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Osteoarticular Pedicle Freezing Using Liquid Nitrogen for the Treatment of Recurrent Chondrosarcoma of the Proximal Humerus

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Abstract Pedicle freezing using liquid nitrogen has been used increasingly in Japan in the last decade for the treatment of long bone tumors with good results. We describe our case of a recurrent chondrosarcoma of the proximal humerus treated with pedicle freezing of the entire osteoarticular segment due to involvement of the metaepiphyseal aspect. A late traumatic fracture occurred 8 months after surgery. Osteosynthesis was done with good union; however, subchondral collapse was noted at the humeral head. Functional outcome is satisfactory.Augmentation with vascularized fibular graft is advised to prevent subchondral collapse and late fractures. In cases where joint preservation is not possible, prosthesis composite is an option.

Key words: liquid nitrogen, osteoarticular pedicle freezing, recurrent chondrosarcoma

Introduction

Biologic reconstruction uses materials that are modified for the use in the body. This technique can enhance revitalization of the bone, achieving union and subsequent remodeling, resulting in a better and efficient limb function.[1]

Cryosurgery using liquid nitrogen has been in use in Japan for several years with good results. Bone frozen by liquid nitrogen (-196 ℃) destroys tumor cells thru ice crystal formation and cell dehydration.[2] Advantages include retention of the osteoinductive and osteconductive potential thru preservation of protein and enzymes, no immune response induction and maintenance of sufficient biomechanical strength.[3] Disadvantages include an observed cartilage wear over time and inability to do histologic analysis of the whole specimen for adequacy of margins and effects of chemotherapy.[3]

We present a case of a recurrent chondrosarcoma of the proximal humerus treated with pedicle freezing of the entire osteoarticular segment due to involvement of the entire metaepiphyseal aspect.

Case

In 2006, a 19 year-old male presented with left shoulder pain. Imaging revealed an isolated lytic lesion in the metaphyseal area of the proximal humerus. Initial biopsy was diagnostic of an enchondroma (Fig. 1).

He had subsequent recurrences in which same treatment was performed at another hospital. Repeat biopsy was diagnostic of a low-grade chondrosarcoma (Fig. 2). On the 3rd recurrence, he was referred to our hospital and imaging revealed extension into the epiphyseal area (Fig. 2).

He underwent pedicle freezing of the osteoarticular proximal humerus. Surgical

exposure was done thru the delto-pectoral approach. After protecting the surgeon and surrounding soft tissues, the 13 cm length of the proximal humerus was submerged in the liquid nitrogen container for 20 minutes, and thawed at room temperature for 15 minutes and in warm distilled water for another 15 minutes. Reattachment of the deltoid, pectoralis major, triceps, supraspinatus, infraspinatus, subscapularis was done using suture anchors (Fig. 3).

Six months post-operatively, he had good upper limb function evaluation and shoulder range of motion (0 to 80 degrees of forward flexion, and 0 to 70 degrees of abduction). However, at 8 months post-op, he sustained a fracture of his left humerus after a fall, approximately at the level of the junction of the frozen bone (Fig. 4).

During osteosynthesis, a vascularized fibular graft was initially planned as an augment. However, intraoperatively the area

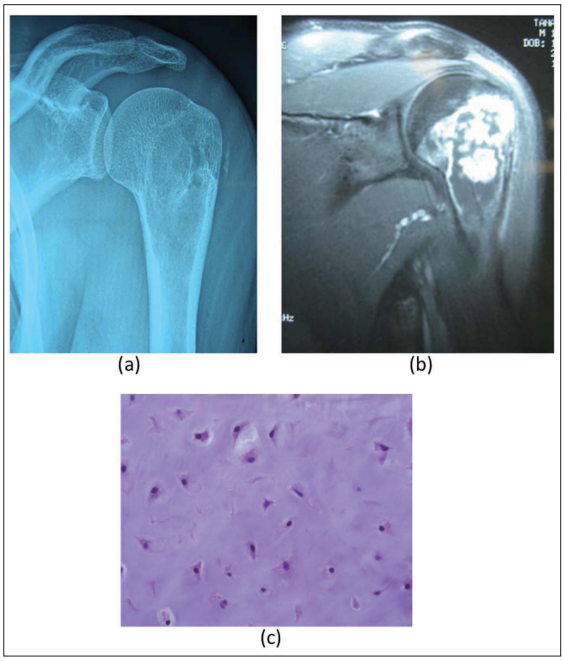

Fig. 1 (a) radiograph, (b) T2W MRI, and (c) histopathology at initial presentation (hematoxylin & eosin stain x200)

