CLINICAL ARTICLE

Chondroblastoma in the Children Treated with Intralesional Curettage and Bone Grafting: Outcomes and Risk Factors for Local Recurrence

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Objective: To review the outcomes of surgical management in the pediatric patients with extremity chondroblastoma. Especially the risk factors of recurrence and growth disorder. And discuss a potential method to decrease the rate of growth disorder by preventing the premature physeal closure.

Methods: Fifteen girls and twenty-seven boys aged from two to 14 years (mean, 11 years) with histologically proven chondroblastoma, who presented from January 2011 to June 2018 at our Hospital, were retrospectively reviewed. Clinical data, radiographic images, histological findings, treatment, functional outcomes, and local recurrence rate were analyzed. Surgical treatment included complete curettage of the tumor and the walls of the lesion followed by bone grafting, No adjuvant methods were used. Recurrence was defined as a return of symptoms and an expansion radiolucency at the operated site. It was confirmed by the histopathological analysis. When recurrence was diagnosed, the medical data were analyzed to detect the effect of different factors on local recurrence. Functional outcome was measured according to Sailhan's functional criteria, designed to provide a standardized method of assessing pediatric chondroblastoma patient postoperatively.

Results: The proximal part of the femur was the most frequently involved site. All the patients had at least 24 months of follow-up; mean duration was 30 months (range, 24–60 months). The local recurrence rate was 9.5%. Three resolved after repeat surgeries without further recurrence, one had a second recurrence and received another more aggressive curettage. Local recurrence of chondroblastoma was associated with age ($P < 0.05$), while not associated with sex, tumor location, the radiological character of the lesion or the grafting method ($P > 0.05$). No pulmonary metastasis was noted at latest follow-up. Five patients suffered from premature closure of physis due to physis injury. Thirty-one patients (73.8%) had a good outcome, and all returned to normal unrestricted activities. Six patients (14.3%) had a fair outcome due to occasional pain, asymmetric range of motion, or radiographic joint changes without arthritis. And five patients (11.9%) had a poor outcome because of chronic pain, loss of joint motion impairing normal life activities, or a limb-length discrepancy and limp.

Conclusions: Aggressive curettage and bone grafting resulted in local control and good outcomes in most pediatric patients. Being less than 12 years of age was the risk factor for recurrence. For those growing patients, premature physeal closure was observed after the curettage, interpositional technique with PMMA would be a good choice for prevention.

Key words: Bone grafting; Children; Chondroblastoma; Curettage; Recurrence

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Introduction

Chondroblastoma is a rare benign bone tumor with potentially aggressive local growth. It was first recognized by Kolodny, who described it as a "giant cell variant" in 1927[1]. A few years later, Codman [2] used the term "epiphyseal chondromatous giant cell tumour." In 1942, Jaffe and Lichtenstein [3] discovered that it originated from chondroblasts, thus distinguishing it from the giant cell tumor of bone. The tumor entity was thus classified as a benign chondroblastic neoplasm and was termed benign chondroblastoma of bone. Chondroblastoma accounts for about 1% of all primary bone tumors and appears to arise from secondary centers of ossification[4]. The tumor is mainly located in a long bone epiphysis and less often in an apophysis[4–10]. It occurs most during adolescence, and is twice as common in men. Some published series showed the most frequent locations were the proximal femur, the proximal tibia, and the distal femur [5,10], Whereas the most frequent locations in other series were the proximal humerus and the distal femur [4,6,9,11,12]. Patients may present with gradual increasing pain, local tenderness, swelling, and limited motion of the adjacent joint. Although large series have reported the surgical outcomes of chondroblastoma, there was little research on pediatric patients with chondroblastoma[8,13,14]. And little research focus on the growth disorders after surgery for those pediatric patients[14].

There is no golden standard treatment for chondroblastoma. The recommended surgical treatment forchondroblastoma varies. Curettage, either alone or in company with bone grafting or packing the cavity with polymethylmethacrylate, or coupled with cryosurgery, are among the techniques which have been described[4]. Although radiofrequency ablation has been reported[15,16], the mainstay of treatment remains surgery especially meticulous curettage combined with bone grafting[4,5,7,8,12,17]. However, resection is still an option for selected patients.

