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PŮVODNÍ PRÁCE

Results of Allografts and Synthetic Grafts in Humeral Simple Bone Cysts

Výsledky aloštěpů a syntetických štěpů u kostních cyst humeru

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ABSTRACT

PURPOSE OF THE STUDY

Simple bone cysts (SBCs) are the most common benign bone lesions in childhood**.** There are many different methods in the treatment of SBCs. There is no consensus on which method to use in the treatment. In this study, we compared the results of allogeneic bone graft or synthetic bone graft in addition to flexible intramedullary nail (FIN) for SBC located in the humerus.

MATERIAL AND METHODS

This retrospective study comparing the data of 19 (group 1: 8 curettage, allograft and FIN; group 2: 11 curettage, synthetic graft and FIN) patients with a mean age of 11.4 (6 to 26; seven female, twelve male) who were surgically treated in our hospital for humeral SBC between April 2014 and January 2020. Patient data included age, sex, anatomical side, stage of the cyst, pathological fracture, previous treatments and complications.

RESULTS

The mean follow-up period was 33.7 months (12 to 61). The average last follow-up Musculoskeletal Tumor Society functional scores for groups 1 and 2 were 27.8 (20 to 30) and 28.6 (21 to 30) ($P > 0.05$). Complete or significant partial radiographic healing rates were achieved in group 1 (75%) compared with group 2 (81.9%). The reoperation rates for groups 1 and 2 were 62.5% (5/8; three for nails removed, two for recurrence) and 36.3% (4/11; two for nails removed, two for recurrence). One patient in group 2 had a 15° varus deformity due to recurrence. No other complications were observed.

CONCLUSIONS

The combination of curettage-grafonage FIN is a common treatment method in recent years, as it provides early cyst healing and limb mobilization in SBCs located in the upper extremity**.** For defects after curettage of the bone cysts, allogeneic or synthetic grafts (granule b-tricalcium phospate) which have similar results in terms of healing can be used as an alternative to each other.

Key words: allografts, bone cysts, bone nails, synthetic grafts, humerus.

INTRODUCTION

Simple bone cysts are the most common benign bone lesions in childhood (19). This is characterized by fluid-filled cystic lesions and often occurs in the metaphyses of long bones in children (10). The cases are mostly seen in the proximal humerus (55–70%) and later in the femur (20%) (28). Although it can be seen at any age, it is most commonly diagnosed between the ages of 5 and 15. There is no standard and specific method to treatment of SBCs. The aims of treatment include cyst aspiration, decompression, early mobilization, and prevention of catastrophic complications. Curettage and grafting, injection applications (fibrin glue, steroids, bone marrow, demineralized bone matrix) decompression of the cyst (multiple drilling, screw), decompression with internal fixation (FINs) are traditional and new methods used in treatment. None of these treatment techniques show a major advantage over the others, and are often associated with high rates of radiographically found partial healing and recurrence. The most frequently reported problem in conventional and new techniques used in the treatment of simple bone cysts is healing with residual or partial lesion. We have been using the curettage grafting method conventionally in our clinic for many years. We preferred to use FIN in addition to curettage grafting due to the favorable contribution of intramedullary decompression, which has recently been widely used, on cyst healing. In this retrospective study, we aimed to present the effects of allograft to fill the defect formed after curettage of simple bone cyst or the effects of synthetic grafts on cyst healing time, radiological and clinical results and complications with FIN.

MATERIAL AND METHODS

This study was carried out after the approval of Dicle University Medicine Faculty Ethical Committee in 04/02/2021, written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article. 19 patients who had an SBC of the humerus were treated by curettage and allografting with FIN (group 1, 8 patients) or curettage and synthetic grafting with FIN (group 2, 11 patients) between April 2014 and January 2020 were evaluated. Patients were randomly selected. The choice of graft type was determined by supply. Between 2014 and 2017, we used allograft because it was easily available. Since we could not obtain allograft between 2017–2020, we used synthetic graft (b-tricalcium phospate granule form).

The patients directly applied to our clinic or emergency department or were referred from other centers due to pathological fracture, pain, or growth of the followed cyst. Large, painful cysts located in the humerus, with or without a pathological fracture were the main indication for surgical treatment. Pathological fracture rates were low in cysts (group 1, 25%; group 2, 9%).

