Surgical Options for the Treatment of Simple Bone Cyst in Children and Adolescents

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ABSTRACT: **Background:** There are several treatment options for simple bone cysts, with treatment depending mainly on the experience and preference of the surgeon and the extension and location of the cyst.

Objectives: To assess our experience with the surgical treatment of bone cyst lesions in pediatric patients at one institution by the same group of surgeons.

Methods: The study group comprised 60 patients (43 boys, 17 girls) treated surgically for monostatic lesions between January 2002 and July 2007. The mean age at surgery was 11.8 years (range 4–17 years). Mean follow-up was 4.2 years. Most of the lesions were located at the proximal humerus. Patients were divided into five groups according to treatment method: a) corticosteroids (methylprednisolone 40–80 mg) (n=26); b) curettage and bone grafting (fibula or iliac crest) (n=16); c) aspiration of the bone cavity and subsequent bone marrow transplantation (n=10); d) internal preventive fixation using an elastic stable intramedullary nail (n=5); and e) curettage and implantation of a synthetic cancellous bone substitute (pure beta-tricalcium phosphate substitute, ChronOS®, Synthes, Switzerland) (n=3).

Results: Treatment success was evaluated by the Capanna criteria. Successful results were observed in 68% (18 complete healing, 23 healing with residual radiolucent areas), 30% recurrence rate, and no response to treatment in one patient (2%). We recorded recurrence in 50% of the children treated by corticosteroid injection, and one child did not respond to treatment.

Conclusions: The best results were achieved in children treated by curettage and the subsequent use of an osteoconductive material, and in children treated with elastic intramedullary nail fixation. Despite our limited experience with calcium-triphosphate bone substitute, the treatment was mostly successful. Because of the short follow-up, further observation and evaluation are necessary.

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KEY WORDS: simple bone cyst, surgical treatment, curettage, corticosteroids, elastic stable intramedullary nail

The unicameral bone cyst is a benign fluid-filled lesion, located mainly in the metaphyses of the long bones in skeletally immature patients [1,2]. More a developmental or reactive lesion than a real tumor, it is sometimes classified as a tumor-like lesion. The cavity of the cyst usually contains a small amount of clear yellowish sero-sanguinous fluid. In the case of a pathological fracture through the cyst, the cyst contains blood. The cyst can be in the growing skeleton, i.e., expanding and/or recurring after treatment, particularly if it is in close proximity to the growth plate. These cysts might heal spontaneously in adulthood [3]. They tend to appear in the first two decades of life, mostly in boys (2:1). On X-ray, the cyst appears as a well-localized radiolucent lytic lesion in the medullary canal, well differentiated, and without periosteal reaction. When the cyst is complicated by a pathological fracture, periosteal reaction can be seen at the fracture-healing stage. The cyst can expand concentrically but never penetrates bone cortex. The indication for treatment is pain, pathological fracture, or risk of such a fracture, for example, if a large cyst is situated in a weight-bearing area [4].

Since Virchow first described this lesion in 1876, several methods of treatment have been proposed and various outcomes described. Currently performed treatment includes observation, aspiration, and injection of corticosteroids [5]; aspiration and injection of bone marrow or demineralized bone matrix [2,6,7]; curettage combined with bone or synthetic grafting [4,8,9]; continuous decompression with intramedullary nailing or cannulated screw [3,10,11,12]; or a combinations of these approaches [13]. The choice of treatment depends on the surgeon's experience and the location and extension of the lesion.

We assessed our experience with the surgical treatment of bone cyst lesions in pediatric patients at one institution by the same group of surgeons. Patients treated conservatively or observed for this pathology were not included in this study.

