MODIFIED VAN NES ROTATIONPLASTY FOR
OSTEOSARCOMA OF THE PROXIMAL TIBIA IN CHILDREN

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Above-knee amputation has been the traditional treatment for osteosarcoma of the proximal tibia. Recent advances in chemotherapy have encouraged the development of limb-salvage techniques. Van Nes rotationplasty for malignant lesions of the distal femur has increased in popularity as a reconstructive technique, but no similar procedure has been described for lesions of the proximal tibia.

We have developed a modified rotationplasty for this lesion and have performed it in four children. The surgical technique, postoperative management and results of the procedure are described. Two patients had delayed wound healing. No other complications have developed and our patients were disease-free at follow-up, while the appearance of the leg was well accepted by the patients and their parents.

This procedure is a useful addition to the armamentarium of the tumour surgeon for the treatment of malignant lesions of the proximal tibia.

Above-knee amputation has been the traditional treatment for osteosarcoma and other malignant tumours of the proximal tibia. However, with the advent of adjuvant chemotherapy, limb-salvage procedures have gained in popularity, without compromising long-term survival rates (Rosen et al 1976; Campanacci et al 1980; Watts 1980; Bleyer et al 1982; Schajowicz 1983; Simon et al 1986). The limb-salvage procedures used in adults and adolescents, such as resection-arthrodesis and prosthetic replacement, present a number of problems in young children. Implant failure and leg length discrepancy can be expected if these procedures are performed in growing, active children.

Kotz and Salzer (1982) and Jacobs (1984) used the Van Nes rotationplasty for the treatment of osteosarcoma of the distal femur and had satisfactory results in terms of patient acceptance and functional ability. Instead of an above-knee amputation, the patient is provided with a functional below-knee stump which is desirable from the standpoint of energy cost (Waters et al 1976). As was shown by Murray et al (1985), these patients can function quite well, out-performing those with above-knee amputations because they have better control of their prosthetic knee. The patient with a rotationplasty is also capable of bipedal walking without the prosthesis, another advantage over the above-knee amputee.

Winkelmann (1986) showed that rotationplasty can be used for osteosarcoma of the proximal femur but no one has described its use for osteosarcoma of the proximal tibia. Since 1985 we have performed four modified rotationplasties for osteosarcoma of the proximal tibia in children. This paper presents the indications, the technique, and the results of the procedure in these patients.

PATIENTS AND METHODS

Modified rotationplasties were performed for stage IIb osteogenic sarcoma of the proximal tibia in four children (Table 1). In each patient the extent of the tumour was

| Table 1. Clinical data of four patients each with stage IIb osteosarcoma of the proximal tibia |
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| Case | Age (yr) at surgery | Sex | Length of follow-up (mth) | Range of motion (degrees) | Complications |
| 1 | 6 | F | 36 | 70 | None |
| 2 | 9 | M | 24 | 40 | Skin breakdown |
| 3 | 8 | M | 14 | 30 | Delayed wound healing |
| 4 | 13 | M | 14 | 30 | None |
estimated by bone scan and computed tomography (CT) and each had open biopsy. Magnetic resonance imaging was also used in the more recent two patients and was extremely helpful in determining the longitudinal extent of the tumour. CT scans of the chest and bone scans were used to diagnose metastatic disease. Each child received pre-operative and adjuvant postoperative chemotherapy, according to the protocol of our oncology department.

Appropriate length (Krajbich 1987). The level of the Van Nes 'knee' needs to be more distal initially (Fig. 1), so that with normal growth of the opposite leg the knees will be at the same level at skeletal maturity.

3. The tibial nerve must be preserved. Division of the nerve would leave the patient with an anaesthetic stump, since the plantar aspect of the foot corresponds to the anterior aspect of the stump. This might lead to prosthetic problems and is a contra-indication to rotationplasty. However, the deep peroneal nerve, which supplies the skin on the dorsum of the first web space of the foot, may be divided if necessary without compromising function.

4. All the vessels of the leg may be sacrificed at the level of the tumour if necessary and later re-anastomosed to their distal extensions.

5. All the muscles of the calf are resected, leaving their distal tendons for later suturing to the muscles of the thigh.

6. The psychological outlook of the patient and his or her family must also be considered in the process of deciding whether or not to perform a rotationplasty. We have found the procedure to be well accepted by our patients, but others have expressed concern about the psychological problems that may arise from the unusual appearance of the rotated foot (Kostuijk et al 1975; Fixsen 1983).

**General principles.** The accepted principles of good tumour surgery are as follows (Enneking, Spanier and Goodman 1980):

1. The resection must allow radical or wide margins of excision. It is the opinion of Watts (1980) and others (Rosen et al 1976; Simon et al 1986) that en bloc excision for osteogenic sarcoma adequately provides these margins, as long as the resection is made well beyond the extent of the lesion as determined by modern radiographic techniques. For rotationplasty, there must be sufficient bone free of tumour distal to the lesion as well; distal tibial involvement is, therefore, a contra-indication.