None of them required pre-procedure biopsy. It was considered that the diagnosis of benign bone cyst was thought to be clear imaging studies, especially plain radiographs and MRI. Histopathological examination revealed a single layer of endothelial cells covering the inner wall of the cyst in all lesions and the diagnosis of simple bone cyst was confirmed.

Data were obtained our orthopedic oncology department which include clinical and radiological evaluations, pathology and operative reports. Age and sex of patients, mean follow-up time, radiological and histopathological findings, presence or absence of a pathological fracture at presentation, previous treatment methods, functional and radiographic results at last follow-up, complication and reoperation rates were collected for each group. The demographic data of the study group are summarized in Table 1. SBCs is most often diagnosed in childhood, between the ages of 5 and 15. However, the ages of our two patients in group 2 were 18 and 26. The average age was 11.4 years (group 1, 6 to 14; group 2, 6 to 26). One patient was recommended to follow up with a shoulder-arm sling in an external center. Most of the patients in the study group (11 patients; 57.8%) had latent cysts (Table 1).

Surgical technique

The patients were operated by orthopedic oncology surgeons under general anesthesia and placed in the supine position. The region of cystic pathology was detected with the help of fluoroscopy. Lesion was reached through a window of approximately 2x2 cm, opened from the thinnest part of the cortical shell (Fig. 1). The inside of the lesion was curetted and pathological materials were removed. Also, cauterization and burr application was applied to reach the entire cyst wall for local adjuvant therapy to reduce the possibility of recurrence. The cystic cavity was washed abundantly with physiological saline. After it was concluded that the cystic

Table 1. Demographic, clinical and radiographic data of groups 1 and 2

	Curettage, allograft and FIN (group 1, n = 8)	Curettage, synthetic graft and FIN (group 2, n = 11)	Total n = 19
Average age (year)	10.5 (6–14)	12.09 (7–26)	11.4 (6–26)
Sex			
Male	5	7	12
Female	3	4	7
Mean follow-up Time (month)	51 (17–61)	21.2 (12–46)	33.7(12–61)
Anatomical side			
Right	5	4	9
Left	3	7	10
Location of the cyst			
Metaphysis	5	5	10
Diaphysis	3	6	9
Stage of the cyst			
Active	5	3	8
Latent	3	8	11
Pathological fracture			
Yes	2	1	3
No	6	10	16
Previous treatments			
Observation with a splint	1	1	2
Steroid injections	0	0	0
Other surgeries	0	0	0

cavity was completely cleared, 2.0–3.0 mm thick flexible intramedullary nailing was applied retrogradely through the 5 mm oval window opened from the distal humeral lateral cortex under the guidance of fluoroscopy. Due to the large cyst cavity and unstable fracture after curettage, two FINs were performed on two patients in group 1, lateral and medial. With the help of FIN, the medullary canal was opened in all patients and its continuity with the lesion was ensured. After FIN was performed, the cyst cavity was filled with a morselized allograft or synthetic graft (TriPho b-tricalcium phosphate granule form 300–500 mm pore size). An average of 15 cc (range, 5–30 cc) grafts were used for each patient.

Postoperative patient management

The patients were followed up with a velpeau bandage until the 4th week. Active finger and wrist and passive elbow movements were started in the first postoperative day in both groups. Active elbow movements were started at the end of the second week. Shoulder movements were started at the end of the fourth week, and the movements were increased gradually.

Radiological and functional follow-up

Postoperative radiological and clinical controls were performed at the first, third, 6th, 12th, 24th month, and at the last follow-up. Cyst healing according to Capanna criteria on control radiographs evaluated (4) (Table 2).

Table 2. Classification of response to simple bone cyst treatment on plain radiographs according to Capanna et al.

Grade	Descriptive term	Definition
I	Healing	Complete recovery. The cystic cavity is filled with bone
II	Healing with residuals	There are signs of healing, but there are still residual cystic areas
III	Recurrence	The cyst cavity is initially filled with bone, but later there are large areas of osteolysis
IV	No response	Do not respond to treatment

To evaluate the functional clinical results, the Musculoskeletal Tumor Society scoring was used. In this scoring; 6 criteria including the patient's pain, functional capacity, emotional state, hand position, dexterity and weight lifting functions are considered and calculated over 30 points. According to this; 23 points and above were rated as perfect, 15–22 points as good, 8–14 points as moderate, 0–6 points as bad (11).

