PAROSTEAL OSTEOSARCOMA

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Forty-one cases of parosteal osteosarcoma were reviewed clinically, radiologically and pathologically. The fibrous and cartilaginous elements of each tumour were graded from I to IV for malignancy. Primary intramedullary involvement was found in one third of Grade I lesions, two-thirds of Grade II and nearly 90% of Grade III lesions. Thirty-five patients with adequate follow-up were also studied and evaluated as to the adequacy of surgical management in relation to the later development of local recurrence or metastasis or both. No metastases were seen from Grade I tumours despite a number of local recurrences. One third of patients with Grade II and half of those with Grade III tumours developed pulmonary metastases and died, all with involvement of the medullary cavity before distant spread. No patients with adequate surgical management developed local recurrence; in those with inadequate treatment there was an 88% local recurrence rate.

Parosteal osteosarcoma is an uncommon tumour and even large institutions mostly have limited experience of its management (Campanacci, Giunti and Grandesso 1968; Campanacci and Giunti 1976; Unni *et al.* 1976; Ahuja *et al.* 1977; Lorentzon, Larsson and Boquist 1980). It is a slow-growing malignant tumour arising from periosteal tissues adjacent to the cortex and frequently displays a high degree of histological differentiation. It has a significantly better prognosis than the more usual varieties of osteosarcoma, and patients with parosteal osteosarcoma must be differentiated from those having intracortical and periosteal forms of osteosarcoma (Dahlin and Unni 1977; Kyriakos 1980; Campanacci *et al.* 1981; Bertoni *et al.* 1982).

This study was undertaken to improve our understanding of the natural history of parosteal osteosarcoma and to try to relate the histological grade to treatment and prognosis. The adequacy of surgical management was also evaluated and correlated with the surgical grade and stage of the tumour.

MATERIAL AND METHODS

Seventy-eight cases of malignant bone-forming tumours, arising primarily from tissue peripheral though adjacent to cortical bone, were reviewed. All had been seen at the

Rizzoli Institute since 1916, but 14 cases not treated there were excluded, as were 23 cases of established periosteal osteosarcoma. Thus, in all, 37 cases were excluded leaving 41 parosteal sarcomata for detailed study. Of these, 33 cases with a minimum follow-up of five years and two patients who developed metastasis or local recurrence within five years were available for assessment of treatment and its results. None of these patients had received either radiation or chemotherapy.

Fig. 1

The age, sex and anatomical distribution of parosteal sarcoma in the 41 cases.

Of the 41 patients (Fig. 1 and Table I) 31 had received all their treatment at this Institute while 10 who had received treatment elsewhere were referred to us for further management after local recurrence. For each patient the records, operation report, radiographs, histological material and, when available, radiographs and photographs of the specimens were reviewed. The aim was complete re-evaluation, including clinical and surgical staging. The records and specimens were retained permanently.