Reported local recurrence rates vary from <10% to >30%[4,5,8–10]. Malignant transformation of recurrent tumors and cases with pulmonary metastasis have been described in the literature, but are extremely rare[18,19]. Suneja[4] reported one 12-year-old patient with recurrent chondroblastoma of the calcaneum proved to be malignant and extensive metastases developed despite amputation. The risk factors for local recurrence have not been well defined and remain controversial. Although studies[9,20] reported low recurrence with use of adjuvant treatments, it is not proven that it is the adjuvant treatments rather than the aggressive curettage that lower the risk of local recurrence. The presence of an aneurysmal bone cyst component [21], biologic aggressiveness[5] and atypical location[8,10] have been reported to be risk factors for local recurrence. These factors were considered not so important by other investigators[22]. The presence of an open physis was considered to be a risk factor for local recurrence[4,8]. In a report of chondroblastomas in a pediatric population, recurrence was as high as 32%. The author thought it may be the less-extensive curettage in young patients for concerning about that aggressive curettage will cause damage to the adjacent open physis[8]. It is also possible that this cartilaginous lesion originating near (or from) the physis maybe more aggressive and may have a higher potential for local recurrence when the physes are still active.

Since the tumor is often localized near to the growth plate, growth disturbances could be expected in those open epiphyseal growth plate patients. Growth disorders are mentioned with a different frequency of 7%–100%[8,13,14,23]. Xiong[14] retrospectively reviewed 18 cases of long bone chondroblastoma with open epiphyseal growth plate, treated with meticulous intralesional curettage and inactivity with alcohol. Allograft implantation was used in 13 patients, autologous iliac bone in two patients, and artificial bone in five patients. All the patients had a shortened limb compared with normal side during the latest follow up. In the other pediatric chondroblastoma research, the author found that in all 76 patients, eight patients had lower limb discrepancy that contributed to fair or poor outcome[8]. Limb length discrepancy and angular deformity may lead to clinical problems, such as posture deformation, gait asymmetry, low back pain, and early degenerative change, also psychosocial problems may occur.

Since the growth disturbances could be expected, preventive treatment should be considered to decrease the rate of the growth disorder in those young patient with open growth plate. Interposition technique would be a good method, which is a part of the resection-interposition technique first described by Langenskiöld [24]. It aims to interpose different materials across the physis to prevent physeal bridge forming and allow growth to restart.

The purpose of the present study was to: (i) evaluate the clinical outcomes after intralesional curettage and bone grafting for chondroblastoma in pediatric patients; (ii) identify the rate of recurrence and the risk factors for recurrence after surgery; (iii) determine the growth disorders after surgery; (iv) discuss a potential method to decrease the rate of growth disorder by preventing the premature physeal closure.

Methods

Inclusion and Exclusion Criteria

Patients were selected using the following inclusion criteria: (i) the primary diagnoses of the patients were chondroblastoma; (ii) the age of the patients were no more than 14 years; (iii) patients were treated by intralesional curettage and bone grafting; (iv) patients had intact clinical and radiographic data; (v) patients had a minimum 2-year follow-up period. The exclusion criteria included: (i) patients with pathological fracture; or (ii) patients with pulmonary metastasis.

Patient Characteristics

Forty-two patients with histologically confirmed chondroblastoma, who presented from January 2011 to

June 2018 at our Hospital, were retrospectively reviewed. At the time of diagnosis and treatment, 33 children's physis were open, while nine were nearly closed.

Medical records were reviewed for each child (age at the time of presentation, gender, initial clinical symptoms, intervals between the first symptom and the time