Wound problems, superficial or deep infection, loss of stabilization or nonunion in early follow-up, physial damage, refracture, extremity damage in the middle and late periods. Complications such as height inequality, deformity and implant failure were recorded. The need for additional surgical intervention for early and late complications was investigated. In both groups, FINs

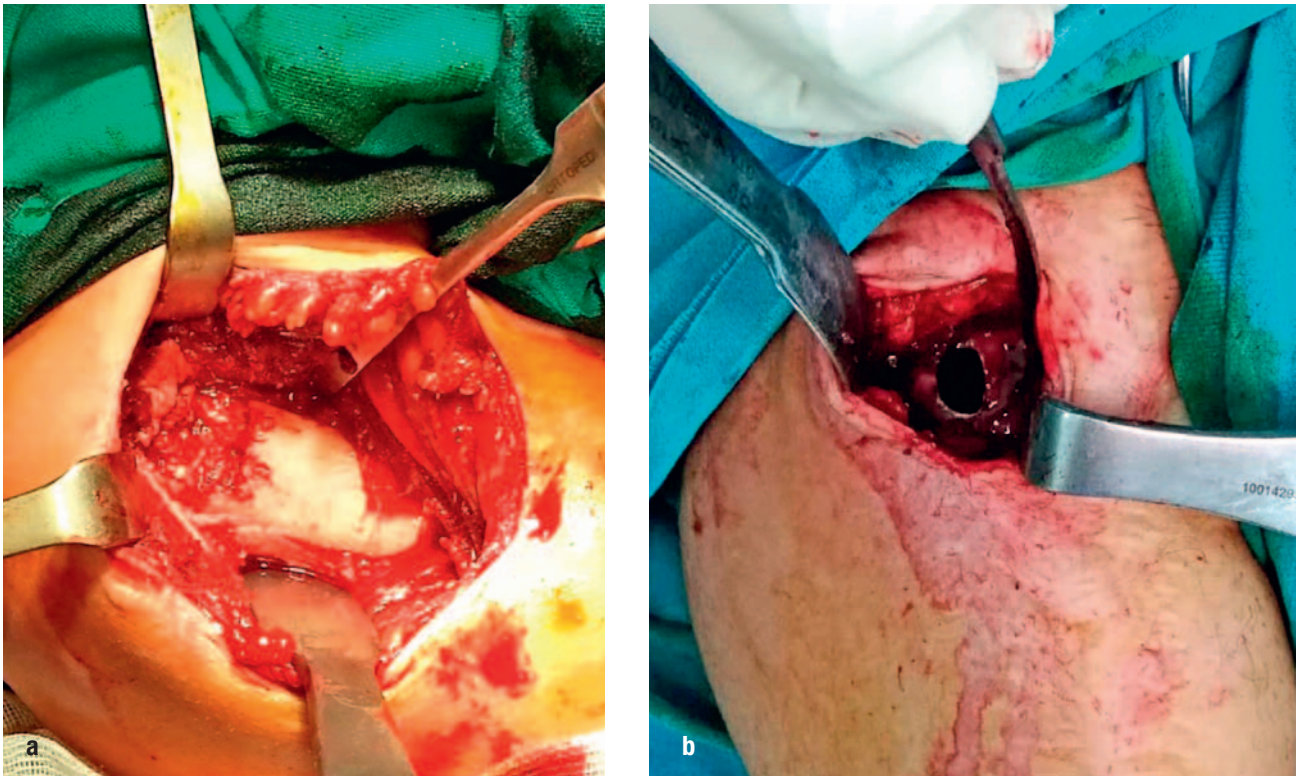

Fig. 1. a – image located proximal to the humerus after open surgery, curettage and allogeneic bone grafting; b – image located proximal to the humerus, in which curettage and synthetic bone grafting were performed by opening a small window from the cortex.

were removed in younger children with complete or significant partial healing at least 1 years after the surgical procedure. The patients close to skeletal maturity or those who had achieved skeletal maturity did not require implant removal (Fig. 2).

Statistical analysis

Measured variables were presented as mean ± standard deviation (SD), and categorical variables were presented as numbers and percentages (%). The Chi-square method was used for categorical variables from statistical methods. For continuous measurement variables, a Student's t-test was used, which tested two different groups. Hypotheses were taken from both directions, and $p \leq 0.05$ was considered statistically significant.