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0301-620X/84/3086 \$2.00

Table I. Details of 41 patients with parosteal sarcoma

Case	Year	Sex	Age (years)	Site	Duration of symptoms	Grade and medullary involvement					Surgical treatment					Adequacy of treatment					Local recurrences*					Metastasis†	Follow-up
						1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5		
1	1916	F	9	Dist. fem.	3 m	3+					Amput.					Yes										NED 66 y	
2	1934	F	24	Prox. fibula	7 m	2+					Marg. dis.					No							8 m (15 m)			Dead 20 m	
3	1942	M	26	Dist. fem.	5 m	1- 1- 1-					Intr. exc.					No	Yes									NED 29 y	
4	1942	F	17	Dist. fem.	2 y	2- 2+ 2+					Intr. exc.					No	No	Yes					21 y (23 y)			Dead 22 y	
5	1951	M	10	Dist. fem.	1 y	1+					Marg. res.					No										NED 31 y	
6	1951	M	34	Prox. hum.	2.5 y	3+					Disart.					Yes							18 m (4 y)			Dead 2 y	
7	1953	F	30	Dist. fem.	6 m	1-					Amput.					Yes										NED 29 y	
8	1954	M	32	Prox. fem.	2.5 y	2+ 2+					Intr. exc.					No	Yes						3 y (5.5 y)			Dead 6.5 y	
9	1955	M	15	Dist. fem.	10 y	3+ 3+					Marg. res.					No	Yes						18 m (11.5 y)			Dead 3 y	
10	1958	F	36	Dist. fem.	6 y	2+ 2+ 3+					Intr. exc.					No	No	Yes					19 y (25 y)			Dead 20 y	
11	1959	M	20	Dist. fem.	4 m	3-					Amput.					Yes										NED 22 y	
12	1959	M	19	Dist. fem.	3 y	1+ 1+					Marg. amp.					No	Yes									NED 23 y	
13	1960	F	24	Dist. fem.	2.5 y	1+					Amput.					Yes										NED 6 y (then lost to F-U)	
14	1961	F	19	Dist. fem.	2 y	3+					Amput.					Yes										NED 21 y	
15	1963	M	21	Dist. fem.	8 m	1- 1-					Intr. exc.					No	Yes									NED 19 y	
16	1963	F	21	Dist. fem.	1.5 y	2- 2-					Intr. exc.					No	Yes									NED 7 y (then lost to F-U)	
17	1964	F	27	Prox. fem.	3 y	3+					Marg. res.					No	No						4 m (3.5 y)			Dead 10 m	
18	1965	M	15	Dist. fem.	2 m	1- 1-					Marg. res.					No	No									NED 17 y	
19	1965	F	13	Prox. ulna	6 y	3+					Wide res.					Yes										NED 17 y	
20	1967	M	26	Prox. fem.	1 m	2+					Disart.					Yes										NED 15 y	
21	1968	M	25	Prox. hum.	3 y	2+ 2+					Marg. res.					No	Yes									NED 14 y	
22	1972	M	20	Dist. fem.	2 y	2+ 2+ 2+					Intr. exc.					No	No	Yes								NED 11 y	
23	1972	M	27	Dist. fem.	2 y	1- 1- 1- 1-					Intr. exc.					No	No	No	Yes							NED 10 y	
24	1974	F	25	Prox. hum.	2.5 y	1- 3-					Intr. exc.					No	Yes									NED 8 y	
25	1974	F	40	Prox. hum.	12 y	2- 3-					Intr. exc.					No	Yes						2 y (14 y)			Dead 3 y	
26	1974	F	26	Dist. fem.	13 m	1- 1- 1- 1-					Intr. exc.					No	No	No								NED 7 y	
27	1976	F	14	Dist. fem.	4 y	1+ 2-					Marg. res.					No	Yes									NED 6 y	
28	1976	F	15	Dist. fem.	5 m	1-					Wide res.					Yes										NED 6 y	
29	1977	M	62	Dist. fem.	2 m	2- 2- 3+					Intr. exc.					No	No	Yes								NED 5.5 y	
30	1977	M	19	Dist. fem.	15 m	2- 2-					Intr. exc.					No	Yes									NED 5.5 y	
31	1977	F	29	Dist. fem.	15 y	2+					Amput.					Yes										NED 5 y	
32	1977	F	13	Dist. fem.	9 m	2- 2+					Intr. exc.					No	Yes									NED 5 y	
33	1978	F	23	Prox. fem.	5 m	2+					Wide res.					Yes										NED 5 y	
34	1978	F	33	Prox. fibula	5 m	1-					Marg. res.					No										Alive with disease 4 y	
35	1979	M	24	Prox. hum.	3 y	3+					Wide res.					Yes							8 m (3.5 y)			Dead 20 m	
36	1981	M	16	Dist. fem.	4 m	2+					Wide res.					Yes										NED 1.5 y	
37	1982	F	27	Prox. hum.	1 y	1-					Wide res.					Yes										Treated Feb 82	
38	1982	F	25	Prox. hum.	9 m	1+					Wide res.					Yes										Treated Mar 82	
39	1982	M	24	Prox. fibula	1 y	3+					Marg. res.					No										Treated Mar 82	
40	1982	M	39	Dist. fem.	1 y	2-					Wide res.					Yes										Treated July 82	
41	1982	M	16	Prox. tibia	1 y	2+					Wide res.					Yes										Treated July 82	

m = months; y = years; + = medullary involvement; - = no medullary involvement; marg. = marginal; intr. = intralesional; exc. = excision; res. = resection; amput. = amputation; dis. = disarticulation; NED = no evidence of disease.