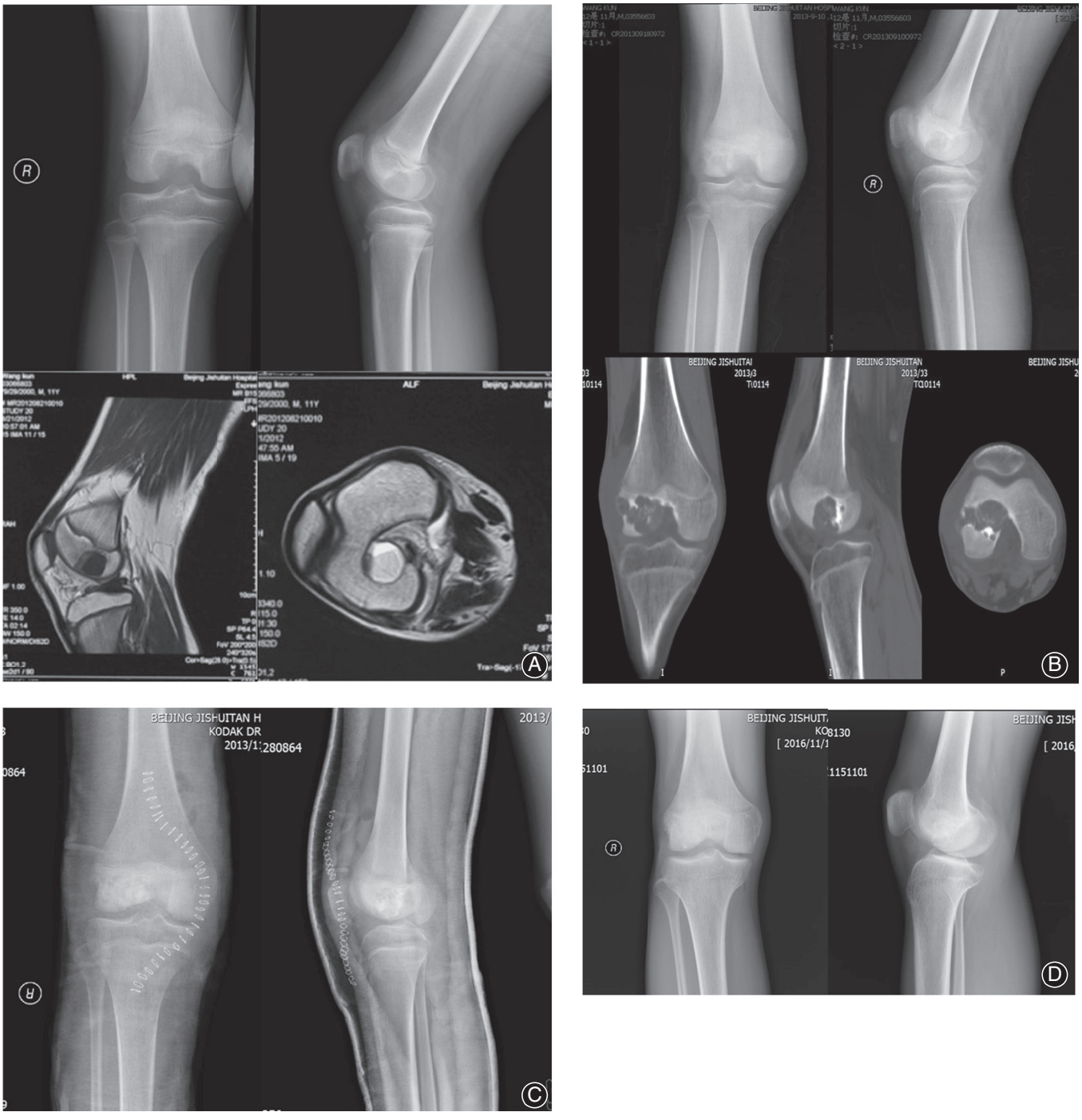

Fig. 1 A recurred case. This patient presented at the age of 11 years with a typical chondroblastoma of the distal femoral epiphysis, clearly shown on X-ray and MRI (A). This was treated by curettage and bone grafting but recurred 11 months later. The radiograph shows the enlarged cavity and the remained artificial bone in the epiphysis (B). This was treated by another aggressive curettage and bone grafting (C). The final radiograph taken 3 years later at skeletal maturity shows the lesion had completely healed and there does not appear to be any damage to the growth plate (D).

of diagnosis, location and activity of lesion, surgical record, pathological record, complications, and radiological result).

Radiographic Classification (Springfield Categorization)

The biological activity was categorized as latent (confined to the bone with a well-defined, complete reactive sclerotic rim surrounding), active (confined to the bone, but had an incomplete sclerotic rim or were contained within a rim of reactive periosteal bone), or aggressive (with poorly defined margin, with minimal or no intraosseous reaction and an extraosseous component that was not surrounded by periosteal bone) according to the radiographic classification of Springfield *et al.*[25]. Chest radiographs were also reviewed to monitor metastasis.

Surgical Technique

Surgical treatment included complete curettage of the tumor and the walls of the lesion. Curettage was done through a window in the epiphysis so as not to damage the growth plate. During the surgery, intralesional curettage was performed by straight and angled hand curettes. No adjuvant methods were used. The defect was washed with saline using pulsed lavage followed by autologous cancellous bone grafts

TABLE 1 Relation between age groups, sex, radiological grade, location, and grafting method, and the occurrence of local recurrence

