

Extremity Osteosarcoma—A Southeast Asian Experience

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Abstract

Introduction: We present our experience with limb salvage emphasising the use of vascularised bone grafts in combination with autoclaved tumour bone for limb salvage in osteosarcoma. **Materials and Methods:** Thirty-six cases with extremity osteosarcoma, all of which were managed at a single institution between 1980 and 1999, were reviewed at a mean follow-up of 9 years (range, 10 months to 200 months). There were 26 patients who underwent limb salvage surgery and 10 patients who had amputation. **Results:** In the limb salvage group, 12 bone defects were bridged using vascularised bone grafts alone while autoclaved tumour bone was used for reconstruction in the remaining 14 patients. In these 14, there were 10 with autoclaved tumour bone and vascularised bone, 2 with autoclaved bone and non-vascularised bone and 2 with autoclaved bone alone. The joint was preserved in 13 of the 26 reconstructions. Of these, 11 involved preservation of the knee joint contributing to a quantum gain in function with 84% good and excellent results. The actuarial survival was 64% at 2 years and 48% at 5 years, with no significant difference between ablation and limb salvage. **Conclusion:** The use of the autoclaved bone provided yet another effective alternative for bridging large defects following resection of high grade tumours.

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Key words: Autoclaved bone, Biological reconstruction, Functional outcome, Vascularised fibular grafts

Introduction

Osteosarcoma is a highly malignant bone cancer occurring primarily in young patients. Although rare, it is still the commonest primary bone cancer seen in Southeast Asia. In Singapore, 69 cases of osteosarcoma were reported by the Singapore Cancer Registry between 1982 and 1992.¹ Our institution has been performing limb salvage for osteosarcoma since 1980, with a significant number of patients from neighbouring countries. Radical en-bloc resection of the tumour resulted in massive bone defects that required reconstruction with vascularised bone grafts or autoclaved autografts. The feasibility of limb salvage surgery increased when more effective chemotherapy as well as the use of preoperative neo-adjuvant chemotherapy was introduced at our institution in the mid-eighties.^{2,3} Limb salvage is now a well accepted mode of surgical treatment in carefully selected patients.^{4,5}

We reviewed 36 patients with extremity osteosarcoma treated at our institution from 1980 to 1999. The clinical presentations, surgical treatments and outcome were

analysed. In particular, we present our experience with limb salvage emphasising the use of vascularised bone grafts in combination with autoclaved tumour bone for limb salvage in osteosarcoma.

Patients and Methods

Forty-seven patients with histologically proven osteosarcoma were seen at our institution between 1980 and 1999. Three patients were excluded due to incomplete case records, while another 2 patients were excluded as they were seen for a second opinion and were not treated at our centre. Five cases were excluded due to insufficient follow-up. A case of osteosarcoma of the pelvis was also excluded from this series. This left 36 patients with extremity osteosarcoma for review. Ten patients underwent amputation, while 26 patients had limb salvage surgery. The patients were staged according to the Enneking's Staging System for Musculoskeletal Sarcoma.⁶ The outcome of the patients in terms of survival and development of metastases were recorded. Major complications and

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secondary operations were documented in the limb salvage group. Statistical analyses were done using the SPSS for Windows software. The actuarial survival of the patients was estimated using Kaplan-Meier's survival curves. A log-rank test was used to compare the different variable factors on the time-related results, with $P < 0.05$ considered to be statistically significant.

Results

The 10 patients who had amputation included 7 males and 3 females, with a mean age of 19.8 years (range, 8 to 42 years). All tumours were in the lower limb. The 26 patients who had limb salvage included 12 males and 14 females, with a mean age of 19.5 years (range, 7 to 57 years). Seven of these patients had tumour in the upper limb. The mean follow-up for all patients was 110 months (9 years), with a range from 10 to 200 months.

Presenting Complaint

The most common presenting complaint was a painful swelling in 22 (61%) patients. Three presented with a painless lump, 7 with a painful joint and 4 with a pathological fracture of the involved bone. Twelve (33%) patients had symptoms for a month before diagnosis, 9 (25%) were symptomatic for 2 months, 7 (19%) had symptoms for 3 months and 8 (22%) had symptoms for more than 3 months before a definitive diagnosis was made.

