

Limb salvage procedures in osteosarcomas around the knee joint.

"La Paz" Orthopaedics and Traumatology Hospital, Madrid, Spain.

Surgical techniques developed for restoring skeletal continuity after a local resection of a bone tumor (limb salvage procedures) revolutionized the management of the patient suffering from osteosarcomas around the knee.

In this article the authors review the current status of various reconstruction procedures; they include osteoarticular allograft arthrodesis, rotation plasty, expandable prosthesis and knee arthroplasty.

In summary they suggest that the knee arthrodesis is the preferred procedure for young and active patients, the rotation plasty should be recommended as the alternative to amputation for very young patients, and the customized prostheses are preferred for patients with limited longevity.

UNITERMS: Osteosarcoma, knee, reconstruction, limb salvage.

The interest in limb salvage has increased dramatically in the last decade in the treatment of conventional osteosarcomas, because it is an attractive alternative to the amputation of the extremity (6,40). This has been possible thanks to the response of the tumor to the management with current adjuvant chemotherapy protocols and the exact knowledge of the local extension as well as surrounding soft tissue and bone marrow seen through an MRI (6,36).

The term limb salvage generally refers to the type of surgical technique which has been developed for restoring the skeletal continuity after a local resection of the bone tumor. Surgery offers a local control of the conventional osteosarcoma while chemotherapy provides a general control of the disease (microscopic metastases) (6).

MRI is the most accurate method of evaluating the intramedullary extent of bone tumors and for demarcating the soft tissue component and its relationship to major neurovascular bundles (15) (1,37).

This diagnostic tool assures that the resection and reconstruction can be more accurately planned and executed by the surgeon. Other fundamental factors include the perfection of different surgical techniques of reconstruction, current concepts of staging and grading of these neoplasms (15), and closer interrelation of medical radiology, oncology, pathology, radiation therapy and orthopaedic surgeon.

The effectivity of the limb salvage procedure is evaluated by the percentage of local recurrence. The usual interval to recurrence after wide aggressive surgical procedures is 12 to 24 months; if a recurrence has not occurred within 2 years, it is unlikely.

After local resection it should be possible to accomplish reconstruction that gives a superior function than the one obtained by amputation; if there is a compromise of neurovascular bundles, and following the reconstruction the limb is not functional, limb salvage is contraindicated and amputation is suggested (42) (32).

The main objective of limb salvage is local control of the tumor. It is clear that no compromise should be made in the excision to permit a particular type of reconstruction. The risk of local recurrence due to an inadequate margin increases when a wide resection is not obtained by the oncologic procedure.

Address for correspondence: Dr. Emérito Carlos Rodríguez Merchán,
Capitan Blanco Argibay 21-G-3A - 28029 - Madrid - Spain
Fax number 07-34- 1-7292808

In younger patients(< 12 years) skeletal immaturity can contraindicate a limb salvage(12)(21). This is particularly true when the resection of one or more epiphyseal plates is required, because an inequality in limb length greater than 10 cm at the end of growth is not functional. In this situation amputation may be an alternative, although rotation plasty or the use of an expandable prosthesis can be considered to preserve the limb(12- 41).

When shortening of less than 5 cm can be expected it can be corrected by an epiphysiodesis of the contralateral extremity; if the shortening is between 5-10 cm a delayed lengthening can be performed.

Tumors about the knee present one of the greatest opportunities for limb salvage, because this is the region most usually affected by the osteosarcoma and because it is the joint where reconstruction is practical to achieve after limb salvage resection(29)(39)(12)(10,38). p73 Approximately 60-80% of osteosarcomas are located around the knee(40)(05).

Although osteosarcomas of distal femur are said by some to have less chance of survival than those found in the proximal tibia, they are more amenable to limb salvage because the reconstruction is much easier technically than those located in the proximal tibia(25)(28).

The problem that exists in proximal tibia reconstruction are: difficulty in reattaching the quadriceps or patellar tendon, inadequate coverage by the soft tissue, skin necrosis and vascular complications. Some author proposed a primary amputation when the patellar tendon can not be reattached(8).

