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Evaluation of the allograft–prosthesis composite technique for proximal femoral reconstruction after resection of a primary bone tumour

Bruce M. McGoveran, MD;* Aileen M. Davis, BScPT, MSc, PhD;† Allan E. Gross, MD;‡ Robert S. Bell, MD†

OBJECTIVE: To evaluate clinical and functional outcomes resulting from the allograft-composite technique used for proximal femoral osteoarticular reconstruction in patients who had limb salvage surgery for primary bone tumours.

DESIGN: A retrospective review of a prospectively gathered database to provide a descriptive study.

SETTING: A tertiary care musculoskeletal oncology unit in a university hospital.

PATIENTS AND INTERVENTIONS: Patients treated between 1987 and 1993 were eligible for inclusion in this study if they met the following criteria: they were treated surgically for a primary malignant bone tumour; and a proximal femoral allograft-implant composite technique was used for the reconstruction.

MAIN OUTCOME MEASURES: Major postoperative complications with emphasis on mechanical complications in the reconstructive composite implant. Functional outcome in a subset of patients using the 1987 and 1994 versions of the Musculoskeletal Tumor Society instrument, the Short-Form-36 and the Toronto Extremity Salvage Score.

RESULTS: There were 5 mechanical and 2 infectious complications requiring surgical intervention. Functional scores were generally low.

CONCLUSIONS: Our results suggest that the perceived benefits of the composite technique may accrue only to a few patients, partly owing to the risk of mechanical complications. Although these can be reduced by avoiding the use of cement in the host femur, the generally poor functional outcomes suggest that this technique needs to be studied further in this group of patients and compared with other reconstructive techniques, particularly the prosthetic implant.

OBJECTIF : Évaluer les résultats cliniques et fonctionnels de la technologie d'allogreffe composite utilisée pour une reconstruction ostéoarticulaire fémorale proximale chez des patients qui ont subi une intervention chirurgicale de sauvetage du membre à cause d'une tumeur osseuse primitive.

CONCEPTION : Revue rétrospective d'une base de données constituée de façon prospective de façon à permettre une étude descriptive.

CONTEXTE : Unité d'oncologie musculosquelettique de soins tertiaires dans un hôpital universitaire.

PATIENTS ET INTERVENTIONS : Les patients traités entre 1987 et 1993 pouvaient être inclus à l'étude s'ils satisfaisaient aux critères suivants : ils avaient subi une intervention chirurgicale pour une tumeur osseuse maligne primitive et l'on avait utilisé pour la reconstruction une technique composite d'allogreffe-implant fémoral proximal.

PRINCIPALES MESURES DE RÉSULTATS : Principales complications postopératoires mettant l'accent sur les complications mécaniques dans l'implant composite de reconstruction. Résultat fonctionnel chez un sous-ensemble de patients utilisant les versions 1987 et 1994 de l'instrument de la Musculoskeletal Tumor Society, la formule courte 36 et le Toronto Extremity Salvage Score.

From the †University Musculoskeletal Oncology Unit, ‡Division of Orthopedic Surgery, Mount Sinai Hospital and the University of Toronto, Toronto, Ont.

**Resident, University of Toronto*

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Correspondence to: *Dr. Robert S. Bell, Suite 476, Mount Sinai Hospital, 600 University Ave., Toronto ON M5G 1X5; fax 416 586-8397*

RÉSULTATS : Il y a eu cinq complications mécaniques et deux complications infectieuses qui ont obligé à procéder à une intervention chirurgicale. Les résultats fonctionnels ont été en général bons.

CONCLUSIONS : Nos résultats indiquent que quelques patients seulement peuvent profiter des avantages perçus de la technique composite en partie à cause du risque de complications mécaniques. Même si l'on peut réduire ces risques en évitant d'utiliser du ciment dans le fémur hôte, les résultats fonctionnels généralement médiocres indiquent qu'il faut étudier davantage cette technique chez ce groupe de patients et la comparer à d'autres techniques de reconstruction, et en particulier la prothèse.