Histology and Staging

Thirty-four patients had high-grade osteosarcoma. Thirty were Enneking Stage IIB and 4 Stage III. Two patients had parosteal osteosarcoma and were Enneking Stage IB.

Chemotherapy

Prior to 1991, the majority of patients (9 out of 12) received postoperative chemotherapy only, 2 both pre and postoperative chemotherapy and 1 refused postoperative chemotherapy. The most commonly used agents were adriamycin and cisplatin. After 1991, 19 out of 24 patients received pre and postoperative chemotherapy. Three received postoperative therapy only, 1 refused postoperative and only had preoperative chemotherapy, and another refused all chemotherapy. Doxorubicin and cisplatin over 2 to 3 cycles were the preoperative regime. The postoperative regime was dependent on the histological response to the neo-adjuvant chemotherapy. For tumours with more than 90% necrosis, the same drugs were given. In poor responders, the drugs were changed to ifosfamide and high dose methotrexate.

Surgical Treatment

Amputation

Amputation was the primary mode of surgical treatment

in 10 patients. All the tumours were around the knee. Seven were in the distal femur, 2 in the proximal tibia and 1 in the distal tibia. Limb ablation was performed in these 10 patients for the following reasons: fungation of tumour to skin (3 patients), neurovascular bundle involvement (1 patient), tumour adjacent to neurovascular bundle with no clinical or radiological response to neo-adjuvant chemotherapy (1 patient), pathological fracture with metastases to the lungs (1 patient), financial reasons (3 patients) and a suspected skip lesion (1 patient). The patient with the "skip" lesion had a proximal tibia osteosarcoma. Magnetic resonance imaging (MRI) revealed another lesion in the mid femoral shaft suggestive of a skip lesion.⁷ However, the histology after limb ablation showed active haematopoietic cells with no evidence of tumour. High above knee amputation was performed for 7 patients, hip disarticulation for 2 and below knee amputation for 1.

Limb Salvage (Table I)

Limb salvage was performed for 26 patients. For the upper limb, there were 4 proximal humeral and 3 distal radial lesions. For the lower limb, the tumours were all around the knee, with 12 in the distal femur, 6 in the proximal tibia and 1 in the mid tibia. Based on Enneking's criteria, the surgical margins of resection were wide for 24 cases, marginal for 1 and intralesional for 1. In both of the last 2 cases, the tumours were in the proximal humerus and they both died at 31 months and 12 months, respectively, after surgery.

Reconstruction

Upper Limb

Two patients had a vascularised fibular graft, each to bridge the defect after proximal humeral resection with arthrodesis of the shoulder. One patient had the limb shortened and the defect bridged with the osteotomised acromion pedicled on the trapezius between the scapula and remnant humerus and the shoulder arthrodesed. Another had the defect bridged with a pedicled length of clavicle as an interposition graft to achieve shoulder arthrodesis, again with the limb shortened. All 3 distal radial defects were bridged with vascularised fibular grafts, with preservation of the wrist joint in 2 and arthrodesis of the joint in the other.

Lower Limb

In 11 of the 19 lower limbs, the native knee joint was preserved, and in 1, a total knee-autoclaved bone composite was used. In the former, tumour bearing bone segment was resected preserving the subchondral bone and articular cartilage. All soft tissue and tumour tissue were cleared from the resected specimen. The bone was then autoclaved at 130 degrees Celsius for 10 minutes. It was cooled,

TABLE I: LIMB SALVAGE IN OSTEOSARCOMA WITH METHODS OF RECONSTRUCTION (n = 26)