However, with the increased use of local muscle flap and microvascular techniques(free myocutaneous flaps) soft tissue coverage has been improved. However tumors of the proximal tibia have characteristics often make them low risk candidates for resection.

They are small, with little extraosseous extension at the time of diagnosis; in addition, posterior extension with neurovascular bundle involvement is rare because the popliteus muscle is a barrier to extracompartmental spread of the tumors(16).

METHODS OF RECONSTRUCTION

Various reconstruction procedures have been described in the literature for the defects produced by limb salvaging resection of tumors around the knee.

Osteoarticular allograft.

The first total knee replacement was performed in

1908 with an allograft. In 1925, Lexer reported the implantation of 34 total and partial knee replacements, the allografts being obtained from cadavers(27). After 20 years he published his results: a 50% success rate and these results were not repeated until this decade.

However because of the development of osteoarthritis, particularly with poor articular congruency or ligamentous instability, the late results deteriorate in a significant number of patients(about 40%). The indications for osteoarticular allograft are the same of those for prosthetic arthroplasty, although it should be recommended in young patients who are not physically active.

The high complication rate is a major concern in allografts. Principal complications include infection 10-22%(31)(32)(9)(14), fracture 11-19%(31)(14), nonunion or delayed union 14-23%(31)(14). Nonunion or delayed union can be solved with a vascularized autogenous bone graft thus shortening the healing time in order to decrease the fracture risk(31)(37).

An important problem in all biologic reconstruction is the effect of chemotherapy retarding graft incorporation. The chemotherapy does not prevent the graft incorporation but it delays it(09). It has been demonstrated that the formation of bone is decreased with methotrexate and adriamycin(07); the toxic effects of these drugs target osteoblasts and not osteoclasts, so more bone resorption and delayed union are expected.

It has been concluded that allografts can be used for reconstruction in patients who receive aggressive chemotherapy as there was no a statistically significant difference in the functional outcome of patients with and without chemotherapy(14).

Moreover, to date there is no convincing evidence that chemotherapy before surgery improves the p73 oncologic result. It is clear, however, that the tissue planes are better defined; tissue oedema is reduced and more muscle is saved, hence, this makes the surgery easier(37)(14,13).

In following patients with various reconstruction procedures it is known that recurrent tumor may cause bone graft resorption; when this complication occurs, a biopsy should be considered prior to therapeutic decisions because nonneoplastic resorption may closely mimic recurrent tumor.

Arthrodesis.

The original arthrodesis using a large segmental bone grafts to retain length was first reported by Putti and Juvara(19)(20). It was later modified by Merle D Aubigne(33)(34), Campanacci(04), and Enneking(10).

Reconstruction is achieved with an autogenous free

cortical bone graft obtained from the ipsilateral or contralateral extremity and the stabilization of the limb with a custom made intramedullary rod and/or long plates.

Once the bone heals this reconstruction becomes very stable and it is the most durable reconstruction allowing for participation in noncontact sports in 85% of the cases.

However knee arthrodesis has significant functional limitations principally while sitting in small places (37)(10)(19,04)(FIGURES 1A and 1B).

