Research Paper

Have the difficulties and complications of surgical treatment for chondroblastoma of the adjoining knee joint been overestimated?

Liu Qing[a,b], He Hongbo[a], Yuan Yuhao[a], Zeng Hao[a], Long Feng[a], Tian Jian[a], Luo Wei[a,*]

[a] Department of Orthopaedics, Xiangya Hospital, Central South University, Changsha 410008, China
[b] Department of Spine Surgery, The Second Xiangya Hospital, Central South University, Changsha, China

ARTICLE INFO

ABSTRACT

Background and objective: Chondroblastoma is difficult to treat as the tumor is surrounded by both articular cartilage and the epiphyseal plate. The differences in joint shape further complicate the problem. This retrospective study evaluates the efficacy of intraregional aggressive curettage and allogeneic bone grafting for treating chondroblastoma of the adjoining knee joint.
Methods: From February 2010 to February 2017, 36 patients with chondroblastoma of the adjoining knee joint were identified. All patients were treated with intraregional aggressive curettage, phenolization, and allogeneic bone grafting. Follow-up for lesion healing, local recurrence, functional outcomes and secondary osteoarthritis were assessed both clinically and radiologically.
Results: Thirty-six patients (mean age 17 years) were enrolled with a mean follow-up of 51.8 months (18–98 months). The tumor locations were as follows: distal femur (14), proximal tibia (20), and patella (2). Only 1 patient relapsed, 10 months post-operation. All patients had good bone healing. No knee varus or valgus deformity developed. The mean Musculoskeletal Tumor Society functional score was 28.6 ± 1.1 post-operation. At the last follow-up, secondary osteoarthritis was found in 1 patient, the patient was asymptomatic.
Conclusions: Intraregional aggressive curettage, phenolization, and allogeneic bone grafting are effective for treatment of chondroblastoma of the adjoining knee joint.

1. Introduction

Chondroblastoma is a rare primary bone tumor that occurs in young patients and accounts for approximately 1–2% of all primary bone tumors [1,2]. It is locally aggressive, arises from a secondary ossification center in the epiphyseal plates and epiphyses, and has a high rate of recurrence [1,3]. It usually occurs in late childhood or adolescence and men are more frequently affected with a ratio of 3–2 [2,4]. The most frequent sites of involvement are the femur, proximal humerus, and proximal tibia [2,4,5]. Chondroblastoma is histologically characterized by the proliferation of chondroblasts along with areas of mature cartilage, giant cells, and occasionally, secondary aneurysmal bone cyst formation. While generally regarded as a benign entity, chondroblastoma manifests with an intermediate type of behavior, given its ability to recur locally, and, on rare occurrences, metastasize to other sites [1,6,7].

Care should be taken when treating locally aggressive tumors [8,9].

When chondroblastoma grows, the epiphyseal plate and articular subchondral bone are damaged, leading to pain, bone deformity, and joint dysfunction. It is agreed that surgical resection is the only way to treat primary lesions of chondroblastoma [6,7,10]. However, the tumor is surrounded by articular cartilage on one side and the epiphyseal plate on the other, meaning there is not as much aggressive curettage space as in other benign bone tumors, such as giant cell tumor and osteoblastoma [5,11]. Furthermore, the aggressive curettage space for chondroblastoma differs greatly in different joints. Curettage, either alone or in conjunction with bone grafting using autogenous or allogeneic bone grafts or both, has been described in many studies, with a high local recurrence rate and development of secondary osteoarthritis [11–13]. Adjuvant procedures such as cryosurgery or radiofrequency ablation have been used in some patients [14–16], resulting a reduction in local recurrence rate but an increase in cartilage injury and secondary osteoarthritis rate.