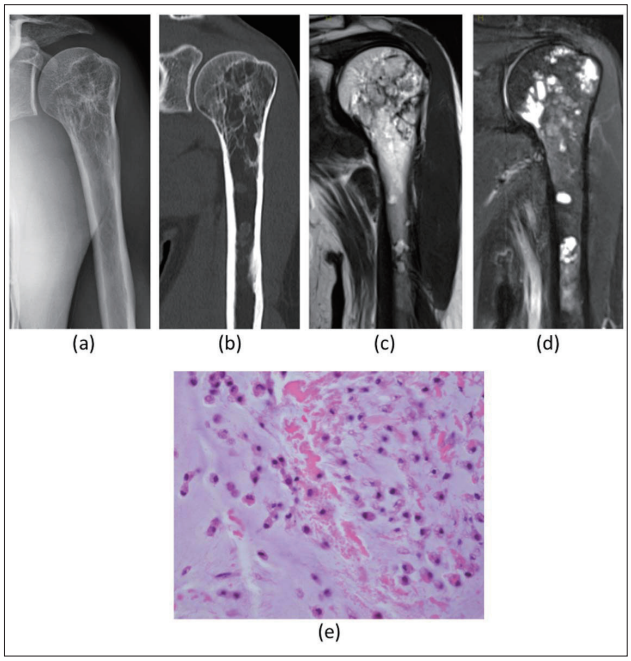

Fig. 2 (a) radiograph, (b) CT, (c) T1W, (d) T2W MRI and (d) histopathology diagnostic of chondrosarcoma (hematoxylin & eosin stain x200)

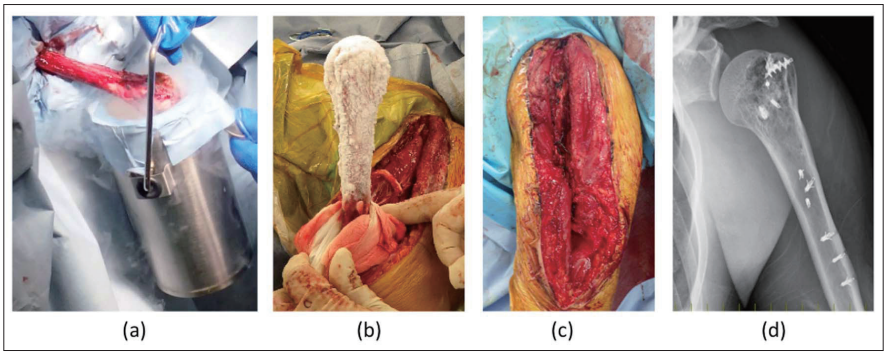

Fig. 3 Pedicle-freezing method. (a) submerging to the liquid nitrogen container for 20 minutes, (b) thawing at room temperature for 15 minutes, and the warm distilled water for 15 minutes; (c) reattachment of shoulder and proximal humerus muscles; (d) post-operative radiograph

of the humerus frozen with liquid nitrogen was shown to have punctate bleeding (Fig. 4), implying viability. The fibular graft was instead applied non-vascularly.

The histopathology of the liquid nitrogen treated bone showed that the chondrosarcoma underwent complete necrosis (Fig. 4) and the bone regenerated, similar to the findings in the study of Tanzawa et al.[4]

At 6 months post-fixation, the fracture has united, however an area of possible bone absorption was noted at the humeral head (Fig. 5).

Discussion

Liquid nitrogen treated bone have been reported to have superior outcome versus heat-treated, due to preservation of proteins and enzymes.[1]

Pedicle-freezing method in particular have advantages in having shorter union time (with single osteotomy) and lower rate of post-operative complications, secondary to early blood flow recovery.[5] Disadvantages of this method include a longer incision and more muscle dissection to accommodate a better arc of rotation. This leads to potential dead space, which can be prevented by better approximation of the soft tissue repair and placement of several vacuum drains.[6]