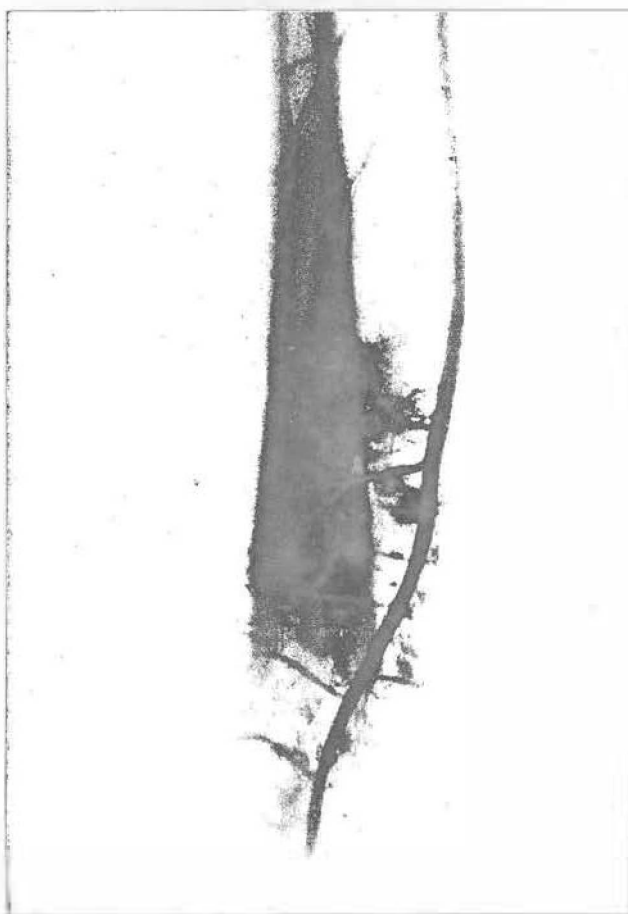


Figure 1. (A) - Angiography of a large, high-grade osteoblastic osteosarcoma arising in the distal femur of a 13-year old female.

Its principal indication is in young active patients to reconstruct the defect created from the intra- or extra-articular wide resection, when these patients accept the permanent stiffening of the joint.

Knee arthrodesis clearly provides more durable stability than an unstable prosthesis or an osteoarthritic allograft(13).

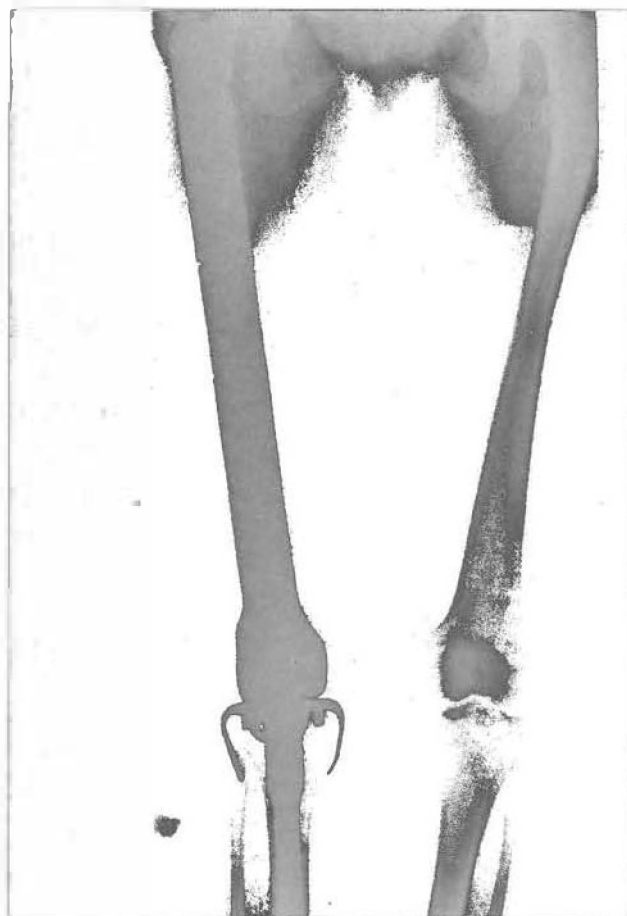


Figure 1. (B) - Roentgenogram after the resection of the involved bone and adjacent soft tissues and reconstruction with a Kotz's total hip and knee prosthesis.

Rotation Plasty.

This procedure was first described in 1932 by Borggreve(02) and was implemented by Van Nes in 1950(47) for the management of congenital defects of the femur. Kotz and Salzer were the first to use this type of reconstruction after the resection of the distal femoral tumors(24). It is a segmental intercalary extra-articular resection of the knee joint preserving the leg, ankle and foot in continuity with the neurovascular bundles.

It has rarely been indicated for reconstruction of proximal tibia defects. It has an advantage over other procedures in that the bone fixation is well covered by muscle and skin and obtains a much wider surgical margin of normal tissue, thus decreasing the local risk of recurrence.

