before the widespread adoption of multiagent chemotherapy in the 1970s, high-grade sarcomas of the extremities often required radical procedures, such as forequarter amputation for proximal humerus lesions⁸. Marcove et al⁶, broadened the criteria for limb-salvage shoulder girdle procedures to include high-grade sarcomas of the proximal humerus and scapula. Nowadays, advance in neoadjuvant and adjuvant chemotherapy combined with rigorous surgical excision, limb-salvage has become the standard of care, yielding five-year survival rates between 60% and 75%⁹.

1. The Biomechanical Imperative in Proximal Humerus Reconstruction

Successful limb-salvage surgery for proximal humerus osteosarcoma requires balancing wide tumor-free margins and restoring maximal limb function. Reconstruction in this region is particularly challenging because it must address both structural replacement and restoration of glenohumeral stability. Wide resection for high-grade osteosarcoma often necessitates sacrificing key musculotendinous insertions, including the entire rotator cuff (e.g., supraspinatus and subscapularis). The loss of these muscle dynamic stabilizers is a major cause of postoperative shoulder dysfunction and instability¹⁰. Therefore, any

reconstructive technique must ensure reliable soft-tissue reattachment and maintenance of joint stability.

2. Rationale for Modified Arthroplasty and Cement Augmentation

This case report highlights the successful management of a large Enneking Stage IIB proximal humerus osteosarcoma using wide *en bloc* excision followed by a modified shoulder arthroplasty technique. A standard tumor stem prosthesis was implanted with bone cement and further stabilized using a 9-hole locking plate.

- **Cement Augmentation:** Polymethyl Methacrylate (PMMA) cement was strategically utilized to enhance the mechanical fixation stability of the remaining diaphyseal. This provides immediate rigid fixation, minimizing the risk of early aseptic loosening, and supporting early postoperative mobilization—important factors for functional recovery and implant longevity⁸.
- **Stability Reinforcement:** The locking plate construct not only reinforced stem-to-bone stability but also provided multiple secure anchor points for reattaching the joint capsule and muscle tissue. This enhanced soft-tissue fixation helps restore shoulder mechanics and reduce postoperative instability, which is a major challenge after the extensive soft-tissue resection¹⁰.
- **Joint Restoration and Stability Verification:** Beyond structural reinforcement, the modified technique prioritized comprehensive joint reconstruction to restore shoulder kinematics. This was achieved through the meticulous reattachment of the remaining rotator cuff tendons and a formal capsulorrhaphy using a PMMA-impregnated mesh, which functioned as a synthetic scaffold to compensate for the resected native joint capsule. Following the reconstruction, a rigorous intraoperative stability check was conducted through a full passive range of motion, specifically assessing for any signs of superior subluxation or multidirectional instability. By integrating these soft-tissue restorative steps with the rigid internal fixation provided by the locking plate, the procedure effectively addressed the dual requirements of oncological wide excision and functional joint preservation, ultimately contributing to the patient's high postoperative MSTS score.

3. Oncological Control and Functional Outcome Analysis

Wide, tumor-free margins were successfully achieved, fulfilling the primary oncologic requirement for preventing local recurrence⁸. The patient's functional recovery was objectively measured using the Musculoskeletal Tumor Society (MSTS) Scoring System.

- **Functional Recovery and MSTS Score:** The patient attained an excellent MSTS score of 80% at the twelve months postoperative follow-up. This score validates the success of the modified reconstructive technique, confirming effective pain control, restoration of key range of motion, and preservation of useful manual dexterity. Achieving this level of function is a definitive benchmark for successful limb salvage in the upper extremity⁹. At the 12-month final follow-up, the functional status of the upper limb was objectively assessed using the Musculoskeletal Tumor Society (MSTS) scoring system. The patient achieved an overall score of 24/30 (80%), categorized as an excellent functional outcome. Specifically, the patient reported a complete absence of pain (5/5) and a high level of emotional acceptance (5/5). While hand dexterity and activities of daily living (e.g., eating and writing) were fully restored (5/5), moderate limitations remained regarding heavy lifting (3/5). The shoulder joint demonstrated an active abduction of 60° and forward flexion of 70°, which represents a significant achievement given the extensive resection of the rotator cuff and deltoid musculature⁸.
- **Follow-up Period:** At the 12-month follow-up, the patient demonstrated excellent functional recovery and oncological stability. Given the aggressive nature of high-grade osteosarcoma, surveillance was performed via regular chest X-rays and clinical examination of the surgical site, revealing no evidence of local recurrence or pulmonary metastasis. The patient successfully completed six cycles of adjuvant chemotherapy without significant toxicity, allowing for an uninterrupted physical rehabilitation program. A structured protocol—beginning with pendulum exercises at week 2 and progressing to active-assisted range of motion by week 6—was instrumental in achieving a substantial improvement in quality of life. Despite the inherent limitations in overhead reach common to proximal humerus reconstructions, the modified technique provided sufficient stability for the patient to achieve independence in daily activities without the need for long-term orthosis.