The distal femur and proximal tibia are both frequent sites of

chondroblastoma, therefore the knee joint is the most commonly involved joint. Compared with the proximal femur and humerus, the distal femur and proximal tibia have larger bone diameters and wider epiphyseal plates. Normally, the percentage of involved epiphysis in chondroblastoma of the adjoining knee joint is smaller. There is more aggressive curettage space in chondroblastoma of the adjoining knee joint surgery than any other joint. However, management of lesions in the proximal tibia and distal femur is challenging because it is difficult to gain full access to intraepiphyseal lesions for completion of curettage [17]. After intralesional curettage, cryosurgery or radiofrequency ablation was used in some studies [14–16], packing with polymethylmethacrylate was also reported [11,18]. These studies showed a lower rate of recurrence, but the complications associated with cartilage injury were high. Whether this is beneficial for the treatment of chondroblastoma of the adjoining knee joint is still debatable.

Aggressive curettage remains the mainstay of treatment for chondroblastoma of bone. It can be achieved by opening wide windows in the distal femur or proximal tibia. The epiphyseal plate and articular cartilage should be protected. Considering that this epiphyseal tumor affects primarily children and young adults, biological reconstruction is recommended for a better long-term prognosis. The purpose of this study was present our experience in treating chondroblastoma of the adjoining knee joint by intraregional aggressive curettage together with allogeneic bone grafting.

2. Materials and methods

2.1. Patients

Between February 2010 and February 2017, a total of 150 patients with chondroblastoma were treated at Xiangya Hospital Bone Tumour Center. Of these, 55 patients had chondroblastoma adjoining the knee joint. The inclusion criteria were: diagnosis of chondroblastoma; tumor locations in the distal femur, proximal tibia, and patella; received treatment consisting of intraregional aggressive curettage together with allogeneic bone grafting; and completed long-term follow-up. In addition to chondroblastoma arising in other anatomical sites, the exclusion criteria were: relapsed chondroblastoma ($n = =2$); pathologic fractures ($n = =6$); treatment using intraregional aggressive curettage together with cement reconstruction ($n = =5$) or radiofrequency ablation ($n = =4$); and loss to follow-up ($n = =2$). A total of 36 patients met the criteria and were included in the study.

Diagnosis was based on biopsy pathological results. X-ray, computed tomography (CT) and magnetic resonance imaging (MRI) were performed to evaluate the tumor. Age, sex, tumor location, lesion length, Enneking stage, aneurysmal bone cyst (ABC) component, invasion of epiphysis plate, physis, invasion of articular cartilage, and follow-up duration were recorded (Table 1). Functional outcomes were assessed by the Musculoskeletal Tumor Society scoring system (MSTS). The Kellgren–Lawrence grading (K–L grade) system was used to evaluate postoperative osteoarthritis. This study was approved by the Research Ethics Committee of Xiangya Hospital (No. 201001081). The patients and their parents (in case of children under the age of 18 years) were invited to participate and provided informed consent upon learning of the study's risks and benefits.

2.2. Surgical technique

All procedures were performed under intravenous general anesthesia with the use of a tourniquet. According to preoperative X-ray, CT, and MRI examination (Fig. 1), the tumor extent was established. Fenestration was performed from the vicinity of the tumor (Fig. 2(a_1), (a_2), (b_1) and (b_2)), and the cortical bone at the fenestration was preserved if it was not involved by the tumor. The bone windows were usually located in the medial side of the medial condyle or the lateral side of the lateral condyle of the distal femur, in the anteromedial or

anterolateral side of proximal tibia, and in the front in patella. It should be large enough to see the tumor directly (Fig. 2(c_1) and (c_2)). Make sure that the margin of bone window should not exceed the epiphyseal line or articular cartilage margin. First, straight and angled hand curettes were used to remove all the visualized tumor tissues. Second, high-speed burr was used to grind and resect the tumor border and bone around tumor. The resection range of bone around tumor was 1 cm in cancellous bone, 1 mm in cortical bone, or up to epiphyseal plate and articular cartilage. Third, high pressure pulsed sterilizing water was used to thoroughly wash the tumor cavity. Fourth, using phenol to wipe exposed epiphyseal plate and articular cartilage through the tumor cavity and the cavity was irrigated again by high pressure pulsed sterilizing water. Lastly, allogeneic bone grafting was harvested to reconstruct the resultant bony defects (Fig. 2(d_1) and (d_2)), using autologous bone mass from the bone window to reconstruct cortical defect, allogeneic cortical bone mass was used in patients who did' not preserve autologous bone mass. For some patients, internal fixation was used to support articular surface. The knee should not be weighed for at least eight weeks.

