Diagnostic procedures and surgical treatment of bone sarcomas

Experience from the Scandinavian Sarcoma Group and Karolinska Hospital

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In 1979, the year when Scandinavian Sarcoma Group (SSG) was created, treatment of patients with osteosarcoma and Ewing's sarcoma was most often amputation. The diagnostic and preoperative tools were plain radiographs and sometimes CT and/or angiography. Histopathologic diagnosis was achieved by open biopsy. In the few cases treated by a local excision, reconstruction was performed with allografts or joint prostheses. The local recurrence rate after local excision of osteosarcoma was sometimes as high as 30% (Bauer et al. 1989). Despite these surgical efforts, most patients died in metastatic disease. At this time, Dr. Gerald Rosen had started adjuvant multidrug chemotherapy of patients with osteosarcoma or Ewing's sarcoma (Rosen at al. 1975, Rosen et al. 1981). At the Karolinska Hospital, Dr. Hans Strander used human leucocyte interferon, instead of chemotherapy, as an adjuvant treatment after surgery in patients with osteosarcoma (Strander 1977).

In this presentation, we will focus on the progress, over the last 25 years, in the diagnostic procedures and surgical treatment of patients with osteosarcoma and Ewing's sarcoma in Scandinavia and our policy at the Karolinska Hospital.

Diagnostic work-up

Imaging

At the Karolinska hospital, the first MRI-equipment was installed in 1983 for investigations of the brain. In 1986, the first patient with a sarcoma was investigated using MRI. It was early obvious that MRI, more clearly than CT, showed the anatomical extent of bone sarcomas, i.e. the soft tissue extension and proximity to important anatomical structures such as joints, nerves and vessels. With MRI the exact intramedullary extension of a lesion and possible skip lesions are visualized, permitting safe limb sparing and sometimes even joint saving surgery (Figure 1). In most textbooks of orthopedic tumor surgery both MRI and CT are recommended

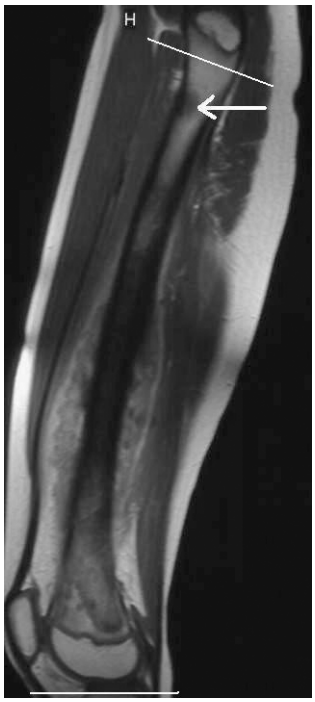


Figure 1. Preoperative MRI of a 10-year-old boy with an extensive osteosarcoma in mid/distal femur and with a skip lesion in proximal femur (arrow). The planned osteotomies for van Ness rotationplasty are outlined proximally and distally.

Table 1. Surgical procedure and local recurrence rate for osteosarcoma patients in Scandinavia

Treatment protocol	Treatment period	n	Limb salvage rate	Local recurrence rate
SSG II	1982–1990	107	27%	6%
SSG VIII	1990–1997	116	57%	7%
ISG/SSG I	1997–2000	54	>90%	0%

Local recurrence rate for ISG/SSG I patients is preliminary as 5 year follow-up will be completed 2005.

Table 2. Number of limb salvage procedures in children (<16 years) with extremity localized osteosarcoma reported from University Hospitals to the SSG Register 1986–2002

Center		n
Norway	Radiumhospital, Oslo	23
	Bergen	8
	Trondheim	3
Sweden	Karolinska, Stockholm	32
	Lund	9
	Sahlgrenska, Gothenburg	8
	Linköping	2
	Umeå	1
Finland	Turku	4
	Helsinki	5
	Koupio	1
Total		96

for diagnosis and preoperative planning. We have not found that CT gives additional information over MRI and plain radiographs and therefore almost never perform CT of bone lesions.