*Local recurrences: time from most recent operation.

†Metastasis: time from first treatment (and from onset of symptoms).

Fig. 2

Fig. 3

Fig. 4

Case 27. Figure 2—A typical angiogram demonstrating displacement of the popliteal vessels and probable intramedullary involvement as indicated by the arrow. Figure 3—Photograph of the cut specimen confirming involvement of the medullary cavity. Figure 4—Radiograph of the cut specimen also confirms medullary involvement.

Radiographic diagnosis. Plain radiographs were available for all 41 patients, and were reviewed collectively by the authors. Only those lesions arising outside bone and with more than 90% of the lesion extraperiosteal were accepted (Figs 2, 3 and 4). In many patients, tomograms and bone scans also were available and, when the lesion was near major vessels, angiograms had frequently been taken. Since 1979 computerised tomography had been performed in the eight primary and recurrent lesions encountered, with improved evaluation of neurovascular or primary intramedullary involvement. Fine-grain radiographs and gross photographs of the specimen in 5 mm multiple slices were available for review in 30 cases.

Pathological criteria for diagnosis and grading. Histological sections were available for microscopic review in all cases. This review was based on one section in three cases, on two sections in seven, and on three to eight sections in the remaining 31 cases. Penetration of the cortex with invasion of the medullary cavity was assessed by inspection, gross photography, radiography, tetracycline labelling (when available) and microscopic sections. Only those cases where invasion was undebatable were accepted as showing medullary involvement.

Three of the authors (MC, FB, PP) who are pathologists, reviewed the slides without prior knowledge of the patient, the location of the tumour, or its nature (whether primary or recurrent); this was in order to establish an agreed diagnosis of parosteal osteosarcoma. The fibrous component of both primary and recurrent lesions was graded from I to IV as previously described for fibrosarcoma (Campanacci and Olmi 1977). The cartilaginous part was graded from I to III as described

for chondrosarcoma (Gitelis *et al.* 1981). No attempt was made to grade the osseous portion of the tumour, which characteristically lacked anaplastic features and could be either woven or lamellar bone.

Fig. 5

Fig. 6

Case 28. Figure 5—Photomicrograph showing fibrous component of the tumour, similar to a Grade I fibrosarcoma (haematoxylin and eosin, $\times 100$). Figure 6—Photomicrograph showing the cartilage component, similar to a Grade I chondrosarcoma.

Histological grading system

Grade I. The fibrous tissue was similar to that in a Grade I fibrosarcoma with only slight increase in cellularity, little nuclear pleomorphism or hyperchromaticity, abundant collagen and rare mitoses. The cartilaginous component was similarly graded and was like that seen in a Grade I chondrosarcoma (Figs 5 and 6).

Grade II. The fibrous component was more cellular with large, slightly pleomorphic and hyperchromatic nuclei, less abundant collagen, and more frequent mitoses. The

Fig. 7

Fig. 8

Case 31. Figure 7 Photomicrograph shows the tumour fibrous tissue which resembles a Grade II fibrosarcoma (haematoxylin and eosin, $\times 100$). Figure 8 Tumour tissue resembling a Grade II chondrosarcoma.

cartilaginous component was similar to Grade II chondrosarcoma (Figs 7 and 8).

Grade III. The fibrous tissue was essentially similar to a Grade III fibrosarcoma with increased cellularity, identifiable collagen, many hyperchromatic and pleomorphic nuclei, and numerous mitoses. The cartilaginous element was like a Grade III chondrosarcoma. In some instances the osseous portion was similar to a classic Grade III osteosarcoma with large cells producing foci of immature osteoid in a lace-like pattern (Figs 9, 10, 11 and 12).

Grade IV. No Grade IV lesions were identified in this series.

