

## Surgical Treatment of Solitary Bone Cyst in Children Using Alloimplants

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**Received:** March 29, 2021; **Published:** April 29, 2021

### Abstract

**Introduction:** One of the traditional methods of treating solitary bone cysts (SBC) is marginal resection and replacement of the defect with bone or ceramic implants. Materials based on allogeneic bone after various types of processing, combining optimal properties for osteoregeneration, may be promising.

**Purpose:** To evaluate the results of surgical treatment of children with SBC using bone alloimplants for the repair of post-resection defects.

**Methods:** The results of examination and treatment of 11 patients (8 boys, 3 girls, age from 5 to 16 years) were analyzed. The diagnosis was made on the basis of a combination of clinical manifestations of the disease, laboratory test data, X-ray and pathomorphological studies. Distribution by localization of the pathological focus: proximal femur - 6 (54.5%), humeral - 2 (18.2%), calcaneal - 2 (18.2%), pubic - 1 (9.1%). Indications for surgical treatment: the presence of a massive focus of bone tissue destruction in the loaded area, a high risk of a pathological fracture, pronounced long-term pain syndrome. All patients underwent marginal resection and chemical treatment of SBC, the defects were filled with osteoplastic material.

**Results:** According to X-ray data, bone tissue restructuring in the area of surgical intervention occurred after 6 - 12 months after operation. After 12 - 18 months the structure of the patients' bones corresponded to normal without or with remnants of plastic material. Infectious complications, relapses of the pathological process and repeated fractures were not observed, pain syndrome was absent, motor activity was restored.

**Conclusion:** The investigated osteoplastic material of allogeneic origin can be recommended for use in the surgical treatment of SBC in children for the plasty of post-resection defects in order to restore the bone structure.

**Keywords:** Solitary Bone Cyst; Children; Bone Implants; Bone Grafting; Surgical Treatment

### Introduction

A solitary bone cyst (SBC) is a single-chamber cavity filled with clear or bloody fluid and lined with a shell of varying thickness, formed by weakly vascularized connective tissue with giant cells similar to osteoclasts, and sometimes with areas of fresh blood crystals [1].

According to M. Volkov (1962, 1974), T. Vinogradova (1973), O. Berezhny (1983), O. Korzh (1977), cysts in patients with dysplasia and tumors. we make up 20% of bones, among children with benign bone tumors - up to 57% [2,3]. In 95% of patients, the typical localization

of SBC is the proximal long bones, most often the humerus and femur [4,5]. SBC also affects the heel bone quite often [6]. In 85% of cases, SBC is diagnosed in the first two decades of life [7], twice as often in males [8].

G. Dupuytren first pointed to the existence of the SBC in 1833 [9]. The clinical and histological picture was described in 1876 by Rudolf Virchow, who considered the SBC as a “decaying enchondroma” [2,5,8,10]. According to the International Histological Classification (2013), “a bone cyst belongs to tumor-like processes and is defined as a cavity filled with serous or serous-hemorrhagic fluid and bounded by a layer of connective tissue of various thicknesses containing single giant cells” [11].

Today there is no generally accepted theory of etiology and pathogenesis of bone cysts, the main reason for their occurrence is considered to be a dystrophic process, the development of which is associated with hemodynamic disorders and impaired outflow of interstitial fluid into the metaphyseal region. Local disorders of hemodynamics lead to increased intraosseous pressure in limited areas of bone with the involvement of adjacent blood vessels and the formation of a cavity filled with fluid (serous, hemorrhagic), with high fibrinolytic activity [6,9].

SBC are mostly asymptomatic until the appearance of a pathological fracture, which can occur after a minor injury and in 50 - 75% of cases is the cause of the first clinical manifestations [2]. Sometimes SBC is diagnosed after an X-ray examination performed for other reasons [6,10]. Clinical signs in the form of pain, contractures in the adjacent joint more often noted in the case of cysts in the proximal femur, they are associated with pathological microfractures [2].

Radiologically, the SBC looks like a lytic center of destruction located in the center of the metaphysis with clear boundaries and a zone of sclerosis on the periphery, often spread concentrically. During growth, the child can migrate to the diaphysis [4,10].

Among the methods of treatment of SBC, puncture and surgery predominate. Puncture of SBC with subsequent injections of steroids is used to reduce intraosseous pressure and suppress proteolytic activity of bone content [8,9]. However, the consolidation of the pathological focus occurs in only 24% of patients after the first injection of steroids [7,10], so usually perform from 2 to 5 manipulations [9]. The disadvantages of the method include the frequency of punctures, a high recurrence rate, the negative impact of steroids on the child's body, the systemic response to them (Cushing's syndrome) [9].