Fine needle aspiration biopsy (FNAB)

Dr. Sixten Franzén introduced FNAB in the diagnosis of prostate cancer more than 40 years ago (Franzén et al. 1960). This fast, nontraumatic, outpatient procedure has during the last 20 years been utilized in both soft- and bone lesions. The reliable results in clinical practice have been shown in several studies (Kreicbergs et al. 1996, Åkerman 1997, Wedin et al. 2000). FNAB is generally accepted at most Scandinavian centers for the diagnosis of soft tissue tumors. In several sarcoma centers in Scandinavia, FNAB is also the first and often only method to reach a conclusive diagnosis of high-grade osteosarcoma. In our experience, a safe diagnosis can be reached without open biopsy in 2 of 3 osteosarcomas by combining clinical, radiological and cytological features. In the remaining cases, when the radiological diagnosis is not typical, cytology must be supplemented with an open biopsy to reach a conclusive diagnosis (Söderlund et al. 2004).

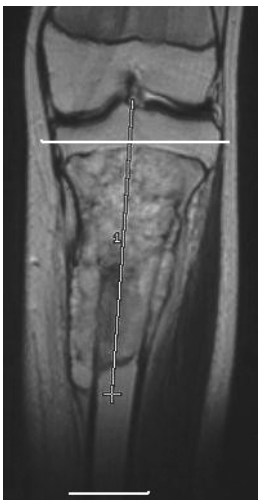
The cytological diagnosis of Ewing's sarcoma is now proven by showing the specific t(11;22) translocation. Open biopsy is not indicated in Ewing's sarcoma unless molecular or cytogenetic studies are inconclusive.

Surgical treatment

Osteosarcoma

The effectiveness of preoperative chemotherapy and imaging was a prerequisite for successful limb sparing surgery in osteosarcoma. In Scandinavia there was still in the late 80s and early 90s a reluctance to accept limb sparing surgery as it was not considered oncologically safe. The reconstructive methods, mostly massive endoprostheses or allografts, were considered to provide poor function and associated with a high rate of secondary procedures. Hence, patients would be better off with a primary amputation as a definitive and only surgery. In the first SSG treatment protocol for osteosarcoma (SSG II 1982–1990) the limb-sparing rate was only 27%. In the second SSG protocol (SSG VIII 1990–1997) limb sparing surgery became gradually more commonly used, 57%. With the ISG/SSG I protocol 1998, limb sparing surgery was generally adopted in Scandinavia, so that the rate was more than 90%. The over-all local recurrence rates have in all these three treatment protocols been lower that 10%, proving that limb-sparing surgery is oncological safe (Table 1).

In Scandinavia, limb-sparing surgery was performed at 11 centers for 96 children (aged 3–16 years) between 1990 and 2002 (Table 2). Only 2 centers had operated more than one child per year! Further development of reconstructive limb-sparing surgery in children may be achieved by centralization of the surgical treatment to one center in each Scandinavian country. Likewise, chemotherapy for these children may best be centralized in this way.



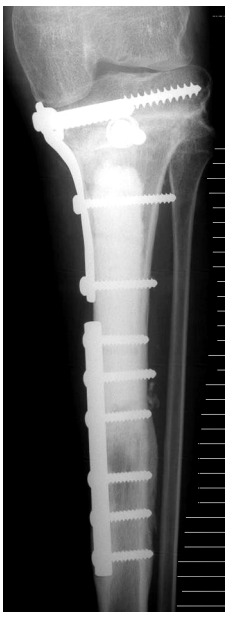


Figure 2. Preoperative MRI of an 11-year-old girl with an osteosarcoma in proximal tibia. A knee joint-saving local excision is possible and the planned osteotomies are outlined through the 9 years later after successful allograft reconstruction. She has virtually normal

Ewing's sarcoma

The place for surgical treatment in Ewing's sarcoma remains unclear. In the 80s, surgical treatment again became popular as late local recurrences were seen after only chemotherapy and radiotherapy. In both SSG treatment protocols for Ewing's sarcoma (SSG IV 1984–1990 and SSG IX 1990–1999) two thirds of the patients were operated. However, in the first protocol 37% were amputated compared to only 13% treated according to SSG IX. The local recurrence rate for patients treated according to SSG IV was 19% and that for SSG IX 10%. We have treated 13 patients for pelvic Ewing's sarcoma since 1990. 5 patients were treated with radiotherapy and 8 surgically, but 6 of these were given preoperative radiotherapy. The indication for preoperative radiotherapy was presence of soft tissue extension after completion of preoperative chemotherapy. We have not noted any complications due to the radiotherapy, i. e. no postoperative infections, and there have been no local recurrences. As for osteosarcoma, the complicated multimodal treatment of Ewing's sarcoma should perhaps be given in only few centers in Scandinavia.