Treatment options for primary malignant tumours of the proximal femur have evolved substantially over the past 25 years. Whereas amputation was once the only option for bone sarcoma, improved imaging methods and adjuvant therapy now permit resection for limb salvage in a large proportion of patients with primary malignant bone tumours. Reconstruction after resection of a tumour remains a complex problem since, in addition to reconstruction of the bone defect, the surgeon must also frequently compensate for the loss of muscles important for hip stability and function. Several reconstructive techniques have been developed to address these issues.[1–4]

Osteoarticular allografts, often used for reconstruction at other anatomic sites,[5] have been used for proximal femoral reconstruction.[3,4] Once properly aligned, the allograft is fixed to host bone with dynamic compression plates (DCPs), and the remaining muscles are reattached. By restoring bone stock and providing an attachment site for hip stabilizers, particularly the gluteus medius muscle, these allografts theoretically might provide the best approximation of normal hip biomechanics.

Prosthetic implantation offers an alternative to reconstruction with allograft. Use of a prosthesis avoids the risk of disease transmitted from the donor, and rehabilitation times tend to be shorter.[6] However, abductor reattachment achieved by suturing tendons to surrounding soft tissues or wiring the osteotomized greater trochanter to the prosthesis seems less likely to be effective than the use of allograft for abductor reattachment.[6]

The allograft-prosthesis, or composite, technique is a hybrid of these 2 techniques. Use of a long-stem prosthesis provides a strong load-bearing strut between the pelvis and distal host femur that bridges the allograft–host junction. By incorporating allograft into the proximal part of the reconstruction, a biologic attachment site for salvaged abductors is available, presenting an opportunity for improved postoperative function. In addition, the use of a prosthesis that is not cemented to host bone and that does not induce bone ingrowth distally allows for a technically simpler revision.

Over the past several years, the composite technique has been used in our unit. We have reviewed our prospectively gathered case files and have evaluated this surgical technique. Data on postoperative complications, limb function and quality of life are included in this evaluation.

Patients and methods

The prospectively collected database from 1987 to 1993 that was developed for primary bone tumours at the University Musculoskeletal Oncology Unit was searched, and patients who underwent composite reconstruction of the proximal femur were identified. Included in this review of surgical technique were the patients with primary malignant neoplasms of bone. Their clinical records and radiographic studies were reviewed to determine the reconstructive technique used, allograft outcomes, functional outcomes, and postoperative complications and failures. Failure was defined as the need to remove the construct, and a complication as any event requiring modification of postoperative treatment that did not require removal of the construct. Interviews, which included completion of the 1987 and 1994 versions of the Musculoskeletal Tumor Society (MSTS) functional evaluation, the Short-Form-36 (SF-36) and the Toronto Extremity Salvage Score (TESS), and physical examinations were also conducted.[7–10]

In all patients the tumours were staged preoperatively by appropriate radiologic studies, bone scintography and histologic studies of biopsies as described by Enneking.[11] Allografts were procured under sterile conditions, radiated to a total dose of 2.5 Mrad, deep frozen at −70 °C and maintained in accordance with the guidelines of the American Association of Tissue Banks.[12]

Preoperative radiographs were used to determine allograft fit. For all procedures, antibiotics were administered prophylactically and operating rooms equipped with laminar flow were used. Generally, body exhaust suits were worn.

Operative technique

In the early phase of the series, one technique was used in the majority of patients (technique 1). After the proximal femur was resected and resection margins were confirmed to be free of tumour, the allograft was brought into position and sized. After reaming, a long-stem prosthesis was cemented into the allograft. A step-cut osteotomy was employed at the host–allograft junction and occasionally reinforced with cortical strut allograft. To promote union, iliac bone graft and circlage wires were used. Distally, the prosthesis was cemented into host bone (Fig. 1). When possible, host greater trochanter was osteotomized and attached to the allograft with interosseous wires. When tumour extended into the greater trochanter and the abductor muscle could be salvaged, the abductor tendons were divided and then sutured to soft tissue conserved on the allograft. On the acetabular side, resurfacing typically consisted of either an uncemented, press-fit component or a cemented component, seated horizontally. When tumour extended into the pelvis, resection and allograft reconstruction were necessary (Fig. 2).