Data	Recurrence [*cases* (%)]		χ^2 value	*P*
	Yes ($n = 4$)	No ($n = 38$)		
Age				
Less than 12 years ($n = 20$)	4 (100)	16 (42.1)	4.863	**0.027**
More than 12 years ($n = 22$)	0 (0)	22 (57.9)		
Sex				
Male ($n = 15$)	3 (75)	12 (31.6)	0.440	**0.507**
Female ($n = 27$)	1 (25)	26 (68.4)		
Grade				
Latent ($n = 18$)	0 (0)	18 (47.4)	4.421	**0.110**
Active ($n = 21$)	3 (75)	18 (47.4)		
Aggressive ($n = 3$)	1 (25)	2 (5.2)		
Location				
Proximal femur ($n = 15$)	1 (25)	14 (36.8)	1.374	**0.712**
Proximal tibia ($n = 13$)	2 (50)	11 (28.9)		
Distal femur ($n = 8$)	1 (25)	7 (18.4)		
Others ($n = 6$)	0 (0)	6 (15.8)		
Grafting				
Autogenous ($n = 12$)	1 (25)	11 (28.9)	0.028	**0.868**
Artificial bone ($n = 30$)	3 (75)	27 (71.1)		

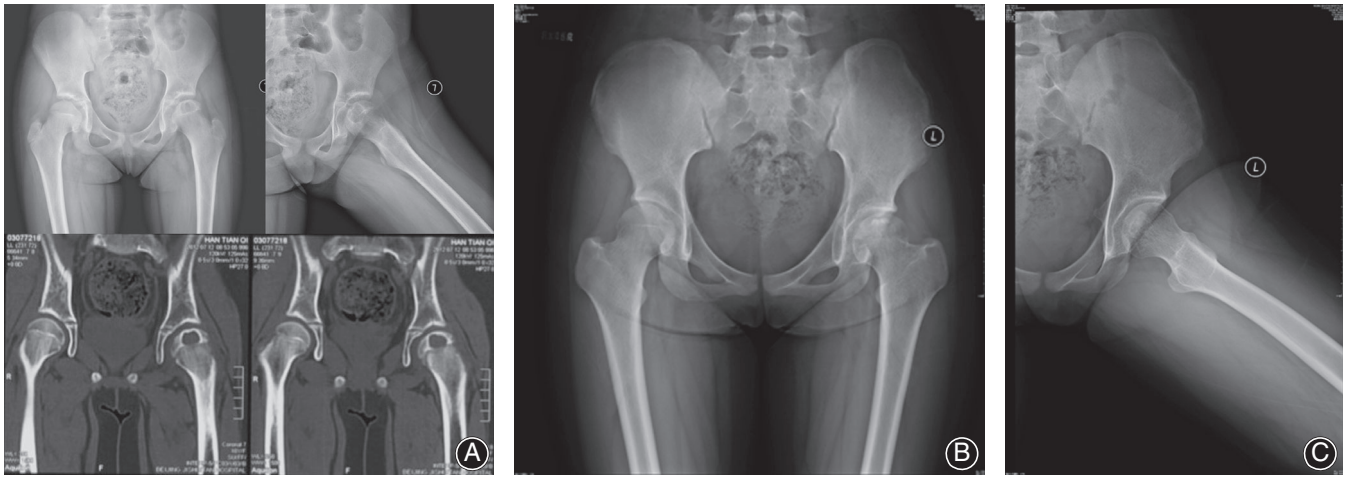

Fig. 2 This patient presented at the age of 10 years with a typical chondroblastoma of the left proximal femoral epiphysis, clearly shown on X-ray and CT (A). This was treated by curettage and bone grafting. The final radiograph taken 6 years later at skeletal maturity shows the lesion had completely healed and showed short neck compared to the normal side (B, C).

or artificial bone. The bone defects after resection were filled with autogenous iliac cancellous bone graft in 12 cases, with artificial bone in 30 cases. Curetted tissues were sent for histopathology.

For femoral head lesions, we used the trapdoor procedure. Patient was under general anesthesia in supine position, with the affected side elevated. Anterior approach (Smith-Petersen approach) was used. Among the 14 hips, seven hips was dislocated anteriorly to expose the lesion. The anterior capsule was incised for dislocation of the hip. The capsule was opened in a "T" shape, one along the edge of the acetabulum, another along the femoral neck. Disruption of blood supply was minimized as the incision is not larger than was necessary for dislocation of the femoral head. The lesion was identified using preoperative images and intra-operative localization. Then a cartilage window was opened up to the lesion. The window size depends on the lesion size and should be large enough to access to the entire tumor. After aggressive curettage and bone grafting, the defect was closed with the cartilage trapdoor.

Patients were advised to remain non-weight-bearing or non-weight-lifting for between six and 12 weeks depending on the site and size of the curetted lesion, and all patients were followed-up with regular radiographs and clinical assessment at 3-month intervals for the first year and then at 6-month intervals until 5 years.

Evaluation of Surgical Outcomes

Local recurrence and complications especially the growth disorders were recorded. Recurrence was defined as a return of symptoms and an expansion radiolucency at the operated site. It was confirmed by the histopathological analysis of the lesion. When recurrence was diagnosed, the medical data were analyzed to detect the effect of different factors on local recurrence. Functional outcome was measured according to Sailhan's functional criteria[8].