2.3. Follow-up and evaluation

Follow-up radiographs were performed directly after surgery, then at 6 weeks, 12 weeks, then every 3 months for the first 2 years, every 6 months for the next 3 years, and annually thereafter. Bone healing, recurrence, and complications (postoperative osteoarthritis and physeal growth restriction) were record. Recurrence of chondroblastoma lesions after surgery was suspected if there was any recurrence of symptoms or abnormalities detected on plain radiography. MRI of the lesion and a CT scan of the chest were performed in suspected cases to confirm recurrence and to detect early metastasis. Functional outcomes were assessed by the MSTS scoring system. Secondary osteoarthritis was classified by using K–L grade system from Grade 0 to Grade IV.

SPSS version 20 (SPSS Inc., Chicago, IL, USA) was used to analyze the data collected in order to determine the relationship between different variables and determine the factors affecting the curative effect. The measurement data are expressed as mean ± standard deviation, and the differences of various factors are analyzed by paired *t*-test. Values of $p < 0.01$ were considered statistically significant.

3. Results

All cases in this study had confirmed chondroblastoma according to postoperative pathological results. No surgical complications related to the procedure occurred. The 24 males and 12 females had a mean age of 17 years (12–26 years). The mean duration of disease was 4.3 months (3–7 months) and the average length of lesion was 28.1 mm (13.6–42.5 mm). The anatomical tumor sites were: the proximal tibia (20), distal femur (14), and patella (2). Radiographs and/or CT images revealed that the physis was open in 10 patients, closing in 17, and closed in 9. Invasion of epiphysis plate was found in 7 patients, accompanied with ABC was found in 6 patients, and invasion of articular cartilage was in 8 patients. All patients were Enneking stage 3, the minimum follow-up was 18 months with a mean follow-up 51.8 months (18–98 months) (Table 1).

Only 1 patient (2.8%) with distal femur chondroblastoma relapsed 10 months post operation, the patient had no pain and underwent a second aggressive curettage and joint preservation surgery. All patients eventually achieved good bone healing (Figs. 3 and 4). Three patients (8.3%) developed physeal growth restriction confirmed by postoperative X-ray, but the length of lower extremities were equal. No patients had knee varus and valgus, limited movement of the knee joint, or infection or fracture.

The mean MSTS functional score was 18.9 ± 1.8 pre-operation, increasing to 28.6 ± 1.1 by the last follow-up, which is considered to be an excellent score. There was a significant difference between pre-

Table 1
Demographic and surgical data of patients.