However, it is essential to acknowledge that this twelve-month evaluation represents only a short-term follow-up. While the early functional outcomes are promising, the patient requires continued mid-term (2–5 years) and long-term surveillance. Such monitoring is vital to rule out late-stage complications common in osteosarcoma management, including delayed pulmonary metastasis and mechanical implant-related issues, such as septic or aseptic loosening of the cemented prosthesis^{7, 8}. A continued favorable outcome beyond the one-year mark will provide stronger validation regarding the durability and long-term viability of this modified surgical method compared to conventional reconstruction options.

In summary, this case report robustly supports the use of the modified limb-salvage approach—combining cemented tumor arthroplasty with supplemental Stability Reinforcement—as a highly effective and functionally rewarding strategy for complex proximal humerus reconstruction after aggressive osteosarcoma excision.

CONCLUSION

Limb-salvage surgery for proximal humerus osteosarcoma remains a formidable challenge, requiring a delicate balance between wide oncological resection and the restoration of complex joint mechanics. This case demonstrates that a modified shoulder arthroplasty technique—utilizing PMMA cement augmentation combined with supplemental locking plate fixation—is a highly effective and reproducible reconstructive option.

The integration of internal fixation provided the necessary structural stability and critical anchor points for soft-tissue reattachment, including the remaining rotator cuff and joint capsule. This approach effectively addressed the common complication of postoperative shoulder instability, resulting in an excellent functional outcome as evidenced by an MSTs score of 80% at the 12-month follow-up. Furthermore, this modification offers a cost-effective and biomechanically sound alternative to expensive modular megaprotheses, particularly in resource-limited clinical settings. While short-term results are promising, continued long-term surveillance remains essential to monitor for late mechanical or oncological complications.

CONSENT

Written informed consent was obtained from the patient itself for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

ETHICAL APPROVAL

Ethical approval was waived by the Institutional Review Board as this is a single case report involving standard clinical care, and no identifiable patient information is disclosed.

GUARANTOR

Muhamad Naseh Sajadi Budi and Muhammad Rifki Faiz accept full responsibility for the work and the conduct of the study, had access to the data, and controlled the decision to publish.

RESEARCH REGISTRATION NUMBER

Not applicable.

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I do not have any funding support.

CONFLICT OF INTEREST

I declare that I have no conflicts of interest.

FIGURES

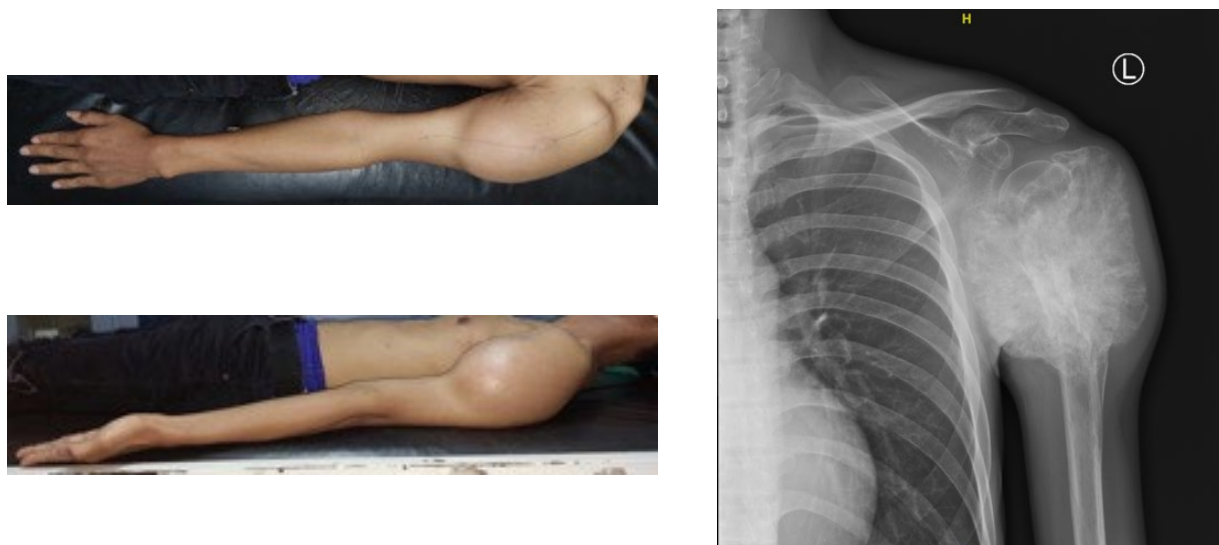


Fig 1. Pre-operative Clinical and Radiographic Assessment. (Left) Clinical presentation showing the progressive enlargement of the mass over the left shoulder. (Right) AP plain radiograph of the left shoulder demonstrating a mixed lytic-blastic lesion localized primarily in the metadiaphyseal region of the proximal humerus, characterized by a sunburst periosteal reaction and cortical breach, consistent with aggressive bone malignancy.