Reconstruction

For extremity bone sarcoma, custom-made or modular endoprostheses have mostly been used. At the Karolinska Hospital we used massive osteoarticular allografts in the early 90s. Most were revised because of stress fractures, arthrosis or joint instability. Allografts are now only used for intercalary defects. With improved imaging and better preoperative chemotherapy we have been able to reduce the surgical margin without increasing the local recurrence rate. Therefore joint sparing surgery has become feasible in selected cases leading to virtually normal function (Figure 2).

In Scandinavia the van Ness rotationplasty was first popularized in Bergen but is now performed at several centers. We have performed rotationplasties in 6 children (age 4–11 years), all with osteosarcoma of the distal and/or mid femur (Figure 3). All are now walkers and function and acceptance by the child and parents appears good. We consider this to be the best method for children under 10 years, and also for older children with extensive tumors. Expandable endoprostheses have only been used in singular cases in Scandinavia.

Modular endoprostethic replacement for bone sarcomas around the knee, proximal femur and humerus provide good function with a low rate of secondary amputations due to local recurrence or prosthetic failures. There are problems with loosening of the femoral component (approximately 5% at 5 years) but these appear manageable with restoration of function after revision. Newer prosthetic designs with a rotating hinge mechanism in the knee may further improve function and lower the rate of loosening (Figure 4). In the humerus, endoprostheses only function as a spacer and active shoulder function is seldom restored. In this reconstruction, there is instead a problem with shoulder joint instability. Shoulder joint fusion with a fibular graft has been used in Gothenburg for many years with good functional results. We have in children used vascular fibula grafts which have retained shoulder stability and also active range of motion (Figure 5). Composites of massive allografts and conventional shoulder endoprostheses have only been used in singular cases.

Massive allografts or custom made endoprostheses for reconstruction in pelvic bone sarcomas are associated with unacceptable failure rates and

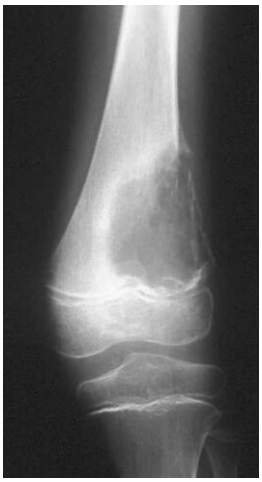
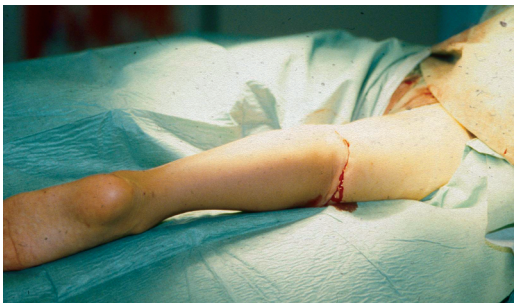
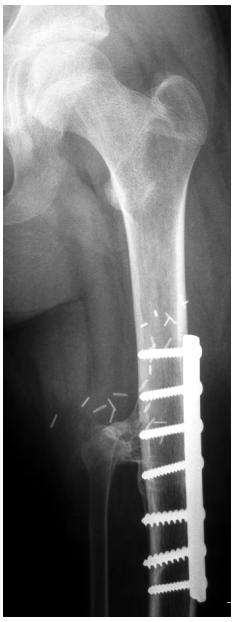


Figure 3. 8-year-old boy with an osteosarcoma in distal femur close to the epiphysis.



Perioperative picture after a van Ness rotationplasty.



5 years later. The boy is physically active and is even roller-skating.