Patients number/gender	Age	Lesion location (R or L)	Duration of Follow-up (month)	Lesion length (cm)	Duration of Disease (month)	Preoperative MSTS score	Postoperative MSTS score	Invasion of articular cartilage	ABC component	Invasion of epiphysis plate	Physis
1/M	16	Femur/R	23	37.8	5	18	29	N	N	N	Closing
2/F	25	Tibia/L	77	28.8	3	20	29	N	N	N	Closed
3/F	17	Femur/R	20	31.7	4	18	26	Y	N	N	Closed
4/M	14	Tibia/R	82	24.8	3	16	29	N	N	Y	Open
5/M	26	Tibia/R	32	18.3	6	24	30	Y	N	N	Closed
6/M	18	Tibia/L	98	30.5	4	20	30	N	N	N	Closing
7/M	12	Tibia/R	35	36.5	6	18	29	N	Y	Y	Open
8/M	16	Femur/R	63	41.5	6	17	28	N	N	Y	Closing
9/M	19	Tibia/L	92	41.5	4	16	28	N	N	N	Closed
10/F	25	Tibia/L	42	34.2	3	18	29	N	N	N	Closed
11/M	13	Femur/R	20	30.7	4	17	28	N	Y	N	Open
12/M	18	Tibia/L	74	30.9	4	17	29	Y	N	N	Closing
13/F	16	Tibia/R	37	13.9	5	17	27	N	Y	N	Closing
14/F	15	Femur/R	48	37.9	4	19	26	Y	N	Y	Closing
15/M	17	Tibia/R	49	22.5	6	19	29	N	Y	N	Closing
16/F	15	Femur/L	65	22.3	4	20	28	N	N	N	Closing
17/M	18	Tibia/L	56	42.5	7	18	29	N	N	N	Closing
18/M	15	Tibia/L	21	27.3	4	22	30	N	N	Y	Open
19/F	18	Tibia/L	93	23.8	4	20	29	Y	N	N	Closing
20/M	12	Tibia/L	48	41.7	6	20	26	N	N	N	Open
21/M	18	Femur/L	22	23.2	3	17	28	N	N	N	Closing
22/M	19	Femur/R	86	31.8	4	21	30	N	N	N	Closed
23/F	22	Tibia/L	42	24.7	4	19	29	N	N	N	Closed
24/M	15	Femur/R	63	31.1	4	16	28	N	Y	Y	Open
25/M	18	Femur/L	44	26.4	3	21	29	Y	N	N	Closing
26/F	15	Tibia/L	83	36.1	4	17	27	N	N	N	Closing
27/F	15	Tibia/R	76	32.5	5	18	29	N	N	N	Closing
28/M	13	Femur/R	34	13.6	3	20	28	N	N	Y	Open
29/M	16	Patella/L	38	26.5	4	21	30	N	N	N	Closing
30/M	23	Patella/L	47	20.8	5	19	30	N	N	N	Closed
31/F	16	Femur/L	18	14.9	4	19	29	Y	N	N	Closing
32/M	13	Tibia/L	46	23.5	3	21	29	N	N	N	Open
33/M	15	Femur/R	53	18.8	2	20	30	N	N	N	Open
34/M	14	Femur/L	77	26.7	4	19	29	N	N	N	Open
35/M	20	Tibia/L	32	22.8	5	21	28	N	Y	N	Closed
36/F	16	Tibia/L	28	19.1	4	19	29	Y	N	N	Closing

MSTS, Musculoskeletal Tumour Society scoring system; ABC, aneurysmal bone cyst; L, left; R, right.

operation and post-operation score ($p < 0.01$). At the last follow-up, degenerative changes were found in 1 patient (2.8%), the K–L grade system changed from Grade 0 to Grade II (Fig. 4); the patients had no symptoms. While the recurrence rate was very low (only 1 patient relapsed) and few complications were found, age, sex, tumor location, ABC component, invasion of epiphysis plate, physis, invasion of articular cartilage, and other clinical factors or radiological data seemed to have no influence on the curative effect (Table 2). The above results suggest that the therapeutic effect of intraregional aggressive curettage and allogeneic bone grafting is satisfactory for the treatment of chondroblastoma of the adjoining knee joint.

4. Discussion

As a primary, locally aggressive benign tumor, chondroblastoma is rare, and is not known to be self-healing [11,19]. Surgery is the only effective treatment for this disease, which should be performed as soon as possible, otherwise lesions may invade the epiphyseal plate or even extend to the metaphysis, resulting in joint malformation and dysfunction [6,7,10]. The risk of local recurrence has been reported to be between 10% and 40% [5,11,12,14,20]. Therefore, the local recurrence of chondroblastoma represents the main challenge [5,20]. There are many factors that affect postoperative recurrence of chondroblastoma, for instance, tumor locations, age, and ABC component [2,5,6,11,21], which affects the acquisition of effective surgical boundaries. Studies showed that epiphyseal plate injury and secondary deformity occurred in about 9% of patients [18], while osteoarthritis secondary to cartilage injury occurred up to 38% patients [13]. These complications also

affected the prognosis. Adjuvant procedures such as cryosurgery or radiofrequency ablation were used in some patients [14–16], resulting in lower reoccurrence rates, but increases rates of cartilage injury and secondary osteoarthritis. The role of adjuvant treatments in the management of chondroblastoma needs to be clarified, as the risks associated with use of such agents must be weighed against the benefits.

