DOI: 10.17816/PTORS5265-74

SOLITARY BONE CYSTS IN CHILDREN

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Received: 22.02.2017 Accepted: 20.05.2017

Summary. Solitary bone cyst (SBC) is one of the most common childhood pathologies of the skeleton. According to different authors, SBC represents 21 % to 57 % of the benign tumors and tumor processes in the bones of children. SBC usually consists of a single chamber cavitary formation filled with a transparent liquid with a straw colored lining of varying thickness, which consists of connective tissue and single giant cells. There is no consensus on the etiopathogenesis of SBC, and the choice of treatment. There are no clear indications for conservative and surgical treatment of SBC. Some authors are inclined to use puncture (minimally invasive) treatments, while others choose more radical surgical methods. Both methods have the same relapse rate at up to 27 %. In this article, we analyzed the published data on the etiology, pathogenesis, diagnosis, and methods of treatment of SBCs in children.

Keywords: Solitary bone cyst, etiopathogenesis, diagnosis, treatment, children.

СОЛИТАРНЫЕ КОСТНЫЕ КИСТЫ У ДЕТЕЙ

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Статья поступила в редакцию: 22.02.2017 Статья принята к печати: 20.05.2017

Солитарная костная киста (СКК) — одна из наиболее часто встречающихся патологий скелета детского возраста и составляет, по данным разных авторов, от 21 до 57 % от всех доброкачественных опухолей и опухолеподобных процессов костей у детей. СКК, как правило, представляет собой однокамерное полостное образование, заполненное прозрачной жидкостью соломенного цвета с выстилкой различной толщины, состоящей из соединительной ткани и единичных гигантских клеток. Нет единого мнения в отношении этиопатогенеза СКК и выбора метода лечения. Отсутствуют четкие показания к проведению консервативного и хирургического способов лечения СКК. Одни авторы склоняются к применению пункционных (малоинвазивных) методов, другие — к более радикальным, хирургическим методам. Те и другие имеют одинаковый процент рецидивов — до 27 %. В статье мы проанализировали литературные данные по этиопатогенезу, диагностике и способам лечения СКК у детей.

Ключевые слова: солитарная костная киста, этиопатогенез, диагностика, лечение, дети.

Background

Solitary bone cyst (SBC) is one of the most common childhood pathologies of the skeleton and represents, according to different authors, 21%–57% of all benign tumors and tumor-like bone processes in children. Although the bone cyst was determined for the first time by Dupuytren in 1833, a detailed description of SBC was provided by Rudolf Virchow in 1876, who described it in his works as “decaying enchondromas” [1, 2].

According to the International Histological Classification of Bone Tumors (WHO, 1993), “solitary (simple or unicameral) bone cysts refer to tumor-like processes and are defined as a cavity filled with a transparent straw-colored fluid with a lining of various thicknesses, consisting of connective tissue and single giant cells” [3].

In clinical practice, the background of this problem is determined by the lack of a consensus on the SBC etiopathogenesis and the choice of

■ For citation: Pozdeev AP, Belousova EA. Solitary bone cysts in children. *Pediatric Traumatology, Orthopaedics and Reconstructive Surgery*. 2017;5(2):65–74. doi: 10.17816/PTORS5265-74.

the optimal method of treatment. To date, these issues remain the subject of many discussions.

General characteristics of solitary bone cysts

SBCs are more common in males than in females (ratio, 3:1). On average, 65% of cases are reported in adolescents and 20% in the first decade of life. The vast majority of pathological foci are localized in the proximal metaphyses of the humerus and femoral bones. Radiologically, a SBC, as a rule, is a unicameral cavity formation that can also be multichambered. However, its multichamber feature is relative, because the osteofibrous tendinea does not overlap the cyst cavity but is located perpendicular to the axis of the bone. Moreover, several researchers assume the multichamber feature as only a radiological symptom associated with hypertrophy of the osseous crest around the cyst [3].

Ethology of solitary bone cysts

One of the first theories of the bone cysts origin, the theory of fibrous osteitis, was proposed by Recklinghausen in 1891. He suggested the inflammatory origin of SBCs and termed this process "fibrous osteitis," which is "characterized by osteolysis, a tumor-like proliferation of fibrous and giant cell tissues" [4].