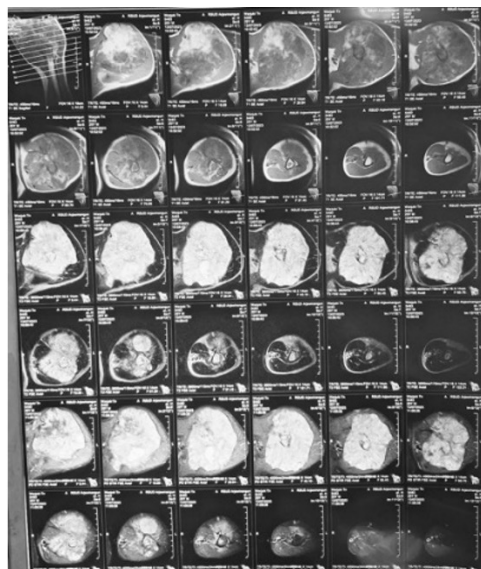


Fig 2. Pre-operative MRI Assessment. Multiplanar T-weighted sequences of the left proximal humerus revealing an inhomogeneous, predominantly hypointense intramedullary lesion. Axial plane views confirm the extensive tumour burden and soft tissue extension while

demonstrating sparing of the major neurovascular bundle, which is critical for surgical planning (limb salvage).