S/No	Age & sex	Site of involvement	Staging	Margins	Reconstruction methods	Graft length (cm)	Complications	Follow-up (mo)	Status
<u>Upper limb</u>									
1.	21 F	Proximal humerus	IIB	Wide	VFG; shoulder arthrodesed	20	1. Radial nerve neuropraxia 2. Vascular anastomotic breakdown requiring exploration	27	DOD
2.	20 M	Proximal humerus	IIB	Marginal	VFG; shoulder arthrodesed	20	Non-union of stress fracture of VFG	31	DOD
3.	57 F	Proximal humerus	IIB	Wide	Shortening and pedicled acromion bone graft; shoulder arthrodesed	4 cm (15 cm gap)		151	CDF
4.	16 M	Proximal humerus	IIB	Intralesional	Pedicled clavicle bone as interposition graft; shoulder arthrodesed	6	Local recurrence*	12	DOD
5.	57 F	Distal radius	IB parosteal	Wide	VFG; wrist arthrodesed	11	Non-union at graft/host junction; union with bone grafting	195	CDF
6.	8 F	Distal radius	IIB	Wide	VFG; wrist joint preserved	15		165	CDF
7.	18 F	Distal radius	IIB	Wide	VFG; wrist joint preserved	16	1. Poor hand function from soft tissue adhesions 2. Secondary amputation for metastases in the hand	11	DOD
<u>Lower Limb</u>									
8.	29 F	Distal femur	IIB	Wide	VFG + ABBM Knee arthrodesed	22 14		20	DOD
9.	16 M	Distal femur	IIB	Wide	VFG + ABBM Knee splinted internally temporarily and eventually preserved	28 32	1. Coagulopathy from massive blood transfusion 2. Quadriceps adhesions (quadriceps plasty) 3. Stress fracture of autoclaved bone	122	CDF
10.	10 F	Distal femur	IIB	Wide	VFG + ABBM Knee joint preserved	17 15		18	DOD
11.	14 M	Distal femur	IIB	Wide	VFG + ABBM Knee joint preserved	28 26	Kuntscher nail failure	22	DOD
12.	17 M	Distal femur	IIB	Wide	VFG + ABBM Knee splinted internally temporarily	17 15	1. Coagulopathy from massive blood transfusion 2. Foot drop from lateral popliteal nerve neuropraxia in donor site 3. Secondary amputation for local recurrence in soft tissue*	31	DOD
13.	17 F	Distal femur	IIB	Wide	ABBM; knee arthrodesed	16		10	DOD

TABLE I: Contd.

S/No	Age & sex	Site of involvement	Staging	Margins	Reconstruction methods	Graft length (cm)	Complications	Follow-up (months)	Status
14.	16 F	Distal femur	IIB	Wide	Anterior tibial myo-osteo flap; knee arthrodesed	20	1. Foot drop after tumour resection 2. VFG for failed pedicled graft and Kuntscher nail failure 3. Non-union at graft/host junction; united with bone grafting	132	CDF
15.	7 M	Distal femur	IIB	Wide	Free epiphyseal transplant using proximal fibula head; knee joint preserved	13	1. Non-union at graft/host junction 2. Pin-tract infection of an external fixator requiring removal 3. Stress fracture at VFG	22	CDF
16.	13 M	Distal femur	IIB	Wide	NVFG + ABBM Knee joint preserved	21 18.5		19	CDF
17.	8 F	Distal femur	IIB	Wide	VFG + ABBM Knee joint preserved	20 19		35	CDF
18.	8 F	Distal femur	IIB	Wide	VFG + ABBM Knee joint preserved	22 21		13	CDF
19.	13 F	Distal femur	III	Wide	NVFG + ABBM Knee joint preserved	28 30		17	CDF
20.	12 F	Mid-tibia	III	Wide	Ipsilateral fibular transfer + ABBM Ankle joint arthrodesed	20 22	1. Infection of autoclaved bone 2. Hind-foot valgus deformity	68	CDF
21.	25 M	Proximal tibia	IIB	Wide	VFG + ipsilateral fibular transfer + gastrocnemius rotation flap Knee arthrodesed	17 15	Local tumour recurrence *	17	DOD
22.	22 M	Proximal tibia	IIB	Wide	VFG + gastrocnemius femoral graft Knee arthrodesed	24 18	1. Non-union at graft/host junction of VFG; united with bone grafting 2. Foot-drop from lateral popliteal nerve palsy in donor limb	179	CDF
23.	26 F	Proximal tibia	IB parosteal	Wide	ABBM + Ipsilateral fibula transfer Knee joint preserved	6 5	Foot drop from lateral popliteal nerve neuropraxia in donor limb; recovered	95	CDF
24.	22 M	Proximal tibia	IIB	Wide	ABBM + Total knee arthroplasty	9	Loosening of autoclaved bone-total knee implant composite	29	DOD
25.	15 M	Proximal tibia	IIB	Wide	ABBM + Ipsilateral fibular transfer Knee joint preserved	28 26	Extensor hallucis weakness	22	CDF
26.	19 M	Proximal tibia	IIB	Wide	Ipsilateral fibular transfer + pedicled femoral graft + pedicled patella graft Knee arthrodesed	12 21		15	CDF