Our rate of recurrence of 2.8% is lower than that reported in other studies which have also included adjuvant techniques such as fluid nitrogen cryopreservation, phenolization and radiofrequency ablation [12,15,22,23]. Only 1 patient with distal femur chondroblastoma relapsed, 10 months post-operation. The patient had no symptoms and underwent a second aggressive curettage and joint preservation surgery. We had 2 cases of patella chondroblastoma with good prognosis, though this is rare. In all our cases allogeneic bone grafting filled the defect left by curettage and, although many lesions were subarticular, all patients eventually achieved good bone healing (Figs. 3 and 4), including the relapsed patient. No patients had limited movement of the knee joint, infection, or fracture. Patients underwent treatment at our unit and were followed up with a mean follow-up of 51.8 months (18–98 months). We evaluated the functional outcome in 36 patients using the MSTS system which changed from 18.9 ± 1.8 pre-operation to 28.6 ± 1.1 at the last follow-up, which is considered to be an excellent score. There was a significant difference between pre-operation and post-operation scores ($p < 0.01$). It has been suggested that the association of the ABC component [11] or age [20] results in a higher rate of recurrence; however, our findings are not in agreement. In our study age, sex, tumor location, ABC component, invasion of epiphysis plate, physis, and other clinical factors seemed to have no influence on
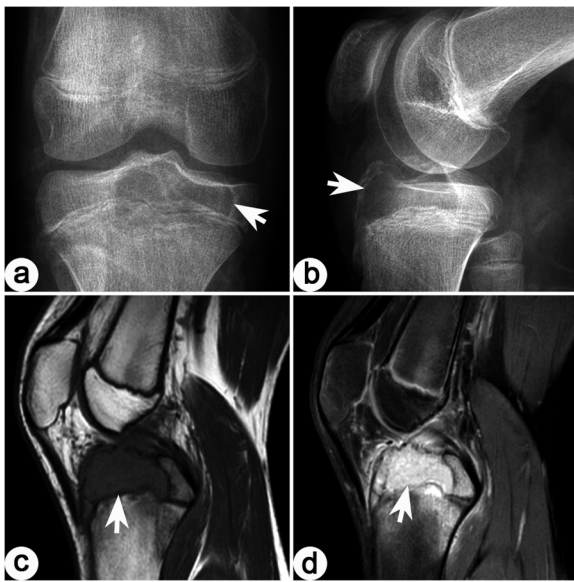
Fig. 1. Typical imaging features of chondroblastoma (arrow denotes lesion). (a) and (b) Anteroposterior and lateral X-ray films of chondroblastoma at the proximal tibia, obvious osteolytic foci with clear margins and no obvious sclerosis were seen. (c) T1WI image shows a hypointense lesion which was located at the secondary ossification center of the proximal tibia, and the well-defined lesion did not break through the articular surface. (d) T1WI enhancement, both the lesion and the reaction area of peripheral edema were obviously enhanced.

the curative effect of chondroblastoma of the adjoining knee joint. Our findings suggested that intraregional aggressive curettage and allogeneic bone grafting were successful in treating the chondroblastoma of the adjoining knee joint.

Effective surgical range is the most important factor in treating chondroblastoma. As chondroblastoma is a benign tumor, skip lesions and metastases are very rare [5]. Insufficient curettage definitely causes tumor recurrence [11,20]. Chondroblastoma was more frequently associated with bone marrow edema, periosteal reaction, soft tissue reaction, and synovitis on MRI examination (Fig. 1), which have a certain effect on the determination of tumor boundaries [24]. Surgeries of