Sailhan's Functional Criteria

This criteria was proposed by Professor Sailhan in 2009 to evaluate the postoperative function of the chondroblastoma children patients, he stated that the result was classified as good if the patient was pain-free and had unrestricted activities (including sports), normal joint mobility, and intact joint surfaces radiographically (radiographic scars from surgical treatment did not exclude patients from this category). The result was classified as fair if the patient had unrestricted activities but had occasional pain (less than once per week), asymmetric joint mobility, a limb-length discrepancy (due to partial or complete epiphyseodesis), and/or radiographic evidence of loss of sphericity of the joint surfaces or of morphological modifications such as coxa vara or varus or valgus deformity. The result was classified as poor if the patient had a modification of his or her daily activities for any reason, such as chronic pain, deformity, or limp.

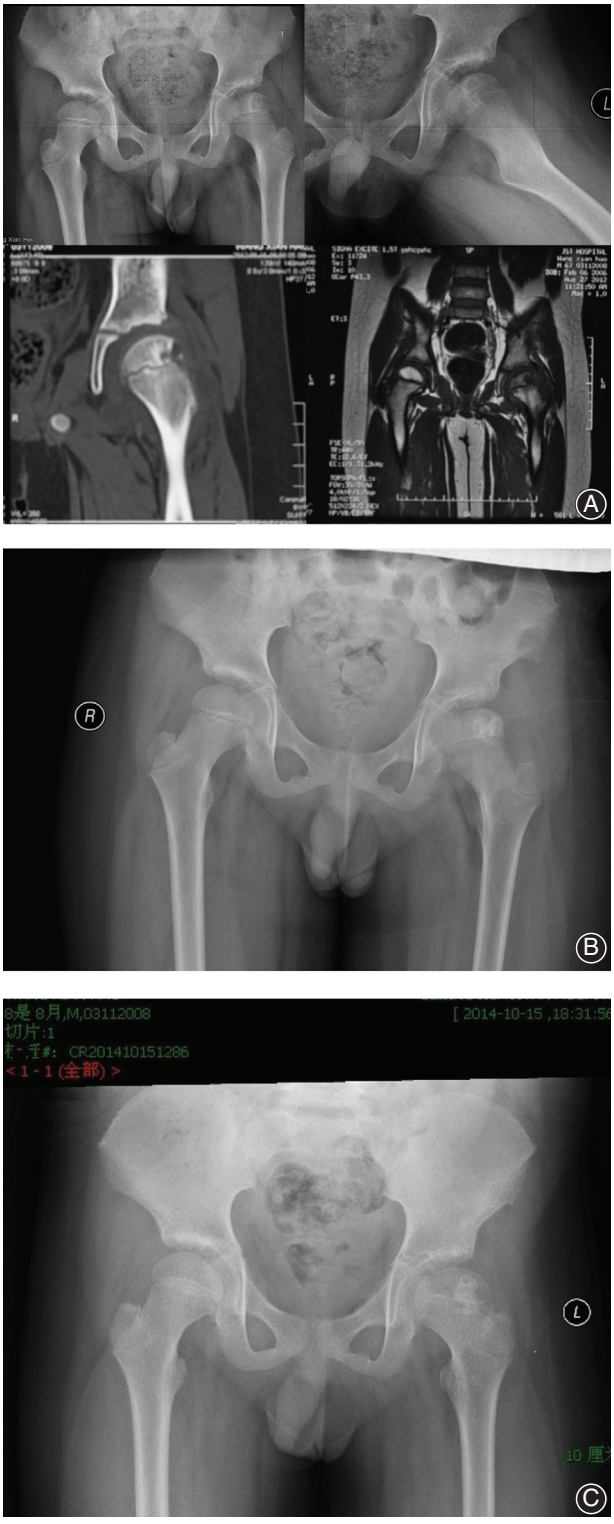

Fig. 3 This 6-year-old boy presented with chondroblastoma of the left proximal femoral epiphysis, shown on X-ray, CT and MRI (A). This was treated by curettage and bone grafting (B). The latest AP view taken 2 years later shows the lesion had completely healed, but with short neck and coxa valgum compared to the normal side (C).

Statistical Analysis

Continuous variables such as age and time of follow-up were expressed as the mean and the standard deviation. Categorical variables such as recurrence were described as a percentage rate. Chi-square analysis was performed to evaluate the difference in various percentages. The significance level was set at $P < 0.05$. All statistical analyses were conducted using SPSS 22.0 for Windows (IBM, Armonk, NY, USA).

