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Follow-up study of cartilaginous bone tumors.

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Abstract

A series of clinical and pathological studies were performed on 74 cartilaginous bone tumors including osteochondromas, multiple cartilaginous exostoses, chondromas, chondromatoses, benign chondroblastomas and chondrosarcomas. Resection was adequate for the osteochondromas, and no recurrence was observed. Out of 14 multiple cartilaginous exostoses, three, all in flat bones showed malignant change. The predominant sites of chondroma were the finger and toe bones, and curettage and bone graft was adequate treatment. Neither recurrence nor malignant change was observed. Two cases of chondromatosis, one of Ollier's disease and one of Maffucci's syndrome, were included in our series. Leg length discrepancy and pathologic fracture were common problems in chondromatosis. Moreover, malignant change was suspected in a hemangioma of the Maffucci's syndrome patient. Benign chondroblastoma was treated by curettage and bone graft, with no recurrence. In our series, 4 primary and 3 secondary chondrosarcomas were observed. Metastasis was seen in only one case. Because of the discrepancy between the biological behavior and histological findings of cartilaginous bone tumors, the malignancy of tumors should be evaluated by clinical signs and symptoms as well as by histological findings.

KEYWORDS: cartilaginous bone tumor, follow-up study, malignant change

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Follow-up Study of Cartilaginous Bone Tumors

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A series of clinical and pathological studies were performed on 74 cartilaginous bone tumors including osteochondromas, multiple cartilaginous exostoses, chondromas, chondromatoses, benign chondroblastomas and chondrosarcomas. Resection was adequate for the osteochondromas, and no recurrence was observed. Out of 14 multiple cartilaginous exostoses, three, all in flat bones showed malignant change. The predominant sites of chondroma were the finger and toe bones, and curettage and bone graft was adequate treatment. Neither recurrence nor malignant change was observed. Two cases of chondromatosis, one of Ollier's disease and one of Maffucci's syndrome, were included in our series. Leg length discrepancy and pathologic fracture were common problems in chondromatosis. Moreover, malignant change was suspected in a hemangioma of the Maffucci's syndrome patient. Benign chondroblastoma was treated by curettage and bone graft, with no recurrence. In our series, 4 primary and 3 secondary chondrosarcomas were observed. Metastasis was seen in only one case. Because of the discrepancy between the biological behavior and histological findings of cartilaginous bone tumors, the malignancy of tumors should be evaluated by clinical signs and symptoms as well as by histological findings.

Key words : cartilaginous bone tumor, follow-up study, malignant change

Because of the discrepancy between the biological behavior and the histological features of cartilaginous bone tumors, the disease is often underestimated, and adequate surgical treatment is not performed. Malignant cartilaginous bone tumors seldom show metastasis. Therefore it is very important to evaluate the tumor correctly and to choose the appropriate surgical intervention. The present authors analysed cases of cartilaginous bone tumor encountered over the past 22 years in our clinic.

Materials

The study was conducted on 74 patients who had benign and malignant cartilaginous bone tu-

mors and were treated in our clinic from 1963 to 1984. There were 22 solitary osteochondromas, 11 multiple cartilaginous exostoses, 26 chondromas, 6 benign chondroblastomas and 7 chondrosarcomas. There was one case of Ollier's disease and one case of Maffucci's syndrome. The sexes of the patients are shown in Table 1. The follow-

Table 1 Types of tumors and sex of patients

Tumor type	Patients		
	Male	Female	Total
Osteochondroma	14	8	22
Multiple cartilaginous exostoses	7	4	11
Chondroma	13	13	26
Ollier's disease		1	1
Maffucci's syndrome	1		1
Benign chondroblastoma	5	1	6
Chondrosarcoma	1	6	7
Total	41	33	74

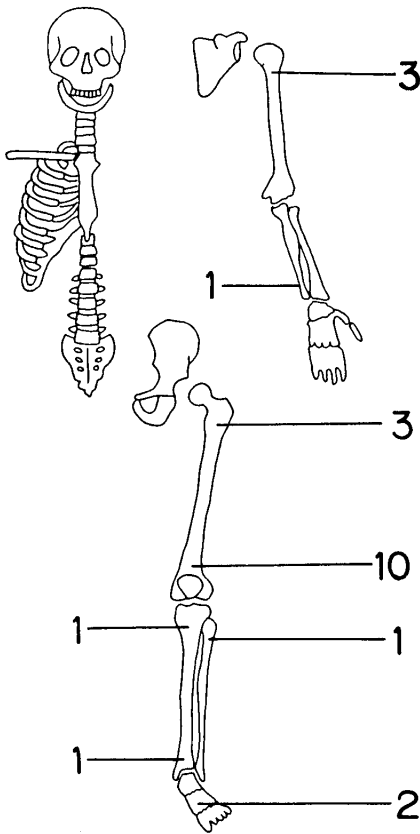


Fig. 1 Site of osteochondromas (22 cases); the numerals show the number of patients.