PATIENTS AND METHODS

The study included 60 patients (43 boys, 17 girls) surgically treated for monostatic simple bone cyst lesions between January 2002 and July 2007, evaluated retrospectively. The mean age at surgery was 11.8 years (range 4–17 years). The mean follow-up

Table 1. Distribution of bone cyst according to locality and treatment method

Locality/ method	Bone marrow	Corticosteroids	Curettage & bone graft	Curettage & synthetic graft	ESIN	Total
Humerus	6	19	–	1	2	**28**
Femur	–	1	9	1	2	**13**
Tibia	3	2	4	–	1	**10**
Fibula	1	3	–	–	–	**4**
Calcaneus	–	1	2	1	–	**4**
MTT	–	–	1	–	–	**1**
Total	10	26	16	3	5	**60**

ESIN = elastic stable intramedullary nail

Table 2. Results according to Capanna classification

Method	Complete healing	Healing with residual radiolucency	Recurrence	No response	Total
Injection of bone marrow	3 (30%)	5 (50%)	2 (20%)	0 (0%)	**10**
Injection of corticosteroids	5 (19%)	7 (26%)	13 (50%)	1 (4%)	**26**
Curettage & synthetic graft	3 (100%)	0 (0%)	0 (0%)	0 (0%)	**3**
Curettage & bone graft	4 (25%)	9 (56%)	3 (19%)	0 (0%)	**16**
Continuous decompression ESIN	3 (60%)	2 (40%)	0 (0%)	0 (0%)	**5**
Total	**18 (30%)**	**23 (38%)**	**18 (30%)**	**1 (2%)**	**60 (100%)**

ESIN = elastic stable intramedullary nail

was 4.2 years (range 3–5.5 years). Most of the lesions (n=28) were located in the humerus. We divided our cohort into five groups, according to mode of treatment [Table 1]:

- Injection of corticosteroids (methylprednisolone 40–80 mg) (n=26)
- Curettage of the bone cavity and bone grafting with fibula or iliac crest (n=16)
- Aspiration of the bone cavity and subsequent bone marrow transplantation (n=10)
- Internal preventive fixation using an elastic stable intramedullary nail (n=5)
- Curettage of the bone cavity with subsequent instillation of synthetic cancellous bone substitute (pure beta-tricalcium phosphate substitute, ChronOS®, Synthes, Switzerland) (n=3).

We do not perform percutaneous or open biopsies before the definitive surgical treatment. The lesions had a typical radiographic appearance, and the aspirated fluid a typical character. Anteroposterior and lateral radiographs were taken on the first postoperative day, and then 6 weeks, 3 months, 6 months, and 1 year after surgery; the patients were then followed at 1 year intervals. In cases treated by the instillation of bone marrow, the first X-ray was taken 6 months after surgery. Results were evaluated according to the radiographic criteria of Capanna:

- Complete healing: when the cyst is fully filled with new bone formation and the cortical margins were thickened
- Healing with residual radiolucency: when the cyst is well consolidated with small radiolucent areas inside
- Recurrence: when the cyst heals initially but large areas of radiolucency and cortical thinning develop
- No evident response to treatment

RESULTS

Successful results were observed in 68% (18 total healing, 23 healing with residual radiolucent areas). There were 30% recurrences and no response to treatment in one case (2%) [Table 2]. We noted recurrence in 50% of the children treated by injection of corticosteroids, and one patient did not respond to treatment. Pathological fractures were demonstrated in 5 patients (8%), without involvement of the physis. The best results were achieved in the children treated by curettage and the subsequent use of osteoconductive material, and in children treated with elastic intramedullary nail fixations.