A few decades later, a group of scientists led by H.L. Jaffe advanced the theory of the origin of bone cysts. The researchers believed that "the cause of their occurrence is a hemorrhage into the medullary cavity or to the spongy bone caused by trauma." This leads to the disruption of intraosseous hemodynamics, difficulty in the blood outflow from the bone, increased intraosseous pressure, and trophic disorders with the development of local bone resorption [5].

In the first half of the twentieth century, A.I. Abrikosov and Stenholm rejected the inflammatory theory of "fibrous osteitis" and proposed an osteodystrophic theory of the origin of bone cysts. According to this theory, "dystrophic changes in bone structures are accompanied by their osteoclastic resorption and subsequent proliferation of connective tissue." However, this concept was not recognized. Besides inflammatory, traumatic, and osteodystrophic theories, a vascular theory of the formation of bone cysts was proposed by G. Engel as "the cyst results from a hemorrhage into the bone, possibly as a result of the vessel rupture, as when a hemorrhage into the brain tissue." After almost 100 years, in 1957, L.P. Kuzmina expressed an opinion that cysts are formed as a result of bone resorption due to excessive development of the meta-epiphyseal network of blood vessels [4, 6].

Later, J. Cohen hypothesized that "on the metaphyseal surface of the growth cartilage, osteogenesis is disturbed; the intensive resorption of bone tissue is accompanied by the proliferation of fibrous tissue, which leads to a disorder of blood flow in venous vessels" [7, 8].

In our country, the theory of the origin of bone cysts because of complex local vascular disorders was recognized by V.O. Marx, A.P. Berezhny, and colleagues. Simultaneously with the vascular theory, the theory of the SBC emergence because of giant cell tumors appeared. It was proposed by A.V. Rusakov and colleagues in 1959 and suggested that "a majority of osteoclastomas do not have blood vessels and the blood flow is maintained through intertissue clefts, which creates conditions for the death of tumor cells and the accumulation of plasma and formed blood elements in different parts of the tumor" [3, 6].

One of the latest theories of the SBC emergence, known as a dysplastic theory, was proposed by G.J. Gareau and C.F. Gregory (1954) and claimed that "a solitary bone cyst arises from the disturbance of bone growth in length." Later, S.T. Zatsepin (1990) suggested that "a solitary bone cyst is a consequence of a special form of dysplasia of the growth zone, which results in a process of enzymatic destruction of abnormal cells, while the vascular system is involved in the process" [6].

Furthermore, the genetic theory was put forward by a group of Brazilian scientists led by Vayego, who found genetic abnormalities among children with SBC in the distal part of the right femur. These disorders include complex genetic aberrations of chromosomes 4, 6, 8, 12, 16, and 21. Further research has revealed various mutations associated with the replacement of amino acids (such as arginine, tryptophan, and serine). The origin of SBCs is possibly related to complex chromosomal rearrangements-translocations (p11.2; q13); for instance, a mutation in the *TP53* gene, which is

located on the short arm of the chromosome 17, encodes p53 protein (a cell-cycle regulator) [9, 10].

Pathogenesis of solitary bone cysts

To date, the mechanism of the SBC emergence remains unclear to a wide extent. Theories presented in the literature include the effect of increased pressure due to fluid stasis, local venous obstruction, an increase in the activity of lysosomal enzymes, prostaglandins, nitric oxide, free oxygen radicals, and genetic disorders. Reportedly, osteoclasts play a significant role in the pathogenesis of SBCs. Presumably, an increase in the level of prostaglandin E_2 in the cystic fluid stimulates the proliferation and activation of osteoclasts. Complex signal pathways exist between osteoblasts and osteoclasts, especially the pathway of producing RANKL (a membrane protein from the family of tumor necrosis factors), without which neither osteoclast production nor their functions can be activated. Interleukin-6 is a key cytokine in the process of bone resorption caused by osteoclasts. Furthermore, monocyte chemotaxis-1 protein promotes the differentiation of monocytes and macrophage inflammatory protein-1α, a potent stimulator of RANKL, promotes the chemotaxis of osteoclast precursors and their differentiation. Thus, elevated levels of monocyte protein chemotaxis-1, macrophage inflammatory protein-1α, and interleukin-6, found in the cystic fluid, stimulate the activity of osteoclasts, which, in turn, contribute to the appearance of macroscopic erosion of bone tissue [11].