At the Institute named after prof. M. Sytenko in the 30s and 40s of the last century used excochleation of the cyst cavity with the subsequent filling of the defect with bone chips. Since 1951, under the conditions of all SBC of long bones in children, the method of M. Novachenko was used - radical resection of the affected area of bone with leaving or removal of periosteum and replacement of the defect with an autograft. In case of large defects, two autografts were placed in them in order to ensure uniform loading of the epiphyseal cartilage. Subsequently, plastics were performed with an alloy implant with Korzh - Talyshynsky fixation (1968), and combined plastics with an autoimplant were also used [12]. Surgery is considered the most appropriate, because often SBC causes pathological fractures, deformities, shortening of bones and, consequently, limb dysfunction [6]. It must include the following elements: decompression, mechanical (curettage of cyst contents) and chemical (phenol, ethyl alcohol, etc.) treatment with bone defect plastic. The most common among the materials for defect replacement are: autobone, allocyst material and various ceramic implants [8]. Currently, the problem of choosing bone and plastic material for reconstructive surgery on skeletal bones, especially in pediatric patients, remains relevant due to high requirements for it. Such material should perform not only replacement function, but also to gradually integrate into the bone, to maintain the physiological level of osteoblastic and osteoclastic activity, promoting the formation and remodeling of bone tissue. The relationship of biomaterial with adjacent tissues, its stability and the nature of osteogenesis in the bone bed depends on the physicochemical properties, histogenetic origin and structure [13].

### Purpose of the Study

To analyze the results of surgical treatment of children with solitary bone cysts under the conditions of use for plastic post-resection defects of bone alloimplants.

### Materials and Methods

The study was performed in accordance with modern requirements of bioethics, its materials were approved by the Committee on Bioethics at the Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine (Protocol № 193 of June 14, 2019).

Method of obtaining osteoplastic material "OMS-A" (certificate of conformity № UA.TR.101-21-2016). The author's technique involves obtaining bioimplants from a donor allogeneic bone. It contains the processes of mechanical, physical, chemical treatment of bone material, which provides complete elimination of both infectious agents and autoimmune factors. Due to the dehydration step, it is possible to obtain a fraction of bone powder that is optimal for filling cavities and ensuring close contact between the treated bone surface and the implant, as well as to obtain a high initial value of factors initiating regeneration at the bone-implant boundary.

Clinical material: The results are analyzed.

Examination and treatment of 11 patients (8 boys, 3 girls) with a diagnosis of "solitary bone cyst", who were treated at the pediatric orthopedics clinic of the Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine. The age at the time of hospitalization ranged from 5 to 16 years.

According to the localization of the pathological focus, patients were distributed as follows: proximal femur - 6 (54.5%), humerus - 2 (18.2%), heel - 2 (18.2%), pubic - 1 (9.1%).

Diagnosis of patients was performed based on a set of clinical manifestations of the disease, laboratory tests, X-ray and pathomorphological examination.

In our observations, the indications for surgical treatment of patients were massive destruction of bone tissue, which can cause pathological fractures.

Surgical interventions were performed under conditions of general or combined (regional in combination with sedation) anesthesia. After the affected part of the bone was skeletonized, fenestration was performed. This usually resulted in a straw-yellow liquid with blood in it. Then, edge resection and chemical treatment of SBC with ethyl alcohol were performed. The resulting defect was tightly filled with deproteinized alloimplant in the form of bone powder. During and after the intervention, they were additionally visually monitored using an electron-optical transducer in several projections. A characteristic feature of the use of the described plastic material is the ability to tightly fill the defect of any size and shape. In cases where the defect is very large (relative to the total size of the bone), additional osteosynthesis was performed. In each clinical case, the metal structure was selected individually. This was most often a plate, and sometimes an intramedullary rod. External fixation of the limb was performed for 1 - 1.5 months. Plaster bandages or orthoses of various stiffnesses were used for this purpose.

The outcome of treatment was evaluated according to the data.

X-ray examination: During the first year after the operation, control images were performed after the completion of fixation and then - every third month; the second - once every six months. X-ray signs of bone shape and structure restoration at the site of the removed pathological focus and bone grafting were analyzed. The condition of the bone in the area of replacement of defects of the upper extremity allowed the restoration of function in 1 - 1.5 months, the weight bearing - in 3 - 4 months; in the case of plastic surgery of lower extremity defects, these terms were 1.5 - 2 months, respectively and 4 - 5 months. The presence or absence of complaints and the degree of recovery of limb function were clinically determined.

## Results and Discussion

The results of surgical treatment using osteoplastic material to replace post-resection defects were evaluated for 2.5 years in 4 (36.4%) patients, 18 months in 3 (27.2%), 12 months in 4 (36.4%).

According to the X-ray examination, the reconstruction of bone tissue in the area of the operation was determined after 6 - 12 months. Later (after 12 - 18 months), the bone structure of children mostly corresponded normal with no or slight remnants of plastic material.

No signs of infection or other postoperative complications, such as recurrence of the pathological process or re-fracture, were observed. The pain syndrome was absent, the volume of movements in the adjacent joint was restored. In general, the results are classified as good and excellent.

Here are clinical examples of the use of de-proteinized alloimplant "OMS-A" in patients with SBC.

### Clinical example № 1

Patient V., 6 years old, went to the clinic in May 2016 with complaints of minor pain in the right hip joint during exercise. From the anamnesis it is known that more than a year ago she received treatment in another institution for a pathological fracture of the proximal right femur.