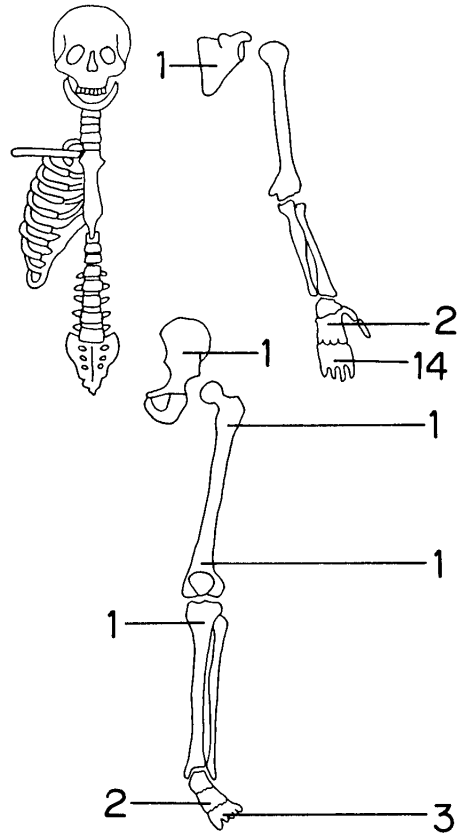


Fig. 3 Site of chondromas (26 cases); the numerals show the number of patients.

Fig. 2 Age distribution of osteochondroma patients (22 cases) and multiple cartilaginous exostosis patients (11 cases).

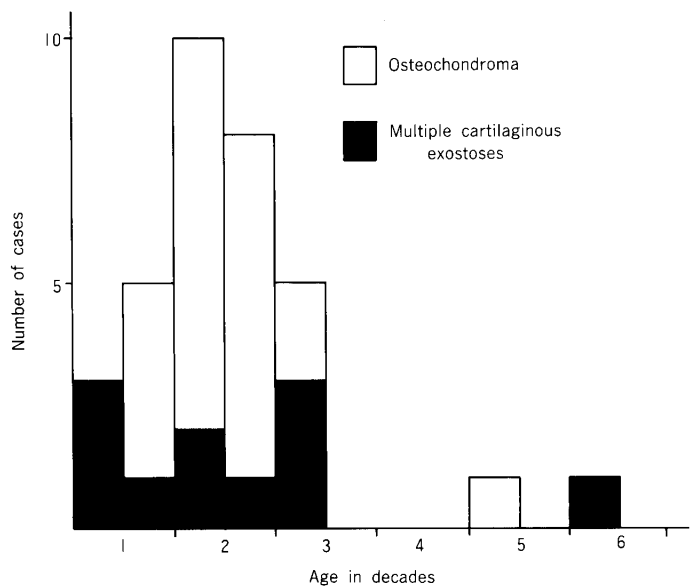
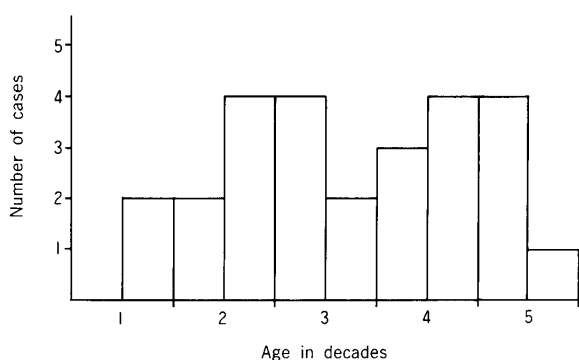


Fig. 4 Age distribution of chondroma patients (26 cases).**Table 2** Age, sex, site and treatment of benign chondroblastomas (6 cases)

Case	Age(years)	Sex	Affected bone	Operation method
1	16	Male	r-Humerus	Curettage, bone graft
2	13	Female	r-Femur	Curettage, bone graft
3	26	Male	l-Femur	Curettage, bone graft
4	25	Male	r-Calcanus	Curettage, bone graft
5	12	Male	r-Femur	Curettage, bone graft
6	28	Male	r-Femur	En bloc resection, prosthesis

Table 3 Clinical course of chondrosarcomas (7 cases)

Case	Age(years)	Sex	Affected bone	First operation method	Recurrence	Metastasis
1	17	Male	l-Pubis	Resection	+	—
2	18	Female	l-Scapula	En bloc resection	+	—
3	22	Female	l-Scapula	En bloc resection	+	—
4	60	Female	r-Humerus	En bloc resection, prosthesis	+	+
5	38	Female	r-Tibia	Curettage, bone graft	+	—
6	54	Female	r-Tibia	Curettage, bone graft	+	—
7	42	Female	l-Ischium	En bloc resection	—	—

up intervals ranged from 2 months to 16 years and 5 months.

There were 13 osteochondromas in the femur, 3 in the humerus, 2 each in the tibia and metatarsus, and one each in the ulna and fibula (Fig. 1). The age distribution of the patients with osteochondromas and multiple cartilaginous exostoses is shown in Fig. 2. There were 14 chondromas in the finger bones, 3 in the toe bones, 2 each in the metacarpus, metatarsus and femur and one each in the scapula, ilium and tibia (Fig. 3). The age distribution of the patients with chondromas is shown in Fig. 4. There were 4 benign chondroblastomas in the femur and one each in the humerus and calcaneus. The ages of the patients are shown in Table 2. The sites of chondro-

sarcomas and ages of the patients are shown in Table 3.

The patient with Ollier's disease was female and 3 years old at the first visit to our clinic. Her bone lesions affected the right half of the body. The patient with Maffucci's syndrome was male and 13 years old at the first visit to our clinic. His lesions were chondromas associated with hemangioma.