ABBM: autoclaved bone and bone marrow graft; CDF: continuously disease free; DOD: died of disease; NVFG: non-vascularised fibular graft; VFG: vascularised fibular graft

* Local recurrence

immersed in gentamicin and coated with the patient’s own bone marrow obtained from the iliac crest before replacing into the bone defect. When replaced, the autoclaved resected bone exhibited a perfect match to the defect created. It was secured to the remnant host bone and subchondral bone with a plate and screws. In cases where the subchondral bone was too thin for stabilisation, a Kuntscher nail was driven through the host bone, the autoclaved bone and knee joint, temporarily stabilising the joint. The Kuntscher nail was withdrawn from the knee joint once union was achieved between the autoclaved bone and the host bone segments, to facilitate knee mobilisation. In 8 patients, vascularised fibula graft was combined with the autoclaved bone to provide immediate and late stability (Fig. 1).

The knee joint was arthrodesed in 6 patients and the ankle joint fused in 1 patient. Autoclaved tumour bone coated with autogenous bone marrow was used in 3 cases to provide bone bulk for stability and to achieve arthrodesis without shortening. In 2 of these patients, a vascularised

fibula graft was added to increase strength and stability. Arthrodeses in the remaining 4 cases were achieved using vascularised bone grafts alone (Table I).

Complications (Table I)

Complications were found only in the limb salvage group. There were 4 cases of non-union in the host-vascularised fibula graft junctions that required bone grafting with uneventful union in all cases. There was 1 case of non-union of a stress fracture of a vascularised fibular graft in a proximal humeral reconstruction which united after bone grafting. One autoclaved bone (case 9) developed a stress fracture which united without any further surgery. One autoclaved tibia was infected at 2 years requiring sequestrectomy and multiple debridements and antibiotics before the infection was completely eradicated (Case 20). One patient who had a distal femoral defect bridged with a tibial osteocutaneous flap required salvage with a vascularised fibula graft (Case 14). Two



Fig. 1a. Radiograph of femur showing extensive involvement of the distal half, up to the physal plate, by osteogenic sarcoma (post chemotherapy).

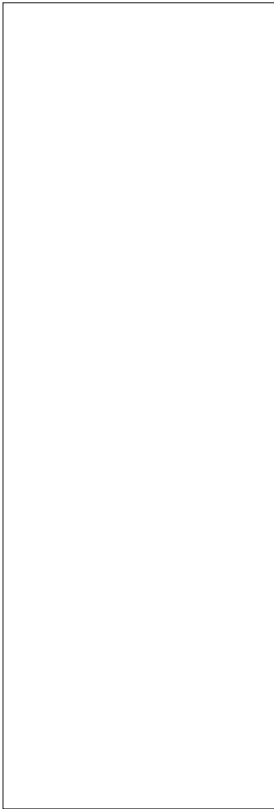
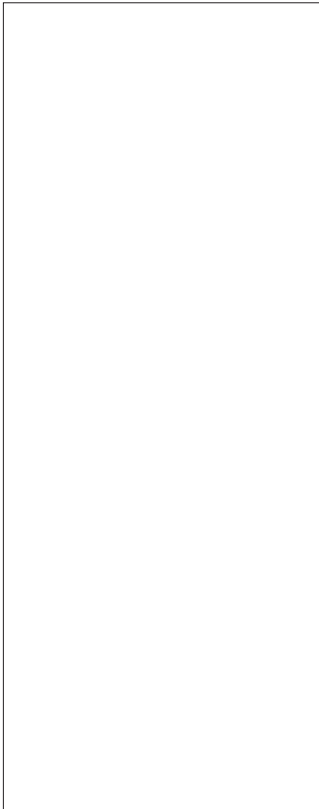


Fig. 1b. Following resection and autoclaving, the tumour bearing bone was reimplanted and internally fixed proximally and distally with plates and screws to the remnant bone. A free vascularised fibula graft also spanned the autoclaved bone. A Kuntscher nail temporarily transfixed the knee to provide immediate stability.