Surgical stage and adequacy of surgery

The system of surgical staging and definition of surgical margins advocated by Enneking, Spanier and Goodman (1980) was used throughout; all operative reports, radiographs and pathological material were reviewed in order to evaluate the margins and the adequacy of each operation. A consensus opinion by all the authors was reached. Histological Grade I and II tumours were

considered as surgical Grade I disease, while histological Grade III lesions represented surgical Grade II disease. The concept of surgical staging into A (intracompartmental) and B (extracompartmental) was difficult to apply, because most lesions projected into adjacent soft tissue with a covering of fibro-fatty tissue and could therefore be described as extracompartmental. When the tumour encircled the bone, it sometimes transgressed several muscular compartments; it might be covered by muscle in one compartment (intracompartmental) and fibro-fatty tissue in another (extracompartmental). Intramedullary involvement could be interpreted as extracompartmental extension.

In general, an adequate surgical procedure was recognised when a cuff of normal tissue completely encased the tumour and, in the case of intramedullary extension when, microscopically, a free margin of normal cortex and marrow was seen between the tumour and the adjacent bone.

RESULTS

Clinical findings. The findings of all the patients in this study are shown in Table I. There were 20 males and 21 females ranging in age from 9 to 62 years with an average of 24 years. A majority of the lesions were on the posterior aspect of the distal femoral metaphysis; the next most common site was the proximal humeral metaphysis. The commonest presenting complaint was a mass in 33 patients (80%), dull aching pain in 24 (59%), and joint dysfunction in seven patients (17%). The duration of symptoms ranged from one month to 15 years, and 34% of patients had had symptoms for more than two years before diagnosis. An important correlation between the duration of symptoms and involvement of the medullary cavity was found. Thirteen of the 14 patients (93%) with symptoms for more than two years had developed intramedullary involvement, while only 14 of the 27 patients (41%) with symptoms for less than two years had developed such involvement ($P < 0.005$). No patient presented primarily with metastatic disease.

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Figure 9—Photomicrograph demonstrating the fibrous element of a parosteal sarcoma which is similar to Grade III fibrosarcoma (haematoxylin and eosin, $\times 100$). Figure 10—Cartilage with an appearance like that of a Grade III chondrosarcoma. Figure 11—Photomicrograph to show the osseous component of a parosteal sarcoma, which is similar to a Grade III classical osteosarcoma (haematoxylin and eosin, $\times 100$). Figure 12—Shows the general pattern of a typical parosteal sarcoma at lower magnification (haematoxylin and eosin, $\times 18$).

Fig. 13

Fig. 14

Fig. 15

Case 36. Figure 13—CT scan of the distal femur demonstrating the lesion and its invasion of the medullary cavity at the arrow. Figure 14—Photograph of the gross specimen confirms involvement of the medullary cavity. Figure 15—Radiograph of the gross specimen also shows intramedullary involvement.

Radiographic findings. These related to the maturity and quantity of the osseous component. In 20 cases, the peripheral areas of the lesion appeared cloudy and indistinct, and were presumably less mature. However a densely mineralised lesion with sharp outer margins did not necessarily imply a lower histological grade. In two patients (Cases 17 and 19) the tumours were heavily radio-opaque with the appearance of mature dense bone, and with sharply demarcated margins, but both were histological Grade III tumours. Fourteen tumours showed large radiolucent areas consisting of fibrous and cartilaginous tissue. A lucent line between cortex and tumour was seen in seven patients (17%). Rarely did there appear to be more than one area of attachment of tumour to cortex.

Cortical erosion or invasion of the medullary cavity was seen or suspected in 24 patients before any treatment (58%). Computerised tomography (CT) in the initial evaluation of the later cases helped considerably in assessing intramedullary involvement as seen in Figs 13, 14 and 15 (Case 36) and in Figs 16, 17 and 18 (Case 40). The CT scan was also helpful in assessing joint

involvement (this occurred in six patients) and in pre-operative planning when the tumour had displaced major neurovascular structures. In most of the latter cases a cuff of fibro-fatty tissue could be identified between the neurovascular structures and the tumour, suggesting that resection would be possible.

Satellite tumour nodules in the soft tissues separate from the primary tumour mass (Unni *et al.* 1976) were never seen in untreated cases; they were however present in six patients with recurrent lesions. This was interpreted as being due to soft-tissue seeding during the initial (inadequate) operation rather than assuming that the nodules had previously been unrecognised.