Fig. 3. Preoperative and postoperative imaging changes of a typical proximal tibial chondroblastoma (arrow denotes lesion). (a) An obvious osteolytic lesion of the tibial plateau can be seen on the anteroposterior and lateral radiographs of the knee joint. (b) CT showed that the boundary of the lesion was clear, the calcification was scattered in the lesion, and the lesion did not break through the articular cartilage and epiphyseal line. (c) and (d) Anteroposterior X-ray films of knee joint were taken 3 months and 36 months after operation, respectively, which showed that the focus area was completely healed, and the local density was obviously increased. e. CT examination 36 months after surgery showed that the original lesion had healed completely, the space of the knee joint was normal, and the articular surface had no sclerosis.

patients were performed by skillful bone tumor experts' group. There were 3 key points. First, opening a large enough bone window to see all parts of the tumor directly and curettage (Fig. 2(b1) and (b2)). Usually a significant amount of normal bone was sacrificed, but deemed necessary. Second, using high-speed burr to grind tumor margin, 1 cm in
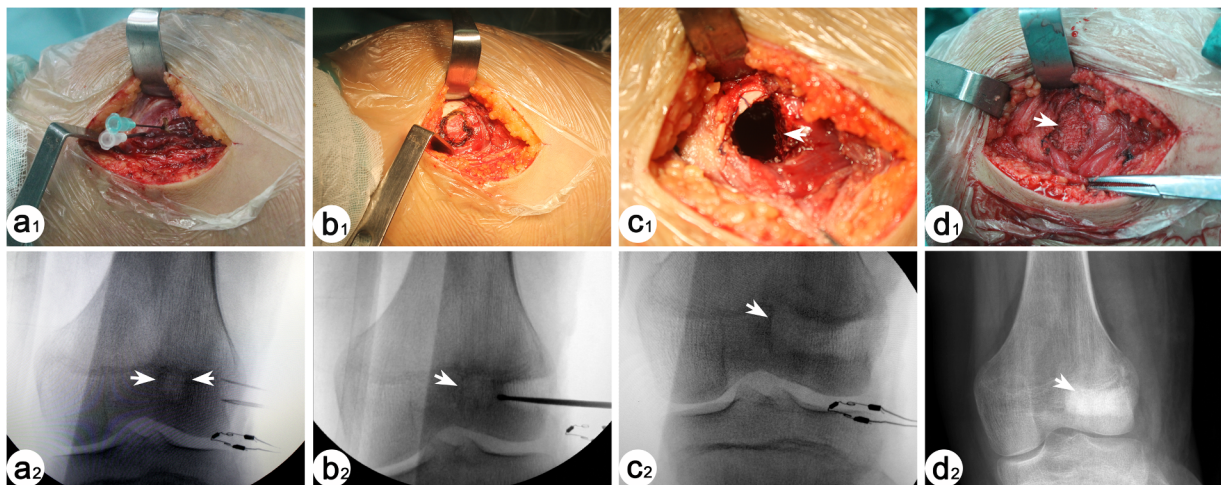

Fig. 2. The specific steps of the surgical procedure and the intraoperative fluoroscopy. (a1) and (a2) Two needles were inserted on the lateral side of the distal femur in order to locate the plane of the lesion and determine the exact location of the lesion by fluoroscopy (arrow denotes lesion). (b1) and (b2) The location of the fenestration was determined according to the results of previous fluoroscopy, and then the lesion is fenestrated from the lateral femoral condyle with a grinding drill to avoid injury to the epiphyseal growth plate. (c1) and (c2) The lesion was scraped out by stealth from the outside, and a distinct low-density change of the lateral condyle of the distal femur was observed by fluoroscopy. (d1) and (d2) Allograft was used to repair the bone defect after focal curettage, and the original bone defect areas were found to be high density grafts by fluoroscopy after the operation (arrow denotes the allograft).