In the later stages of the series, technique 1 was modified to encourage union through compression at the host–allograft junction with weight-bearing by leaving the distal portion of the femoral component uncemented into host bone (Fig. 3) (technique 2). When distal femoral bone stock was considered to provide an inadequate fit, we resorted to distal cement fixation. When the tumour extended down the femur beyond the distance that could be bridged by a long-stem prosthesis, reconstruction consisted of a cemented short-stem alloimplant with cement extending distally to the host-bone junction (Fig. 4). Distal fixation was achieved with a DCP (technique 3).

In all of the cases described here, a standard total hip component was routinely used for acetabular reconstruction. Most recently, bipolar mobile heads have been used whenever possible to avoid replacing the acetabulum.

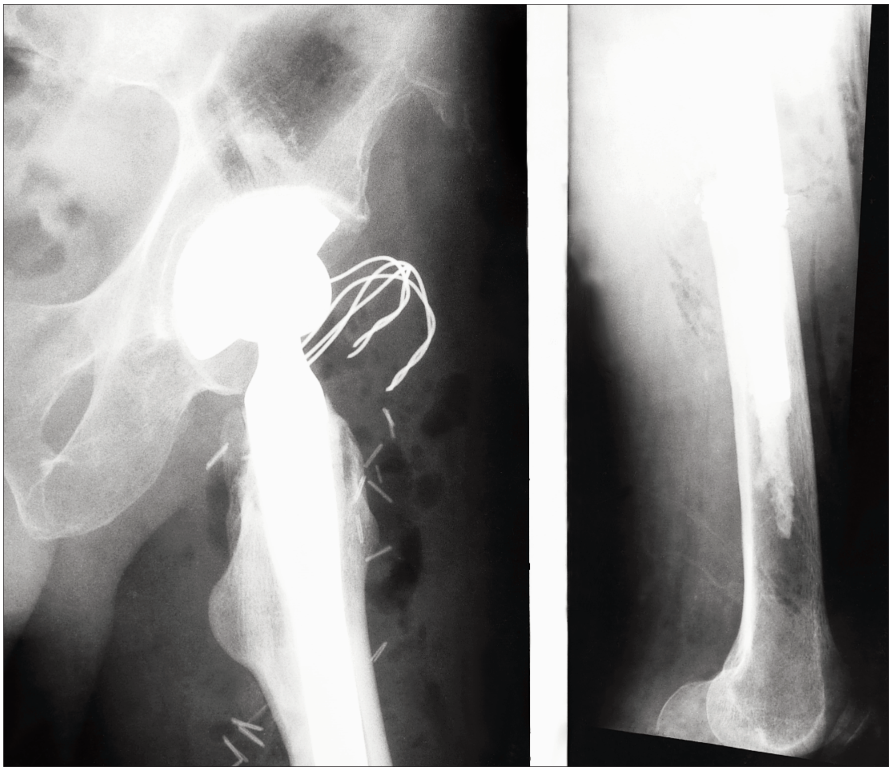

FIG. 1. The prosthesis is cemented both proximally into the allograft and distally into the host bone (technique 1).

