■ ONCOLOGY

The 'other' bone sarcomas

PROGNOSTIC FACTORS AND OUTCOMES OF SPINDLE CELL SARCOMAS OF BONE

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We aimed to identify the incidence, outcome and prognostic factors associated with spindle cell sarcomas of bone (SCSB). We studied 196 patients with a primary non-metastatic tumour treated with the intent to cure. The results were compared with those of osteosarcoma patients treated at our hospital during the same period. The overall incidence of SCSB was 7.8% of all patients with a primary bone sarcoma. The five- and ten-year survival rates were 67.0% and 60.0%, respectively, which were better than those of patients with osteosarcoma treated over the same period. All histological subtypes had similar outcomes. On univariate analysis, factors that were significantly associated with decreased survival were age > 40 years, size > 8 cm, the presence of a pathological fracture, amputation, involved margins and a poor response to pre-operative chemotherapy. Multivariate analyses showed that age > 65 years, amputation and involved margins were all statistically significant prognostic factors. Involved margins and poor response to pre-operative chemotherapy were associated with an increased risk of local recurrence. SCSB has a better prognosis than osteosarcoma when matched for age. Most prognostic factors for osteosarcoma also seem to apply to SCSB. Patients with SCSB should be treated in the same way as patients of the same age with osteosarcoma.

Osteosarcoma, Ewing's sarcoma and chondrosarcoma are the three most common primary malignant sarcomas of bone. There are a number of other primary malignant bone tumours which do not fit neatly into one of the above three types, and these are generally known as 'spindle cell sarcomas of bone'. They are rare and include such entities as fibrosarcoma, malignant fibrous histiocytoma, leiomyosarcoma and others. There have been a number of differing diagnostic descriptions for these tumours, although the recent World Health Organization (WHO) classification has retained the characterisations for all types.¹ Most spindle cell sarcomas that produce collagen but not osteoid were initially identified as fibrosarcomas, latterly as malignant fibrous histiocytomas, and currently as spindle cell sarcomas of bone. Based on this inconsistent terminology and the rarity of these tumours, precise epidemiological data are difficult to obtain.

This heterogeneous group of sarcomas seems to affect an older age group than the more common bone sarcomas. There is a wide variation in the age of the patient at the time of diagnosis, which ranges in most cases from the third to the sixth decade.² Males and females seem to be equally affected,² although there is

a slight male preponderance in specific types of spindle cell sarcoma.³⁻⁵ The long bones of the lower limb are most commonly affected,^{2,6,7} and the clinical presentation does not differ from that of the classic bone sarcomas. Similar treatment to that recommended for osteosarcoma, including chemotherapy and excision, is generally recommended, once the patient's age and general condition have been taken into account.⁸ The typical radiological appearance of a spindle cell sarcoma is a poorly defined lytic lesion without osteoid formation or punctate calcification, and with very little periosteal reaction (Fig. 1).

Only a few studies have reported the prognostic factors and outcome of this type of bone sarcoma.^{2,3,6} Our aim was to identify the incidence of spindle cell sarcomas of bone and to investigate their outcome and any possible prognostic factors.

Patients and Methods

All patients with a sarcoma of bone which was not an osteosarcoma, chondrosarcoma or Ewing's sarcoma, and who had been treated at the Royal Orthopaedic Hospital, Birmingham, between 1970 and 2006, were included in the study. We accepted the pathological diagnosis made at the time of diagnosis: no review of the

Fig. 1

Radiograph (left) and MRI scan (right) of a patient with spindle cell sarcoma of the distal femur.

pathology of the tumour specimen was carried out specifically for the purpose of this study, although patients treated between 1985 and 1993 had all had their diagnosis externally peer-reviewed. Patients who were diagnosed with a spindle cell sarcoma on the basis of a biopsy but in whom the resection histology indicated another diagnosis were excluded. Patients who were only referred to the hospital for consultation were also excluded, as were patients presenting with recurrent disease and those who had no available follow-up data.

Patients were identified from a prospectively compiled database and further information was obtained from the medical records. Institutional Board approval was obtained for the study. Patient, tumour, treatment and outcome data were recorded. This included the year of diagnosis, gender, age at the time of diagnosis, maximum tumour size, location (extremity or trunk), the bone involved, and the presence or absence of a pathological fracture before treatment. We also noted any history of previous malignancy, as well as the histological type and grade and stage of the tumour at the time of diagnosis. Treatment data included the initial treatment received (surgery, chemotherapy, radiotherapy or other and combinations thereof), the type of surgical treatment (classified as amputation or limb salvage), and the margins of excision. We noted the type and timing of chemotherapy (pre-operative, post-operative, both) and, when available, the histological response to pre-operative chemotherapy. Follow-up data included the time to local recurrence, the time to metastasis, the time to last follow-up, if alive, or the time to death.