DISCUSSION

Despite the fact that many authors have published studies on the treatment of simple bone cysts, the exact etiology and pathogenesis remain unclear. The most widely accepted theory is that a focal defect in metaphyseal remodeling leads to venous obstruction and rising internal pressure leading to an increase in cyst size. There are many surgical treatment options, including aspiration and injection of corticosteroids [5], aspiration and injection of bone marrow [2,6], curettage combined with bone or synthetic grafting [4,8,9], continuous decompression with intramedullary nailing [10,11], or combinations of these approaches [13]. The trend is towards surgery, to diminish the internal cyst pressure. Small asymptomatic lesions in the upper extremities should be treated conservatively and observed radiologically [3]. Larger lesions (with a risk of pathological fracture), symptomatic lesions, and cysts of the lower extremities are usually treated with curettage (with or without bone grafting or internal fixation) or aspiration and injection (often using steroids, bone marrow aspirate, demineralized bone matrix or other materials) [3,7,12]. Fractures through the cysts in the upper extremity can be treated conservatively, contrary to pathological fractures in the femur or tibia where curettage, bone grafting or internal fixation is indicated [3]. In our cohort, we treated five pathological fractures using elastic stable intramedullary nails with satisfactory results.

Because the recurrence rate after curettage and bone grafting was approximately 50%, corticosteroid injection was

introduced in the mid-1970s as an effective new treatment [5]. The recommended dose is up to 200 mg of methylprednisolone, according to the age of the child and the size of the cyst [3]. In our cohort we used 40–80 mg Depo-Medrol®. Campanacci et al. [14] published their results of 141 bone cysts treated by instillation of methylprednisolone. They recorded complete healing in 42%, healing with residual radiolucency in 48%, and no response to treatment in 10%, with a recurrence rate of 15%, in contrast to our study that found a 50% recurrence rate with this method. Because the mechanism of action of methylprednisolone is unclear and there are no prospective studies on the treatment of the anti-prostaglandin effect of corticosteroids inside the bone cyst, we believe that this technique acts more by decreasing the pressure of the cyst than by any other effect. Thus, we do not see the necessity for increasing the dosage of methylprednisolone inside bone cysts in children. The majority of bone cysts treated by corticosteroid injection in our cohort had poor prognostic factors for successful percutaneous treatment (multiloculated appearance, large size, radiographically active lesion). On the other hand, most of the cysts were situated in a non-weight-bearing bone, the humerus, and we believe that this was the reason why our treatment was less active.

Osteogenic elements of bone marrow promote cyst healing by stimulating bone formation [2]. Lokiec and co-researchers [2] first reported consolidation of the cyst in all patients managed with percutaneous autologous bone marrow grafting. Docquier and Delloye [6] proposed that simple decompression by fluid aspiration with a large trocar followed by a single autologous bone marrow injection promotes healing of simple bone cysts. In our cohort, we achieved complete healing in 30% by this method and healing with residual radiolucency in 50% of patients.

Although the above-mentioned methods result in consolidation of the cyst, they do not maintain mechanical stability of the weakened bone [13]. For this reason, several authors report using intramedullary nailing of simple bone cysts as a minimally invasive easy technique, helpful for complete healing of the cyst by continual decompression and early stability of the bone. In our study, use of this method led to a successful outcome in all the patients, comparable to the results of Roposch et al. [11], De Sanctis and Andreacchio [10], and Knorr et al. [15].

In large simple bone cysts situated in weight-bearing bones, a combination of techniques can be used for stimulation of healing, respecting the minimal invasiveness of the bone graft intake which enables early mobilization. After the report of Gál and colleagues [8], we used a calcium triphosphate substitute in combination with bone marrow and bone autografts to fill simple bone cysts over 120 ml, and achieved excellent results [Figures 1 and 2].

Figure 1. Anteroposterior and lateral radiogram of a 16 year old boy with solitary bone cyst of the distal femur [**A**, **B**], anterior-posterior and lateral radiograms 6 months after curettage and filling with bone grafts, bone marrow and calcium triphosphate substitute ChronOS® [**C**, **D**].

Figure 2. Radiogram of 10 year old boy with simple bone cyst of the proximal femur. The fracture was treated successfully with an elastic stable intramedullary nail.

CONCLUSION

Our study shows that the best results were achieved in the children treated by curettage followed by an osteoconductive material, and in children treated by elastic intramedullary nail fixation. Although our experience with calcium-triphosphate bone substitute is small, we do see a positive trend, and further evaluation is necessary.

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