Angiography was valuable in defining the relationship of the tumour to the major vascular structures particularly in the popliteal and axillary regions. It was also useful in identifying unossified recurrent neoplastic nodules in the soft tissues. This was especially true before the CT scan became available.

Bone scanning was only of use in deciding the level

Fig. 16

Fig. 17

Fig. 18

Case 40. Figure 16—CT scan showing the tumour completely encasing the shaft of the femur and the main vessels (arrow), without any obvious intramedullary involvement. Figure 17—Photograph of the cut specimen confirms encasement of the femur by tumour, but no involvement of the medullary cavity. Figure 18—Angiogram one month after operation shows the artery to be patent. Treatment has been by *en bloc* cylindrical resection of the femur and main vessels with subsequent vascular reconstruction.

of resection when periosteal structures appeared to be involved. Usually the scan showed only an area of dense uptake within the lesion. No metastatic lesions were identified by bone scanning. When pulmonary metastases had developed (nine patients), these were identified by plain radiography or by tomography.

Pathological findings. The most frequent gross pathological finding was a lesion arising from periosteal tissue producing mature dense bone with numerous areas of fibrocartilage, an appearance confirmed by radiography. Tetracycline labelling frequently helped in evaluating the margins of resection and in the choice of appropriate sections for microscopic examination. Only rarely was the surface of the tumour covered by a cartilaginous cap. Intramedullary involvement was confirmed in 24 (58%) of the primary cases and in three cases with multiple recurrences. It was eventually present in 66% of cases. Multiple sections were frequently required to assess intramedullary involvement and to evaluate the surgical margins of excision.

Microscopically, tissue from a typical lesion showed well-formed osseous trabeculae in a fibrous stroma with a variable cartilaginous component. The periphery of the tumour was usually more cellular, with abundant osteoid and was less mature. Near the basal portion of the tumour, the trabeculae became thicker and the fibrous component more collagenous and less cellular.

Fifteen of the 41 patients (37%) were identified as having histological Grade I tumours. Five of these were subsequently found to have intramedullary involvement (33%). The histology of the intramedullary portion was similar in character and grade to that of the extrasosseous component. Seventeen tumours (42%) displayed histological Grade II tissue; 11 of these patients (65%) had intramedullary involvement initially. There were thus almost twice as many Grade II as Grade I tumours with medullary cavity involvement. Nine of the 41 patients (21%) had histological Grade III lesions; eight of these (90%) had involvement of the medulla.

In only four of the nine cases of Grade III tumours were Grade III osteoblasts observed to be producing lace-like osteoid as in classic osteosarcoma. In three of these cases this appearance was seen in foci in an otherwise typical pattern of parosteal osteosarcoma; in the fourth case it was seen with a Grade III local recurrence after treatment for an originally Grade II lesion. Although these four cases showed medullary cavity involvement, the diagnosis of classical osteosarcoma could be excluded on the basis of the duration of symptoms and the radiographic findings. No Grade IV lesions were identified in this series.

The significance of grading and intramedullary involvement are detailed above, but it must be emphasised that it was not exceptional to find areas of different histological grades present in the same tumour (Grade I+II in three cases, Grade II+III in six cases). This confirms the importance of wide and multiple sampling.

Clinical results. The overall results of surgical management as well as the significance of intramedullary involvement and of local recurrence and other parameters, were assessed in 35 patients. These patients (Cases 1 to 35 in Table I) all had a minimum follow-up of five years or had developed local recurrence or metastatic disease within five years of the initial treatment.

The follow-up ranged from 3 to 66 years (average 18 years) from the onset of treatment. Twenty-five patients (71%) are at present free of disease; 11 of these have no detectable lesion after one or more local recurrences at four months to 25 years (average 7.8 years) since their last treatment, or at 5 to 29 years (average 14 years) since their first treatment. Nine patients (26%) developed pulmonary metastases at four months to 21 years (average 5.6 years) since their first treatment or, more significantly, at 1.5 to 23 years (average 10 years) from the onset of symptoms.