At the time of their initial diagnosis all patients underwent staging with a chest radiograph, or after 1980 a CT scan of the chest, a bone scan and a biopsy. MRI was usually used from 1993 onwards to assess the extent of the tumour; prior to which CT scans were used. Patients were followed up on a standard regimen with radiographs of the site of the initial tumour and chest every three months for the first two years, every six months for the third, fourth and fifth years, and yearly thereafter.

Data were also obtained for comparison from a cohort of patients with osteosarcoma treated at our centre over the same period.

Definitions and standardisations. Age was analysed both as a continuous and as a categorical variable. For the purpose of analysis, patients were divided into three age categories: those aged < 40 years at the time of diagnosis, those between 40 and 65 and those > 65. These groups were chosen as they match the age groups used in the treatment of osteosarcoma, with patients > 40 being ineligible for most chemotherapy trials but still receiving chemotherapy up to age 65, after which most will not receive chemotherapy. The maximum tumour size was regarded as its largest dimension, estimated from the pathology reports following resection or from MRI evaluation at the time of diagnosis, whichever was greater. A cut-off size for the categorical analyses was 8 cm (≤ 8 cm *versus* > 8 cm), as this is used in the TNM classification of bone tumours.⁹ The histological classification was based on the nomenclature available at the time, and more recently on the WHO classification.¹ The surgical margin was determined from the resection specimen and was defined as wide when the tumour was at least 1 cm away from the edge of the specimen, marginal when the margins were clear but the tumour was < 1 cm away from the edge, or intralesional where tumour extended to the edge of the specimen or if there had been contamination during the operation. No macroscopic tumour was left behind after resection in any patient. The histological response to chemotherapy was defined according to the percentage of tumour cell necrosis. Good responders were regarded as patients who had > 90% tumour necrosis in the resected pathology specimen, whereas poor responders had $\leq 90\%$ of tumour necrosis.

The follow-up period was calculated from the date of diagnosis. Outcome measures were the development of metastases, local recurrence, or death for any reason related to the tumour.

Statistical analysis. Only patients who presented with non-metastatic spindle cell sarcoma and had been treated with the intent to cure were included in the analyses of prognostic factors. Both univariate and multivariate analyses were performed. Cox's regression models estimated univariate and multivariate hazard ratios for each predictor of interest.¹⁰ Only variables that had prognostic significance in the univariate analysis were included in the multivariate model. Variables for which the proportion of missing data exceeded 20% were excluded from the multivariate analysis. Overall survival and local recurrence-free survival were calculated according to the Kaplan-Meier method.¹¹ Five- and ten-year survival rates were also calculated for the above metrics. An independent samples *t*-test was used to determine whether or not there was a significant difference in the mean values between patients. Other differences between groups were evaluated using Fisher's exact test or the Mann-Whitney test as appropriate. Analyses were conducted using SPSS version 14.0 (SPSS, Inc., Chicago,

Table I. Characteristics of the 234 patients included in the study

	Number (%) [*]
Decade of diagnosis	
1970 to 1979	5 (2.1)
1980 to 1989	58 (24.8)
1990 to 1999	111 (47.4)
2000 onwards	60 (25.6)
Males:females	138:96
Metastasis at diagnosis	35 (15.0)
Mean age (years) (SD)	45.2 (19.4)
Previous malignancy	15 (6.4)
Mean size of tumour (cm) (SD)	10.4 (6.0)
Extremity:trunk	204:30
Site in long bones (n = 201)	
Proximal	76 (37.8)
Distal	114 (57.6)
Middle	11 (5.5)
Pathological fracture	59 (25.2)
Histological type	
Spindle cell sarcoma	97 (41.5)
Malignant fibrous histiocytoma	76 (32.5)
Leiomyosarcoma	30 (12.8)
Fibrosarcoma	20 (8.5)
Angiosarcoma	11 (4.7)
Grade (n = 183)	
I	8 (4.4)
II	19 (10.4)
III	156 (85.2)
Treatment with curative intent	196 (83.8)
Limb-salvage:amputation (n = 218)	172:46
Surgical margins	
Wide	106
Marginal	47
Involved	29
Use of chemotherapy	169 (72.2)
Good response to chemotherapy	36 (31.9)