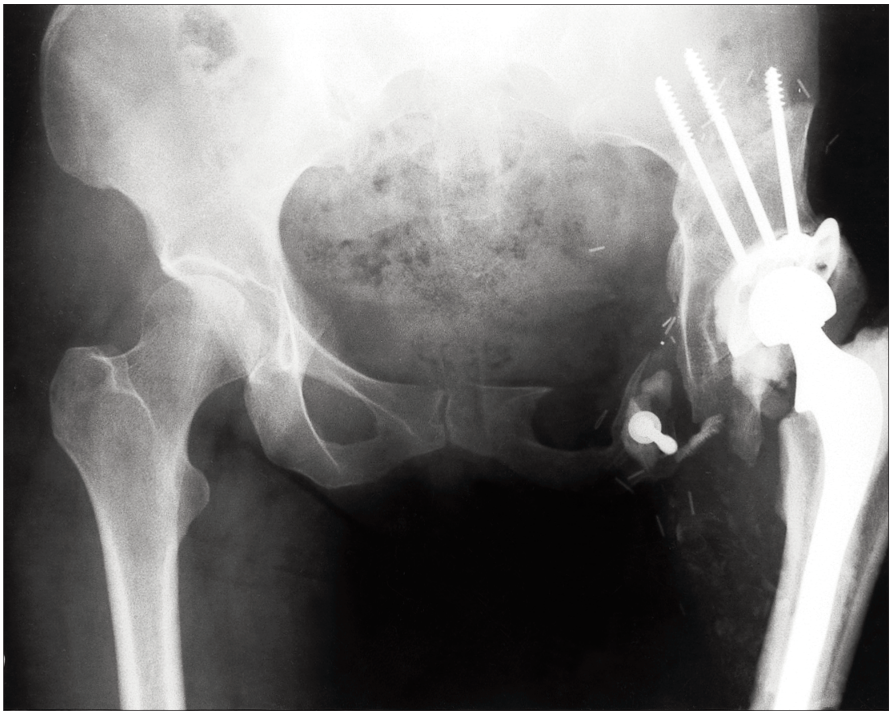

FIG. 2. When the tumour extended into the pelvis, reconstruction was undertaken using allograft on both the pelvic and the femoral side.

Functional status measurement

The 1987 MSTS assesses functional outcome, including the parameters of pain, range of motion, strength, deformity, stability, function and acceptance of the surgical procedure. Each parameter is scored on a scale of 0 to 5, with a higher score signifying a better result. Individual parameter scores are then summed to a final global score out of 35.[7]

FIG. 3. In later patients, the prosthesis was cemented into the allograft and press-fit distally (technique 2).

The 1994 MSTS assesses functional outcome, including the parameters of pain, gait, function, acceptance, support and walking. Again, each parameter is scored on a scale of 0 to 5, with a higher score signifying a better result. The raw score is converted to a percentage. This MSTS differs from the first not only in content, but also in allowing exclusion of categories not applicable to a particular patient.[8]

The SF-36 is a reliable, validated generic instrument of health status designed to measure patient-perceived health along the dimensions of physical functioning, role functioning — physical, role functioning — emotional, bodily pain, general health, vitality, social functioning, mental health and health transition.[9] Each dimension's raw score is converted to a 100 point scale, with a higher score signifying a lesser degree of disability.

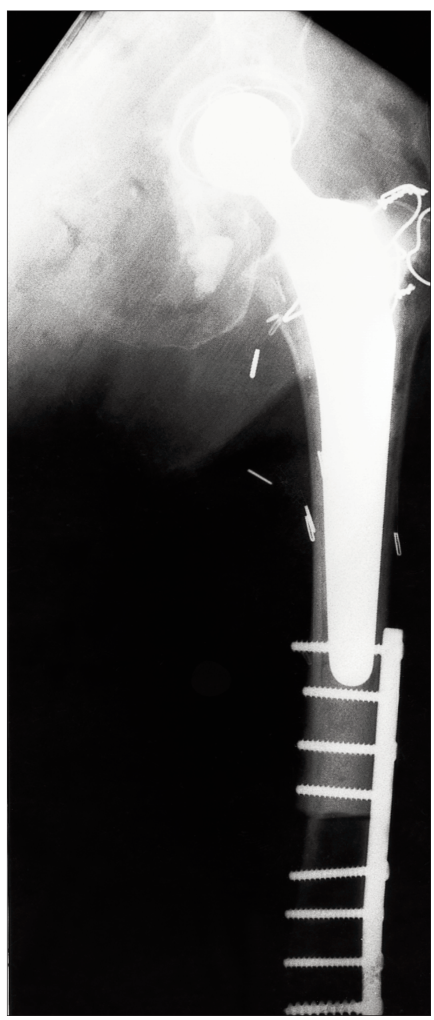

FIG. 4. When the tumour extended distally, a short prosthesis was cemented proximally. A dynamic compression plate was then used to fix the allograft to the host bone (technique 3).