There were 30 local recurrences in 20 patients. Thirteen patients each had one recurrence, five had two recurrences, one had three recurrences, and one patient developed four local recurrences before receiving adequate surgical treatment. The time to appearance of local recurrences varied from eight months to 14 years (average 4 years) from the last treatment. Six of the local recurrences appeared only in the soft tissues. Of the 20 patients who developed recurrences, only one (Case 34) refused further treatment and is presently alive and free of metastatic disease, four years from first treatment.

Table II. Results in terms of histological grade in the 35 patients with adequate follow-up

Grade	Cases	No current disease	Metastasis	Local recurrence (treated)
I	13	12 (92%)	—	9 (69%)
II	14	9 (64%)	5 (36%)	10 (71%)
III	8	4 (50%)	4 (50%)	1 (13%)

Treatment and prognosis

Until 15 years ago the surgical management of patients with musculoskeletal tumours varied. Before that time many of the lesions were "shaved off", with frequent local recurrence, but since then most of our patients have been managed by two of the authors (MC and AG) who have a special interest in musculoskeletal oncology, and have developed a systematic management programme.

Analysis of the results in terms of histological grade (Table II) indicates that nearly all tumours will recur locally if not adequately removed. Of 13 patients with histological Grade I lesions, nine (69%) had local recurrence, but no patient with a Grade I lesion developed metastatic disease regardless of the number of local recurrences. Of 14 patients with histological Grade II lesions 10 (71%) had local recurrence; five developed metastatic disease and died. Of these five patients, four

had initial intramedullary involvement and the fifth (Case 4) developed intramedullary spread after the first recurrence. Four of these five patients had one or more local recurrences prior to metastasis, but one (Case 2) developed metastatic disease without evidence of local recurrence. This tumour showed evidence of primary intramedullary involvement at the time of initial treatment.

Eight patients presented with histological Grade III lesions and seven (87%) had initial intramedullary involvement. Four of these seven developed metastatic disease. One of the four had local recurrence after inadequate surgery and three patients (Cases 6, 17 and 35) developed metastatic disease without local recurrence.

Table III. Results in terms of medullary involvement

Medullary involvement	Cases	No current disease	Metastasis	Local recurrence (treated)
Yes	20	12 (60%)	8 (40%)	8 (40%)
No	15	13 (87%)	1* (7%)	12 (80%)

*Involvement present in a local recurrence appeared 20 years before metastasis (Case 4)

The relation between involvement of the medullary cavity and subsequent development of pulmonary metastases is shown in Table III, which illustrates that penetration into the bone marrow correlates with an increased risk of metastasis. Of the nine patients developing metastatic disease, eight had primary medullary involvement and one developed medullary involvement after one local recurrence. We have not seen metastasis without prior involvement of the medullary cavity.

As has been reported by other authors (Unni *et al.* 1976; Ahuja *et al.* 1977; Dunham, Wilborn and Zarzour 1979; Lemaire and Mommens 1979; Lorentzon *et al.*

1980) an association of increasing histological grade with local recurrence was found. Nineteen cases were available for the evaluation of the histological grade of the local recurrence. Fourteen patients (74%) showed no evidence of change of grade of malignancy after 1 to 14 years (average 5 years). Two originally Grade I lesions progressed; in one (Case 24) it changed from histological Grade I to Grade III in seven years, and in another (Case 27) from Grade I to Grade II in six years. Three lesions changed from Grade II to Grade III in 2 to 14 years.

Results related to adequacy of operation

To assess the adequacy of operation in relation to subsequent recurrence and general prognosis, each of the 35 patients with an adequate follow-up was evaluated and the results are summarised in Table IV.

First procedure. The first surgical procedure was judged to have been adequate in 12 patients (34%) and inadequate in 23 (66%). Of the 12 patients with adequate surgery, none had local recurrence; two died of pulmonary metastases 29 and 54 months after the onset of symptoms, and 10 were clinically free of disease 5 to 66 years after operation. Of the 23 patients who had an inadequate operation, 20 had local recurrence eight months to 13 years postoperatively, two died of pulmonary metastases without evidence of local recurrence 27 and 48 months after the onset of symptoms, and one patient is clinically free of disease 31 years after operation.