RESULTS

The patients in groups 1 and 2 were followed for a mean of 51 (range, 17–61 months) and 21.2 (range, 12–46 months) months. All pathological fractures took an average of 8 weeks (range, 6–12 week) boiled without problems. Radiological recovery generally started from the third month in both groups and was largely observed at the 12th month follow-up. Some patients 12–18 it was observed that it continued between months. Although the mean time to union was shorter in group 1 (10.2 months; range, 8-12 months) compared to group 2 (12.5 months; range, 9-18 months), no statistical difference was found ($P>0.05$).

Cyst healing rates were higher in group 2 (81.9%; 9/11 patients), but this difference was statistically insignificant when compared with group 1 (75.1%; 6/8 patients) ($P >0.05$). MSTS functional scores were perfect for all patients in both groups at final follow-up, with no statistically significant difference between group 1 (27.8; range, 20–30) and 2 (28.6; range, 21–30). ($P > 0.05$) (Table 3).

In the postoperative period, no superficial or deep infection, wound problem, limb length difference, physis damage due to elastic nail penetration or further fractures was observed in either group. Recurrence was observed in 4 patients in both groups (group 1 25%, 2/8 patients; group 2 18.1%, 2/11 patients). Before surgery the cyst was active in 3 (75%) and latent in 1 (25%) of these four patients. Due to recurrence, a patient in group 2 developed a 15° varus deformity malunion of the humerus. Varus malunion did not cause any obvious clinical findings in the patient.

Intramedullary nails were removed in 5 patients both group without any complications. The reoperation rates for groups 1 and 2 were 62.5% (5/8; three for nails removed, two for recurrence) and 36.3% (4/11; two for nails removed, two for recurrence).

DISCUSSION

Many methods are available to treat simple bone cysts, but there is no consensus yet on the best method. The aim of treatment is to prevent or manage pathologic fracture, promote cyst healing, recurrence and deformity.

In the treatment, the cyst membrane, which produces the cyst fluid and the destructive enzymes (PG E2, IL-1b2 and gelatinase) in the fluid, is cleaned. Steroid injection inhibits the enzymes in the cyst fluid that cause bone destruction, but cannot affect the cyst membrane (27). The low morbidity of the procedure and the ease of administration have made steroid injection common; however, the need for multiple injections, high rate of partial recovery, recurrence and long recovery time are disadvantages (24). Bone marrow and DBM injections have been reported to have low recurrence rates compared to steroid injection in part because they stimulate bone formation by stimulating cyst healing with their osteogenic potential (8, 6). However, they also have no effect on the cyst membrane.