The TESS is a disease-specific measure of patient-perceived function. Thirty questions, on a response scale of 1 to 5, assess the patient's ability to perform a variety of common daily activities after resection of lower limb sarcoma. Patients have the options of omitting questions not relevant to them and adding additional items to the core list. The final raw score is converted to a score out of 100, with a higher score suggesting a lower level of disability. The TESS is a reliable, validated instrument.[10]

Study group

Eighteen patients with primary malignant neoplasms of bone were identified, 1 of whom died within the first postoperative week and was excluded. A second patient was excluded owing to missing information. Demographic data for the remaining 16 patients (10 women, 6 men) are provided in Table I. The mean age of the patients was 51 years (range from 25 to 83 years). Postoperative follow-up, calculated as the interval between the date of original surgery and most recent contact, averaged 47 months (range from 24 to 93 months). Diagnoses included chondrosarcoma (8 patients), osteosarcoma (3 patients), malignant fibrous histiocytoma (2 patients), multiple myeloma (1 patient), Ewing's sarcoma (1 patient) and hemangiosarcoma (1 patient).

Operative procedure

In 5 patients, distal cementing was

used, in 9 patients there was no distal cementing and in 2 cases the short-stem alloimplant (with DCP) technique was used (Table II). Fourteen patients received long-stem prostheses, all of which were cemented into allograft. Of these, 13 had step-cut osteotomies. Thirteen had autograft applied to the allograft–host junction. As well, 4 patients underwent pelvic allograft reconstruction.

Abductor muscles were managed by greater trochanteric osteotomy in 5 of the 16 patients, by abductor tendinotomy and attachment to allograft greater trochanter only in 4 patients, by attachment to surrounding soft tissues only in 2 patients, and with a combination of allograft-soft tissue reattachment in 2 patients. Whenever the length of residual abductor tendon was sufficient, reconstruction was carried out to the allograft. When the residual tissue was insufficient to attach to the graft, it was sutured to whatever residual distal soft tissues remained. In 3 patients, tumour spread necessitated complete abductor muscle resection.

It is recognized that the multiple variables present within this small group of patients limit the confidence placed in any comparison of subgroups. We have therefore limited this review to a descriptive analysis of results.

Results

Five (32%) of the 16 patients in the study group died of their disease.

Complications

There were 9 complications involving 8 patients (Table III). There were 2 incidents of allograft–host nonunion (Fig. 5). Both patients required reoperation: repeat bone grafting in one and bone grafting and additional DCP fixation in the other. Union was subsequently achieved in both cases. There was one case of delayed union that ultimately resulted in an allograft fracture. This was managed with a second allograft-implant reconstruction. Two additional allograft fractures were noted. The first was found incidentally at a routine follow-up visit and subsequently healed without intervention. The second, involving a short-stem allograft-prosthesis, required removal and a second allograft-implant procedure (Fig. 6). Three allograft infections occurred. Conversion to an uncemented tumour prosthesis was required in one case, and construct removal with no additional reconstruction was used in another. The third allograft infection, the result of a perforated viscus, resolved with bowel repair and antibiotic therapy. No manipulation of the allograft was required. In summary, although the numbers of patients treated with cement versus no cement distally are too small to draw comparative conclusions, there was 1 implant failure in 5 cases using cement distally and no failure in the 9 uncemented cases.

Functional status

Thirteen patients were assessed by both versions of the MSTS. Of the 3 patients not assessed, 2 had their constructs removed and 1 declined to participate. The mean (and standard deviation) global score for the 1987 MSTS was 22.4 (6.3), and for the 1994 MSTS was 58.3 (18.5). Results for the 1987 and 1994 MSTS are summarized in Tables IV and V, respectively.