A.A. Chigira and a group of Japanese researchers studied the pressure of the cystic fluid and found it to be higher than the contralateral normal bone (more than 2-3 mmHg). A.P. Berezhnyi believed that SBC is a "pathological state of a reactive nature that arises in the growth zone due to a disorder of intraosseous homeostasis and increased intraosseous pressure associated with it" [12, 13].

Clinical characteristics of solitary bone cysts

Clinical studies have demonstrated that SBCs predominantly do not manifest themselves in the form of certain symptoms and in 75% of cases are detected because of a pathological fracture. Clinical manifestations in the form of pain and contractures in the adjacent joint are more often observed with the development of a cyst in the proximal femur and are likely associated with pathological micro-fractures. Moderately expressed pain syndrome occurs in children and in the case of the active growth of a cyst [6].

A.P. Berezhnyi (1985) categorized cysts into active, losing activity, and latent/passive base on the severity of clinical symptoms:

- Active cysts are most often found in children of early, preschool, and primary school age; they are localized in the metaphysis of the growth zone; manifested with moderately severe pain syndrome, swelling, and pathological fractures;
- Active cysts that lose activity are found in children of primary and senior school age; occur asymptomatically or with flaccid clinical symptoms, are diagnosed after a pathological fracture at the level of the focus of destruction of the bone tissue; and
- Latent/passive cysts are diagnosed in children of senior school age; they are detected accidentally or because of a pathological fracture of the diaphysis [13].

Diagnosis of solitary bone cysts

The most widely used method of diagnosing SBCs is plain radiography of the affected segment of the bone in two standard projections. Localization and X-ray pattern of SBC are determined by the activity and remoteness of the course of the pathological process. Thus, according to the X-ray classification of SBCs, proposed by A.P. Berezhnyi, the following phases of SBCs are distinguished:

- The "*osteolysis phase*" is characterized by a massive destruction of the spongy material of the metaphysis, the contact of the cavity with the epiphyseal growth cartilage, the sharp thinning of the cortical layer of the bone, and swelling. The integrity of the cortical bone plate is intact, and no cortical plate delimits the cyst cavity from the medullary canal. The duration of this phase is 8-12 months.
- In the "*delimitation phase*," a SBC is localized in the metadiaphysis, there is no contact with the epiphyseal growth cartilage, a cellular pattern (the focus of clarification) is typical, a moderate swelling of the bone is visible, and the cyst cavity is delimited by the cortical plate from the medullary cavity. The duration of this phase is 6–8 months.
- In the "*recovery phase*," a cyst is localized in the diaphysis region and is characterized by the complete isolation from the medullary cavity by the cortical plate and a small volume. The development cycle of a SBC from the onset to healing lasts for more than 2 years [13].

The pathognomonic X-ray signs of SBC are the "sunken fragment," proposed by Reynolds in 1969, and comprising the projection detection of small bone fragments inside the bone focus itself, which is confirmed by the fluid character of the contents, and the "ascending bubble," proposed by Martin I. Jordanov in 2009, representing the presence of a gas bubble at an independent distance from the lytic bone edge after a pathological fracture [14, 15].

During contrasting, the cavity of a bone cyst is uniformly injected with a contrast agent, enabling its differentiation from other tumor and tumor-like bone lesions, to determine its true size and relationship with the growth zone and to establish the development phase. Although angiograms of SBC display no deviations of the vascular pattern from the normal, ultrasonography of bone cysts reveals a change in the shape of the bone surface, deformity of the periosteum, the configuration and size of the cavity formation, and the structure of the contents regarding density. However, it should be noted that regarding the extent of information provided, an ultrasound examination of bone cysts is inferior to radiographic methods, but is useful as an additional examination [6].

