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**Long-term Results of Massive Intercalary Endoprosthetic Reconstruction With Short Segment Compressive Osseointegration With and Without Cement Augmentation**

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**Abstract:**

**Background:** Intercalary endoprosthetic reconstruction following diaphysectomy offers significant functional advantage through preservation of native joints proximal and distal to the resected defect. Due to the requirement of stem fixation, use of such implants is restricted by the amount of bone remaining adjacent to the defect.

**Questions/Purpose:** The purpose of this study was to review the complications and the oncologic and treatment-based outcomes seen in short-segment fixation of intercalary endoprosthetics in patients who have undergone diaphysectomy of the femur and tibia to determine the viability of this treatment option for management of these difficult situations.

**Patients and Methods:** Three males and 3 females were treated between 2005 and 2009 with short segment fixation double Compress<sup>®</sup> (Biomet, Inc.<sup>™</sup>, Warsaw IN, USA) intercalary endoprosthesis. Customizing the anchor plugs and adding polymethylmethacrylate cement augmentation enabled the short segment fixation. Patient demographics, complications, oncologic outcomes, and treatment-based outcomes were recorded prospectively and reviewed retrospectively.

**Results:** Five cases were following diaphysectomy with en bloc tumor resection and limb salvage for malignant tumors of the long bones of the lower extremities and the other case was a revision implant for multiple failed and infected intercalary allografts. Average age of the patients at surgery was 35 years (range 12-86 years). Five cases involved the femoral diaphysis, while 1 involved the distal tibial metadiaphysis. Patient characteristics, surgical management, and clinical outcomes of the study patients are presented in the Table.

Overall outcomes were good at average follow-up of 35 months (range 10–84 months), including case 3, who returned to dancing 1 year postoperatively despite being non-weight bearing for 8 years prior to surgery. Four patients died from systemic disease progression. All patients were followed for at least 2 years with the exception of two patients, who died from systemic disease progression at 10 months and 1.5 years postoperatively (cases 4 and 5, respectively). Two patients remain alive and free of disease at the time of abstract submission. One patient with a soft tissue sarcoma with secondary bone involvement (case 5) was the only patient to exhibit local disease recurrence. This occurred in the adjacent soft tissues and was amenable to re-resection with retention of the prosthesis.

The shortest segment of bone to achieve stable fixation was 3.7 cm. Two patients required revision of only a portion of the prosthesis. Both suffered a femoral implant fracture 6 months (case 6) and 37 months (case 1) postoperatively at the proximal spindle/anchor plug junction. One patient required a return to surgery for dissociation of the Morse taper of the proximal implant body that was treated successfully with open reduction and retention of prosthesis. One patient suffered a periprosthetic fracture 25 months postoperatively as a result of trauma that healed uneventfully with closed casting and without the need to return to the operating room. No patient required revision of the entire implant or revision to an amputation. No patient exhibited aseptic loosening and no case was complicated by infection.

Follow-up radiographs have demonstrated appositional new-bone formation at each implant/bone junction, which has persisted throughout follow-up of up to 7 years postoperatively. In every case, the adjacent joints were preserved, and in case 1, the adjacent open physal plates could be preserved allowing for uninterrupted, continued growth (Figure). It has been recommended a period of 6 weeks of non-weight-bearing follow implantation to prevent early failure from loss of fixation seen in the temporarily necrotic bone from the high compression loads generated by the implant. However, one striking clinical observation during the postoperative period in this series was the lack of pain associated with the compression mechanism. This lack of pain proved challenging, in that all but case 1 attempted to resume normal activities within the first 3 weeks postoperatively. Early failure was not observed in this series as a result.

**Conclusions:** Compressive osseointegration via short-segment fixation may serve to extend the benefits of joint preservation to patients who previously had limited reconstructive options. Augmentation with cement may help alleviate potential issues of eccentric anchor plug placement, overcompression, and high bending stresses seen in uncemented fixation into the flaring, widened metaphysis of long bones. Early ambulation in the present series did not adversely affect early component stability or long-term osseointegration. Because of the obvious functional advantages of joint preservation, this method should be considered over joint replacement arthroplasty whenever epiphyseal-sparing resections can be accomplished in tumor surgery with a remaining segment of bone of at least 3.7 cm long for adequate fixation.

**Level of Evidence:** IV, case series

**Table.** Cases of short-segment double compressive osseointegration intercalary endoprosthetic reconstruction. DOD = dead of disease; yrs = years; mo = months; wks = weeks; Y = yes; N = no; MFH = malignant fibrous histiocytoma; fx = fracture; sx = surgery.

Case	Diagnosis	Location	Age at Sx	Follow-up	DOD	Neoadjuvant/Adjuvant Therapy	Cement Augment	Length of Shortest Bone Segment Canal (cm)	Complications
1	Ewing's sarcoma	Femur	12	7 yrs	N	Neoadjuvant/ adjuvant chemotherapy	Y	5.6	Periprosthetic fx between prosthesis and native joint 25 mo from sx treated successfully closed and proximal anchor plug stem fx 37 mo from sx requiring revision of the anchor plug
2	Osteosarcoma	Tibia	13	2 yrs	Y	Neoadjuvant/ adjuvant chemotherapy	Y	3.7	None
3	Intercalary allograft septic failure	Femur	21	2.5 yrs	N	None	Y	4.6	Proximal femur fx intraoperatively treated successfully with revision bone cut during the same procedure

4	MFH of bone	Femur	62	10 mo	Y	Neoadjuvant/ adjuvant chemotherapy	N	5.4	Dissociation of implant body Morse taper 3 wks from sx treated successfully with open reduction and retention of prosthesis
5	MFH of soft tissue with bone invasion	Femur	86	1.5 yrs	Y	None	Y	5.6	Soft tissue local recurrence 12 mo from sx treated with wide resection and retention of prosthesis
6	Periosteal osteosarcoma	Femur	17	3.5 yrs	Y	Neoadjuvant/ adjuvant chemotherapy	Y	8.2	Catastrophic implant failure at the proximal spindle/anchor plug junction 6 mo from sx treated successfully with revision of proximal anchor plug and spindle

**Figure.** Case 1 intercalary endoprosthetic reconstruction. (Left) Index reconstruction with bipolar short segment compressive fixation. Both femoral physes were spared, with cementation and custom shortened anchor plug required distally; (Right) Follow-up radiograph 7 years after index procedure. Note successful continued normal growth of the limb as a result of the custom component sparing the adjacent physes.