Five patients also completed the SF-36, the results of which are summarized in Table VI. The same 5 patients also completed the TESS. Of the 11 patients who did not complete the SF-

Table I

Demographic Data for the 16 Patients in the Study Group*

Case no.	Sex/age, yr	Date of operation	Diagnosis	Stage	Length of follow-up, mo
1	M/32	08/91	OS	IIa	49
2	F/28	11/93	ES	—	22
3	F/68	01/91	MM	N/A	52
4	M/25	01/92	OS	IIb	25
5	F/63	02/91	CS	IIb	48
6	F/36	12/89	OS	IIb	65
7	M/58	12/90	CS	Ia	54
8	F/59	06/92	CS	IIb	39
9	F/42	11/89	HS	IIa	67
10	F/41	06/89	CS	IIb	12
11	F/62	03/87	CS	Ia	39
12	M/70	12/87	CS	IIa	93
13	F/83	01/88	MFH	IIa	20
14	F/63	02/87	MFH	IIb	60
15	M/31	02/88	CS	Ib	34
16	M/59	08/89	CS	IIb	73

*In all cases the tissue at the margin of the excised tumour was negative for malignant cells.
OS = osteosarcoma, ES = Ewing's sarcoma, MM = multiple myeloma, CS = chondrosarcoma, HS = hemangiosarcoma, MFH = malignant fibrous histiocytoma

36 and TESS, 5 died before the start of instrument utilization, 2 had their constructs removed, 2 were unable to complete the questionnaires because of language barriers, 1 declined to complete the questionnaire, and 1 had metastatic disease. Mean dimensional scores on the SF-36 were below reported norms in all dimensions except vitality and social role ability. The mean TESS score was 71.2 (21.6) (range from 37.0 to 91.0).

Table II

Surgical Technique Used in the 16 Patients in the Study Group

Case no.	Step cut	Autograft	Abductor management*	Reconstruction of pelvic side	Operative technique†
1	Y	Y	2	N	2
2	Y	Y	1	N	2
3	Y	Y	1	N	1
4	Y	Y	3	Y	2
5	Y	Y	2, 3	N	3
6	Y	Y	4	Y	2
7	Y	Y	1	N	2
8	Y	Y	4	Y	2
9	Y	Y	2	Y	2
10	Y	Y	4	Y	1
11‡	N	Y	2	Y	2
12	Y	Y	3	N	1
13	Y	Y	1	N	3
14	Y	N	2, 3	N	1
15	Y	Y	2	N	1
16	Y	Y	1	N	2

*1 = greater trochanteric osteotomy, 2 = abductor tendinotomy with reattachment to allograft greater trochanter, 3 = abductor tendinotomy with reattachment to soft tissues, 4 = complete abductor resection
†1 = Long-stem femoral prosthesis cemented distally, 2 = long-stem femoral prosthesis press fit distally, 3 = short-stem prosthesis, allograft–host junction secured with dynamic compression plate
‡Used dynamic compression plate at the allograft–host junction.

Table III

Postoperative Complications

Complication	Case no.	Outcome
Allograft delayed union	12	Allograft fracture (see below)
Allograft nonunion	7	Repeat bone grafting with subsequent union
	16	Repeat bone grafting and plate fixation with subequent union
Allograft fracture	5	Asymptomatic
	12	Allograft-implant removal, allograft-implant reoperation
	13	Allograft-implant removal, allograft-implant reoperation
Allograft infection	8	Resolved with bowel repair and antibiotic therapy
	14	Allograft-implant removal
	15	Allograft-implant removal, conversion to a megaprosthesis

Correlation of function and management of abductors

Function was tested in 4 of the 5 patients for whom a trochanteric osteotomy was used in resecting the tumour with subsequent trochanteric reattachment of the allograft. Three of these 4 patients could abduct their leg against gravity. In contrast, only 3 of 9 patients tested for abductor strength

FIG. 5. This allograft-implant was cemented proximally and press fit distally. The allograft failed to unite until a secondary bone graft was performed (case 7 in Table I).

after suturing abductors into the allograft bone, allograft soft tissue or into the surrounding soft tissues could abduct against gravity. These results suggest that reattachment of the trochanter to the allograft may provide a better chance of achieving antigravity strength in abduction.