Figs. 1c & 1d. Final result showing complete incorporation of the autoclaved bone to the host bone. The Kuntscher nail has been withdrawn to facilitate knee mobilisation.

patients required revision of broken Kuntscher nails (Cases 11 and 14). An anastomotic failure occurred in a patient with a vascularised fibula graft requiring exploration 2 weeks post surgery (Case 1).

Other complications included coagulopathy after massive blood transfusion (2 patients) and pin tract infection requiring revision (1 patient). One patient who had knee reconstruction using an autoclaved bone-total knee implant composite developed loosening of the implant (Case 24). He was, however, able to walk full weight bearing with a walking stick. He succumbed to metastases 29 months after limb salvage.

Donor Site Morbidity

This included transient lateral popliteal nerve palsy in 2 and a permanent foot drop in 1. Loss of the distal fibula physis following ankle arthrodesis resulted in a valgus hindfoot in 1 patient.

Local Recurrence

There was no local recurrence in the 10 patients who had limb ablation. In the 26 patients with limb salvage, 3 (11.5%) had local recurrence. Two of these had local recurrence in the scar from possible tumour seeding at the time of surgery 5 months post surgery, and 1 recurrence in the soft tissue 9 months after limb salvage. All 3 died from lung metastases (Case 4 died 12 months post limb salvage, Case 12 died after 31 months and Case 21 died after 17 months). There was no recurrence within any of the autoclaved tumour bones.

Metastatic Disease

Nineteen patients had lung metastases. Four patients had lung metastases at first presentation while another 15 developed lung metastases between 3 and 24 months post surgery (mean, 11.2 months). Twelve out of these 15 patients (80%) who developed distant disease presented within 1½ years of surgery. Of the 19 with lung metastases, 9 underwent thoracotomy and metastasectomy. Of these, 5 succumbed to the disease while 2 are still surviving – 1 with no evidence of disease and 1 alive with disease. The mean survival time of the remaining 10 patients who refused thoracotomy or were unfit for surgery was 20 months.

Survival

At the time of review, 20 patients were alive. Nineteen patients were disease free and 1 was alive with metastases. Fifteen had died from the disease and 1 patient died from carcinoma of the breast. The estimated Kaplan-Meier 2- and 5-year actuarial survival was 64% and 48%, respectively, when all 36 patients were analysed as a single group with a diagnosis of osteosarcoma. When we compared

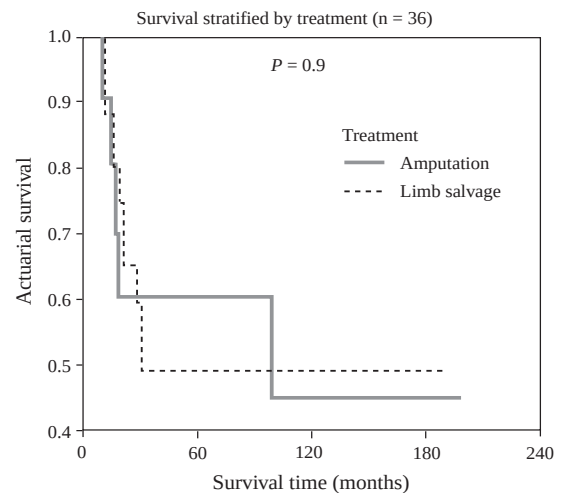


Fig. 2. Actuarial survival of 36 patients with osteosarcoma stratified by treatment groups of amputation versus limb salvage.