^{*} All numbers represent the available data. Percentages were calculated from available data

Fig. 2

Histogram showing the distribution of the 234 patients included in the study.

spindle cell tumour after radiotherapy and ten had an unrelated previous malignancy. The mean tumour size was 10.4 cm (3 to 50). The most common site affected was the distal femur in 96 patients (41%), followed by the proximal tibia in 32 (13.7%), proximal femur in 32 (13.7%), pelvis in 26 (11.1%) and the proximal humerus in ten patients (4.3%). In all, 59 patients (25.2%) presented with a pathological fracture at diagnosis; patients with a tumour in the proximal femur were at the greatest risk of fracture (17 of 32 patients, 53%). Nine of the 234 patients were judged to have low-grade tumours (3.8%); the remainder were high grade.

The most common histological diagnosis (at the time) was spindle cell sarcoma in 97 patients, malignant fibrous histiocytoma (MFH) in 76, leiomyosarcoma in 30, fibrosarcoma in 20 and angiosarcoma in 11. There was a significant change in the frequency of these diagnoses over the duration of this study (Fig. 3).

Of the 35 patients with metastases at the time of diagnosis, 28 had chemotherapy and 17 also had resection of the primary; five had surgery but no chemotherapy, and two had palliative radiotherapy only. Their median survival was 21 months, with an 8% five-year survival rate. Only one patient is still alive after resection of the primary tumour (which was completely necrotic) and concurrent resolution of the lung metastases, which have not reappeared after 73 months.

Three patients received palliative care only: one with an inoperable 24 cm radiation-induced spindle cell sarcoma of the chest wall and two with large and inoperable pelvic tumours. All three died within five months of diagnosis.

Treatment with the intent to cure was therefore undertaken in 196 patients without metastases at diagnosis. In general, patients under the age of 65 received chemotherapy and surgery, whereas those over 65 were treated by surgery alone.

Illinois). All p-values were two-tailed, and those < 0.05 were considered statistically significant.

Results

The characteristics of eligible patients are shown in Table I.

A review of the oncology database identified 3012 patients with a primary bone sarcoma, of whom 234 (7.8%) fitted the diagnosis of a spindle cell sarcoma and had full clinical and follow-up data. Of these, 35 (15%) had metastases at diagnosis. Five patients were diagnosed between 1970 and 1979 and represented 5.5% of all bone sarcomas diagnosed in that period; 58 were diagnosed between 1980 and 1989 (9.5% of all bone sarcomas), 111 between 1990 and 1999 (10.6% of all) and 60 from 2000 onwards (7.5% of all). The median age of the patients was 45 years, but their ages ranged widely, from seven to 87 (Fig. 2). The male to female ratio was approximately 1.5:1 (138 males and 96 females); 14 patients (6%) reported a history of previous malignancy, four of whom developed a

Fig. 3

Chart showing frequency of diagnoses over the different periods of the study (MFH, malignant fibrous histiocytoma).

Chemotherapy was given to 140 of the 196 patients: 133 of the 159 (84%) under the age of 65 years, but only seven of the 37 (19%) who were over 65. Of the 26 patients under the age of 65 who did not have chemotherapy, four had a low-grade tumour, four had associated disease that prevented the use of chemotherapy, and the remaining 18 were treated before chemotherapy was used routinely in the management of spindle cell sarcomas. The main chemotherapy regimen administered was the same as that being used for osteosarcoma at the time, and was a combination of doxorubicin and cisplatin. More recently, some patients were treated with multidrug regimens as for osteosarcoma, using doxorubicin, cisplatin, ifosfamide and methotrexate. Of the 140 patients who had chemotherapy, 102 (73%) had it pre- and post-operatively, and the rest had it post-operatively only, as was the case in the early years of this study. The histological response to pre-operative chemotherapy was recorded as good (> 90%) in 36 (31%) patients who had their response assessed. In patients under the age of 40, 23 (37%) had a good response, whereas 12 (26%) of those over 40 and under 65 had a good response. One patient with good response to chemotherapy was over 65. We could not identify any difference in response to the different regimens.