Second procedure. Nineteen of the 20 patients with local recurrences after their first procedure underwent a second operation. One patient refused further surgery (Case 34). Of the 19 procedures, 11 were considered to be adequate and of these, four are clinically free of disease at less than five years and four are free of disease at more than five years since operation. Three patients after adequate operation died of metastatic disease 9, 13 and 15 years respectively after the initial onset of symptoms. Of the

Table IV. Results of surgical treatment

Operation	Estimate of adequacy	Cases	No evidence of disease		Metastasis	Local recurrence
			Follow-up < 5 y	Follow-up > 5 y		
Initial operation	Adequate	12	0	10	2	0
	Inadequate	23	0	1	2	20*
Operation for first recurrence	Adequate	11	4	4	3	0
	Inadequate	8	0	1	0	7
Operation for second recurrence	Adequate	5	1	2	2	0
	Inadequate	2	0	0	0	2
Operation for third recurrence	Adequate	0	0	0	0	0
	Inadequate	2	1	0	0	1
Further operation	Adequate	1	1	0	0	0
	Inadequate	0	0	0	0	0
Total operative procedures	Adequate	29	6	16	7	0
	Inadequate	35	1	2	2	30

*One patient (Case 34) refused a second operation and is now alive with local recurrence

eight inadequately treated patients, one is free of disease at 10 years but the other seven have all had local recurrence at from 16 months to 14 years after their second operation.

Third procedure. The seven patients with second local recurrences all underwent another operation, usually one of greater magnitude. Five of these seven procedures were felt to be adequate and three of these five patients were free of disease 2½, 5 and 25 years after operation. Two patients with adequate procedures and without local recurrence died of metastatic disease 23 and 25 years after the initial onset of symptoms. Two operations were judged to have been inadequate and these patients had recurrences at 1 and 2½ years after operation.

Additional procedure. Two patients with three local recurrences were operated on again and two of the procedures were believed to have been inadequate. One patient is free of disease at nine months, but the other patient after three years had a fifth recurrence which necessitated amputation.

In all, 64 surgical procedures were performed in 35 patients. Of these operations 29 are believed to have been adequate and no local recurrences were observed in these patients. Thirty-five of the 64 operations were judged inadequate and 30 patients (86%) developed local recurrence.

DISCUSSION

In our experience, parosteal osteosarcoma is approximately one order of magnitude less frequent than classic osteosarcoma but nearly twice as common as the periosteal variety (Campanacci and Giunti 1976; Lemaire and Mommens 1979). There was no sex preference, but more than half the tumours arose from the posterior aspect of the distal femoral metaphysis. The tumour rarely involved the tibia, which is the most common site for periosteal osteosarcoma (Bertoni *et al.* 1982). No lesions were found originating in sites other than the major tubular bones.

Sixty-six per cent of the tumours studied eventually involved the cortex and the medullary cavity of the bone; in 58% this involvement was present at the time of initial diagnosis and treatment. We use the term parosteal osteosarcoma for lesions projecting from the periosteal tissues with a mushroom-like radiographic appearance even when the radiographic and gross appearance strongly suggests early intramedullary involvement. The prolonged duration of symptoms in these patients even before operation, and the natural history of the lesion, corresponds much more closely to parosteal osteosarcoma than to a central osteosarcoma which has invaded and penetrated the adjoining cortex. Involvement of the medullary cavity appeared to correlate with the duration of symptoms before operation and with the histological grade of the tumour.

A wide margin of excision probably ensures adequate surgical treatment of parosteal osteosarcoma at

any surgical grade or stage. We have no evidence for the development of primary tumour satellite nodules or of "skip" metastases in parosteal sarcoma, so it would seem that truly radical or compartmental surgery is rarely indicated.

It is however important to define what constitutes an adequate surgical margin. In classical osteosarcoma without evidence of "skip" metastases, we consider that an adequate surgical margin must include continuous compartmental muscular cover over a lesion that primarily involves the medullary cavity and does not have, or has only a limited, extracortical extension. The trans-medullary margin should include the entire circumference of the shaft 5 to 10 cm from the nearest point of abnormality on a bone scan or computerised tomogram.

