


# Injectable calcium sulfate vs mixed bone graft of autologous iliac bone and allogeneic bone

## Which is the better bone graft material for unicameral bone cyst in humerus?

Jin Li, MD, PhD<sup>a</sup>, Saroj Rai, MD, PhD<sup>b</sup>, Renhao Ze, MD, PhD<sup>a</sup>, Xin Tang, MD, PhD<sup>a</sup>, Ruikang Liu, MD<sup>c</sup>, Pan Hong, MD, PhD<sup>a,\*</sup> 

### Abstract

Unicameral bone cyst (UBC) is a benign fluid-filled lesion, mainly located in the metaphyses of long bones in children and adolescents. Elastic stable intramedullary nail (ESIN) is adopted in our institute for UBCs since 2010, and bone grafting was performed simultaneously. This study aims to evaluate the efficacy of ESIN decompression combined with different bone graft materials.

All patients with the diagnoses of UBCs of the humerus, treated with ESINs and bone grafting between January 2010 and June 2018, were analyzed retrospectively. The bone grafting included injectable calcium sulfate, a mixture of the autologous iliac bone and allogeneic bone. All patients were categorized into 2 groups: ICS (injectable calcium sulfate) group and MIX (a mixture of the autologous iliac bone and allogeneic bone, ratio: 1:3) group. All the information was collected from the Hospital Database.

In all, 17 patients (8.8 ± 2.3-year-old, male 8, female 9) in the ICS group and 19 patients (8.9 ± 1.9-year-old, male 10, female 9) in the MIX group were included in this study. Patients in both groups were followed up for more than 2 years (average, 3.4 ± 1.3 years). No recurrence was observed in either group. There was no significant difference between the two groups concerning the patient's demographic parameters, including sex, age, and affected side. All patients in both groups displayed excellent and good shoulder function, and there was no significant difference between the 2 groups ( $P = .29$ ). As for the Capanna classification, there was no significant difference between these 2 groups ( $P = .78$ ).

Intramedullary nailing has the advantage of a minimally invasive procedure, immediate stability, and continuous decompression. ICS showed similar results as a mixture of the autologous iliac bone and allogeneic bone.

**Abbreviations:** CT = computed tomography, ESIN = elastic stable intramedullary nail, UBC = unicameral bone cyst.

**Keywords:** humerus, injectable calcium sulfate, pathological fracture, unicameral bone cyst

Editor: Oguzhan Ekizoglu.

JL is the first author of the manuscript.

The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

<sup>a</sup>Department of Orthopaedic Surgery, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China, <sup>b</sup>Department of Orthopedics and Trauma Surgery, National Trauma Center, National Academy of Medical Sciences, Mahankal, Kathmandu, Nepal, <sup>c</sup>First School of Clinical Medicine, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China.

\*Correspondence: Pan Hong, Department of Orthopaedic Surgery, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430022, China (e-mail: hongpan2013@foxmail.com).

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How to cite this article: Li J, Rai S, Ze R, Tang X, Liu R, Hong P. Injectable calcium sulfate Vs. mixed bone graft of autologous iliac bone and allogeneic bone: which is the better bone graft material for unicameral bone cyst in humerus?. *Medicine* 2020;99:23(e20563).

Received: 25 February 2020 / Received in final form: 1 May 2020 / Accepted: 5 May 2020

<http://dx.doi.org/10.1097/MD.00000000000020563>

## 1. Introduction

Unicameral bone cyst (UBC) is a benign fluid-filled lesion, mainly located in metaphyses of long bones in children and adolescents.<sup>[1–3]</sup> The proximal humerus and femur account for almost 90% of the lesions in long bones. The treatment of UBCs has continued to evolve. Current methods include close observation with regular follow-up, injection of steroids,<sup>[4,5]</sup> bone marrow,<sup>[6,7]</sup> DBM,<sup>[8]</sup> decompression using elastic stable intramedullary nail (ESIN),<sup>[8–10]</sup> cannulated screws,<sup>[11]</sup> curettage and bone grafting.<sup>[12]</sup> All these methods showed variable results.

Although the etiology of UBCs remains elusive, blockage in the venous drainage is the most favored mechanism. Factors contributing to bone resorption are high internal pressure and fluid accumulation, venous stasis, and developmental anomaly occurring in the veins.<sup>[13–15]</sup> Therefore, opening the medullary canal using ESIN, which favors the healing of the lesion, was proposed and reported by multiple authors.<sup>[10,16,17]</sup>

ESIN is adopted in our institute for UBCs since 2010, and bone grafting was performed simultaneously. This study aims to evaluate the efficacy of the decompression using ESIN combined with different bone graft materials.