Of the 196 patients, 194 underwent a surgical procedure. The other two patients deteriorated while having chemotherapy and died before surgery could be carried out. A limb salvage procedure was carried out in 154 patients (79%) and 40 (21%) had an amputation. Of the 52 patients with a pathological fracture, 16 (31%) underwent amputation, compared with 24 of the 142 (17%) without a fracture ($p = 0.03$). Data on surgical margins

were only available for 162 patients, as these had not routinely been reported before the mid-1980s when Enneking's definitions¹² became widely accepted. The surgical margins were wide in 96 (60%) patients, marginal in 41 (25%) and involved in 25 (15%).

Prognostic factors related to survival. The mean follow-up was 90 months (1 month to 29 years). Of the 196 patients with non-metastatic disease who had undergone definitive treatment, the overall five- and ten-year disease-specific survival rates were 67.0% and 60.0%, respectively. On univariate analysis the factors that were statistically significant for decreased survival were older age, tumour size > 8 cm, the presence of a pathological fracture, the need for amputation, involved surgical margins and a poor response to pre-operative chemotherapy (Table II). Although there were only nine patients with low-grade tumours, their survival was not statistically different from that of those with high-grade tumours. On multivariate analysis, age, amputation and involved surgical margins were significantly associated with the risk of death (Table II). No other factor was associated with survival on multivariate analysis, although size and response to chemotherapy were excluded from these analyses owing to the extent of missing data.

The development of local recurrence was associated with a 2.5-fold increased risk of death ($p < 0.001$). Among patients who developed both metastasis and local recurrence, those who developed them at different times (regardless of the sequence) were three times less likely to die than those who developed them synchronously ($p = 0.04$). There was no difference in outcome between patients with different pathological diagnoses (Fig. 4).

Table II. Univariate and multivariate analyses of prognostic factors for survival in patients with spindle cell sarcoma of bone treated with curative intent (CI, confidence interval)

	Univariate analysis hazard ratio (95% CI)	p-value	Multivariate analysis hazard ratio (95% CI)	p-value
Decade of diagnosis (Reference: 1970 to 1979)				
1980 to 1989	0.61 (0.21 to 1.78)	0.37		
1990 to 1999	0.48 (0.16 to 1.41)	0.18		
2000 onwards	0.49 (0.16 to 1.55)	0.23		
Female	0.87 (0.55 to 1.36)	0.53		
Age (per year)	1.02 (1.01 to 1.04)	< 0.001		
Age category (Reference: < 40 years)				
40 to 65 years	1.72 (1.02 to 2.90)	0.04	1.32 (0.72 to 2.44)	0.37
> 65 years	3.20 (1.76 to 5.81)	< 0.001	2.62 (1.33 to 5.16)	0.006
Previous malignancy	1.39 (0.56 to 3.43)	0.48		
Size > 8 cm*	2.41 (1.00 to 5.83)	0.05		
Site (Reference: Extremity)				
Trunk	1.36 (0.72 to 2.57)	0.35		
Site in long bones (Reference: Proximal)				
Distal	0.88 (0.53 to 1.46)	0.63		
Medial	0.74 (0.22 to 2.45)	0.62		
Pathological fracture	1.94 (1.23 to 3.08)	0.005		
Histological type (Reference: Spindle cell sarcoma)				
Malignant fibrous histiocytoma	1.25 (0.74 to 2.12)	0.41		
Leiomyosarcoma	0.80 (0.34 to 1.85)	0.60		
Fibrosarcoma	1.42 (0.68 to 2.98)	0.35		
Angiosarcoma	1.91 (0.66 to 5.49)	0.23		
Grade (Reference: Grade I)				
Grade II	1.26 (0.26 to 6.27)	0.77		
Grade III	1.34 (0.32 to 5.52)	0.69		
Type of surgery (Reference: Limb Salvage)				
Amputation	1.99 (1.23 to 3.21)	0.005	2.09 (1.20 to 3.65)	0.009
Surgical margins (Reference: Wide)				
Marginal	1.09 (0.59 to 2.01)	0.79	1.02 (0.54 to 1.92)	0.96
Involved	2.66 (1.48 to 4.77)	0.001	2.35 (1.28 to 4.32)	0.006
Use of chemotherapy	0.68 (0.43 to 1.08)	0.10		
Poor response to pre-operative chemotherapy*	5.97 (1.79 to 19.87)	< 0.001		

* size > 8 cm and poor response to pre-operative chemotherapy were not included in the multivariate analysis because of the amount of missing data

Prognostic factors related to the risk of local recurrence. Local recurrence occurred in 30 patients (17.1%) during the follow-up period. The mean time to recurrence was 23 months (3 to 140) and it was significantly related to the margins of excision and the percentage necrosis after chemotherapy (Table III). Patients with a clear surgical margin and > 90% tumour necrosis had a 4.5% risk of local recurrence. Patients with a marginal or involved margin and < 90% necrosis had a 43% risk of local recurrence. Patients with a pathological fracture did not have a greater risk of local recurrence than those without a fracture ($p = 0.91$).