Treatment and Results

Solitary osteochondromas

Preoperative signs and symptoms were

pain (9 cases), tumor (7 cases), tumor with pain (4 cases), limping and discomfort (one case each). Eleven patients who did not complain of tumors were diagnosed as having osteochondromas by x-ray examination. Twenty-one patients were treated by resection of the osteochondroma. Postoperatively they had no complaints, and recurrence was not observed. Resection and bone graft was carried out in one case of osteochondroma of the humerus, because the bone tumor was so huge that a large area of the cortex had to be removed.

Multiple cartilaginous exostoses

Hereditary factors were observed in all cases of multiple cartilaginous exostoses. Preoperative signs and symptoms were tumor (8 cases), tumor with pain (2 cases) and pain (one case). Forty-four lesions were treated by resection only. Two lesions (proximal radial and proximal fibular lesions) were resected en bloc including the very end of the bone.

Postoperatively, signs and symptoms improved in all cases; however, reoperation was necessary in 2 cases. The first case

Fig. 5 X-ray picture of Ollier's disease lesion in 6-year-old female. A: Right tibia and fibula. B: Right femur.



was a cartilaginous exostosis of the proximal phalanx of the right index finger of a girl whose age was one year and 10 months. One and a half years after the operation, the tumor recurred, and motion range of the metacarpo-phalangeal joint of her index was limited markedly. Although the tumor was resected again, the function of the metacarpo-phalangeal joint did not improve. The second patient was a boy who has been under our clinical control since 4 years of age. Exostoses of both distal femurs and proximal tibias were resected when he was 11 years old; however, recurrence of the tumors and genu valgum developed after 2 years. At 16 years of age, the tumors were resected again, and osteotomy of the right tibia was carried out in order to correct a valgus deformity.

Chondroma

Preoperative signs and symptoms were fracture due to minor trauma (9 cases), pain (8 cases), tumor (6 cases) and tumor with pain (3 cases). Eight patients out of the 9 cases with fractures had no complaints before then. Four patients were treated by resection, 6 patients were treated by curettage. Curettage and bone graft was carried out in 14 cases. The distal phalanx of the third finger of one patient was treated by a disarticulation of the distal interphalangeal joint. The proximal phalanx of the third toe of one patient was treated by resection of phalangeal bone and transplantation of a bone block because the tumor occupied nearly the whole bone. Postoperatively, no recurrence was observed.

Ollier's disease

A three-year-old girl visited our clinic complaining of asymmetry of her lower extremities. Bone tumors were observed by x-ray examination in the right side of her body (Fig. 5). A bone tumor in her right

tibia was biopsied, and she was diagnosed as having Ollier's disease. Since then she has been under our clinical control. Six years later, her right lower extremity was 10 cm shorter than the left. Except for limping, she had no complaints. Although a brace for the equalization of leg length was prescribed, she did not use it.

Maffucci's syndrome

Soon after birth, parents noticed a deformity of both hands of their son. When he was 3 years old, he visited an orthopedic clinic and was diagnosed as having multiple chondromas. After that he had no medical control at all, although he noticed a tumor in his right forearm and asymmetry of his lower extremities. When he was 13 years old, he developed a pathologic fracture of the right femur and was referred to our clinic. The site of pathologic fracture was the metaphysis of the right femur where a huge bone tumor was recognized.

The fracture was treated by hip spica cast, and good bony union was obtained within 3 months. In other limb bones, many bone lesions were observed, but these lesions showed no malignant signs and symptoms. The tumor in the right forearm grew so huge at that time and the surface of the tumor became so irregular that malignancy was highly suspected (Figs. 6, 7). Moreover, the function of his right hand was disturbed markedly. An amputation below the elbow was performed. Histologically, the bone lesion was a chondroma, and the tumor of the forearm was a hemangioma. Therefore, a diagnosis of Maffucci's syndrome was made. He achieved good walking ability by applying a long leg brace to the right side for the equalization of his leg length, and he obtained good activity of daily living by applying a right functional below-the-elbow prosthesis.



Fig. 6 Hemangioma on the right forearm of Maffucci's syndrome patient (13-year-old male).

Benign chondroblastoma

Preoperative signs and symptoms included pain in all cases. The intervals between the onset and the operation ranged from one month to 19 months (average, 8 months). Ages, sexes, sites of lesions and operation methods are shown in Table 2. Only one right femoral neck was treated by en bloc resection and prosthetic replacement, because the lesion was so huge that reconstructive surgery using a bone graft could not be carried out. Five curettage and bone graft cases showed no complaints and no recurrence. The prosthetic case showed a shortening of the right leg and limitation of hip joint movements, because of central migration of the prosthesis that was observed by x-ray examination 6 years after the operation. Now a long leg brace with ischial weight bearing is used in order to

avoid the central migration of the prosthesis.

Chondrosarcoma

Ages, sexes, sites of lesions and operation methods are shown in Table 3. Three out of the 7 patients had multiple cartilaginous exostoses. The intervals between the onset of symptoms of benign conditions and malignant changes ranged from 9 months to 17 years (average, 7 years and 8 months). The signs and symptoms of malignant changes were pain and rapid tumor growth.

