Graft survivals after bone tumor resection and reconstruction using tumor-bearing frozen bone in the extremities

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INTRODUCTION:
The treatment of bone tumors involves tumor resection with appropriate surgical margins, chemotherapy, and radiation therapy. Reconstruction methods for bone defects after bone tumor resection are classified into endoprosthesis and biological reconstruction. Frozen autografts have several advantages, including good osteoinduction, osteoconduction, simple procedure, short operative time, and revitalization. Furthermore, various techniques, such as pedicle freezing, hemicortical freezing, and composite use of prostheses, have been developed to prevent freezing-related postoperative complications, such as fracture, delayed union, and osteoarthritis. On the other hand, some patients require removal of the frozen bone due to postoperative complications such as surgical site infection (SSI), tumor recurrence, or fractures of the grafted bone. To identify appropriate procedures and indications for tumor-bearing frozen autografts, information about predictive factors for graft survival is important. In this study, graft survival and its predictive factors were investigated in patients who underwent reconstruction with a tumor-bearing frozen autograft after bone tumor resection in the extremities.
METHODS:
This retrospective cohort study included 123 patients based on the following inclusion criteria: (1) histologically confirmed bone tumors, (2) located in the extremities, (3) reconstruction using a frozen autograft, and (4) follow-up period of ≥6 months. There were 61 males and 62 females (median age 25 years, range 6–90). Tumor location was the femur in 71 patients, tibia in 35 patients, humerus in 16 patients, and radius in 1 patient. There were 94 primary and 29 metastatic bone tumors.
The associations among various parameters, including age, sex, BMI, tumor location, chemotherapy, freezing method, type of implant, length of the frozen bone, operative time, intraoperative blood loss, and graft survival were investigated. Graft survival was defined as the time from the day of the operation to the day of removal of the tumor-bearing frozen autograft.
The freezing procedure was performed using the following steps: freezing the tumor-bearing bone in liquid nitrogen for 20 min, thawing at room temperature for 15 min, and thawing in distilled water for 10 min. Freezing procedures were classified into (1) free freezing, (2) pedicle freezing, and (3) hemicortical freezing. The free-freezing procedure included excision of the bone lesion by bicortical osteotomy with an appropriate surgical margin, curettage of the bone lesion, and freezing in liquid nitrogen. The pedicle freezing procedure involved exposure of the bone lesion using either proximal or distal osteotomy, prevention of tumor contamination by utilizing surgical sheets, curettage of the bone lesion, and freezing in liquid nitrogen. The hemicortical freezing procedure comprised hemicortical resection of the tumor in cases with eccentric tumor location in the long bone, curettage of the lesion, and freezing in liquid nitrogen. Tumor-bearing frozen bone was reconstructed using plates, intramedullary nails, or composites using prostheses.
RESULTS:
The mean length of the grafted bone was 13.7 ± 6.1 cm. The 5- and 10-year graft survival rates were 83.2% and 70.2%, respectively. Among the 123 frozen autografts, 25 (20.3%) were removed because of complications, including infections in 12 (9.8%), local recurrences in 8 (6.5%), and fractures in 5 (4.1%). In patients who underwent graft removal, the mean time to graft removal was 49.3 (range, 1–150) months.
In the univariate analyses, male sex, BMI of ≥23.6, tibial tumor, and chemotherapy were significantly associated with poor graft survival, whereas pedicle/hemicortical freezing procedures were associated with better graft survival. The 5-year graft survival rates in males and females were 76.8% and 89.6%, respectively ($p = 0.017$). The 5-year graft survival rates in patients with BMIs of ≥23.6 and <23.6 were 68.4% and 87.1%, respectively ($p < 0.001$). The 5-year graft survival rates were 100% in the upper extremities, 84.4% in the femur, and 73.4% in the tibia. Graft survival in patients with tibial tumors were significantly lower than in those with tumors located at other sites ($p = 0.034$). The 5-year graft survival rates in patients who underwent chemotherapy and those who did not were 80.3% and 91.1% ($p = 0.033$), respectively. The 5-year graft survival rates were 100% in patients who underwent hemicortical freezing, 93.6% in those who underwent pedicle freezing, and 70.6% in those who underwent free freezing. Hemicortical/pedicle freezing procedure had significantly better graft survival than the free freezing procedures ($p = 0.001$). The 5-year graft survival rates were 88.8% in reconstruction using plates, 85.1% in frozen autograft-prosthesis composite reconstruction, 71.1% in reconstruction using intramedullary nails, and 75.0% in other or combination use of implants. Although the use of intramedullary nails resulted in a lower graft survival rate, no significant difference was observed ($p = 0.077$). Age, length of the frozen autograft, operative time, and intraoperative blood loss were also not significantly associated with graft survival.
To identify independent predictors for graft survival after reconstruction using tumor-bearing frozen autografts, male sex, BMI of ≥23.6, tibia, chemotherapy, and freezing procedure were included in the Cox proportional hazards regression

models. Multivariate analysis revealed that a BMI of ≥23.6 (HR, 3.4; p = 0.005), tibia (HR, 2.3; p = 0.047), and hemicortical/pedicle freezing procedure (HR, 0.3; p = 0.016), were independent predictors of graft survivals.

DISCUSSION AND CONCLUSION:

In summary, the present study showed a BMI of ≥23.6 (HR, 3.4; p = 0.005), tibia (HR, 2.3; p = 0.047), and freezing procedure (HR, 0.3; p = 0.016) were independent predictors of graft survival. Pedicle freezing and hemicortical freezing are recommended in cases where these techniques can be applied to.