the survival between the amputation group with the limb salvage group, without considering the disease stage, the survival was 60% at 2 and 5 years in the amputation group and 65% at 2 years and 49% at 5 years in the limb salvage group (Fig. 2). There was no significant difference in survival between the 2 groups with $P = 0.9$. When we compared only Enneking stage IIB osteosarcoma in the amputation group ($n = 8$) with that in the limb salvage group ($n = 22$), the 2- and 5-year survival was 75% and 56%, respectively, in the amputation group compared to 59% and 39%, respectively, in the limb salvage group. Again, this difference in survival was not statistically significant with $P = 0.37$. When gender, duration of symptoms, site of primary tumour, margin of resection, presence of lung metastases, local recurrence, Enneking staging and treatment method (amputation versus limb salvage) were analysed against survival (alive or dead) using multivariate analysis, only site of primary tumour ($P = 0.001$) and presence of metastases ($P < 0.001$) were found to be independent adverse factors associated with poor survival.

Functional Outcome

Functional results were based on the modified system for the evaluation of surgical management of musculoskeletal tumours proposed by Enneking at the Limb Salvage in Musculoskeletal Oncology Symposium in Florida 1985.⁸ Fifteen of the surviving patients were available for functional assessment. The results are shown in Table II. For knee reconstructions, there were 5 (42%) excellent, 5 (42%) good and 2 (16%) fair results. For upper limb reconstructions, the results were all fair. There were no poor results in either group. The numbers for the upper limb are too few for firm conclusions.

TABLE II: INTERNATIONAL SOCIETY OF LIMB SALVAGE (ISOLS) FUNCTIONAL EVALUATION

Knee (12 patients)				
	Excellent	Good	Fair	Poor
Overall	5	5	2	0
Motion	6	2	2	2
Pain	11	1	0	0
Stability	11	1	0	0
Deformity	4	5	3	0
Strength	8	4	0	0
Functional activity	8	4	0	0
Emotional acceptance	9	3	0	0
Shoulder (1 patient)				
	Excellent	Good	Fair	Poor
Overall	0	0	1	0
Motion	0	0	0	1
Pain	1	0	0	0
Stability	1	0	0	0
Deformity	0	0	1	0
Strength	1	0	0	0
Functional activity	1	0	0	0
Emotional acceptance	1	0	0	0
Wrist (2 patients)				
	Excellent	Good	Fair	Poor
Overall	0	0	2	0
Motion	1	0	1	0
Pain	2	0	0	0
Stability	0	0	2	0
Deformity	0	0	1	1
Strength	0	2	0	0
Functional activity	0	0	2	0
Emotional acceptance	1	1	0	0

Discussion

Our review showed that limb salvage does not compromise survival when compared to limb ablation; same findings in previous studies.^{4,5,9} The 2- and 5-year survival of 65% and 49% in the limb salvage group is comparable to previous studies⁹ and to the 60% 2- and 5-year survival figures in the limb ablation group. Yip et al⁹ reported an overall survival rate of 62.9% at 2 years and 43% at 5 years with preoperative and postoperative chemotherapy from a series in Hong Kong. Ogihara et al¹⁰ reported a 60% 5-year survival in a study from Osaka. With an intensive chemotherapy regime, the survival improved to 68%. The prohibitive cost of chemotherapy and adverse side effects have prevented universal acceptance of aggressive chemotherapy regimes by patients in this part of the world. Only 21 out of the total of 36 patients completed the full course of neo-adjuvant and adjuvant chemotherapy in this series. The local recurrence rate of 11.5% in this series is comparable to other published data.⁴

The presence of lung metastases, however, correlated with poor survival.

Ablative surgery is a viable and an acceptable alternative to limb salvage in developing countries. There were no complications and no recurrence in our series. Ablation is often the only alternative for many of these patients who presented late with advanced disease after having sought traditional medical treatment. The high and rising cost of chemotherapy and complex reconstructive procedures for limb salvage, available in only a few selected centres in Southeast Asia, are often prohibitive for the majority who need such procedures.