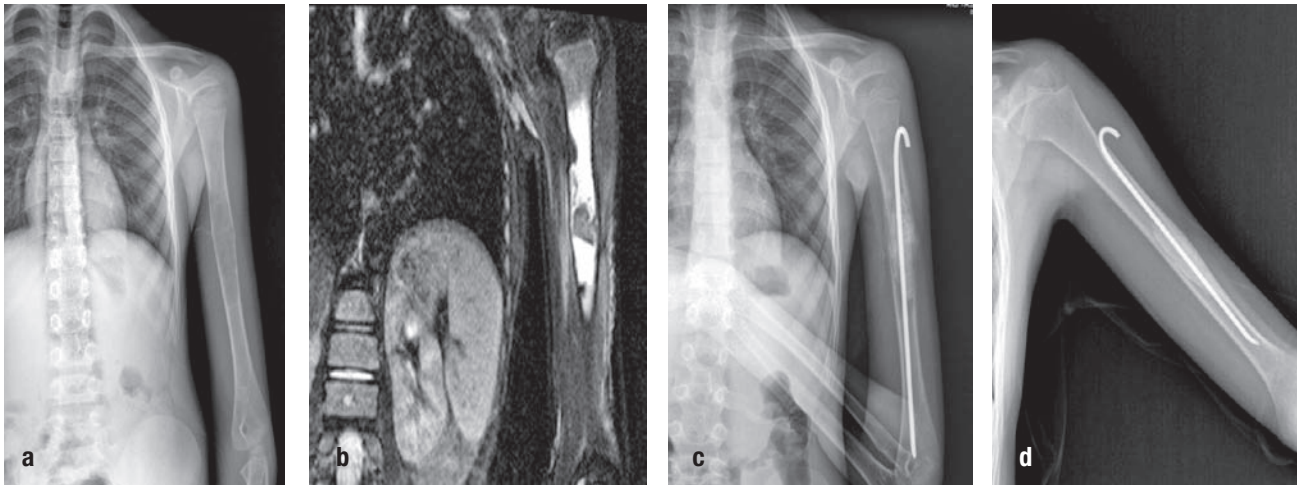

Fig. 2. 8-year-old male patient. He was operated for BCC located in the left humeral diaphysis. Cyst decompression, curettage and allograft and FIN were performed. After 60 months of follow-up, it is seen that the cystic cavity is filled with new bone and the bone is fused. Grade 1 improvement was detected according to Capanna criteria. a – preoperative X-ray; b – preoperative MRI section; c – postoperative 1st week control X-ray; d – final control X-ray.

Table 3. Groups 1 and 2 postoperative last follow-up radiographic and functional results (P>0.05)

	Group 1, n=8 (curettage, allograft and intramedullary nailing)	Group 2, n=11 (curettage, synthetic graft and intramedullary nailing)
Radiographic healing		
Capanna grade [n (%)]		
Grade I Complete	5 (62.5)	6 (54.5)
Grade II Partial	1 (12.5)	3 (27.2)
Grade III Recurrence	2 (25)	2 (18.1)
Grade IV No response	0	0
Average MSTS score [n (%)]	27.8 (range, 20–30)	28.6 (range, 21–30)
Perfect (23–30)	7 (87.5)	10 (90.9)
Good (15–22)	1 (12.5)	1 (9.09)
Moderate (8–14)	0	0
Bad (0–8)	0	0

MSTS – Musculoskeletal Tumor Society

The most commonly used traditional methods of treatment are open curettage grafting and steroid injection. Despite the high rate of partial recovery, recurrence and surgical morbidity associated with open curettage grafting treatment, this method is still widely used (23, 24). In a retrospective study of 73 patients published by Alemdar C. et al. in 2015; were compared steroid injection and curettage with allogeneic bone grafting. Recovery time was found to be shorter and success rate was higher in curettage graft group (1). P. Gál et al. in 2009 compared the containing stereoids Depo-Medrol with the injectable tricalcium phospate chronOS Inject in the treatment of juvenile bone cysts.

In 18 patients treated with chronOS Inject, 100% cyst healing was achieved without the need for additional surgery. Cyst healing was achieved in 12 of 24 patients (50%) treated with Depo-Medrol without the need for another surgery. They showed that the results treated with the chronOS Inject method were significantly better than with Depo-Medrol (14).

In another study, A. Joeris et al. treated 24 patients with bone cysts with chronOS Inject, an injectable tricalcium phosphate. Except for one patient, all pathological fractures healed within five weeks after the injection without any serious side effects (18).

Decompression of simple cysts has been practiced for many years. Chigara suggested that the intra-cyst pressure due to venous obstruction is higher than other parts of the bone, and he achieved successful results with multiple drilling in 7 patients (7). There are studies in which continuous drainage is provided with cannulated screw and good results are obtained. However, high local recurrence rates have been reported with this method (2, 21).

Although good results have been reported in studies on cyst decompression with percutaneous methods, repeat surgery may be needed (10, 22).

In Hunt's study, percutaneous curettage-grafting was applied to 20 patients with simple humeral cysts. A second operation was required in five patients (25%), and a third operation was required in one (4%) patient. Improvement was achieved in all patients (17).

In recent years, many studies have suggested the use of flexible intramedullary nails (FIN) in the treatment of simple cysts (20, 25, 5). Bumci stated that the connection of the cyst wall with the medullary canal changes the microcirculation and stimulates bone formation (3). Givon et al. stated that intramedullary nails allow passage through the medullary canal without causing a large gap in the cyst wall, thus decompressing the cyst (16). Intramedullary nails have positive contributions to cyst healing with continuous drainage. Although good results have been reported, high partial recovery rates are a disadvantage of decompression with flexible nails alone. In a series of 32 bone cysts in which he applied isolated intramedullary nails, Roposch achieved complete recovery in 14 (44%) patients, healed with residual in 16 (50%) patients, and observed recurrence in 2 (6%) patients (26). Similarly, high residual healing and recurrence have been reported in the isolated open curettage-grafting method of the cyst (15).