2. Careful pre-operative planning is required to determine the level of resection and to decide which structures must be sacrificed and which can be preserved. The amount of bone resected depends upon the age of the patient and the predicted growth which will produce a thigh of
Surgical technique. The patient is positioned supine on the operating table and a disposable sterile tourniquet is applied and inflated. We used two elliptical circumferential incisions to produce a rhomboidal area of skin to be resected with the tumour mass, much as described by Kotz and Salzer (1982). The rhomboid is not symmetrical, as the proximal incision is placed more vertically than the distal one, to compensate in part for the discrepancy between the circumferences of the thigh and the leg. The ceps tendon is sectioned, together with the vastus medialis and lateralis, in a V-like fashion. The distal femur and the distal tibia are then divided as planned and the resected specimen is removed and submitted for pathological examination.

The distal segment is turned through 180° and osteosynthesis is carried out. Vascular anastomoses are performed as necessary and the nerves and vessels are coiled among the muscles to avoid acute kinks. The thigh incisions are made approximately 5 cm distal to, and proximal to, the planned resection levels, and are extended proximally and distally in a longitudinal fashion to allow adequate exposure for the dissection.

The sartorius, gracilis and hamstring muscles are divided approximately 5 cm from their insertions and labelled. The medial and lateral heads of the gastrocnemius are detached from their origins on the distal femur. This facilitates exposure of the neurovascular bundle in the proximal part of the popliteal fossa. Vessels and nerves are then sacrificed as necessary, or dissected free and preserved as planned pre-operatively. The anterior tibial artery has almost always to be divided at its origin and frequently the deep branch of the peroneal nerve also. The structures to be sacrificed are then divided distally. The tendons which control the ankle and foot are identified, labelled and divided. Finally, the quadri-

Case 1. Level gait with a prosthesis 29 months after a modified Van Nes rotationplasty. The patient could climb and descend stairs in step-over-step fashion.

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therapy is resumed 10 days to two weeks after the surgical procedure. The plaster cast is maintained for four to six weeks to allow for tendon healing, and then discarded. Gentle passive and active exercises are then begun. Movement in the new knee (ankle) is initially quite limited; but with time and continued exercise, improvement occurs in both range of motion and strength, providing eventually a useful joint. Prosthetic fitting is carried out 10 to 14 weeks after the operation; however, full function in the prosthesis is not achieved until at least six months to one year later.

Early results. The early results are given in Table I. Two patients had wound problems, but at present all four are free of disease.

DISCUSSION

The treatment of malignant tumours of the proximal tibia by above-knee amputation, resection arthrodesis of the knee, or internal prosthetic joint replacement, all leave young patients functionally disabled. The importance of the knee cannot be overstated. From the point of view of energy consumption, Waters et al. (1976) showed that patients with below-knee amputations outperformed those with above-knee amputations and Murray et al. (1985) demonstrated that their patients with rotationplasty were better able to participate in normal activities such as running and climbing stairs than patients with above-knee amputations. It is in the performance of these activities that most conventional limb-sparing procedures are a disappointment. Even those techniques which utilise internal prostheses to preserve knee motion are sometimes hampered by insufficient quadriceps power. Certainly, the quadriceps mechanism must be largely preserved for these procedures to be successful.

The morbidity of the various limb-sparing techniques needs to be considered in assessing their value. The longevity of an internal knee prosthesis, and the level of activity which can be allowed without causing early mechanical failure of the implant are major concerns with this form of treatment, especially in children. Allograft replacements are associated with high rates of infection and fracture. Neither resection-arthrodesis nor prosthetic joint replacement address the problem of leg-length discrepancy in young children. Our technique, which takes into account the growth potential predicted by Moseley’s graphs (Krajbich, 1987), helps with this problem, so that at skeletal maturity the normal knee and the new knee of the affected leg can end up at the same level. Precise leg length is readily adjusted by the below-knee prosthesis.

To our knowledge no one has before described the Van Nes rotationplasty for tibial lesions. Perhaps the reason for this is the need to remove much of the leg musculature, depriving the ankle (new ‘knee’) of its prime movers. Our modification, which preserves the distal tendons for re-anastomosis to the muscles of the thigh, provides a solution to the problem.

Delayed wound healing, encountered in two of our patients, indicates that the utmost care must be employed in wound closure and the avoidance of undue tension. It is better to leave large skin flaps, and later trim them during closure than to risk compromising flap viability. This is particularly true for the skin over the anterior border of the distal tibia, where there is very little underlying soft tissue.

What function can one expect from the anastomosed muscle-tendon units, when all of the prime movers of a joint have been divided? This is the major difference between our procedure and rotationplasty performed for lesions of the distal femur. It is necessary to tension the muscle-tendon units appropriately and to allow adequate time for their repair. It has been shown that, in children, muscle tension can gradually adjust itself with growth (Ziv et al. 1984). For this reason we at present recommend this procedure only for growing children. Figures 1 and 2 demonstrate the functional result that can be expected with this procedure, with excellent range of motion of the new ‘knee’ and a good gait.

Finally, the cosmetic appearance of the leg must be considered. As also reported by Kotz and Salzer (1982), Jacobs (1984) and Winkelmann (1986), our patients were pleased with the appearance, and regarded the procedure as an operation to save the leg rather than as an amputation. Our patients had the benefit of meeting others who had undergone rotationplasty; the shape of the limb in the patients undergoing rotationplasty for proximal tibial lesions is somewhat better than when it is performed for distal femoral lesions. There is more bulk to the thigh and a less abrupt change in width from femur to tibia.

In summary, rotationplasty after excision of malignant lesions of the proximal tibia is a valuable addition to the procedures available to the tumour surgeon, and in selected patients is superior to the other available procedures in children.

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REFERENCES


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