Prostheses for the ablative group are available locally. These are affordable and reliable and allow most activities of daily living (ADL). The time taken to rehabilitate these patients who are young and adaptable is remarkably short. Patients can also go through several of these prostheses throughout their lives at no great cost. Cosmetically and functionally however, much is to be desired. The presence of a limb is vital for body image and confidence,¹¹ and our patients still prefer limb salvage if at all possible, as has been shown by other studies.^{9,12}

For the upper limb however, limb salvage becomes critical to preserve a functional and sensate hand. In this series, limb salvage in the upper extremity was achieved using a vascularised bone graft interposition with arthrodesis of the shoulder in all shoulder tumours. In 2 patients, joint preservation was possible with distal radial neoplasms. The fibula is ideally suited for proximal humeral and distal radial reconstructions. In the shoulder, the fibula graft is passed through a fenestration in the remnant scapula neck to secure proximal fixation and the construction is bridged with a reconstruction plate from the scapula to the distal humerus. Supplementation of the arthrodesis site with cancellous bone graft from the iliac crest was important for achieving union. Use of the acromion or clavicle as interposition grafts may not provide sufficient stability, length or bone mass for arthrodesis, and addition of cancellous bone graft from the iliac crest is required. Very often, these reconstructed limbs are often short.

For the wrist, the proximal fibula and its articular cartilage surface restored distal radial anatomy to a great extent and mobility at the “radio-carpal”, mid-carpal and carpo metacarpal joints gave satisfactory wrist function. When the distal ulna cannot be preserved in some distal radial tumours, then arthrodesis of the wrist by bridging the radial defect leaving the ulna defect unattended preserved forearm rotation.

In the lower extremity, limb salvage with preservation of knee joint function was achieved in 11 out of 19 resections. The autoclaved bone coated with bone marrow was effective

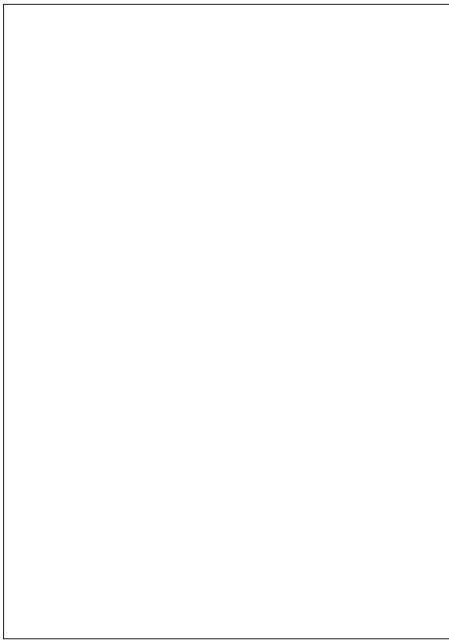


Fig. 3a. Radiograph of tibia with parosteal sarcoma.

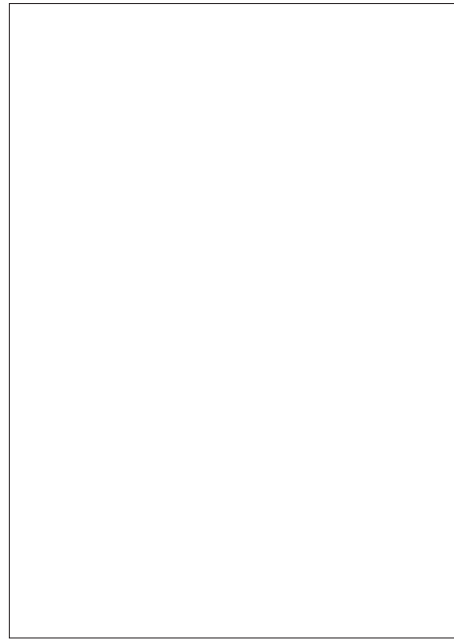


Fig. 3b. Final result after resection and reconstruction with autoclaved bone. Note use of ipsilateral fibula as a pedicled vascularised bone graft to bridge the autoclaved bone.