Subchondral collapse was observed in our case at 14 months after pedicle-freezing. Several studies have reported similar findings and this was attributed to osteochondral necrosis, or a late cartilage degeneration.[1] Factors that may cause this are more than 20 cm of bone frozen, using the free-freezing method, and using an osteoarticular graft.[2] In contrast to this, a study reported no cartilage collapse was seen after pedicle-freezing of a distal radius osteoarticular segment.[7] Theoretically this may be due to possible chondrocyte regeneration or chondrogenic differentiation of synovium-derived stem cells.[4] We postulate that healing of the frozen fragment is due to migration of donor mesenchymal cells from the medullary

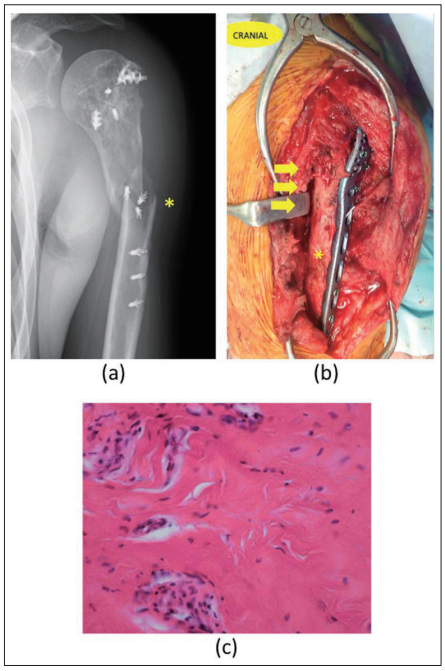

Fig. 4 8 months after pedicle-freezing. (a) fracture (*asterisk*) at junction; (b) intraoperative punctate bleeding (*arrows*) observed on previously frozen bone; (c) histopathology showing complete necrosis of the chondrosarcoma (hematoxylin & eosin stain x200)

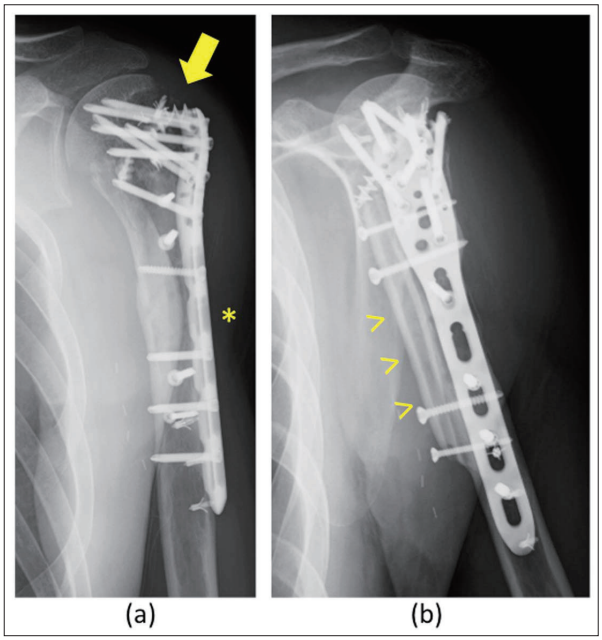

Fig. 5 6 months after osteosynthesis. (a) fracture union (*asterisk*) observed, but an area of bone absorption (*solid arrow*) noted on the epiphyseal area; (b) non-vascularized fibula onlay graft (*arrow heads*)

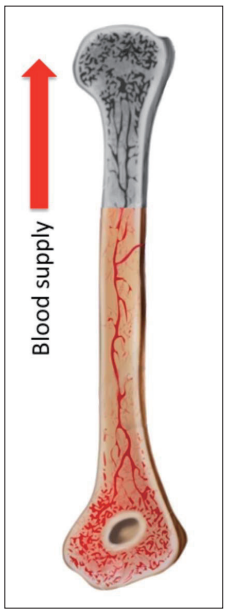

Fig. 6 Possible migration of donor mesenchymal cells from the medullary cavity of the unfrozen part

cavity of the unfrozen part (Fig. 6). Hence this requires more effort from the cells to reach the epiphyseal area. To prevent subchondral collapse, we suggest augmenting using vascularized bone, prosthesis composite or boning cement.

Late fracture was seen in our case, secondary to trauma. Using a vascularized fibular graft, especially for those who are young with a more active lifestyle, may prevent this.[8]

In conclusion, pedicle freezing with liquid nitrogen is an effective treatment for malignant bone tumors in the proximal humerus. Augmentation with vascularized fibular graft can be used to prevent subchondral collapse and late fractures. And, in cases where joint preservation is not possible, prosthesis composite is an option.

Conflict of Interest

The authors declare no conflict of interest.

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