The distal portion of the extremity is rotated 180 degrees, and the defect closed by fixing the rotated tibia

to the remaining femur. The patient is fitted with a knee prosthesis; he bears weight on the sole of the foot and there is no risk of neuroma formation or phantom pain.

There is less energy expended in walking by patients with this technique than in those patients who have had below the knee amputations(03).

In more than 25% of patients psychological problems have been reported(23).

Expandable prostheses.

In young children, while limb salvage has a definitive role, problems arise for limb length discrepancy. This problem can be solved by the concept of an expandable growing prosthesis, but the concept has many problems in application; breakage or loosening with short longevity of this prosthesis being the principal one. However the number of other complications exceed those of any other technique.



Figure 2. (A) - Osteosarcoma arising in the proximal tibia of a 38-year old male.

This is a hinged total knee prosthesis in which the femoral component can be periodically lengthened through a small incision with a minor surgical procedure(12)(26).

A recent publication analyzed 31 patients with this type of prostheses over a 6-year period. There were 6 aseptic loosening of the prostheses requiring revision.

The procedure remains a clinical research project and before wide application more research is required for long-term prostheses and the issue of loosening in these very young patients remains an unsolved question.

Arthroplasty.

The prostheses should be constrained total knee with a hinged device, because after performing wide resection of the tumor, the surgeon removes the soft tissues surrounding the joint, producing a significant lack of articular stability.



Figure 2. (B) - Roentgenogram after the resection of the involved bone and reconstruction by a Juvara's knee arthrodesis.

These devices can be fixed with or without cement and can be customized to make up for the length of the defect. The advantages of the prostheses are: retention of motion, a shorter rehabilitation period required, and fewer early complications(37).

Main indications are in elderly patients where a shorter rehabilitation time is important and the low demand on the reconstruction is a significant factor(14).

It is principally used in patients with osteosarcoma of the distal femur, because the reconstruction of proximal tibia has the problem of re-insertion of the patellar tendon; the arthroplasty demonstrates better results in the reconstruction of the hip (18)(FIGURES 2A and 2B).

CONCLUSIONS

Controversy remains as to which is the better reconstructive procedure around the knee after limb salvaging resection of osteosarcomas; important factors are tumor location, lifestyle, patient preference, chemotherapeutic needs and the surgeon's experience.

Knee arthrodesis is the recommended procedure for young and active patients because a stable and stiff knee is preferable to an unstable prosthesis or osteoarthritic allograft, rotation plasty is the recommended alternative to amputation for very young patients and customized prostheses are preferred for patients in which longevity is limited either because of age or tumor prognosis.

ACKNOWLEDGEMENTS

This work has been supported by a grant of Fundacion Caja de Madrid.