The clinical course of the 3 patients with multiple exostoses was as follows:

Case 1. The patient visited an orthopedic clinic because of pain of his left lower extremity and was diagnosed as having multiple cartilaginous exostoses by x-

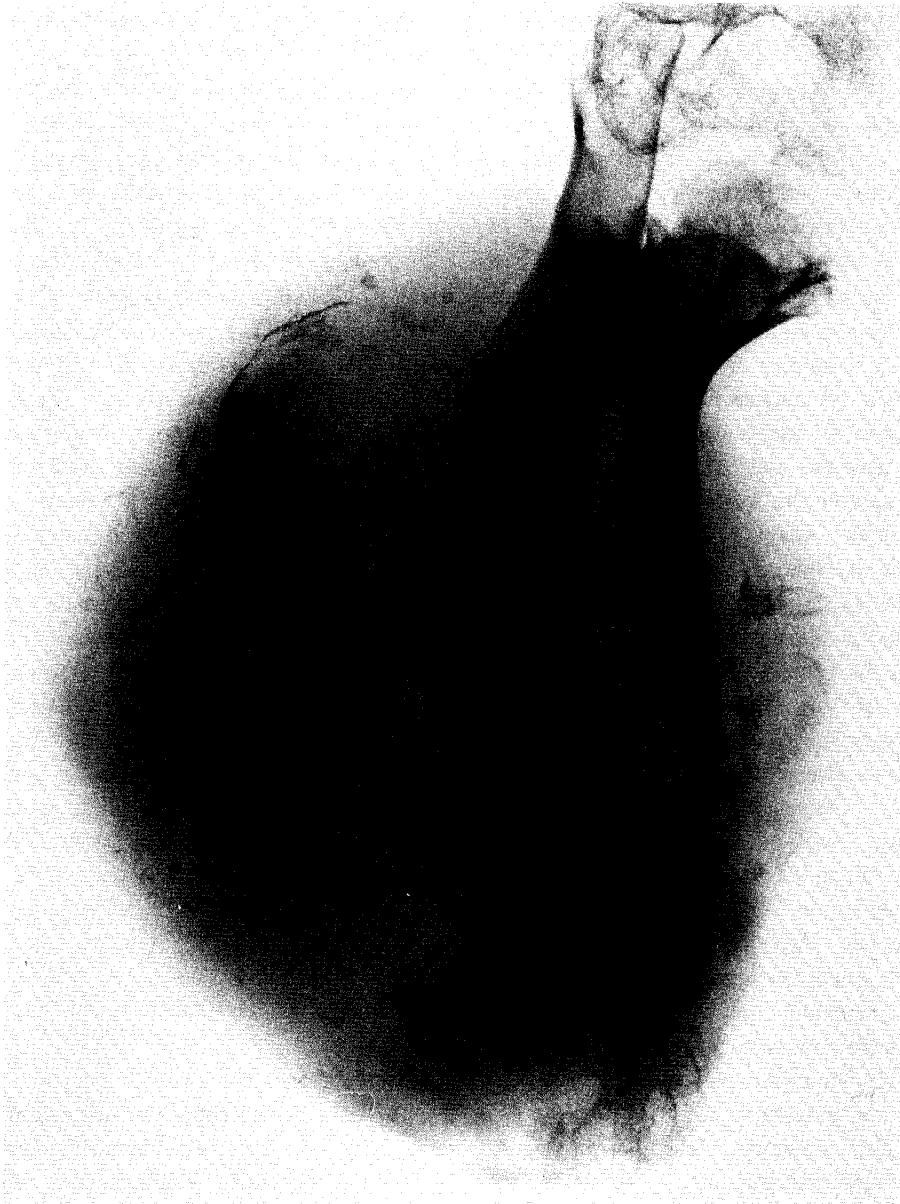


Fig. 7 X-ray picture of Maffucci's syndrome lesion shown in Fig. 6.

ray examination. He did not complain of the tumor before then. Nine months later, at 17 years of age, he noticed a hard and rapidly growing tumor in his lower abdomen. Resection of the tumor was performed. Nine months later, the tumor recurred and resection was performed again. Soon after

the second operation, the tumor grew rapidly and it became inoperable. Ten months after the second operation the patient died because of renal failure.

Case 2. The patient had been under our clinical control since 14 years of age because of multiple cartilaginous exostoses.

When she was 18 years old, an osteochondroma of the left scapula grew rapidly. A partial scapulectomy including the tumor was carried out. Ten months later, the tumor recurred and a total scapulectomy was done. However, the tumor recurred 6 times after the second operation. Resection of the tumor was carried out 6 times. The final operation was at 25 years of age. After that she has had no recurrence of the tumor.

Case 3. Although the patient had noticed multiple cartilaginous exostoses since 5 years of age, no medical control was undertaken. When she was 22 years old, an osteochondroma of the left scapula grew rapidly. A partial scapulectomy including the tumor was performed. However, one year later, recurrence of the tumor was observed. A total scapulectomy was carried out. After that the tumor did not recur again.

Four out of the 7 chondrosarcomas were primary chondrosarcomas. The clinical course and treatment were as follows:

Case 4. The patient developed a fracture of the neck of the right humerus at 58 years of age. At that time, an x-ray examination revealed a bone lesion in the fracture site. Although further examinations were recommended, she refused them and had no medical control. Two years later, she sustained severe pain and swelling in her right shoulder and visited our clinic. En bloc resection of the upper half of the right humerus with prosthetic replacement was carried out. Two years and 8 months later, the tumor recurred and a right total scapulectomy including the tumor was carried out. After that 2 operations were performed for recurrence within 2 years. Three years and 9 months after the first operation, pulmonary metastasis was observed. Although chemotherapy was applied, she died 3 years later.