Results

Preoperative Characteristics

There are 15 girls and 27 boys, with an age range at presentation from 2 to 14 years (mean 11 years). The mean duration of symptoms at the time of presentation was 5.8 (range, 1 to 28) months. Sites of involvement were: the proximal femur ($n = 15$), the distal femur ($n = 8$), the proximal tibia ($n = 13$), the distal tibia ($n = 1$), the patella ($n = 1$), the proximal humerus ($n = 4$). There were nine patients with tumors extension from the epiphysis to the metaphysis. Overall, the most commonly involved bone was the proximal part of the femur (15 patients, 35.7%), followed by the proximal part of the tibia (13 patients, 30.9%) and the distal part of the femur (eight patients, 19.0%). According to the Springfield's classification, 18 were latent, 21 were active, and three were aggressive.

Sailhan's Functional Criteria

Thirty-one patients (73.8%) had a good outcome without pain or growth disturbance, and all returned to normal unrestricted activities. Six patients (14.3%) had a fair

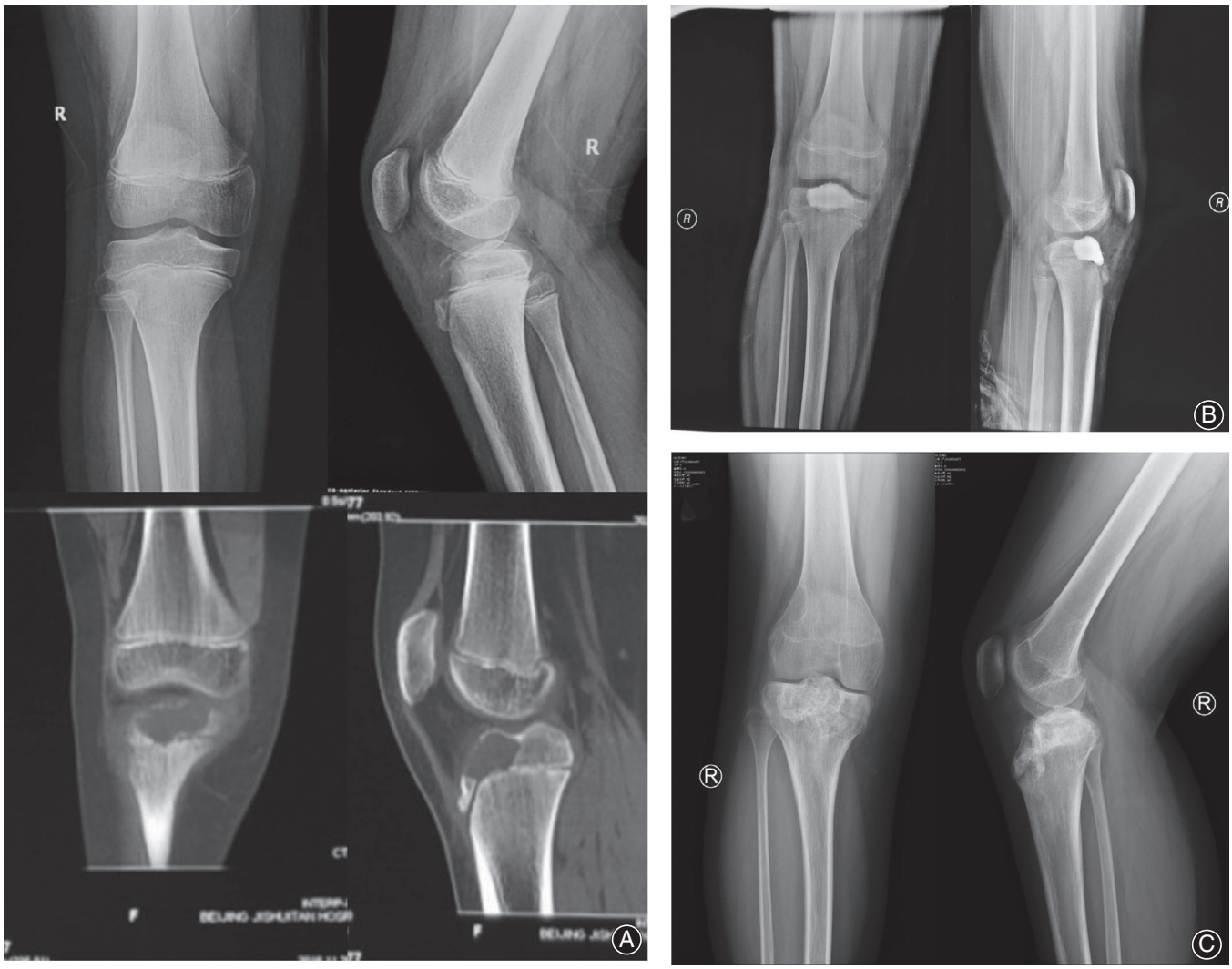

Fig. 4 Chondroblastoma of the proximal tibiaepiphysis in a 12-year-old boy before (A), during (B), and 3 years after (C) curettage and defect filling with bone grafting. Latest follow up shows around 10 degrees proximal tibia varus.