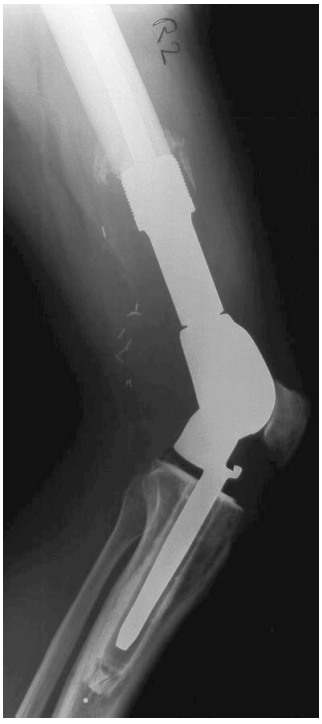


Figure 4. 6 weeks after reconstruction of distal femur with a Modular Tumour System (METS) rotating hinge knee prosthesis from Stanmore Implants, London. The hydroxyapatite collar can be seen proximally, already with some

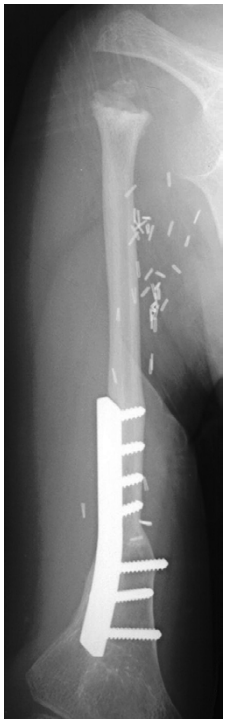


Figure 5. 2 years after successful reconstruction of more than half of the humerus of a 7-year-old boy with an osteosarcoma. The vascularized, proximal fibula with cartilage, epiphysis, and physis proximally is growing and the boy has active elevation/abduction.

have not been used in Scandinavia. We have instead tried reconstruction with minimal use of reconstructive material to lower the complication rate. Hip arthrodesis provides good function but is often not feasible. Transplantation of fibula, lengthening of the femur, or leaving the femur with a flail joint are possibilities, which are safer short and long-term, with acceptable functional results (Figure 6).

Metastatic osteosarcoma

The persistency in surgical treatment of lung metastases has increased during the last 20 years. Lung metastases evident at diagnosis or discovered during follow-up are removed surgically whenever feasible. At the Karolinska Hospital, surgical treatment of the primary tumor and thoracotomy with excision of lung metastases is performed after completion of preoperative chemotherapy. During the last 10 years, 8 patients with osteosarcoma presented with lung metastases at diagnosis. 2 had widespread disease and died early, the

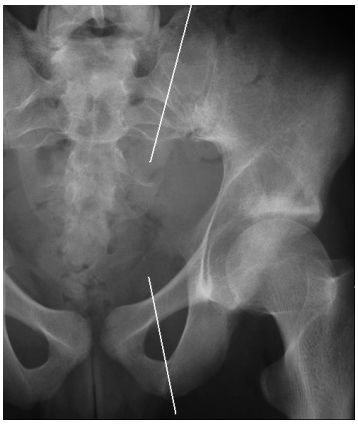
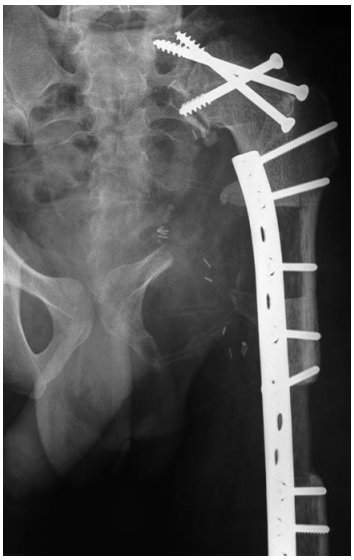


Figure 6. An 18-year-old boy with a Ewing's sarcoma in left hemipelvis. The planned osteotomies through sacrum and os pubis are outlined.



7 years after pelvic resection, femoral lengthening and sacrofemoral pseudartrosis. He is walking with one cane and without pain.

remaining 6 were operated for primary tumor and metastases simultaneously. We have not found that this procedure increases the complication rate.

Conclusion

The surgical treatment for osteosarcoma and Ewing's sarcoma has evolved tremendously during the last 20 years. Limb-sparing surgery for a 15-year-old child with an osteosarcoma of the distal femur is no longer experimental surgery. We can assure the child and parents that the cancer can be totally removed with preserved function. However, the low incidence of bone sarcomas, the large age span of bone sarcoma patients, and the many different locations, makes each type of reconstructive procedure rare. Continued development and assessment of reconstructive procedures in Scandinavia will only be assured by further centralization of the surgical treatment of patients with osteosarcoma and Ewing's sarcoma.

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