Discussion

Our current allograft-implant technique employs a long-stem prosthesis cemented proximally into allograft and uncemented distally into host femur. A step-cut is made at the allograft–host junction. Abductor muscles are reattached preferably by greater trochanteric osteotomy; if this is not possible, abductor tendons are sutured to the allograft or attached to the surrounding soft tissue. When tumour on the femoral side extends beyond the range of this technique, a short-stem allograft-implant is cemented into a long allograft, which is fixed to host femur by DCP. Although acetabular reconstruction with total hip components was used in this series, bipolar articulating cups are used whenever possible today.

Nine complications were noted in the series of 16 patients (56%). Two of these, 1 minor infection and 1 asymptomatic allograft fracture, required no orthopedic intervention. The other 7 complications were associated with delayed union in 6%, nonunion in 12%, allograft fracture in 12%, and allograft infection in 12%.

Our infection rate is comparable to that of other published series. Zehr, Enneking and Scarborough reported[6] 3 (14%) allograft infections in a series of 21 patients who underwent composite reconstruction. Others have reported allograft infection rates of between 4% and 14%.[3,5,13] The frequency of infection likely reflects the extent of the reconstructive procedure.

The 2 symptomatic allograft fractures in this series were predictable, based on the techniques used. The fracture in case 13 (Table I) occurred at the point of stress concentration between a short implant and a DCP. There was minimal overlap between the plate and implant to avoid this stress concentration effect (Fig. 4). The second fracture (case 12, Table I) occurred after cementing the stem into the distal femur. In retrospect, this distal cementing opposed collapse at the osteotomy site, resulting in nonunion and eventual fracture.

The potential for allograft to serve as a biologic attachment site for the abductor muscles after trochanteric osteotomy or tendon attachment to the graft was expected to provide good hip function and stability. MSTS scores, however, were generally low, partly because of the emphasis both versions place on abductor function. In the 1987 version, for example, abductor function is a key factor in both the strength and the stability scores. In the 1994 version, the parameters walking, gait, and support all implicitly assess abductor function. Consequently, with impaired abductor function, patients are penalized across many parameters, producing low global scores and percentages. In this study, 3 of 4 patients treated with trochanteric osteotomy and fixation to the allograft were able to abduct against gravity. Patients with abductors attached to the allograft in the absence of bone were less likely to be able to abduct against gravity.

FIG. 6. Fracture of the allograft below the tip of the prosthesis.

Table IV

1987 Musculoskeletal Tumor Society Instrument Scores in 13 Patients

Measure	Pain	Range of motion	Strength	Deformity	Stability	Function	Acceptance	Global score
Minimum	3	0	0	1	0	0	1	5
Maximum	5	5	5	5	5	5	5	35
Mean	3.8	4.0	1.7	4.4	1.7	2.8	4.5	22.4
Standard deviation	1.0	1.5	1.7	1.3	1.7	1.2	1.2	6.3

Overall rating: good, 6 patients; fair, 2 patients; poor, 5 patients

Similar results were found with functional assessment using the SF-36, most average dimensional scores from which either approximated or were below the 25th percentile based on United States population sample norms.[9] The low psychosocial dimensional scores are likely attributable to the diagnosis of cancer.[14] The low scores in the physical component reflect an impairment in hip function beyond that required for basic activities, such as walking one block; at this activity level patients generally indicated only mild limitation. At higher activity levels, which included more protracted stair climbing or walking, as well as participation in sports, patients reported severe limitations. The impression that the composite technique appears able only to restore sufficient hip function for relatively low activity levels is also supported by TESS scores. Once again, patients indicated that they were quite able to perform lower demand, self-care activities but were much more limited in high-demand mobility activities.

Although the data are not presented here, our group has experience of prosthetic reconstruction after excision of a proximal femoral tumour. There is no question that reconstruction with a prosthesis is technically simpler than allograft-implant composite reconstruction and that the superior initial fixation achieved with a prosthesis facilitates rehabilitation. The potential advantages of the allograft-implant composite are: superior abductor attachment, and therefore better ambulation as well as increased ease of revision, since bone is conserved.