Case 5. The lesion was found incidentally by x-ray examination when she

complained of right gonalgia. Open biopsy showed a benign chondroma of the right tibia, and curettage and bone graft was performed. However, 3 years later, pain and recurrence of a rapidly growing tumor were observed. En bloc resection and arthrodesis of the right knee joint were carried out. Two years after the second operation, she had no recurrence of tumor.

Case 6. The lesion was found incidentally by x-ray examination when she complained of right gonalgia. Because open biopsy showed a benign chondroma of the right tibia, curettage and bone graft was carried out. However, 7 years later, severe pain and swelling developed in her right knee joint. Open biopsy showed malignancy and an above-the-knee amputation was carried out. One year after the amputation, she had no recurrence or metastasis.

Case 7. The lesion was found incidentally by x-ray examination when she felt left coxalgia. En bloc resection of the ischium including the tumor was performed. For 3 years following the operation, she showed no recurrence or metastasis.

Microscopic Findings

Solitary osteochondroma

Well differentiated cartilage cells of the cartilaginous cap proliferated lobularly under the thickened periosteum. The cells were various in size and slightly bigger than normal ones. Cellularity was not uniform in some areas. The nuclei showed no atypism or mitosis. The cartilaginous matrix was normal, although degeneration of the matrix was observed in some parts (Fig. 8).

Multiple cartilaginous exostoses

Histological findings of multiple carti-

Fig. 8 Microscopic findings of osteochondroma on the right proximal femur of a 17-year-old male. Although cartilaginous cells were various in size, they were well differentiated. Hematoxylin-eosin stain, $\times 4$.



laginous exostoses were nearly the same as those of solitary osteochondroma. However, a band-like zone of enchondral ossification was observed under the cap. The bone trabecula grew toward the center of the marrow (Fig. 9).

Chondroma

Well differentiated cartilage cells proliferated producing matrix (Fig. 10).

Ollier's disease

Well differentiated cartilage cells proliferated under a thickened periosteum. The features were quite similar to those of chondromas.

Maffucci's syndrome

In the bone marrow, well differentiated cartilage cells proliferated in a lobular pattern. Degeneration of the matrix was observed.

Histological findings of the large soft-part tumor in the right forearm showed angioma. Many vessel lumina were observed in the deep layer of the cutis. They were surrounded by endothelial cells and dilated cavernously. Because smooth muscle fibers were scattered among the proliferated vessel lumina, this tumor seemed to be a venous angioma. In some vessel lumina there were organized thrombi, and in the peripheral part of the tumor, heavy hemosiderin

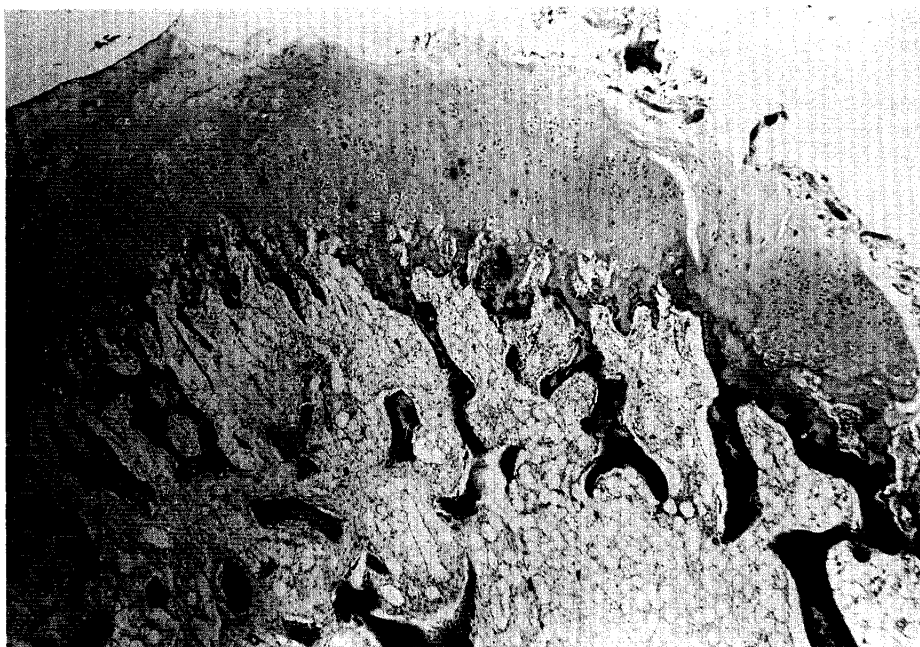


Fig. 9 Microscopic findings of multiple cartilaginous exostoses on the right distal femur of a 4-year-old male. A band-like zone of enchondral ossification under the cartilage cap and bone trabeculae toward the bone marrow are findings different from the solitary osteochondroma. Hematoxylin-eosin stain. $\times 4$.