Furthermore, a computed tomography (CT) scan more accurately determines the actual size of a bone cyst and the degree of damage to the breadth of the tubular bone, the nature of the contents of the focus, and its density. The density of the SBC contents is 6–12 Hounsfield units (HU). During an MRI scan, the signal intensity is similar to the fluid signal. The pathognomonic is the absence of bone septa, a sign of "level-level" [characteristic of an aneurysmal bone cyst (ABC)]. The surrounding soft tissues are not changed [16].

A polyphasic bone scintigraphy is required not only in the case of differential diagnostics but also to determine the activity of the pathological process and establish the prognostic criteria in the case of the recurrence of cysts after surgical treatment. In cysts not complicated with a pathological fracture, a uniform distribution of radiopharmaceutical agent (DRA) is determined in all phases. The reduction of perfusion and fixation of DRA in the cyst region (fluctuation in the indices within the range of 0.7–0.8) indicates the severity of the dystrophic process. In the case of a cyst with a "fresh" pathological fracture, the indices of all phases are increased, whereas, in a "long-standing" fracture, the DRA hyperfixation is be determined only in the bone phase. When the recurrence occurs after the previous surgical intervention, an increased accumulation of DRA in the field of destruction is characteristic. The quantitative prognostic criterion for the recurrence of a cyst is the coefficient of differential accumulation (CDA = 2.0); when it exceeds, a relapse occurs. Thus, a bone scintigraphy is a rather informative additional method of examination in patients with SBC that enables to obtain objective data on the state of regional circulation and functional activity of bone tissue in the area of the lesion [17].

In cases where the X-ray/CT data, location of the focus, age of a patient, or clinical data are not characteristic of a SBC, and the calcified sites are determined, an open biopsy is conducted. Macroscopically, a SBC is a unicameral cavity filled with a straw-yellow liquid with a white or brown soft tissue parietal lining. The microscopic structure of a SBC is determined by the presence of fibrous tissue with a moderate content of spindle-shaped mononuclear cells of the stroma (a type of fibroblasts), absence of their organization, presence of osteoclasts, single giant cells scattered throughout the affected area, and conglomerates of giant cells. The fibrous capsule of a cyst may contain hemorrhages, deposition of hemosiderin, fibrin, and an assembly of siderophages [18].

This pathology must be differentiated from ABC, nonosteogenic fibroma, osteoblastoclastoma, telangiectatic osteosarcoma of a low-degree malignancy, tubostitis, chondroblastoma, osteoblastoma, fibrous dysplasia, chondromyxoid fibroma, and eosinophilic granuloma. An ABC, unlike a SBC, is localized not only in the long tubular bones but also in the vertebrae and flat bones. During the active growth phase, it is characterized by a more pronounced dynamics of the destruction of bone tissue. During the clinical phase, patients complain of pain in the affected segment and lameness. In the early stages, the focus is located eccentrically in the metaphyseal section of the tubular bones, which are attached to the growth zone. The focus has a cellular structure (resembling "soap bubbles"), wherein the cortical layer is sharply thinned, and the periosteal reaction is not pronounced significantly. Macroscopically, an ABC is a multichambered cavity formation containing a bloody liquid. The parietal lining of the cyst is in the form of tumor-like areas of gray

or reddish-brown tissue. The density of the ABC content is 45–50 HU. According to an MRI scan, an ABC is a multichambered/multicellular pathological formation with a pathognomonic trait, a "level-level" symptom [19, 20].

Nonosteogenic fibroma is localized in long tubular bones, the foci are located eccentrically, and have irregular round/oval shape with clear boundaries. The internal structure of the foci is cellular-trabecular, resembling a "bunch of grapes." A distinctive feature of this pathological process is the ability to "self-healing." Macroscopically, the bone wall is thinned with "cyanotic" hue. The content of the pathological focus is represented by areas of homogeneous soft tissue of brown, light brown, or yellow color (most areas of the same color alternate with those of the other). Microscopically, the pathognomonic sign of nonosteogenic fibroma is the presence of a storiform pattern – collagen fibers of the intercellular matrix and fibroblast-like cell elements that form bundles of non-uniform thickness along different directions. The density of the nonosteogenic fibroma contents is 60–70 HU, which is confirmed by its soft tissue nature [18, 19].