REFERENCES

1. BLOEMM, J.L.; TAMINIAU, A.H.M. & EUDELINK, F. et al. - Radiologic staging of primary bone sarcoma: MR imaging, scintigraphy, angiography, and CT correlated with pathologic condition. *Radiology* 169:805-810, 1988.
2. BORGGREVE, J.- Kniegelenkesatz durch das in der beinlängsachse um 180 gedrehte fussgelenk. *Arch Orthop Unfallchir* 28: 175-182, 1930.
3. CAMMISA, F.P.; LANE, J.M. & GLASSER, D.B.; et al.- Van Nes tibial rotation-plasty: a functionally viable reconstructive procedure for distal femoral tumors in children. *Orthop Trans* 11:447, 1987.
4. CAMPANACCI, M. & COSTA, P.- Total resection of distal femur or proximal tibia for bone tumors: autogenous bone graft and arthrodesis in twenty six cases. *J Bone Joint Surg* 61B:455-463, 1979.
5. DAHLIN, D.C. & COVENTRY, M.B.- Osteogenic sarcoma: a study of six hundred cases. *J Bone Joint Surg* 49A:101-107, 1967.
6. DEMPSEY, S. Introduction to limb salvage surgery for sarcomas. *Orthop Clin North Am* 22:1-5, 1991.
7. DICK, H.M.; MALININ, T. & MNAYMNEH, W.- Massive allograft implantation following radical resection of high-grade tumors requiring adjuvant treatment. *Clin Orthop* 197:88-95, 1985.
8. EILBER, F.R.- Limb salvage for high grade sarcomas: UCLA experience. NIH Consensus Development Conference, Limb Sparing Treatment, Adult soft tissue and osteogenic sarcomas. Bethesda, Maryland, December 3-5, 1984.
9. ENNEKING, W.F. & MINDELL, E.R.- Observations on massive retrieved human allograft. *J Bone Joint Surg* 73A:1123-1142, 1991.
10. ENNEKING, W.F. & SHIRLEY, P.D.- Resection-arthrodesis for malignant and potentially malignant lesions about the knee using intramedullary rod and local bone grafts. *J Bone Joint Surg* 59A:223-236, 1977.
11. ENNEKING, W.F.; SPANIER, S.S. & GOODMAN, M.A: A system for the surgical staging of musculoskeletal sarcomas. *Clin Orthop* 153:106-120, 1980.
12. FINN, H.A. & SIMON, M.A.- Limb salvage surgery in the treatment of osteosarcoma in skeletally immature individuals. *Clin Orthop* 262:108-118, 1991.
13. FRIEDLANDER, G.E.; TOSS, R.E. & DOGANIS, A.C.; et al. Effects of chemotherapeutic agents on bone. *J Bone Joint Surg* 66A:602-609, 1984.
14. GEBHARDT, M.C.; FLUGSTAD, D.I. & SPRINGFIELD, D.S.; ET AL.- The use of bone allograft for limb salvage in high grade extremity osteosarcoma. *Clin Orthop* 270:181-196, 1991.
15. HEARE, T.C.; ENNEKING, W.F. & HEARE MM. Staging techniques and biopsy of bone tumors. *Orthop Clin North Am* 20:273-285, 1989.
16. HUDSON, T.M.; SPRINGFIELD, D.S. & SCHIEBLER, M.- Popliteus muscle as a barrier of tumor spread: computer tomography and angiography. *J Comput Assist Tomogr* 8:498-503, 1985.
17. JAFFE N. Chemotherapy for malignant bone tumors. *Orthop Clin North Am* 20:487-503, 1989.
18. JOHNSON, M.E. & MANKIN, H.J.- Reconstruction after resections of tumors involving the proximal femur. *Orthop Clin North Am* 22:87-103, 1991.
19. JUVARA, E. Procédé de résection de la partie supérieure du tibia avec substitution, à la partie enlevée d'une greffe prélevée sur le fémur. *Presse Médicale* 29:241-243, 1929.
20. JUVARA, E. Reconstitution de la tige osseuse fémoro-tibiale, interrompue par la résection d'une des extrémités osseuses, qui constitue l'articulation du genou, par une greffe provenant du