in providing stability and bone bulk for union with the remnant host bone. The autoclaved bone provided a framework for osteogenic bone marrow cells to lay down bone to bridge the autoclaved bone to the host bone. The ready availability of autoclaved bone and the perfect matching of anatomy are added advantages. The addition of a vascularised bone graft facilitated union in the whole construction. The patella tendon was reattached to the autoclaved bone whenever indicated and provided knee extension. The autoclaved bone was also used as a spacer in cases where the knee joint are arthrodesed and provided the bone bulk required to achieve fusion. The vascularised fibular graft was combined with the autoclaved bone in the majority of the reconstructions and provided a strong cortical bony strut for immediate stability. It is readily available often from the ipsilateral extremity where it may be transferred as a pedicled bone graft for proximal tibial and very distal femoral reconstructions. Lengths of up to 32 cm have been used and once united with the recipient bone segments (remnant femur or tibia and the autoclaved bone) no further interphase problems were seen unlike tumour prosthesis¹² or allograft bone.¹³ Early weight bearing and rehabilitation can be started immediately because of excellent stability provided by the reinforced reconstruction. Further, hypertrophy of the fibula was observed as the patient began weight bearing. Taguchi et al¹⁴ have previously shown that the addition of a vascularised bone graft resulted in improved union of the autoclaved bone to the remnant bone.

Autoclaving of the tumour bearing bone leaves no residual tumour tissue as shown by histological studies from the autoclaved bone in all our cases. Furthermore, there was no recurrence in the 14 cases of autoclaved bone on follow-up. Late infection occurred in 1 of the 14 autoclaved bone reconstructions (Case 20). This infection was ultimately eradicated. Others have also reported favourable results with autoclaved bone used as a spacer after tumour resection.^{15,16}

The use of the patient's own tissue is a vital step in limb salvage reconstruction in developing countries. Following Taylor's first report on the use of the vascularised fibula as a spacer in post trauma tibial defects,¹⁷ Weiland in 1977¹⁸ and Pho in 1979¹⁹ had publicised the use of this bone in reconstruction following tumour resection. The fibula alone, however, was insufficient in the weight bearing lower limb. Stress fractures of the vascularised fibula required the need for protection till the transplanted bone hypertrophied. The supplementing of the fibula with the patient's own autoclaved bone is useful in preventing stress fractures and to allow early full weight bearing and rehabilitation of the reconstructed limb without external support.

Harvesting of a free vascularised fibula is technically demanding and time consuming and needs microvascular expertise. The use of the ipsilateral fibula as a pedicled graft, especially in cases of distal femoral and proximal tibial osteosarcoma, overcame the need for microvascular

anastomoses in some of our cases (Fig. 3).

Non-vascularised fibula grafts were used with autoclaved bone in distal femoral reconstruction in 2 patients when the bed was considered sufficiently healthy. In both patients, healing was uneventful. However, the fibula did not hypertrophy.

Autoclaved bone alone was used on 2 occasions, 1 for arthrodesis of the knee and the other for total joint arthroplasty of the knee. In both, the defects were small, 16 cm and 9 cm respectively, and an addition of a vascularised graft was not deemed necessary.

Custom prostheses are only available in specialised centres and are prohibitively expensive for use in developing countries. Although they provide immediate stability and allow early mobilisation and weight bearing, mechanical failure and host bone-implant interphase problems can potentially compromise long-term good results in young patients.^{12,20}

The initial outlay for the development and the subsequent maintenance of a bone bank has discouraged the use of allografts in developing countries, and the attendant problems of infection, disease transmission and the failure of the bone as a stable lasting structure have compounded this stance.¹³ In the long run, a successful biological reconstruction with the patient's own tissue is likely to outlast any prosthesis or allograft.

Ablative procedures and fitting with affordable prostheses are attractive alternatives to limb salvage for lower limb sarcomas. Limb salvage has a high morbidity as shown in this series and the time needed to rehabilitate patients is much longer should complications arise. However, studies indicate that patients still prefer limb salvage.^{9,12} The favourable outcome in the surviving patients in this review indicates the important role of biological reconstruction. The use of the autoclaved bone combined with a vascularised fibula graft has provided a new possibility in reconstruction. It provides the surgeon with absolute control over the material he uses and the surgical environment in which he operates. Joint preserving techniques used in this series go a long way in optimising this reconstruction.

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