In this series, the functional outcome scores indicate that an average patient walks with a limp, uses a cane and is restricted to low-demand activities. The potential advantages of abductor attachment to allograft are likely offset by the muscular and neurovascular damage to the abductor mechanism caused by the resection of proximal femoral sarcoma. It should be recognized that this situation is different from the one in which bulk allograft is used for proximal femoral revision. In the revision scenario, soft-tissue attachments to host bone are preserved and used to resurface the allograft bone.[15] In revisions, there is limited dissection of the soft tissues and this likely improves eventual ambulatory function. The difference in the magnitude of soft-tissue dissection in removal of a proximal femoral tumour is substantial and the results of proximal femoral reconstruction with either allografts or implants should be separated for revision versus tumour cases.

Once the allograft has healed to host bone, the composite reconstruction probably has a mechanical advantage over prosthetic reconstruction. However, to realize this advantage it is critical that the implant is not cemented into host bone. If cement is used in the host femur, compression at the allograft–host junction is lost and union may be delayed, placing the same mechanical strains at the junction as are present in the cemented prosthesis. Indeed, until union occurs, the allograft-implant composite functions much as a prosthesis. As seen in

Table V

1994 Musculoskeletal Tumor Society Instrument Scores in 13 Patients

Measure	Pain	Function	Emotional acceptance	Supports	Walking	Gait	Global score, %
Minimum	0	0	0	0	0	0	0
Maximum	3	5	5	5	5	4	90
Mean	2.1	3.7	3.9	1.8	3.7	2.3	58.3
Standard deviation	1.1	1.8	1.5	1.2	1.3	1.5	18.5

Table VI

Short-Form-36 Scores in 5 Patients

Measure	Physical function	Role — physical	Bodily pain	General health	Vitality	Social function	Role — emotional	Mental health
Minimum	5	0	41	47	40	62.5	0	32
Maximum	55	100	100	100	100	100	100	100
Mean	24.0	50.0	58.8	68.6	71.0	85.0	80.0	72.8
Standard deviation	19.8	46.8	24.5	21.2	24.6	16.3	44.7	26.7
Sample Means*	84.15 (23.3)	80.96 (34.00)	75.15 (23.69)	71.95 (20.34)	60.86 (20.96)	83.28 (22.69)	81.26 (33.04)	74.74 (18.05)

*Sample means are norms for the general United States population (*n* = 2474).

case 12 (Table I), this type of reconstruction is at risk for implant failure at the junction site.

The final potential advantage of allograft-implant reconstruction is ease of revision. When the implant is uncemented into the distal femur, the composite is much easier than a prosthesis to remove in the case of either infection or fracture. Removal of the allograft-implant composite requires only a simple osteotomy at the junction site rather than difficult extraction of a cemented prosthesis.

Others have directly compared patients with allograft-implant and prosthetic reconstruction of the proximal femur after tumour resection and have found no difference in the functional outcome of the 2 groups.[6] We had anticipated that patients with allograft-implant composite reconstruction might fare better because of the potential for improved abductor attachment. Based on this study, we now use allograft implants for reconstruction if it is possible to salvage the trochanter for reattachment to the graft and if the level of femoral resection and the diaphyseal diameter of the host femur permit stabilization of the osteotomy with a long-stem femoral prosthesis. If these conditions are not met, we generally choose a prosthesis without allograft.

We have documented some of the advantages and limitations of the allograft-implant composite for proximal femoral reconstruction. Of the 3 surgical techniques used in these 16 patients, we prefer the method of bridging the junction site with a long-stem prosthesis that is cemented in the allograft and uncemented in the host. If the proximal defect after tumour resection extends well distal to the femoral isthmus, it may be impossible to stabilize the allograft with available implants. In this scenario, we use a DCP overlapping the prosthesis to achieve stability.

The relative advantages of allograft-implant composite and prosthetic reconstructions are not yet clear and will require either comparative studies or further documentation of the outcomes of both reconstructive techniques. At present, there is little documentation of the outcome of either technique in the literature so the presentation of data related to either technique is useful. To be of greatest value, these reports should include only patients who undergo curative resection of primary bone tumours and should exclude patients treated for revision arthroplasty or metastatic tumours.

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