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Evidence-Based Strategies for Optimizing Management of Cystic Lesions in Elongated Tubular Skeletal Structures

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Abstract: Cystic lesions of long tubular bones remain one of the most challenging orthopedic pathologies in pediatric and adolescent patients due to their tendency toward progression, repeated pathological fractures, deformation of the affected segment, and high recurrence rates following conventional treatment. The need for a treatment strategy that ensures radical removal of the cystic cavity, full restoration of bone architecture, prevention of relapse, and preservation of limb function has stimulated the development of advanced minimally invasive and reconstructive approaches. The present method is based on combining radical surgical excochleation of the cystic focus with reconstruction of the bone defect using various interchangeable osteoplastic materials, including autologous bone grafts, medical cement, collopan preparations, and modern bone-substitute grafts. This multimodal technique enables stable filling of the defect, stimulates osteogenesis, and provides conditions for reliable structural repair.

A key component of the method is the use of transosseous osteosynthesis based on Ilizarov technology, which makes it possible to perform controlled reposition, compression, distraction, and correction of deformities while preserving vascular supply and biological integrity of the bone. Endoscopic visualization is applied as an auxiliary technique to monitor the radicality of the resection, minimize surgical trauma, and reduce the risk of recurrence. The effectiveness of the method was evaluated in children and adolescents with cystic lesions of the proximal femur, complicated in many cases by deformities, repeated fractures, or limb-length discrepancies. The combination of directed osteotomy, osteoplastic reconstruction, and controlled external fixation provided reliable conditions for the formation of high-quality bone regenerate, early functional recovery of the limb, and restoration of physiological biomechanics.

Long-term radiological and functional outcomes confirm that the described method offers significant advantages over traditional techniques. It ensures complete remodeling of the bone without recurrence, preserves joint mobility, corrects deformities, restores limb length, and reduces the total duration of treatment by 1.5–2 times.

Keywords: long tubular bone, cystic formation, femoral neck, trochanteric region, osteosynthesis, endoscopic surgery, osteoplasty.

Introduction

Cystic lesions of long tubular bones represent a significant challenge in orthopedic practice, particularly among children and adolescents. These lesions often lead to structural weakening of the bone, increased risk of pathological fractures, and secondary deformities of the affected limb, which can compromise mobility and quality of life. Conventional management approaches, including conservative therapy, puncture with corticosteroid injections, and open surgical

resection, often show variable outcomes, with frequent recurrence and delayed functional recovery. Recent advances in minimally invasive and reconstructive surgical techniques, including transosseous osteosynthesis and endoscopic-assisted procedures, have provided opportunities for more precise removal of cystic tissue while preserving surrounding bone and soft tissue. Such approaches aim to restore normal biomechanics, promote osteogenesis, and reduce both treatment duration and risk of relapse.

Aim of the study

The aim of this study was to evaluate the effectiveness of a rational, evidence-based surgical approach for the treatment of cystic lesions in long tubular bones, combining radical excision, osteoplastic reconstruction, and transosseous fixation techniques. Specifically, the study sought to assess the anatomical and functional outcomes of the proposed method, determine the rate of bone regenerate formation and consolidation, evaluate the incidence of recurrence and postoperative complications, examine the potential for minimizing surgical trauma through endoscopic-assisted visualization.

Materials and methods

Surgical treatment was carried out under epidural anesthesia. Initially, three crossing Kirschner wires were inserted through the iliac wing and secured to the Ilizarov apparatus arc support (fig.1). Another group of intersecting wires was placed at the junction of the upper and middle thirds of the femur and fixed in an arcuate or ring support. A third set of needles was introduced through the distal metaphysis of the femur and attached to a separate ring. All supports were unified using three to four threaded connecting rods.

A targeted incision was made over the greater trochanter, followed by careful layer-by-layer dissection to expose the proximal femur. A subperiosteal trepanation window was created using chisels, after which thorough intraosseous curettage of the cystic cavity was performed. All altered tissues of the femoral neck and greater trochanter were excised within the boundaries of healthy bone. The remaining cavity was coagulated and treated with alcohol to reduce recurrence risk.

At the lower margin of the femoral neck, an oblique osteotomy was executed (from inferolateral to superomedial direction), forming a beak-shaped distal fragment congruent to the proximal defect. The distal segment was then inserted into the proximal part to restore the anatomical neck–shaft angle (125°–130°), ensuring tight bone-to-bone contact.

Three additional Kirschner wires were passed through the trochanteric region and the proximal end of the distal fragment, securing the reconstructed segment to the Ilizarov frame with hinged rods. The surgical wound was carefully closed in anatomical layers. Aseptic dressings were applied to the operative field and wire insertion points.

After 3–4 weeks, radiological confirmation of primary regenerate formation allowed dismantling of the proximal frame on the iliac wing. Patients were then prescribed a rehabilitation program focused on restoring hip joint mobility and adapting gait to new biomechanical conditions.