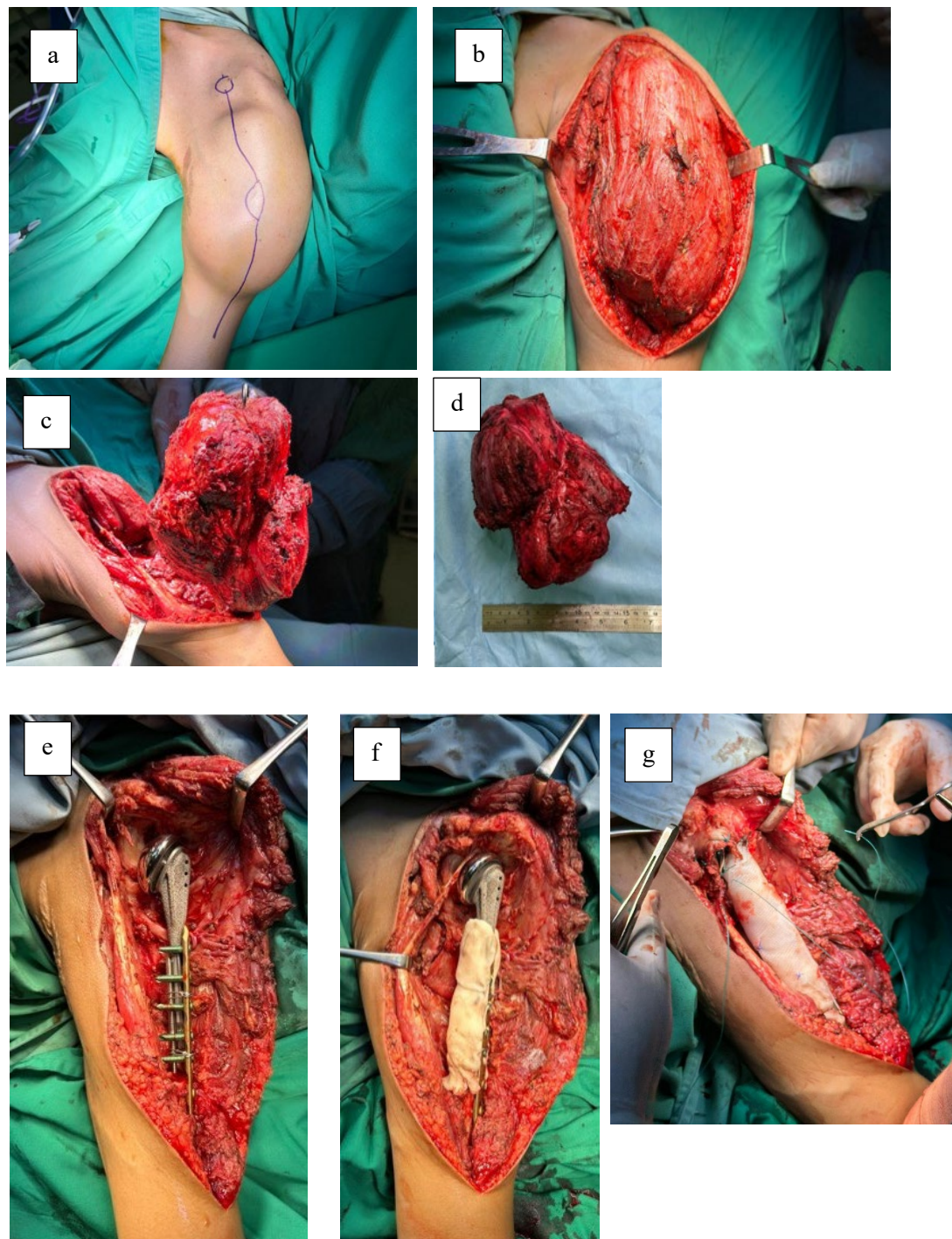


Fig 3 .Intraoperative Steps of Modified Limb-Salvage Reconstruction. (a) Preoperative skin marking for the planned deltopectoral approach. (b) Surgical dissection and exposure of the large tumor mass (*in situ*). (c) Successful *en bloc* wide excision of the tumor. (d) Tumor

specimen post-excision measured approximately 14 x 18 x 8 cm. (e) Reconstruction phase demonstrating the modified cemented shoulder arthroplasty technique, where the shoulder stem prosthesis (size-24) is inserted, followed by (f) augmentation with bone cement and secured with a 4.5 narrow locking 9-hole plate and screws for stable osteosynthesis. (g) Joint reconstruction with meticulous reattachment of the remaining rotator cuff tendons and a formal capsulorrhaphy using a PMMA-impregnated mesh

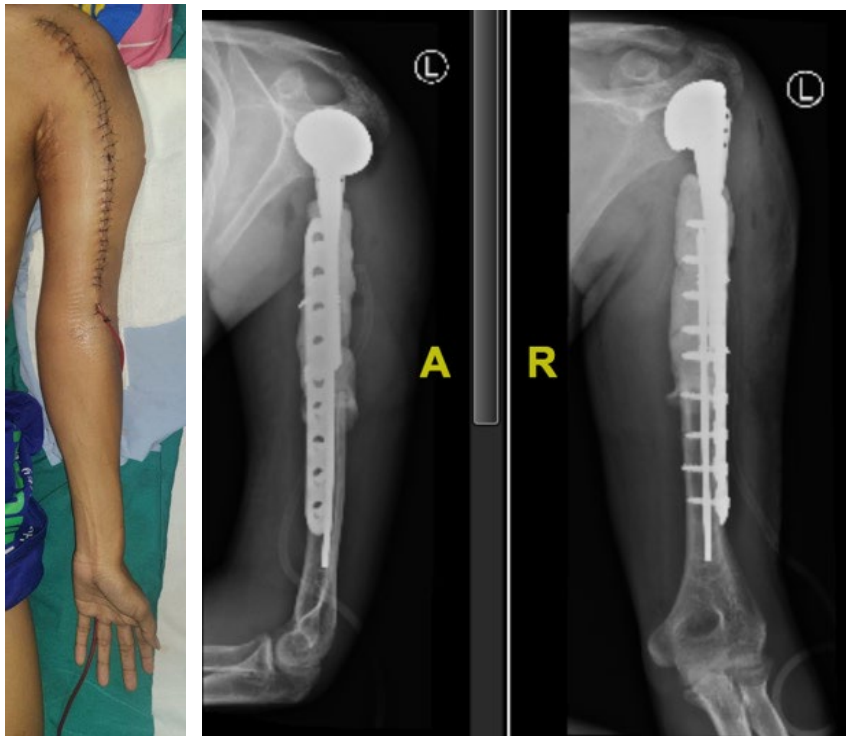


Fig 4. Immediate Postoperative Status. (Left) Clinical appearance of the wound following closure via the deltopectoral incision. (Middle & Right) Postoperative AP and lateral radiographs showed correct placement of the cemented shoulder stem prosthesis and stable fixation with the plate and screw construct (Stability Reinforcement).



Fig 5. Functional Outcome at Twelve Post-Surgery. Clinical photographs illustrating the patient's active shoulder movements including abduction and internal rotation (reaching the lower back). These findings support the excellent MSTS score of 80% achieved during the short-term follow-up.

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