Treatment of solitary bone cysts. Results

The treatment of SBCs has long been the subject of scrutiny and numerous discussions since the late nineteenth and early-twentieth century. To date, in the treatment of children with SBCs, two main tendencies prevail, conservative and surgical. Conservative methods of treatment include a puncture method without/with the administration of various drugs that accelerate the repair of bone tissue in the pathological focus: bone marrow injections, steroid injections, and demineralized allograft bone injections (using these methods separately and in combination; Table 1).

Table 1

A comparative analysis of conservative methods of treatment of solitary bone cysts

Author of the method, year	Essence of method	Results
Berezhnyi AP, Burkova LM, 1990 [13]	The method of puncture treatment: perforation of the bone wall of the cyst; lavage of the cavity with 0.9% saline solution of sodium chloride, 5% solution of aminocaproic acid; administering into the cavity of the cyst of 10,000–20,000 Un. of contrykal.	The authors observed the first signs of reparation 2–3 months after the start of treatment, but more often the repair began in 4–6 months and ended in 10–36 months.
Pavone V. et al., 2013 [16]	Puncturing and administering methylprednisolone acetate in the cyst cavity.	The results of treatment of 23 patients: excellent in 65% and a pathological fracture observed in 17%.
Scaglietti Oscar, 1962 [21, 22]	Puncturing and administering methylprednisolone acetate in the cyst cavity.	Of 82 patients, 60% had excellent and good results, 36% had satisfactory results, and 4% had no dynamics.
Capanna R. et al., 1982 [22]	Puncturing and administering methylprednisolone acetate in the cyst cavity.	Of 95 patients, 80% had satisfactory results, 11.5% had a relapse, and 6% showed no effect.
Di Bella Claudia, 2010 [23]	Group 1: Puncturing and administering methylprednisolone acetate in the cyst cavity. Group 2: administering to the cavity of the cyst of demineralized bone allomatrix and bone marrow	In group 1: of 143 patients after the first procedure, a positive response was observed in 21%. In group 2: of 41 patients, a positive effect after the first injection was observed in 59%.
Ulici A. et al., 2012 [24]	Conservative treatment: - administering steroid drugs; - administering bone marrow;	Results of treatment with steroid injections (35 patients): no effect was observed in any patient after one injection; a positive effect was observed after two injections in 2 patients (5.7%), after three injections in 10 patients (28.5%), and after four injections in 14 patients (39.2%). In 5 patients (14%), there was no effect. When using the method of bone marrow injection (12 patients), 9 of them (75%) had a good response after the first injection.

Table 1

Author of the method, year	Essence of method	Results
Traub Frank, 2016 [25, 26]	Puncture treatment/injection of methylprednisolone acetate.	A group of 22 patients with a SBC was selected. In 19 patients (86.3%), a pathological fracture occurred and 5 patients (27.3%) underwent repeated steroid injections. There was no effect in 27.3% (6 of 22) of patients.
Kadhim Muayad, 2014 [27, 28]	A total of 62 articles with a retrospective analysis of the treatment of patients with SBCs were selected. Notably, 1128 cysts were treated with methylprednisolone acetate and bone marrow injections were performed in 114 cysts.	It was found that injections of methylprednisolone acetate in 77.4% led to healing, which was comparable to bone marrow injection (77.9%).
Tenilin N.A., 1995 [29, 30]	The method of permanent flow drainage of the cyst cavity.	This method was used to treat 24 patients. Of these, there were 16 (66%) patients with SBCs. In general, a good result was obtained in 58.4% and a satisfactory result in 33.3% of patients. The total positive outcome of treatment was 91.7%.
Mohammed M. Zamzam et al., 2008 [31]	Puncture treatment in combination with bone marrow injections.	Treatment was performed in 28 patients: 7 of them were treated twice (25%) and 5 had treatment three times with an interval of 3 months (17.8%). Bone cyst healing was achieved in 23 patients (82%). Of these, partial reparation occurred in 13 patients (46%). In 3 patients (10.7%), there was no effect.
Docquier, Delloye, 2003 [32, 33]	Percutaneous injection of bone marrow after aspiration of the cyst contents.	Results of treatment of 17 patients: a positive effect of treatment was obtained in 13 patients (76.4%), relapses were observed in 2 (11.6%), and the absence of effect was observed in 2 patients (11.6%).