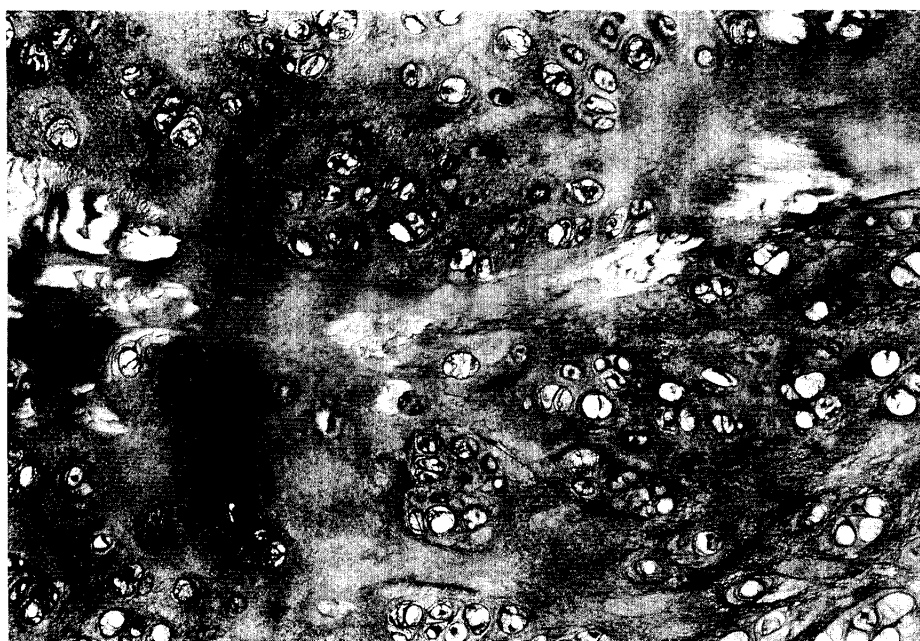


Fig. 10 Microscopic findings of chondroma on the right 3rd metacarpus of a 12-year-old female. Cartilage cells show no atypism or mitotic figures. Hematoxylin-eosin stain. $\times 16$.

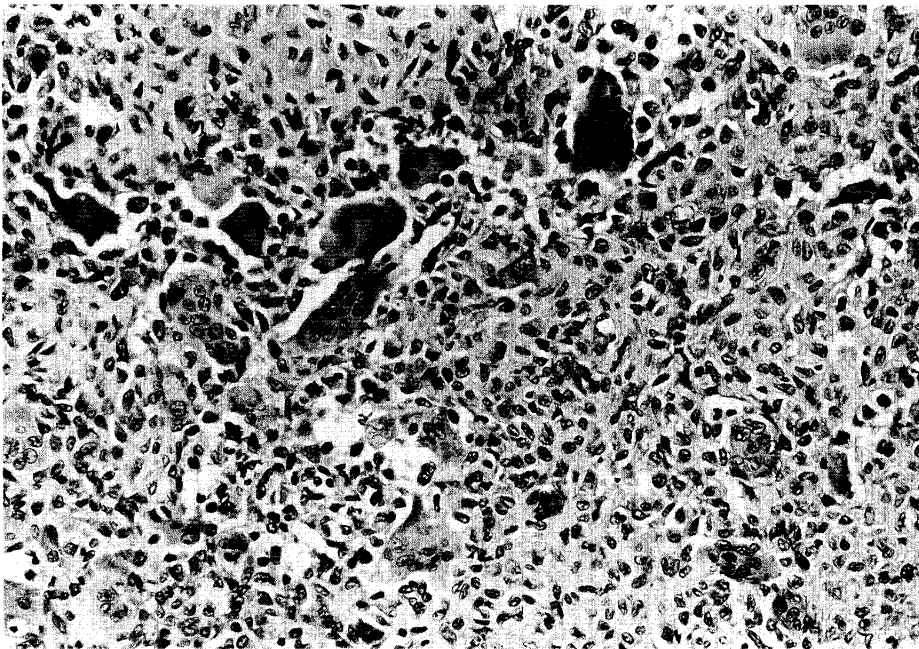


Fig. 11 Microscopic findings of benign chondroblastoma on the right proximal femur of a 26-year-old male. The figure shows a peripheral part of the tumor: multinucleated giant cells and histiocytes were characteristically observed. Hematoxylin-eosin stain. $\times 16$.