Comparison with osteosarcoma. These results have been compared with those for patients with osteosarcoma treated at our hospital over the same period and using the same protocol (i.e. similar chemotherapy regimens and surgical decision making). We calculated the overall survival rates for patients with a spindle cell sarcoma of bone in two age categories (40 years or under and > 40 years) based on the previously published results of patients with an osteo-

sarcoma. The five- and ten-year survival rates of patients aged 40 years or less with a spindle cell sarcoma of bone were 74.7% and 71.9%, respectively. These results compare favourably with those for patients treated for osteosarcoma during the same period who received similar chemotherapy in one of the sequential European Osteosarcoma Intergroup trials: these reported five-year survival rates of 53% for patients under the age of 40 with a non-metastatic limb osteosarcoma.¹³⁻¹⁵

In patients over the age of 40 with a spindle cell sarcoma, the five- and ten-year survival rates were 59.7% and 50.3%, respectively. These compare with the five- and ten-year overall survival figures for patients over the age of 40 years with osteosarcoma, of 46% and 33%, respectively.¹⁶ Based on the results of our study, and when matched for age, patients with a spindle cell sarcoma who were treated at our institution over the past 25 years have had a better rate of survival than those who had an osteosarcoma.

Fig. 4

Kaplan-Meier survival curve showing the similarity in disease-specific survival of the four main types of spindle cell sarcoma of bone (MFH, malignant fibrous histiocytoma).

Discussion

Spindle cell sarcomas of bone are a heterogeneous group of primary malignant bone tumours that do not fulfil the histological criteria for a diagnosis of osteosarcoma, chondrosarcoma or Ewing's sarcoma. Little is known about their behaviour and the factors associated with their outcome. Most published studies have described specific types of spindle cell sarcomas of bone and are either case reports or case series limited by sample size, and do not evaluate prognostic factors.^{8,17-21}

A paper from the Mayo Clinic reported 225 fibrosarcomas of bone diagnosed over an 85-year period, but only 92 patients with available clinical and follow-up data were analysed.² The reported disease-free survival for the whole group at five years was 28%, but increased to 45% for patients diagnosed after 1980. The five- and ten-year survival rates were 33.4% and 29%, respectively, and older age, location in the axial skeleton, grade, stage, surgical margins and type of surgical procedure significantly affected overall survival. A study of 81 patients from the same institution reported that the overall prognosis for patients with MFH was not significantly different from that described for patients with osteosarcoma.⁵ Surgical margins were the only factor associated with prognosis. Huvo et al⁴ found that the five-year survival of the 130 patients included in their study of MFH was 53%, and that high grade, older age and the presence of metastases were associated with reduced survival. The use of chemotherapy has also been reported to be associated with a favourable outcome in MFH.^{3,22-24} Capanna et al³ reported a 34% five-year and 28% ten-year survival rate and, apart from the use of chemotherapy, the status of the surgical margin was also a significant predictor. Bielack et al²²

reported a 59% five-year disease-free survival among the 125 patients with MFH included in their study.

Our study is the largest series of patients with this rare type of bone tumour which has been evaluated to date, and reports the factors associated with their outcome. The five- and ten-year survival rates for the 196 primary spindle cell sarcomas of bone that had not metastasised at the time of diagnosis and were treated with the intent to cure were 67% and 60%, respectively. The prognostic factors associated with decreased survival were similar to those in other comparable series, and to those of patients with an osteosarcoma: large tumour size, older age, pathological fracture, need for amputation and poor response to pre-operative chemotherapy were all significant: risk factors for local recurrence were also similar to those in patients with an osteosarcoma: close surgical margins and poor response to pre-operative chemotherapy were the two most significant factors.

