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Induced Membrane Technique Combined with Surgical Lengthening of an Humerus Defect Secondary to Chronic Osteomyelitis: Case Report

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Abstract **Case Report**

Surgical management of long bone defects remains a considerable challenge for orthopedic surgeons, particularly in septic conditions. We present the case of an 8-year-old girl with a history of chronic osteomyelitis in the left humerus, referred to us following a pathologic fracture, initially managed with humeral osteosynthesis and grafting. Subsequently, the induced membrane technique was employed for pseudarthrosis after a recurrent fracture. Following consolidation, significant humeral shortening was observed, necessitating surgical lengthening using an external fixator, resulting in a satisfactory final outcome.

Keywords: Induced Membrane Technique, Surgical Lengthening, Humers, Chronic Osteomyelitis.

INTRODUCTION

The management of post-infectious bone loss in the pediatric population represents a complex and challenging aspect of current orthopedic practice. It involves numerous difficulties, including the selection of appropriate bone reconstruction methods and the handling of infectious complications.

The induced membrane technique, pioneered and popularized by A.C. Masquelet [1], marks a significant breakthrough in bone defect reconstruction surgery. Prior to its development, only allografts and vascularized grafts were feasible options. This technique has since emerged as the gold standard for segmental bone reconstruction in children, enabling the restoration of significant bone losses.

We report the case of an 8-year-old girl treated by induced membrane technique then a surgical lengthening for an humerus defect secondary to chronic osteomyelitis, with good bone healing.

CASE PRESENTATION

An 8-year-old girl with a history of chronic osteomyelitis affecting her left humerus was referred for management of a pathological proximal diaphyseal fracture. Following successful control of the infection, a stable elastic centromedullary pinning procedure combined with grafting was performed. The patient exhibited positive clinical progress, with subsequent consolidation of the humerus.

Subsequently, the child presented with an iterative fracture of the humerus, with breakage of the osteosynthesis material and recurrence of local infection (Figure 01). The osteosynthesis material was removed and the locoregional infection was controlled with antibiotics. The evolution was marked by pseudarthrosis of the fracture site, with an estimated loss of bone substance of 3 cm, representing an IOR of 15% of the length of the humerus, hence the decision to perform the Masquelet technique.

During the first stage of Masquelet technique, the patient underwent an anterolateral approach of the left arm opposite the loss of bone substance, excision of necrotic tissue and avivement of the bone margins, with osteosynthesis using a Metaizeau wire and placement of surgical cement. (Figure 02)

The 2nd stage was performed 8 weeks later, and consisted of reopening the old incision, removing the biologic cement while respecting the induced membrane, and filling the bone defect with a corticospongious graft harvested from the iliac crest.

Post-operative follow-up was straightforward, with immobilization in a brachio-anthebrachiopalmar splint that molded the shoulder. Bone consolidation was achieved at 9 months, with a RUST score of 16.

The patient had retained a significant length inequality of 5 cm, or an IOR of 25%, treated by lengthening osteotomy using an external lengthening fixator, with a satisfactory final clinical result and good radiological consolidation (Figure 03).

Figure 1: X-Ray: Iterative fracture of the humerus, with breakage of the osteosynthesis material

Figure 2: X-Ray: First stage of Masquelet technique, with osteosynthesis using a Metaizeau wire and placement of surgical cement

Figure 3: X-Ray: Final radiological result after lengthening osteotomy using an external lengthening fixator

DISCUSSION

The management of post-infectious bone loss presents a highly complex and contemporary challenge, characterized by various difficulties in selecting appropriate bone reconstruction strategies. This is often compounded by the necessity to address infectious complications and ensure adequate musculocutaneous coverage.

In cases of minimal bone defects, a single-stage autologous bone graft is typically recommended. However, when this option is not feasible, several surgical reconstruction techniques are available.

Initially, the surgical techniques of Ilizarov distraction osteogenesis [2], bone transport [3], and allograft [4], were considered the gold standard for managing large bone losses. Subsequently, with the introduction of microsurgery, vascularized fibula grafting became widely utilized [5]. Towards the end of the twentieth century, Masquelet [1] introduced a novel surgical technique based on the induction of a membrane by a cement spacer.

In post-infectious bone defects, reconstruction remains a significant challenge, with the primary goals being to sterilize the infectious site and reconstruct the bone defect. In our case, the child presented with a recurrent humerus fracture and localized infection. Our initial objective was to control the infection by removing the osteosynthesis material and administering antibiotics. Subsequently, we decided to proceed with the first stage of the Masquelet technique using a cement spacer.

In septic osteoarticular surgery, the cement spacer serves a dual purpose: it maintains the space before grafting and provides bacteriological control. In cases of uncontrolled sepsis, the cement spacer may be removed, and after meticulous preparation, a new cement spacer can be inserted. If the infection is successfully controlled, the second stage of the induced membrane technique can be performed approximately 8 weeks after cement insertion.

Some authors have recommended performing the second stage early after the first one, citing a higher rate of growth factors reported several weeks after the initial stage. However, others have suggested modulating this delay based on the location of the defect, such as the femur and humerus, where the consolidation of the membrane may take longer due to a single main vascular axis [6]. In our experience, the second stage was conducted 8 weeks after the first one. However, we believe that a longer delay of more than 8 weeks between the two stages may not significantly impact the osteo-inductive and osteogenic properties of the induced membrane, as described by Gindraux *et al.*, [7], and Giannoudis and Harwood [8].

Consolidation was achieved within 9 months, which is consistent with the findings of the Gouron [9], series, where an average consolidation time after the second stage of Masquelet was reported as 9.1 months (ranging from 2 to 25 months).

Humeral lengthening, in comparison to femoral or tibial lengthening, is relatively uncommon. One possible explanation for the rarity of humeral lengthening is that minor shortening of the humerus seldom presents a significant functional or cosmetic impairment to the patient. Consequently, only a limited number of reports on humeral lengthening can be found in the international orthopedic literature, whereas reports on humeral shortening are more prevalent [10-15]. The most common causes of humeral shortening include osteomyelitis or growth plate closure resulting from a tumor [16-18].

In our case, the retained humeral shortening could be attributed to the damage to the upper extremity of the humerus, which is responsible for approximately 80% of bone growth. Additionally, the initial bone defect may not have been completely filled by the graft, contributing to the observed shortening.

Humeral lengthening can be associated with several complications, especially when the limb is lengthened by more than 20% [19]. However, there have been numerous studies demonstrating humeral lengthening exceeding 20% with minimal complications. For instance, in an analysis by Hosny [20], 56 humeral lengthenings were conducted on 46 pediatric patients, resulting in a mean lengthening of 55%. Similarly, other studies have reported humeral lengthenings ranging from 40% to 60% [21-23].

In the present case, humeral shortening amounted to 20%, and we initiated distraction with a lengthening rate of 1 mm per day. Two months after the removal of the external fixator, radiographs revealed satisfactory consolidation of the humeral shaft, with no evidence of fracture or deformity. However, a discrepancy of 1 cm in length was observed, and the patient expressed satisfaction with the resulting discrepancy in upper limb length.

CONCLUSION

In cases of post-infectious long bone defects, the induced membrane technique presents itself as a viable option. This case has demonstrated that this approach is entirely feasible for the humeral location in children, yielding favorable outcomes.

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