- dédoublément de l'extrémité osseuse opposé. **Bulletins et Mémoires de la Société Nationale du Chirurgie** 55:541-556, 1929.
21. KENAN, S.; BLOOM, N. & LEWIS, M.- Limb sparing surgery in skeletally immature patients with osteosarcoma. The use of an expandable prosthesis. **Clin Orthop** 270:223-230, 1991.
 22. KLEIN, M.J.; KENAN, S. & LEWIS M. Osteosarcoma. Clinical and pathological considerations. **Orthop Clin North Am** 20:327-345, 1989.
 23. KNAHR, K.; KOTZ, R. KRISTEN, H.; et al.- Functional results after resection of tumors about the knee. In Enneking WF(ed): Limb salvage in musculoskeletal oncology. New York, Churchill Livingstone, 1987.
 24. KOTZ, R. & SALZER, M.- Rotation-plasty for childhood osteosarcoma of the distal part of the femur. **J Bone Joint Surg** 64A:959-963, 1982.
 25. LARSSON, S.E.; LORENTZON, R. & WEDREN, H. et al.- The prognosis in osteosarcoma. **Int Orthop** 305:67-74, 1981.
 26. LEWIS, M.- The use of an expandable and adjustable prosthesis in the treatment of childhood malignant bone tumors of the extremity. **Cancer** 57:499-506, 1986.
 27. LEXER, E. Joint transplantation and arthroplasty. **Surg Gynecol Obstet** 40:789-809, 1925.
 28. LOCKSHIN, M.D. & HIGGINS, I.T.- Prognosis in osteogenic sarcoma. **Clin Orthop** 58:85-90, 1968.
 29. MALAWER, M.M. & MCHALE, K.A. Limb sparing surgery for high-grade malignant tumors of the proximal tibia. **Clin Orthop** 239:231-248, 1989.
 30. MANKIN, H.J.; DOPPELT, S.H. & SULLIVAN R, et al. Osteoarticular and intercalary allograft transplantation in the management of malignant tumors of bone. **Cancer** 50:613-630, 1982.
 31. MANKIN, H.J.; GEBHART, M.C. & TOMFORD, W.W. The use of frozen cadaveric allografts in the management of patients with bone tumors of the extremities. **Orthop Clin North Am** 18:275-289, 1987.
 32. MNAYMNEH, W. & MALINTN, T.- Massive allografts in surgery of bone tumors. **Orthop Clin North Am** 20:455-467, 1989.
 33. MERLE, D'AUBIGNE, R.; MÉARY R. & THOMINE JM. Resection dans les tumeurs. **Revue Chirurgie Orthopédique et Réparatrice de l'Appareil Moteur** 52:305-324, 1966.
 34. MERLE, D'AUBIGNE, R.; & DEJOUNAY, J.P.- Diaphyso-epiphyseal resection for bone tumors at the knee. **J Bone Joint Surg** 40B:385-395, 1958.
 35. O'FLANAGAN, S.J.; STACK, J.P. & MCGEE, H.M.J. et al.- Imaging of intramedullary tumor spread in osteosarcoma. A comparison of techniques. **J Bone Joint Surg** 73B:998-1001, 1991.
 36. ROSE, G.; CAPARROS, B. & HUVOS, H.G.- Preoperative chemotherapy for osteogenic sarcoma: selection of postoperative adjuvant chemotherapy based on the response of primary tumor to preoperative chemotherapy. **Cancer** 49:1221-1230, 1982.
 37. SIM, F.H. & CHAO, EYS.- Prosthetic replacement of the knee and large segment of the femur or tibia. **J Bone Joint Surg** 61A:887-892, 1979.
 38. SIM, F.H.; BEAUCHAMP, C.P. & CHAO, E.- Reconstruction of musculoskeletal defects about the knee for tumor. **Clin Orthop** 221:188-201, 1987.
 39. SIMON, M.A.; THOMAS, N. & MANKIN, H.J.- Limbs salvage treatment versus amputation for osteosarcoma of distal end of the femur. **J Bone Joint Surg** 68:1331-1337, 1968.
 40. SWEETNAM, M.A. Malignant bone tumor management. 30 years of achievement. **Clin Orthop** 247:67-73, 1989.
 41. VAN NES, C.P.- Rotation plasty for congenital defects of the femur: making use of the ankle of the shortened limb to control the knee joint of a prosthesis. **J Bone Joint Surg** 32B:12-15, 1950.
 42. ZIMMER, W.D.; BERQUIST, T.H. & MCLEOD RA, et al.- Bone tumors: magnetic resonance imaging versus computer tomography. **Radiology** 155:709-718, 1985.

RESUMO

Procedimentos de salvamento dos membros nos osteosarcomas do joelho.

Diversas técnicas cirúrgicas foram desenvolvidas para recuperar a continuidade esquelética. Após ressecção de um tumor ósseo (técnicas para salvar os membros) de forma que revolucionaram o tratamento dos pacientes portadores de osteosarcomas do joelho.

Neste artigo os autores revisam os conceitos atuais de diversos procedimentos de reconstrução; entre eles: a artrodesis com aloenxerto; a plastia de rotação, as próteses expansíveis e a artroplastia de joelho.

Em resumo, sugerem que a artrodese do joelho é o procedimento de eleição para os pacientes jovens e ativos, que a plastia de rotação deve ser a alternativa à amputação nos pacientes muito jovens e que as próteses sob medida são preferíveis nos pacientes com longevidade limitada.