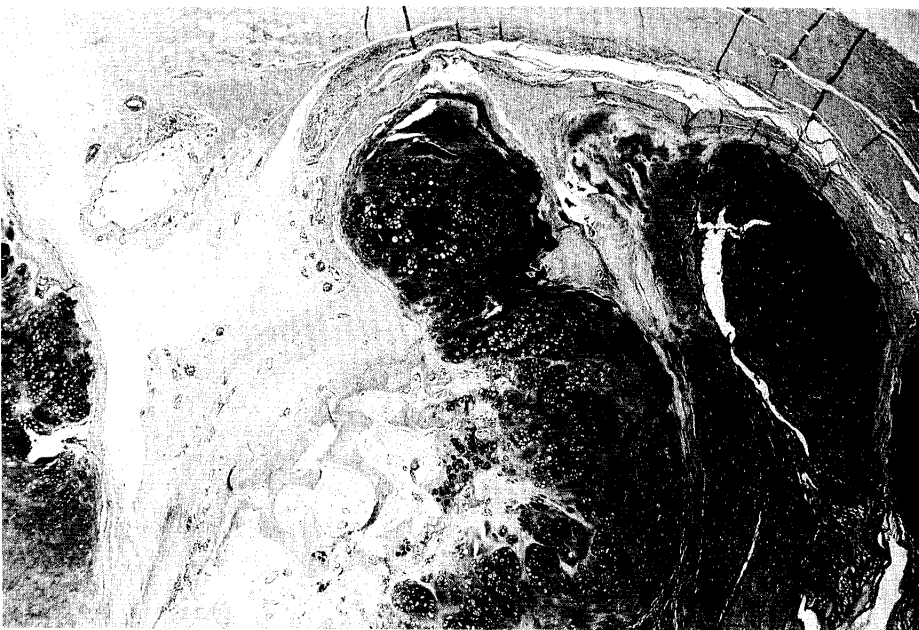
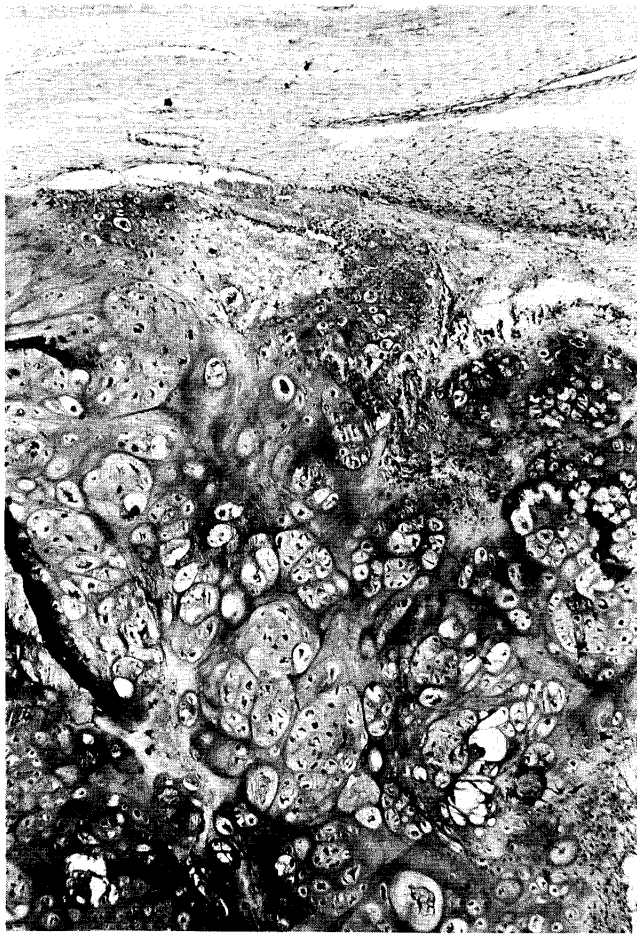


Fig. 12 Microscopic findings of primary chondrosarcoma on the right proximal tibia of a 38-year-old female. Tumor cells proliferate in a lobular pattern and invade the surrounding tissue. Cellularity is not uniform, and necrosis is observed in some parts. Hematoxylin-eosin stain. $\times 4$.

Fig. 13 Microscopic findings of secondary chondrosarcoma on the right scapula of a 20-year-old female. Bizarre cartilaginous cells proliferated in a lobular pattern. There is less matrix than in the primary chondrosarcoma. Hematoxylin-eosin stain. $\times 4$.



deposition and infiltration of inflammatory cells were observed.

Benign chondroblastoma

The characteristic feature of benign chondroblastoma was small polygonal cells which proliferated in a lobular pattern. In the center of the lobules, cartilaginous matrix was produced and a considerable amount of differentiated cartilaginous tissue was observed. At the peripheral part of the lobules, there were multinucleated giant cells and histiocytes which engulfed hemosiderin. Histological findings of the peripheral part were quite similar to those of giant cell tumor of bone (Fig. 11).

Chondrosarcoma

Primary chondrosarcoma. Tumor cells were spindle, polygonal or stellate in shape, and they proliferated in a lobular pattern producing a cartilaginous matrix. In the area where cellularity was high, bizarre tumor cells were observed. Tumor cells invaded the surrounding tissue and destroyed the normal cortex. Cellularity was not uniform and necrosis was observed in some parts. Nuclei were big and showed atypism and mitotic figures. Although blood vessels were recognized in stroma between lobules, there were no blood vessels in the matrix which was produced by tumor cells. Tumor tissue was rather clearly demarcated from

surrounding connective tissue (Fig. 12).

Secondary chondrosarcoma. In secondary chondrosarcomas, spindle, polygonal or stellate tumor cells were fewer than in primary ones, but many bizarre cartilaginous cells were observed. The proliferation pattern was also lobular. There was little matrix (Fig. 13).

Discussion

Although cartilaginous bone tumors were the most common bone tumors observed in our study, discrepancies between the biological behavior and histological findings of the tumors were noted. In order to choose the proper surgical procedure, such as curettage, simple resection, en bloc resection with reconstruction and amputation, the malignancy of the tumor should be evaluated not only by signs and symptoms, x-ray films and microscopic findings, but also by age, multiplicity and the site of the lesions.

Osteochondromas and multiple cartilaginous exostoses were rather easy to diagnose; however, the latter had the potentiality for malignant change. Rapid growth of the tumor after skeletal maturity indicated malignant change. The sites of lesions were mainly flat bones, such as the scapula and pelvic bone. In our 3 cases, there were 2 tumors in the scapula and one in the ischial bone.