## 2. Materials and methods

All the patients with a diagnosis of UBCs of the humerus, treated with ESINs and bone grafting between January 2010 and June

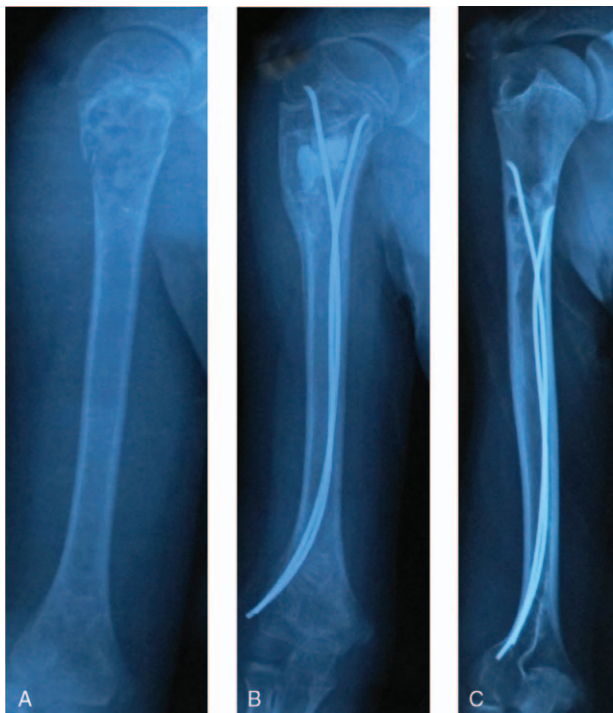
2018, were analyzed retrospectively. Institutional Review Board approval from Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology and informed consent from the patient's legal guardians had been obtained beforehand.

Inclusion criteria were as follows: patients of both sexes under the age of 15 years with a diagnosis of UBC in the humerus treated with ESINs and bone grafting. The bone grafting included injectable calcium sulfate, a mixture of the autologous iliac bone and allogeneic bone (ratio: 1:3). All patients were categorized into two groups: the ICS (injectable calcium sulfate,  $n=17$ ) group, and the MIX (a mixture of the autologous iliac bone and allogeneic bone,  $n=19$ ) group. Exclusion criteria: patients with incomplete medical history or radiographs, and follow-up less than 24 months. All the information was collected from the Hospital Database.

### 2.1. Surgical technique

No open or percutaneous biopsies prior to the surgery were performed. The diagnosis of UBC was strongly suspected based on its typical imaging characteristics, including X-rays, computed tomography (CT) scan, and magnetic resonance (MR) imaging. The diagnosis was confirmed by the presence of fluid-filled space during the surgery. The insertion of the nails was performed in a retrograde fashion.

Initially, the lesion was located under the fluoroscopy, and then an approximately 2 to 4 cm incision was made over the cyst. The cyst wall was then opened with the help of a small hemostatic clamp or osteotome. The drained fluid was carefully observed for the confirmation of the UBC. After making sure of the UBC,



**Figure 1.** UBC in the right proximal humerus in 11-year-old boy using injectable calcium sulfate. A. Preoperative image of the right humerus. B. Postoperative image of the right humerus. C. Full-length radiograph of the right humerus at 30-month follow-up.



**Figure 2.** UBC in the left humerus of a 9-year-old boy using a mixture of autologous and allogeneic bone. A. Radiograph of the left humerus before surgery. B. Radiograph of the left humerus after surgery. C. Radiograph of the left humerus at 12-month follow-up.

the cyst wall was freshened by a curette. Then, a 2 to 3 cm skin incision was made on the lateral aspect of the distal humerus over the supracondylar ridge. After the soft tissue clearance, two nail insertion points, at least 1 cm proximal to the physis and each 1 cm apart and directing proximally, were made using an awl. The appropriate size nails were then inserted and advanced to the site of the lesion proximally to provide stability of the pathological fracture. The position of the tip of ESINs was ascertained under the fluoroscopy. Then the ICS or MIX was used to fill the cavity. A long-arm slab was used for immobilization for 4 weeks after surgery. Sports activities were not allowed until the cyst showed consolidation on X-rays (Figs. 1 and 2).

### 2.2. Evaluation of patients

Anteroposterior (AP) and lateral radiographs of the affected arm were performed on the 1st postoperative day, and 1-month, 3-month, 6-month, 12-month, 18-month, 24-month after the surgery. After that, the annual out-patient visit was required. All the radiographs were evaluated according to the criteria of Capanna.<sup>[18]</sup> The shoulder function was evaluated using the rating scale of the American Shoulder and Elbow Surgeons (ASES).<sup>[19]</sup>

### 2.3. Statistical methods

Data collected was expressed in absolute numbers and percentages. Statistical analysis using Student's *t* tests was carried out to detect the difference in response to the treatment between two groups.  $P < .05$  was considered statistically significant.

Parameters	ICS (n=17)	MIX (n=19)	P value
Age (yr)	8.8±2.3	8.9±1.9	.92
Sex			
male	8	10	.74
Female	9	9	
Side			
Left	6	10	.28
Right	11	9	

ICS=injectable calcium sulfate, MIX=mixture of autologous iliac bone and allogeneic bone.