outcome due to occasional pain, asymmetric range of motion, or radiographic joint changes without arthritis. And five patients (11.9%) had a poor outcome because of chronic pain, loss of joint motion impairing normal life activities, or a limb-length discrepancy and limp. In the group of six patients with a fair outcome, the most common were occasional pain (three patients), radiographic abnormalities (two patients) and a limb-length discrepancy of 1 cm (one patient). In the group of patients with a poor outcome, one patient complained of pain more than once a week, one had a limb-length discrepancy, and three patients had a stiff joint.

Rate of Recurrence and Risk Factors for Recurrence

Local recurrence of the tumor occurred in four of the 42 cases (9.5%). The average age of these four patients were 10 years. The mean time from the initial operation to recurrence was 8 months (range 6–11 months). Of these four patients, one had a tumor in the distal femur (Fig. 1), one was in the proximal femur, and two was in the proximal tibia. Recurrence was local, involving the initial site. All the recurrence was confirmed by the pathology. The patients underwent the same technique but more extensive. Among them, three healed with no further recurrence until the latest follow-up, one developed a second recurrence and was treated with another aggressive curettage. She was doing well with no evidence of persistent or recurrent disease. There were no cases of metastases. Local recurrence of chondroblastoma was associated with age ($P < 0.05$), but not associated with sex, tumor location, the radiological character of the lesion or the grafting method ($P > 0.05$) (Table 1).

Growth Disorders after Surgery

Five patients with open physis had growth disorder. There are two girls and three boys, with an age range at presentation from 6 to 12 years (mean 10 years).Premature closure of the physis were detected, two in the proximal femur physis caused short neck (Figs 2 and 3) and around 1 cm LLD, one in the proximal tibia caused slight genu recurvatum, one in the proximal tibia caused 10 degrees varus (Fig. 4),that later osteotomy would be considered. One in the distal femur caused slight genu valgum.

Discussion

Chondroblastoma is a rare benign, locally aggressive, primary cartilage bone tumor. To our knowledge, there are few studies that focus on cases of chondroblastoma in pediatric patients. In 2009, Frederic Sailhan[8] reviewed 87 cases of chondroblastoma in patients with open physis with a mean age of 12.5 years at the time of diagnosis and treatment. He found epiphyseal chondroblastomas have a higher risk of recurrence when compared with metaphyseal, apophyseal, and epiphyseal-metaphyseal lesions. It is an interesting finding which is different from previous research.

Epidemiologic Characteristics

Most chondroblastoma series have shown a male predominance. In our series, the male: female ratio was 1.8:1, that is consistent with the reports of others[4,6–8,10,12]. The peak age of occurrence was between 12 and 14 years of age, with most of the patients falling in this range. And the youngest patient was 2 years old. In our series, most frequent locations were the proximal femur, the proximal tibia, and the distal femur, which is the same as some published series[5,10]. Whereas the most frequent locations in other series were the proximal humerus and the distal femur[4,6,9,11,12].

Risk Factors for Recurrence

There is no golden standard treatment for chondroblastoma, although radiofrequency ablation has been reported[15,16], the mainstay of treatment remains surgery especially curettage combined with bone graft[4,5,7,8,10,12]. In our series, intralesional curettage followed by bone grafting was performed in all the patients to preserve the involved joint. No adjuvant treatments, such as cryotherapy or phenol were used to avoid extra damage to the growth plate. Although studies[9,20] reported low recurrence with use of adjuvant treatments, it is not proven that it is the adjuvant treatments rather than the aggressive curettage that lower the risk of local recurrence.