Clinically, at the time of hospitalization, a slight restriction in range of motion (not more than 5° in all planes) in the right hip joint was detected. Radiologically, the focus of lytic destruction with a clear sclerosis rim and a slight "swelling" of the cortical layer in the proximal part of the right femur was diagnosed as SBC (Figure 1a and 1b). Surgical intervention was performed: marginal resection of the cyst with bone defect plastics with implants of allogenic origin (Figure 1c). After surgery for 1.5 months carried out cast fixation, then 3 months the patient moved with crutches (2 months - without weight bearing, 1 month - with weight bearing as tolerated). Full weight bearing is allowed after 5 months after surgery (Figure 1d).

Its mode was determined by the results of control radiographs. After 12 months. after surgery, radiographs revealed signs of almost complete reconstruction of the implant material in the area of the tibial defect (Figure 1e), after 15 months signs of complete reconstruction of bone material in the area of implantation (Figure 1f).



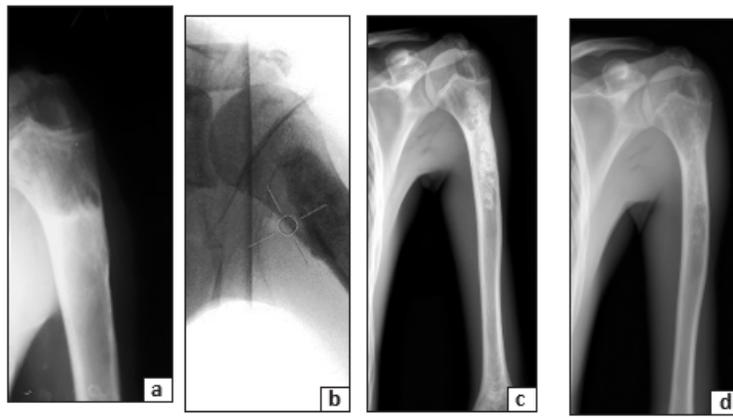
**Figure 1:** Radiographs of patient V: a, b) at the time of hospitalization; c) after surgery and filling the bone defect with an allo-implant; d) in 6 months; e) after 12 months; f) after 15 months.

**Clinical example № 2**

Patient K., 14 years old, went to the clinic with complaints of minor pain in the left shoulder joint during exercise. From the anamnesis about 5 months ago he was treated in another institution for a pathological fracture of the proximal left humerus.

Clinically, at the time of hospitalization, a slight restriction in range of motion (not more than 5° in all planes) in the left shoulder joint was noticeable. According to the established scheme, the patient was examined. Radiologically, the focus of lytic destruction with a clear sclerosis rim and a slight “swelling” of the cortical layer in the proximal part of the left humerus was classified as SBC (Figure 2a). Surgical intervention was performed: marginal resection of the cyst with bone defect plastics with implants of allogeneic origin (Figure 2b). After surgery for 1.5 months performed fixation with a soft orthosis. Weight bearing as tolerated is allowed one month after surgery, full - 4 months. The weight bearing mode was determined according to the control radiography, which was performed every 3 months. During the first year after surgery, every 6 months during the second.

After 12 months. after surgery, radiologically revealed signs of almost complete reconstruction of the implant material in the area of the humeral defect (Figure 2c), after 18 months complete reconstruction of bone material in the implantation zone is visualized (Figure 2d).



**Figure 2:** Radiographs of patient K: a) at the time of hospitalization; b) after surgery and filling the bone defect with an alloimplant; c) after 12 months; d) after 18 months.

The approach to the treatment of SBC should be individual in each case and depends on the localization, aggressiveness and prevalence of the process. Although there is no standardized surgical treatment of SBC, its purpose is to eliminate the bone defect, restore its integrity and functionality and prevent the occurrence of pathological fractures [7]. It includes the following stages: decompression, mechanical (curettage) and chemical (phenol, ethyl alcohol, etc.) treatment with plastic bone defect. Bone autograft, allograft material and various ceramics are most often used for this purpose [8]. They all have both positive and negative qualities. In particular, taking an autograft prolongs the operation time, worsens the patient's condition due to additional injury [14]. Ceramic implants differ from natural bone in architecture and mechanical properties. The use of allogenic bone implants (allograft) to replace defects after SBC removal is considered to be the most effective in childhood. They perform not only a replacement function, but also gradually integrate into the adjacent bone tissue, maintain the physiological level of activity of osteoblasts and osteoclasts, promote the formation and remodeling of bone tissue [6,13].

In our study used for bone cavities after removal of SBC certified material of allogenic origin "OMS-A" (certificate of conformity № UA.TR.101-21-2016). According to the results of the study, radiological signs of its reconstruction were established, which lasted from 1.5 to 18 months. After 15 months in 5 patients (45%) complete restructuring of implants with restoration of bone structure was recorded.

### Conclusion

In the study, bone allogenic implants are a promising material for defect plastics after removal of benign tumors and tumor-like bone lesions.

The obtained results make it possible to recommend bone-plastic material of allogenic origin for use in the scheme of surgical treatment of solitary bone cysts in children.

### Conflict of Interest

The authors declare no conflict of interest.

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**Volume 12 Issue 5 May2021**

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