Eleven percent of Jaffe's cases and 17.6% of Schajowicz's cases showed malignant change (1, 2). In our series, 3 chondrosarcomas occurred out of 14 multiple cartilaginous exostoses (21.4%). They were all heredity. Our solitary osteochondroma showed no malignant change. Dahlin, however, reported that 4.1% of his operated cases showed malignant change (3).

Rapid growth of the tumor was a sign of malignant change, but the microscopic find-

ings of the tumor were quite similar to those of osteochondromas, *i.e.*, little atypism and few mitotic figures. The existence of bizarre cartilage cells was recognized only by careful microscopic survey, but was the most characteristic microscopic finding. The tumor was very often estimated as a benign lesion histologically when the bizarre cartilage cells were not observed, leading to a discrepancy between the biological behavior and histological findings. The rapid growth of the pre-existing tumor was the most important information.

Our chondroma cases showed no malignant change. Dahlin stated that no malignant change of chondroma was observed in 54 secondary chondrosarcomas (3). Chondroma was characteristic in its site, *i.e.*, mainly the finger and toe bones were affected. Curettage and bone graft was the ordinary procedure for the treatment of chondromas. Satisfactory results were obtained in most cases. However, 2 patients who had huge lesions were treated by resection of the affected bone. In these cases, reconstructive surgery, such as bone block implantation, was required.

Ollier's disease and Maffucci's syndrome are rather rare conditions. One case each was experienced in our series. Malignant change following these two conditions is seldom reported (4-6). Our case of Maffucci's syndrome was highly suspicious of involving a malignant hemangioma, but a surgical specimen showed no malignancy. The most common problems of these conditions were leg length discrepancy and pathologic fracture. From our experiences, it was indicated that conservative treatment such as orthosis was preferable to surgical intervention.

Differential diagnosis was very important in benign chondroblastomas, especially differentiation from giant cell tumors of bone, chondromyxoid fibromas and chondrosarcomas. The key to the diagnosis of the

benign chondroblastomas was the microscopic findings. Although a lot of multinucleated giant cells were recognized, the pathognomonic finding was the chondroid matrix which was observed in the center of a lobular proliferation of small polygonal cells. In addition, multinucleated giant cells were scattered in the peripheral part. From these findings and clinical signs and symptoms, it was possible to distinguish benign chondroblastomas from giant cell tumors, chondromyxoid fibromas and chondrosarcomas. No malignant change was observed in our benign chondroblastoma series. However, Kiryakos *et al.* (7) reviewed 21 reports about atypical, aggressive and malignant chondroblastomas and stated that 11 cases out of 23 showed distant metastasis.

Although the secondary chondrosarcomas grew rapidly, the primary chondrosarcomas showed rather slow growth of the tumor. The histological appearance of primary chondrosarcomas varied. Underestimation of the microscopic findings and under-surgery often took place in cases of primary chondrosarcoma. Two out of our 4 cases were under-evaluated, and the chondrosarcoma recurred after the curettage and bone graft.

In 1963, Henderson and Dahlin (8) surveyed 288 chondrosarcomas at the Mayo Clinic and pointed out that recurrent tumors often occurred because cells spilled into the wound at the operation. Our chondrosarcoma case 2 was operated on 8 times within 8 years. The recurrent tumors were considered to arise from the implantation of tumor cells at each operation. It is necessary to avoid any chance of cells spilling into the wound.

In 1952, O'Neal and Ackerman (9) stated that chondrosarcomas could be divided into three groups, low-grade malignant, moderately malignant and highly malignant, according to the variation in nuclear size, double nuclei, multinucleated giant cells,

enchondral osteogenesis and calcification. In 1977, Evans *et al.* (10) reported malignancy-grading according to mitotic rate, cellularity and nuclear size. In 1980, Mankin *et al.* (11) and, in 1981, Gitelis *et al.* (12) discussed malignancy-grading. Moreover, in 1980, Enneking *et al.* (13) developed a system for the surgical staging of musculoskeletal sarcoma. These systems for the grading of malignancy do not differ greatly as to their histological criteria. Variety of shape and size of tumor cells, atypism and mitosis, invasion of tumor cells into surrounding normal tissues and pattern of the chondroid matrix were the most important criteria. In order to get this information accurately, each part of the tumor should be investigated thoroughly. In addition to microscopic findings, the growing attitude of the tumors (biological behavior) was an important factor for the estimation of malignancy. In our cases, rapid growth was observed in the secondary chondrosarcomas.

As to metastasis, Lindbom *et al.* (14) reported a 21% incidence of distant metastasis in a study of 39 cases. Henderson stated that 69.2% of the adequately treated chondrosarcoma patients survived 10 years, while only 19.4% of the inadequately treated patients survived 10 years. Only one of our patients, who refused adequate treatment, showed pulmonary metastasis.

It was considered that cartilaginous bone tumors, including chondrosarcomas, were surgically curable if the lesion was evaluated correctly. After a correct diagnosis was made the proper surgical procedure should be performed. However, in multiple lesions, such as Ollier's disease and Maffucci's syndrome, surgical intervention should be avoided because the main complaints of these conditions are leg length discrepancy and pathological fracture.

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