Our local recurrence rate is 9.5%, while the reported rates of local recurrences ranged from 4.8% to 32%[4,5,8–10]. The presence of an aneurysmal bone cyst component[21], biologic aggressiveness[5] and atypical location[8,10] have been postulated to be factors related to local recurrence. However, controversy still exists. These factors were not considered important by other investigators[22]. Chondroblastoma usually affects young patients. The presence of an open physis was considered to be a risk factor for local recurrence[4,8]. In a report of chondroblastomas in a pediatric population, recurrence was as high as 32%. The author thought it may be the less-extensive curettage in young patients for concerning about the adjacent open physis[8]. We found young age to be associated with local recurrence. In our series, all the patients whose tumors recurred were less than 12 years. As the curettage method were the same as the other patients, we do not believe that an open physis prevents the surgeon from doing an adequate curettage due to fear of injuring the growth plate. In a recent multicenter retrospective study with 126 patients, the author stated that age and status of the physis were not the factors related to recurrence[10], but the mean age of the patients was 18.8 years that is older than ours.

There seems to be agreement on that surgical technique plays a part in chondroblastoma recurrence. The significant risk factor associated with local recurrence is inadequate curettage. Thus, careful preoperative planning that leads to appropriate access to the lesions and thus performing an adequate curettage of the entire tumor are very important[26]. Simple curettage has been associated with higher recurrence rates[27]. Some authors recommend a combination of curettage and high-speed burr to reduce the rate of recurrence[5,6,9]. We do not use burr in fear of the heating

that would damage the physis. We only use curettages in extending the curettage. During the operation, curettage was performed as aggressively as possible without injuring the physis. In one patient with a small lesion in the proximal tibia epiphysis, navigation was used to locate the lesion and avoid more damage to the growth plate.

Aggressive curettage is appropriate although it could damage the growth plate. The damage could be minimized by adequate exposure, meticulous curettage and even navigation system. Suneja *et al.*[4] believe that the growth plate is resilient, and with proper care, aggressive curettage is appropriate, Non-aggressive curettage could be with less damage to the growth plate, but with higher rate of recurrence [27], would need a second even third more aggressive surgery, that would cause higher risk of injury to the growth plate, bringing about growth plate arrest and articular cartilage damage. In our series, four patients had recurrence after curettage, and a more extensive curettage was performed, causing more damage to the soft tissues around the growth plate or articular cartilage, that resulted in unsatisfied joint function and poor outcome according to Sailhan's functional criteria.

Growth Disorders after Surgery

Growth disorders are mentioned with frequencies of 7%–100%[8,13,14,23]. Xiong *et al.*[14] retrospectively reviewed 18 cases of long bone chondroblastoma with open epiphyseal growth plate, treated with meticulous intralesional curettage and inactivity with alcohol. Allograft implantation was used in 13 patients, autologous iliac bone in two patients, and artificial bone in five patients. All the patients had a shortened limb (1.5–30 mm) compared with normal side during the latest follow up. In our series, five patients (11.9%) experienced premature closure of the physis postoperative due to physeal damage, and osteotomy was advised for two of them to correct the deformity.

Potential Method to Prevent Growth Disorder

As we know, the etiology of premature physeal closure for these patient could be tumor invasion or iatrogenic injuries. Besides careful preoperative planning, adequate exposure, meticulous curettage and even navigation system, preventive treatment could include interposition technique, which is a part of the resection-interposition technique first described by Langenskiöld [24]. It aims to interpose different materials across the physis to prevent physeal bridge forming and allow growth to restart. Some authors recommended additional interpositional materials such as silicone and bone cement (polymethylmethacrylate(PMMA))[28]. PMMA was originally used for filling large bone defects, providing mechanical stability. The presence of PMMA also allowed early detection of local tumor recurrence at the bone-cement interface[29], that was better than allograft, autologous iliac bone or artificial bone. The heat of PMMA polymerization and the direct toxic effect of its monomers were considered as a possible mechanism of adjacent cellular toxicity[30]. In a word, since the growth disorder happened in those age less than 12 years, which is the risk factor for the recurrence, an aggressive curettage with cement occupation would be a better choice for these age group patients especially those physis was invaded by the tumor.

Limitations

There are two limitations in this study. First is the retrospective design, which may weaken the strength of our conclusions. Second, the sample size was relatively small, but due to the rare nature of this tumor, large prospective observational studies or randomized controlled trials are not likely to be feasible. So a multicenter study would be a good method. However, our study did have strength, it contained a homogeneous group of patients from a single institution, all of whom were operated on by surgeons with similar operative indications and surgical techniques. Our findings may help surgeons identify high-risk patients for recurrence and take precautions to avoid related complications, especially the premature physeal closure.

Conclusion

In conclusion, chondroblastoma in the growing child is most frequently located in the proximal femur with significant male predilection. Aggressive curettage and bone grafting resulted in local control and good outcomes in most pediatric patients. Being less than 12 years of age was the risk factor for recurrence. For those growing patients, premature physeal closure was observed after the curettage. Interpositional technique with PMMA would be a good choice for prevention.

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