Therefore, in the treatment of bone cysts, it is aimed to reduce the residual and relapse by adding FIN to the open curettage graft. Erol B. et al. In a bone cyst series of 34 cases, using an average of 60 cc (range, 30–150 cc) autograft-allograft mixture, combining open curettage grafting with FIN, achieved complete radiological recovery in 28 (82%) patients and partial radiological recovery in 6 (18%) patients. No recurrence was observed in any patient, and no additional surgical intervention was required (13). In another study of 21 bone cysts located in the humerus, an average of 60 cc (range, 30–150 cc) cancellous allograft was used, and 16 (76.1%) patients in the isolated curettage grafting group recovered completely and 4 (19%) patients partially healed; recurrence occurred in 1 (4.8%) patient. In the curettage grafting and FIN combination group, complete recovery was achieved in 15 (93.7%) patients and partial recovery was achieved in 1 (6.3%) patient. No recurrence was reported in any patient. In the study, it was stated that postoperative complication rates were high because open curettage grafting was performed in both groups. Since internal fixation was provided in the group with FIN, early extremity movements were start-

ed and it was concluded that the cyst healed in a shorter time (12). Ke Zhang et al. showed that the addition of FIN to curettage and grafting using autograft, allograft and artificial bone graft increased healing with the effect of continuous decompression by providing continuity between the cyst wall and the intramedullary area. They achieved 90% successful cyst healing in the group treated with curettage, grafting and FIN (29).

There are very few studies on the type and amount of graft used in the surgical treatment of simple bone cysts. Erol B. et al. achieved complete union in all children by using an average of 60 cc autograft-allograft mixture for curettage-grafting and FIN combination (13, 12). We used an average of 15 cc allograft or synthetic (granule b-tricalcium phospate) with FIN in our series. We achieved complete union of 75.2% in the allograft group and 81.9% in the synthetic graft. Cyst healing occurred in an average of 10.2 months in the allograft group and 12.5 months in the synthetic graft. However, we could not find a statistically significant difference in terms of union time. F. Celebi et al. compared the effect of allograft and synthetic grafts on the duration of cyst union after curettage of benign bone tumors and achieved significantly early cyst union in the allograft group (9).

Since only curettage and grafting or only FIN treatment causes residual healing and recurrence in bone cysts, we aimed to reduce these by adding FIN to curettage and grafting in our study (26, 15). When we compared with the publications in which curettage, grafting, and FIN were combined, the recurrence rates were found to be higher in both groups in our study (13, 12, 29).

Recurrence occurred in 2 (25%) patients in the allograft group and in 2 (18.1%) patients in the synthetic graft group, requiring additional surgical intervention. We found that if the cyst was active before surgery, the probability of recurrence was high. Of the 4 patients who developed recurrence in both groups, 3 had active cysts before surgery.

Another reason for the high rates of recurrence is the small amount of grafts used. We used an average of 15 cc of allograft or synthetic graft. To reduce the recurrence rate, we applied dual local adjuvant treatment (cauterization and burr application) to the cyst wall after curettage. It may be useful to conduct studies with larger case series to evaluate the effect of graft amount and lesion activity on cyst healing.

Allogeneic grafts can be applied easily, but they have disadvantages such as the risk of carrying infectious diseases and being expensive. Synthetic grafts are plentiful, mimic bone tissue, and are biocompatible, but have slightly longer resorption times. In our study, the results of allogeneic and synthetic grafts in bone cyst treatment were similar in terms of union time, amount of union, and postoperative extremity functional scores.

The negative aspects of our study are that it is retrospective and the number of patients in both groups is low. In this study, FIN was added to both groups (allogeneic and synthetic graft) to allow early mobilization of the extremity with intramedullary stabilization after cyst decompression and grafting.

CONCLUSIONS

The combination of curettage-grafonage FIN is a common treatment method in recent years. Allogeneic or synthetic bone grafts (granule b-tricalcium phospate), which have no superiority over each other in terms of cyst healing can be used of bone cyst treatment. Also, adding FIN to treatment may reduce residual healing and recurrence of the cyst as it provides early cyst

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