Some limitations of this study should be acknowledged. First, we have deliberately reported the results of patients using the pathological diagnosis made at the time and agreed by the multidisciplinary group at our centre. Given the change in nomenclature that has happened over the years, some diagnoses have become almost entirely extinct (e.g. MFH and fibrosarcoma). We have, however, shown that in this population, no matter what diagnostic label is applied, patients appear to have an identical outcome when treated in the same way. This suggests either that the precise diagnosis is immaterial and they should all be classified as 'spindle cell sarcoma of bone', or that current methods of differentiating between the different pathological entities are not sufficiently sophisticated to affect treatment or outcome. Histological review and confirmation of the

Table III. Univariate and multivariate analysis of prognostic factors for the risk of local recurrence in patients with spindle cell sarcoma of bone treated with curative intent (CI, confidence interval)

	Univariate analysis hazard ratio (95% CI)	p-value	Multivariate analysis hazard ratio (95% CI)	p-value
Decade of diagnosis (Reference: 1970 to 1979)				
1980 to 1989	0.29 (0.06 to 1.37)	0.12		
1990 to 1999	0.38 (0.09 to 1.68)	0.20		
2000 onwards	0.59 (0.13 to 2.69)	0.49		
Female	0.59 (0.29 to 1.19)	0.14		
Age (per year)	1.00 (0.97 to 1.02)	0.67		
Age category (Reference: < 40 years)				
40 to 65 years	1.09 (0.53 to 2.22)	0.82		
> 65 years	0.21 (0.47 to 3.14)	0.70		
Previous malignancy	1.07 (0.26 to 4.47)	0.92		
Size > 8 cm*	1.48 (0.55 to 3.94)	0.43		
Site (Reference: Extremity)				
Trunk	1.51 (0.59 to 3.88)	0.40		
Site in long bones (Reference: Proximal)				
Distal	1.36 (0.62 to 2.98)	0.45		
Medial	0.74 (0.09 to 5.84)	0.77		
Pathological fracture	1.17 (0.56 to 2.42)	0.68		
Histological type (Reference: Spindle cell sarcoma)				
Malignant fibrous histiocytoma	0.76 (0.35 to 1.63)	0.48		
Leiomyosarcoma	0.36 (0.08 to 1.58)	0.18		
Fibrosarcoma	0.90 (0.30 to 2.74)	0.86		
Angiosarcoma	2.31 (0.67 to 8.01)	0.19		
Grade (Reference: Grade I)				
Grade II	0.64 (0.15 to 2.68)	0.54		
Grade III	0.34 (0.10 to 1.16)	0.10		
Type of surgery (Reference: Limb salvage)	0.50 (0.18 to 1.40)	0.19		
Amputation				
Surgical margins (Reference: Wide)				
Marginal	1.66 (0.71 to 3.89)	0.25	1.65 (0.47 to 5.86)	0.44
Involved	2.89 (1.19 to 7.02)	0.02	7.55 (2.41 to 23.62)	0.001
Use of chemotherapy	1.13 (0.53 to 2.39)	0.76		
Poor response to pre-operative chemotherapy*	5.79 (0.30 to 6.13)	0.02	5.69 (1.23 to 26.36)	0.03

* size > 8 cm and poor response to pre-operative chemotherapy were not included in the multivariate analysis because of the amount of missing data

diagnosis using contemporary histochemistry may well alter the precise diagnosis of many of the tumours in this group, but we believe that it is unlikely to alter our results, as they were similar in all diagnostic categories. This will be the subject of future research.

Our proportion of marginal and intralesional resections was higher than might be considered acceptable, but our definitions are probably stricter than those of many other units and have been used consistently for over 25 years. Although our definition of wide and marginal would in many units be considered an R0 resection, most of the intralesional resections would also be classified as R1. Therefore, using our definitions, a tumour close to the neurovascular bundle could only ever be removed with a marginal excision, whereas many units would consider that a margin with 1 mm of normal tissue could be described as wide.

Despite the fact that this study is the largest in the literature, it is still of limited sample size and possible associations could have been missed, especially with respect to histological subtype and the subtle advantages of one type of chemotherapy over another.

Primary spindle cell sarcomas of bone are usually of high grade and behave in a similar manner to osteosarcomas when matched for age, although possibly with a slightly better outcome. They have a high incidence of pathological fracture, and the behaviour of all histological subtypes seems to be the same, owing to a lack of osteoid formation, and they are therefore more likely to be lytic. These patients should be treated in the same way as those with an osteosarcoma, with pre-operative chemotherapy and wide surgical resection. Most of the classic prognostic factors that have been identified for osteosarcoma seem to apply to spindle cell sarcoma.

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