Fig. 4. Preoperative and postoperative imaging changes of a typical distal femur chondroblastoma. (a) A distinct low-density osteolytic lesion was found in the intercondylar fossa of the distal femur. (b) CT showed that there were scattered calcifications in the lesion on the cross section, and the tumor had broken through the articular cartilage in the coronal position of the inter-condylar spine. The sagittal position shows that the tumor has invaded the epiphyseal line. (c)–(f) Anteroposterior X-ray manifestations were at 1 week, 6 months, 24 months and 42 months postoperatively. The tibial inter-condylar spine changed 24 months postoperatively, which belonged to grade I of K–L grade system. The medial knee joint space was suspi-ciously narrowed at 42 months post-operatively, which belonged to grade II of K-L grade system.

Table 2
General statistical data of patients.

Gender, n (%)		
M	24(33.3%)	
F	12(66.7%)	
Age (years)	17.0 ± 3.6	
Lesion length (mm)	28.1 ± 8.1	
Disease course (months)	4.3 ± 1.1	
Lesion location (R or L), n (%)		
tibia	20(55.6%)	R:16(44.4%)
femur	14(38.9%)	L:20(55.6%)
patella	2(5.6%)	
Duration of Follow-up (months)	51.8 ± 23.8	
MSTS score*	P < 0.01	
Preoperative	18.9 ± 1.8	
Postoperative	28.6 ± 1.1	
ABC component, n (%)		
Yes	6(16.7%)	
No	30(83.3%)	
Invasion of epiphysis plate, n (%)		
Yes	7(19.4%)	
No	29(80.6%)	
Invasion of articular cartilage, n (%)		
Yes	8(22.3%)	
No	28(77.8%)	
Physis, n (%)		
Open	10(27.8%)	
Closing	17(47.2%)	
Closed	9(25.0%)	
Postoperative osteoarthritis, n (%)	2(5.6%)	
Physeal growth restriction, n (%)	3(8.3%)	

MSTS, Musculoskeletal Tumour Society scoring system; ABC, aneurysmal bone cyst; L, left; R, right.

* According to the analysis of paired t-test, significant statistical difference was found between preoperative and postoperative limb function using the MSTS scoring system.

cancellous bone, 1 mm in cortical bone, or up to epiphyseal plate and articular cartilage was removed (Fig. 2(c_1) and (c_2)). The distal femur and proximal tibia are sufficient for aggressive curettage. Third, using phenol to wipe the exposed epiphyseal plate and articular cartilage through the tumor cavity, high pressure pulsed sterilizing water was used to thoroughly wash the tumor cavity. As tumor cells normally tightly attach to the epiphyseal plate and articular cartilage instead of growing inside, this procedure would eliminate the attached tumor cells [25]. Our study results indicated that this type of aggressive curettage was sufficient.

Epiphyseal plate injury and growth arrest is of more importance in knee tumors than in tumors found at other sites [26]. Suneja et al. [20] and Sailhan et al. [2] considered that recurrence was likely to be due to incomplete curettage as surgeons are understandably concerned that aggressive curettage will cause damage to the growth plate. However, Lin et al. [5] reported that an open growth plate in chondroblastoma surgery was not found to correlate with local recurrence, and in most cases, the open epiphysis plate did not considerably impact bone growth. Xiong et al. [21] indicated that for patients with chondro-blastoma with invasion of epiphyseal plate, postoperative growth complications were usually caused by tumor destruction otherwise by opening epiphyseal plate surgery, which this study concurs with. Good results were obtained in spite of our policy of aggressive curettage. Only 3 patients (8.3%) developed epiphyseal growth restriction, confirmed through postoperative X-ray, but the length of both lower extremities were equal, and their epiphyseal plates were obviously involved with the tumor pre-operation. No patients developed knee varus or valgus. We therefore believe that the growth plate of the adjoining knee joint is resilient, and, with proper care, aggressive curettage is appropriate. An important reason may be that the epiphyseal plates of the distal femur and proximal tibia are usually large; therefore, only a small percentage of the epiphyseal plates were involved with the tumor. Furthermore, according to the Dales and Harris classification [27], epiphyses of the distal femur and proximal tibia are both type B (The epiphysis is only partly covered by articular cartilage. The blood supply of epiphyseal plate comes from the soft tissue attached to the epiphysis, which would not be damaged too much in our operation) and the epiphysis has a good blood supply to cure damage. Therefore, it is effective and safe to manage the exposed epiphyseal plate with phenol and high pressure pulsed sterilizing water.