In all conservative treatment methods discussed above, the percentage of positive results varies from 21% to 80%. The highest efficacy was demonstrated by the puncture method with the administration of steroid drugs into the cyst cavity (good results, 50%–80%), followed by the method of flow-washing drainage of the cyst cavity (58.4%) and the puncture method with bone marrow injections (30%-70%). The percentage of relapses varied from 1% to 27% because neither the stage of the course of the bony cyst was taken into account nor clear indications for the application of this or a conservative treatment method were determined.

Surgical methods of treatment of SBCs include curettage of the contents of a cyst, various variants of bone resections (marginal, segmental, subperiosteal/total resection) with defect grafting with bone auto- or allografts, reinforcement of the cyst cavity with intramedullary elastic nails without/with filling of the cavity with allografts, and decompression of the cyst cavity with cannulated screws (Table 2).

Of all the methods of surgical treatment described above, the most optimal method that could satisfy the criteria for evaluating the efficacy of the treatment (high rate of repair, low percentage of relapses) cannot be distinguished. The highest rate of repair is observed after intramedullary osteosynthesis with an elastic nail (in 90%-100% of patients) and marginal resection with allografting (in 76%–93% of patients). The table shows that the percentage of relapses (regardless of the choice of treatment method) varies from 8% to 27%. This study revealed that the "active" cysts (located close to the growth zone) often recur, which suggests that the surgical treatment of SBCs in the active phase of the course results in frequent relapses, repeated pathological fractures and, as a consequence, shortening of the segment of the affected limb. Success in many respects depends not only on the choice of the method of surgical treatment but also on whether we use auxiliary methods (such as chemical treatment and electrocoagulation of the cyst walls).

According to N.F. Sivak, the administration of synthetic inhibitors of fibrinolysis after removal of the contents of a cyst enables to eliminate the process in 96.2% of patients. According to different authors (Campanacci et al. and Vergel de Dios

et al.), the frequency of recurrences after curettage varies from 18% to 50%. A total of 90% relapses occurred in patients younger than 20 years, with the average age of relapsed patients as 13 years. In addition, the "active" forms of cysts recurred more often. Given the high rate of relapses, Campanacci et al. proposed that in addition to surgery, chemical treatment of the walls of the cavity with zinc chloride and phenol should be performed. Meier, Tsokas, and Willital believed that the use of a laser with SBCs prevents the recurrence of the pathological process. Furthermore, the additional use of electrocoagulation of the cyst cavity reduces the occurrence of relapses by up to 11.8% (Rizzo, Dellaero, Harrelson et al., Frantov A.R). With the implementation of subperiosteal/total resection, the number of relapses decreased to 4%-8% [3, 4].