### 3. Result

As shown in Table 1, 17 patients (8.8±2.3-year-old, male 8, female 9) in the ICS group and 19 patients (8.9±1.9-year-old, male 10, female 9) in MIX group were included in this study. Patients in both groups were followed up for more than 2 years (average, 3.4±1.3 years). No recurrence was observed in either group. There was no significant difference between the two groups concerning the demographic parameters, including sex, age, and affected side.

As shown in Table 2, all patients in both groups displayed excellent and good shoulder function, and there was no significant difference between the 2 groups ( $P=.29$ ). As for the Capanna classification, there was no significant difference between these 2 groups ( $P=.78$ ).

### 4. Discussion

As shown in the result, patients in ICS and MIX group showed similar and good outcomes. ESIN is an effective and safe method for treating UBCs in the proximal humerus. Injectable calcium sulfate showed similar outcomes compared with mixed bone grafting, and it did not necessitate larger incision and longer operative time to harvest iliac bone and perform bone grafting.

Although there was a continuous publication of the studies about UBCs, very little is known about its etiology and pathogenesis.<sup>[17]</sup> Venous obstruction is the main cause which is accepted by several authors.<sup>[14,15]</sup> Therefore, using ESIN for continuous drainage of the cyst fluid and continuous decompression of the cyst seems a reasonable choice for the treatment of UBCs.

Many authors have widely reported intramedullary nailing without bone grafting for UBCs in long bones, but the healing rate varied in different studies.<sup>[9,10,16,17]</sup> Compared with plating, in addition to providing stability for pathological fracture, ESINs

have the advantage of being carried out through a relatively smaller incision, diminishing the blood loss, shortening duration of hospital stay, and faster return to daily life.<sup>[10]</sup> Besides, the injection of corticosteroids or bone marrow and bone grafting could be performed simultaneously.

Curettage and bone grafting has been considered as the gold standard for many years,<sup>[20]</sup> but it demonstrated a low healing rate, about 25% to 35%.<sup>[11]</sup> In a study, percutaneous curettage alone showed to be superior to intralesional injections,<sup>[21]</sup> addition of the calcium sulfate during the bone grafting increased the healing rate to 66%<sup>[22]</sup>; however, the recurrence remained high as 25%.<sup>[23]</sup> The purpose of bone grafting is to provide an osteogenic stimulus to enhance healing.<sup>[24]</sup>

In order to increase the healing rate, ESINs and bone grafting were combined and used in the treatment of UBCs in our institute. Injectable calcium sulfate is an available commodity, and the volume is estimated according to the preoperative CT scan. However, the injectable calcium sulfate was not covered in medical insurance in our province. Although autograft has a higher rate of complete or partial healing than allografts in large defect,<sup>[25]</sup> limited sources are frequently insufficient to fill large defects in children. Therefore, a mixture of the autologous iliac bone and allogeneic bone was used as bone grafting material in our institute. Autologous iliac bone required additional incision to harvest the bone, resulting in longer operative time, increased risk of hematoma and infection. Besides, the injectable calcium sulfate can be placed in the cavity through a mini-incision; however, in the MIX group, it required a larger incision to expose the lesion and pack the cavity with bone graft.

There were no significant differences between the two groups concerning the clinical outcomes in our study. Besides, CaSO<sub>4</sub>, CaSO<sub>4</sub>/CaPO<sub>4</sub> composite was reported as an effective alternative to autologous bone grafts.<sup>[26,27]</sup> And the combination of cancellous allograft and autograft proved to be successful as well in our study. As for the ratio, 1:3 is more likely a technical tip than a validated hypothesis. The results in this study might be partly due to the curettage and disruption of the cavity lining. Moreover, the presence of ESINs decompresses the cavity continuously.

There were multiple limitations in our study. First, the sample size was small, because we only included the patients of UBCs in humerus; second, the follow-up was not long enough; third, ESINs with only allogeneic bone grafting was not adopted in our institute; fourthly, indications and treatment selection were based on clinical criteria and physician discretion rather than objective criteria; fifthly, novel material including biodegradable polylactide implant was not used in the study.

### 5. Conclusion

Intramedullary nailing has the advantage of being a minimally invasive procedure, immediate stability, and continuous decompression. ICS showed similar results as a mixture of the autologous iliac bone and allogeneic bone.

### Author contributions

**Conceptualization:** Pan Hong.

**Data curation:** Renhao Ze.

**Formal analysis:** Ruikang Liu.

**Investigation:** Xin Tang.

**Software:** Ruikang Liu.

Clinical outcomes	ICS (n=17)	MIX (n=19)	P value
Capanna Classification			
1	7 (41%)	7 (37%)	.78
2	10 (59%)	12 (63%)	
3	0 (0%)	0 (0%)	
4	0 (0%)	0 (0%)	
1+2	17 (100%)	19 (100%)	1
Recurrence	0	0	1
ASES Score	89.5±2.7	90.5±3.0	.29

ICS=injectable calcium sulfate, MIX=mixture of autologous iliac bone and allogeneic bone.

**Supervision:** Pan Hong.

**Validation:** Pan Hong.

**Writing – original draft:** Pan Hong.

**Writing – review & editing:** Jin Li, Saroj Rai, Pan Hong.

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