If postoperative limb shortening occurred after fragment alignment, a secondary osteotomy was performed at the lower third of the femur. Gradual distraction began on postoperative days 5–7 at a rate of 0.25 mm 3–4 times a day until the planned length was restored.

Fixator removal was determined by a combination of clinical-radiological criteria:

- uniform regenerate density comparable to adjacent bone,
- clear cortical plate formation visible in two projections,
- absence of pathological mobility or pain under axial (up to 30% of body weight) and lateral load tests.

In most cases, no additional immobilization was required following device removal (fig.2).

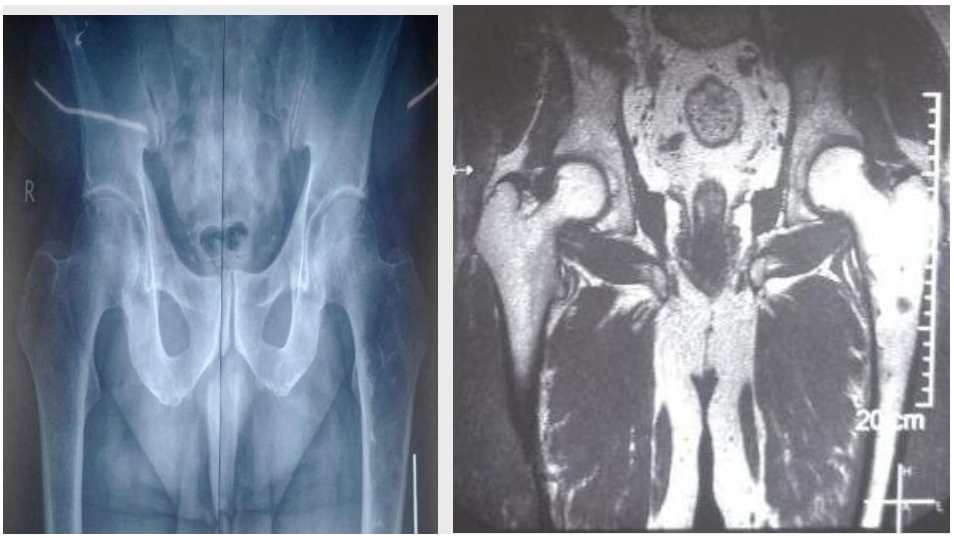
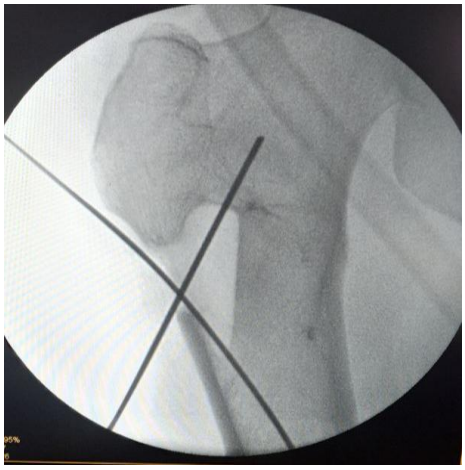
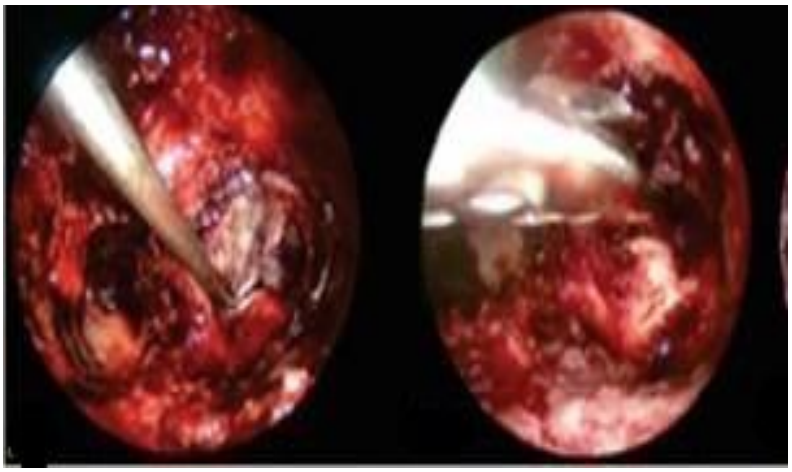