In parosteal osteosarcoma the tumour is, by definition, originally extracortical, and it most often presents in an extracompartmental area such as the popliteal fossa or the axilla. In these regions the tumour is not covered by muscle, nor included within a muscular compartment, but grows into the loose fibro-fatty tissue adjacent to neurovascular structures. If these neurovascular structures can be dissected away from a freely movable fibro-fatty tissue plane completely covering and encasing the entire tumour and the contiguous bone, then we believe that this is an adequate surgical margin, regardless of the histological grade. If, however, the perivascular fibro-fatty tissue is adherent and the vascular structures cannot be freed by gentle dissection, we believe that the margin will be inadequate; what is needed is resection of the vessels *en bloc*, if necessary with vascular reconstruction (Case 40). If the surgeon persists in dissecting through reactive and adherent tissue and accepts this margin as adequate, the patient is likely to develop local recurrence (Case 27).

The above comments are difficult to apply to recurrent tumours because of the difficulty in distinguishing between reactive tissue, surgical scar, and possible tumour contamination during the previous operation. Wide surgical margins in the management of recurrent tumours cannot eliminate the possibility of local recurrence. Wide margins are probably adequate for the treatment of recurrent lesions which have been carefully evaluated before operation by radiography, angiography and computerised tomography. This is especially true of Grade I lesions which do not appear to produce metastases. Recurrent lesions with multiple soft-tissue satellite nodules may however require amputation to provide sufficient local control of higher grade lesions.

Surgical margins should theoretically be greater for the treatment of histological Grade II and Grade III tumours; local control, however, appears to be almost entirely related to the adequacy of surgery and not to the histological grade of the lesion. Eighty-eight per cent of those patients with an intralesional or an inadequate marginal excision subsequently developed local recurrence. It would therefore seem that wide surgical margins

are probably adequate treatment for patients even with higher grade lesions, since no patient who was believed to have had adequate excision developed local recurrence (Table IV).

The use of the surgical staging system advocated by Enneking *et al.* (1980) was not particularly useful in the analysis of patients in this study, because of the propensity of parosteal sarcoma to develop in poorly defined anatomical regions.

No metastases developed in those patients with histological Grade I lesions regardless of intramedullary involvement or of the number of local recurrences. There were no metastases without prior involvement of the medullary cavity in histological Grade II and III lesions. The development of metastases appears to be influenced by increasing histological grade, the invasion or involvement of the medullary cavity by the higher grade lesions, and the duration of persistent disease in histological Grade II and Grade III tumours. These observations suggest that histological Grade I lesions, with or without intramedullary involvement, and histological Grade II and III tumours not invading the medullary cavity do not carry a significant risk of metastasis, and have a good prognosis if operation is adequate. The risk of metastases and of local recurrence appears to increase with the duration of the tumour. This factor also increases

the likelihood of progression of malignancy and of subsequent involvement of the medullary cavity. The significant incidence of pulmonary metastasis among those patients with Grade III parosteal osteosarcoma and involvement of the medullary cavity, suggests that, for them, adjuvant chemotherapy should be considered.

Local recurrence is a function of inadequate surgical treatment; a wide margin of excision appears adequate for any grade or stage of parosteal osteosarcoma as it has been defined.

The above observations should be accepted with some caution, for though parosteal osteosarcoma is rare and its potential for malignancy has on occasions been overestimated (leading to amputation when wide resection would have been adequate) sometimes its aggressiveness has been underestimated, and inadequate treatment has led to repeated local recurrence and occasionally to the development of metastatic disease. In the future, careful surgical staging before operation using all present-day radiographic techniques, including angiography and CT scanning with careful assessment of the surgical margins, will increase our knowledge of the biological potential and natural history of this lesion, thereby further improving the prognosis of this remarkably curable tumour.

The authors thank Dr G. E. Lorenzi and Jean Oberhaus for their secretarial help. This paper was supported in part by a grant from the Italian National Research Council, special project "Control of Neoplastic Growth", No. 82.00253.96.

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