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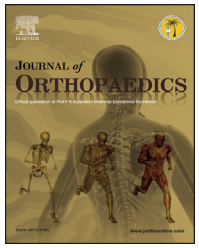

Original Article

Comparison of gait parameters in distal femoral replacement using a metallic endoprosthesis versus allograft reconstruction

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ABSTRACT

Background/aim: Restoration of gait mechanics after reconstruction have been associated with improved functional outcomes and increased longevity of the reconstruction. The goal of this study is to compare the gait mechanics of an allograft reconstruction of the distal femur to both metallic endoprosthetic reconstruction relative to normal control subjects.

Methods: Gait parameters were captured using motion capture system, and then analyzed and compared for patients with metallic endoprosthetic reconstructions, and patients with allograft reconstructions of the distal femur following resection of malignant bone tumor, with subjects having no history of musculoskeletal disorders serving as a control group.

Results: All reconstructed distal femurs following tumor resection resulted in decreased range of motion reflected in observed flexion/extension angles compared to the normal limbs. The allograft reconstructed knees demonstrated normal patterns of rotation whereas the metal subjects had abnormal patterns of rotation and statistically significant differences in rotational moments.

Conclusion: Allograft distal femoral reconstruction after malignant excision remains a viable option for surgeons faced with problems associated with iatrogenic muscle, bone and soft tissue defects.

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1. Introduction

Malignant bone tumors of the distal femur are often managed with wide excision of the primary lesion without amputation. The goals of limb salvage surgery are to retain as much uninvolved tissue as possible to maximize the functional outcome for the patient. The reconstruction options for limb preserving segmental distal femoral resection include metallic endoprosthesis, osteoarticular allograft, intercalary allograft arthrodesis, and tumor sterilization (radiation, cryotherapy or microwave treatment) of the distal femur.[1–5]

Acceptable medium to long-term outcomes have been reported for both endoprosthetic and osteoarticular allograft reconstruction types.[3,4,6] The advantages and disadvantages of each reconstruction type have been described elsewhere,[3,7] but of particular interest to this study are the benefits derived from having soft tissue attachments on the allograft for the purposes of reconstruction and thus reproducing normal kinematics of the knee. Endoprosthetic reconstructions of the distal femur rely on fully constrained mechanical articulations to provide mediolateral and anteroposterior stability. The allograft reconstruction provides attachment points for collateral and cruciate ligaments as well as retained muscles from the thigh and pelvis. Loss of the cruciate ligaments in the native knee has shown to result in diminished proprioception in the knee.[8,9] The complex relationship of lower extremity proprioception and muscle response is thought to play an important role in the standing balance of subject.[10] Standing balance, more than muscle strength, has been found to correlate with measureable gait parameters in patients undergoing lower extremity physical therapy following knee injury.[11]

Restoration of gait mechanics after reconstruction have been associated with improved functional outcomes and increased longevity of the reconstruction.[12,13] Prior studies have thoroughly evaluated the mechanics of the distal femoral metallic endoprosthesis both in clinical follow up and in implanted telemetric studies.[12–14] The goal of this study is to compare the gait mechanics of an allograft reconstruction of the distal femur to both metallic endoprosthetic reconstruction relative to normal control subjects. We hypothesized that proprioception would be improved in the allograft reconstruction group and this would be evidenced as well in more normal gait parameters.

2. Methods

Patients with malignant and benign aggressive tumors of the distal femur who underwent wide resection and reconstruction of the distal femur were identified from our institutional database. We selected a group of patients that lived in close proximity of the testing area, were independent ambulators and were followed for at least two years from the date of surgery.

Ten patients who underwent resection of a malignant bone tumor participated in a post-operative evaluation of gait parameters. Five of the patients had resection of malignancy followed by metallic endoprosthetic reconstruction. Five patients had allograft reconstructions of the distal femur. Ten volunteer subjects served as a control for the same gait parameters. The demographics of the two study groups are shown in Table 1. Notable is the significant difference in the age of the patients with the allograft group and the time from surgery.

Data was collected using eight Vicon® motion capture cameras (Vicon Motion Systems, Inc, Oxford, England) with standard reflective markers and four Kistler® force plates (Kistler Instrumente AG, Winterthur, Switzerland). All measurements completed during the testing session using participants who provided informed consent prior to enrolling in this study. Procedures were approved by the University of Miami's institutional review board for human subjects. Trials consisted of patients walking naturally over force plates more than ten times.

The six best trials were selected whereby the subject's foot contacted one force plate at any one moment during the gait cycle. The three groups analyzed were patients with metal replacements (Stryker® cemented modular rotating knee system without patellar resurfacing), fresh frozen osteoarticular allografts (all from a single tissue bank procured aseptically and cryopreserved with glycerol followed by controlled rate freezing), and normal control subjects. Joint position during gait cycle was recorded to allow for classification of the gait pattern by descriptive statistics.

To assess proprioception, the center of pressure or the point location of the vertical ground reaction force vector, was measured. Sway or the displacement of the body from the center of gravity was determined. To conduct this experiment, subjects stood with one foot on separate force plates simultaneously for 45 s. The variations in the center of pressure in the anteroposterior and mediolateral directions were recorded in millimeters. The subjects were tested with their eyes closed to maximize the reliance on proprioceptive input from the extremities to maintain standing balance. Means and standard deviations were collected for the parametric data and groups were compared using Student's t-test with alpha set to 0.05 to assess for statistical significance.

Table 1 – Patients demographics.

	Metallic	Allograft	p
Sex (% male)	80.00	80.00	
No of subjects	5	5	
Height (cm)	175.75 (±8.49)	163.00 (±8.01)	
Weight (kg)	89.63 (±15.46)	66.04 (±8.27)	
Age in years	42.25 (±5.9)	28.60 (± 5.6)	0.006
Post operative limb length discrepancy	1 cm	3 cm	0.095
Side	2R, 3L	2R, 3L	
Years post operative	3.6 (±0.8)	7.4 (±5.4)	<0.0001
Control group			
No of subjects			10
Height (cm)			175.75 (±1.90)
Weight (kg)			71.81 (±3.86)
Age in years			26.58 (±0.97)