Figure 1. Cystic formation of the proximal epimetaphysis of the left femur





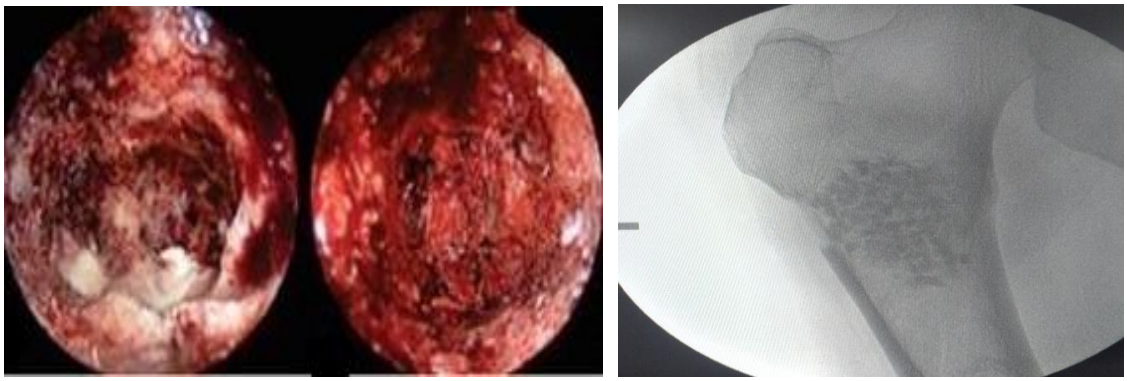


Figure 2. During the operation

Results

This surgical algorithm was implemented in seven patients aged 8 to 16 years with cystic lesions of the proximal femur (five boys and two girls). Prior to admission, the group collectively experienced eleven pathological fractures. These had been treated with plaster immobilization (5 cases), skeletal traction (2 cases), marginal resections (3 cases), and one subperiosteal resection with cortical allografting (fig.3).

On admission, deformities were present in most patients: five exhibited coxa vara (85°–120°), while two had coxa valga (135°–145°). Limb-length discrepancy was noted in four cases, with two patients showing shortening (3–4 cm) and two demonstrating excessive length due to hip deformity.

The longitudinal extension of cystic lesions varied from 4 to 10 cm. When deformity of the cervico-trochanteric region was present, the described targeted osteotomy technique was applied to reconstruct normal biomechanical alignment. Limb shortening was fully corrected in four children: in two, discrepancy was preexisting, and in two, it developed after fragment realignment during surgery. Excessive limb length in two patients was corrected simultaneously with the main procedure [1].

Average duration of Ilizarov fixation was 106.7 ± 14 days. In all cases, favorable clinical outcomes were achieved. Parameters considered included pain absence, segment stability, restoration of limb length, joint mobility, absence of deformity, and lack of recurrence (fig.4).

Long-term observation (1–5 years) showed: complete anatomical reconstruction of the femur, physiological remodeling of bone tissue, preservation of normal cervico-diaphyseal angles,full functional recovery of adjacent joints, no recurrence of the disease.

Thus, combining directed osteotomy, compression-distraction osteosynthesis, and osteoplastic reconstruction produced stable, long-lasting results and reduced treatment duration by 1.5–2 times compared to conventional techniques.

Figure 3. Cystic formation of the distal epimetaphysis of the left fibula

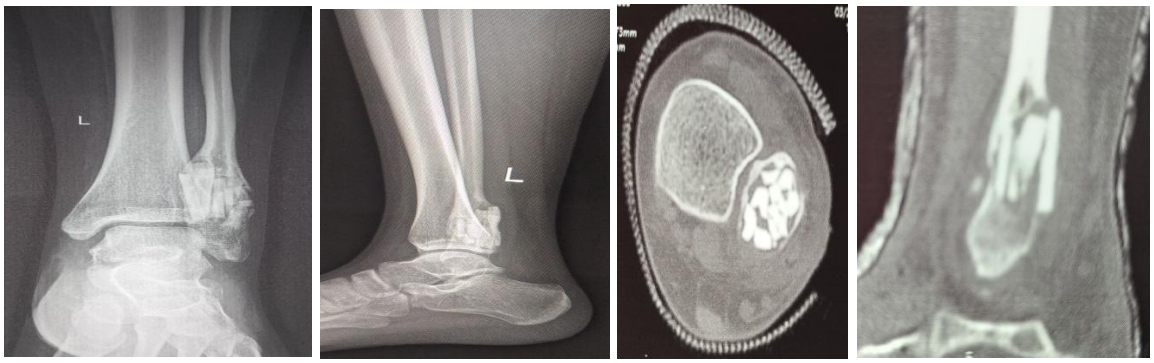


Figure 4. After the operation

Conclusion

Endoscopic support significantly improved visualization of the cystic cavity, enabling reliable assessment of the radicality of resection and minimizing soft tissue and bone trauma. For this purpose, the "STORE" arthroscopic system and BIOS instrument set were utilized.

The minimally invasive endoscopic approach was successfully applied in all patients, allowing radical excision of the pathological tissue through small access portals. Follow-up over 6 months to 2 years revealed no recurrence of cystic lesions, with the exception of a single fracture at the osteoplasty site, which healed without complications [2].

Thus, endoscopic assistance in the treatment of cystic lesions of long tubular bones ensures: minimal surgical trauma, better visualization of the operative field, higher accuracy of pathological tissue removal, reduced recurrence rates, safe and effective radical surgery.

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