Table 2

A comparative analysis of surgical methods of treatment of SBCs

Author of the method, year	Essence of method	Results
Ulici A. et al., 2012 [24]	Intramedullary osteosynthesis with elastic nails (5), diaphysectomy combined with bone grafting (4), curettage + bone grafting (11), curettage + bone tissue replacement (8), curettage + bone grafting + osteosynthesis (24)	In a group of 52 patients, after surgical treatment, relapse was observed in 14 patients (27%).
Traub Frank, 2016 [26]	Intramedullary osteosynthesis with elastic nails, curettage with subsequent bone grafting with auto- and allografts.	Overall, the relapse rate after primary surgery was 26.1%. In 37 patients (26%), repeated surgical intervention was required. In 2 patients (1.4%), no effect was observed.
Tenilin NA, Bogosyan AB, Sosnin AG., 1995 [29]	Segmental resection/marginal excision	Segmental resection was conducted in 17 patients: organotypic restructuring occurred in 18.8% of patients, nonorganotypic in 68.7%, and relapse was diagnosed in 12.5%. Of 25 patients who underwent marginal excision, organotypic restructuring occurred in 44% of patients, nonorganotypic in 47.2%, and relapse was diagnosed in 8.8%.
Gentile J.V. et al., 2013 [34]	Curettage in combination with injection of composite material of calcium phosphate-sulfate ($CaSO_4$–$CaPO_4$)	A group of 16 patients was selected. Cystic cavity repair started in 93.7% (15 of 16 patients) after the first procedure. Complete healing was observed in 87.5% (14 of 16 patients).
Shirai Toshiharu et al., 2015 [35]	Use of hydroxyapatite cannulated screws.	Treatment of 43 patients: obliteration of the cystic cavity was achieved in 38 patients (88.3%) on average after 6 months. Cystic cavities remained in 2 patients (4.6%) and 5 (11.5%) patients had recurrent cysts.
Soo Min Cha, 2014 [36]	Insertion of elastic intramedullary nails	In a group of 57 patients diagnosed with a SBC of the proximal femur: a relapse of cysts occurred in 7 patients (12.2%).
Hwan Seong Cho [37]	Intramedullary decompression of the nails in combination with the filling of the cyst cavity with demineralized bone matrix.	Of 25 patients diagnosed with a SBC (17 active and 8 latent cysts), healing occurred after the first procedure in 92% (23 of 25) and in 100% after the second procedure; the relapse was observed in 8% of patients.
Muayad Kadhim, 2014 [38, 39, 40]	Curettage (31 patients); curettage with allografting (353 patients); curettage and autografting (128 patients); elastic intramedullary nails (205 patients); cannulated screws (61 patients).	In 76.1% of patients after curettage, complete or partial repair was observed, and in 23.9% of patients, there was no effect. Treatment of SBCs with the use of intramedullary elastic nails without curettage in 100% of patients leads to an early recovery, while continuous decompression with cannulated screws in only 89%.

For many decades, authors have paid close attention to the options of grafting material. For more than 50 years, three types of bone grafts have been used in the practice of bone grafting surgery, auto-, allo-, and xenografts. D. Vanchikov, A.P. Noskov, and G.A. Krasnoyarov used a biocompatible, resorbable polymer "straw" [4, 6].

I.G. Herzen et al. in 2013 performed a comparative analysis of grafting of bone cavity defects with composite materials based on hydroxyapatite

and revealed the advantages of calcium phosphate cement, namely, intensive biodegradation, and the formation of firm coossification [41].

Conclusion

Although the literature offers various theories of origin, the mechanisms of occurrence, and treatment options for SBCs in children, no consensus occurs on this. A comprehensive examination is the key to the success of differential diagnosis of this pathology. Currently, the main problem is the selection of the optimal method of treatment of bone cysts in children. No clear indications for conservative and surgical treatment exist at present. In the last decade, most foreign authors have favored minimally invasive methods of treatment, such as puncture and injection (e.g., injections of steroids, bone marrow, and demineralized bone matrix), which have a high percentage of good results. However, the technique of puncture treatment has the following drawbacks: an extended period of treatment, hospitalization, and long periods of obliteration of the cystic cavity. While injections of bone marrow and steroids have the same positive effect, the term of hospitalization is shortened. In the case of surgical treatment, while some authors confine themselves to curettage, others suggest exploring a more definitive method of surgical treatment (segmental resection). In addition, opinions differ regarding the timing of surgical treatment. According to one data, treatment of bone cysts in the active phase leads to a high percentage of relapses, and it is necessary to initiate treatment after the end of the osteolysis phase. Meanwhile, several authors argue that the use of intramedullary decompression combined with the demineralized bone matrix grafting in the active phase is characterized by a low relapse rate (8%). A low percentage of relapses, a high incidence of adjustment of grafting material, and the absence of postoperative complications are the main criteria for the treatment efficacy. Thus, many conflicting opinions exist about the surgical treatment of cysts in children. However, in recent years, the scales are gradually inclining toward minimally invasive methods. Although the need for reinforcement of the affected bone with intramedullary metal structures and the use of cannulated screws remains debatable, the mechanism of their therapeutic effect is not explained or proven by any author, which confirms once again the necessity of further study of this pathology and the search for optimal methods of treatment.

Funding and conflict of interest

The work was performed on the basis of and with the support of the Turner Scientific and Research Institute for Children's Orthopedics of the Ministry of Health of Russia. The authors declare no obvious and potential conflicts of interest related to the publication of this article.

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