Secondary osteoarthritis seems to be the most common long-term complication in treating chondroblastoma. Farfalli et al. [13] reported that 38% of chondroblastoma patients with curettage and bone grafting developed secondary osteoarthritis in a mean follow up of 77 months. They observed degenerative changes in six of 14 patients with distal femur tumors (three cases were Grade III and three grade IV); and two of 11 with proximal tibia chondroblastoma after treatment (both Grade III). It seems likely that the high risk of degenerative arthritis was re-lated to the initial aggressiveness of the treatment, especially in patients with proximal femoral chondroblastoma. There were 8 patients with invasion of the articular cartilage in our study. However, with a mean follow-up of 51.8 months, only 1 patient (2.8%) was found to have degenerative arthritis according to the K–L grade system, with the

scorer changing from Grade 0 to Grade II over the 42 months follow up (Fig. 4); the patient had no symptoms. The incidence of secondary osteoarthritis is significantly different, even considering the different follow-up time. There could be 2 reasons for this. In consideration of tumor cells, they tightly attach to the articular cartilage instead of growing inside and we did' not use high-speed bur to bur the cartilage to reduce injury. Moreover, the epiphysis of the distal femur and proximal tibia have a good blood supply to repair the subchondral bone. These will reduce the incidence of secondary osteoarthritis. The final incidence requires further long term follow up.

As chondroblastoma occurs in young patients and involves epiphysis, the long term function of the joint should be considered during treatment. Care must be taken when deciding on fillers for reconstructing the resultant bony defects. Autologous bone grafting [11,28,29], polymethylmethacrylate [11,18], demineralized bone matrix sponge human allograft [28], and vascularized fibular grafts [30] have been used in recent reports, and all of them with good results. In our study, allogeneic bone grafting was harvested to reconstruct the resultant bony defects, using autologous bone mass from the bone window to reconstruct cortical defect. Allogeneic cortical bone mass was used in patients who did' not preserve autologous bone mass. All patients eventually achieved good bone healing (Fig. 3). The epiphysis of the distal femur and proximal tibia have a good blood supply to heal bone defects. The filler plays the role of bone filling and bone induction. As patients are young, we will not recommend using polymethylmethacrylate. Allogeneic bone grafting is efficient; therefore, autologous bone grafting is not suggested as the source is very limited.

Our study had certain limitations. First, the follow up time is not long enough to establish all long-term complications, especially secondary osteoarthritis. Moreover, growth arrest is of more importance for tumors of the knee than of those at other sites and obviously would occur only in patients who were skeletally immature; because we had few such patients, we cannot accurately assess the frequency of this event. Other limitations of our study include its retrospective nature and the absence of a direct comparative group or randomized comparison. Also, some patients had a shorter radiographic than clinical follow-up and the films were not subjected to blinded review. Overall, complications in our patients, such as osteonecrosis, secondary osteoarthritis, and growth arrest, were lower than other research reports. The prognosis is very good. According to our results, we need to clarify whether the difficulty and complications of surgical treatment for chondroblastoma of the adjoining knee joint have been overestimated. Satisfactory prognosis could be achieved by using a standard and experienced treatment, as reported in this study.

5. Conclusion

In conclusion, our findings suggest that aggressive curettage, phenolization, and bone grafting are effective in treating chondroblastoma of the adjoining knee joint. This is the only study which focus on the treatment of chondroblastoma of the adjoining knee joint. Complications were found to be rare and the recurrence rate was low. Satisfactory prognosis could be achieved by using a standard and experienced treatments

Declaration of interest

The authors declare that they have no conflict of interest.

Acknowledgments and funding

Ethical review committee statement

This study has been approved by the Research Ethics Committee of Xiangya Hospital (No. 201001081), and all patients and their parents (in case of children under the age of 18 years) gave their informed consent.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jbo.2019.100240.

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