Resection and Reconstruction of Calcaneal Tumors – A Review

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Abstract

Introduction: Calcaneum is a rare site for Ewing's sarcoma. The treatment includes neoadjuvant systemic therapy followed by surgical resection and adjuvant systemic therapy. The reconstruction options in this era of limb salvage for bone tumors are not much established in calcaneal tumors in view of limited reporting. Various other reconstruction options available are allograft, iliac crest autograft, and custom-made prosthesis.

Case Report: We have reported a 13-year-old female patient with Ewing's sarcoma of calcaneum diagnosed by imaging and biopsy. The patient underwent neoadjuvant chemotherapy and then had undergone total calcanectomy with allograft reconstruction. The post-operative outcomes are fair, and the patient is on adjuvant chemotherapy at present.

Conclusion: Biological reconstruction in the form of allograft is a reliable option with regard to the functional outcomes for calcaneal resections.

Keywords: Calcaneum, Ewing sarcoma, total calcanectomy, allograft.

Introduction

Ewing sarcoma of the calcaneum is a rare diagnosis that commonly affects diaphysis of long bones and rarely flat bones and bones of hands or feet of children 5–20 years [1]. It is not resection but the reconstruction after total calcanectomy that poses an actual challenge. For the rarity of the disease location, the reconstruction options and their outcomes are less studied and reported. This article is a review of various reconstruction options available for calcaneal resections.

Case Report

We had a 13-year-old female child who presented with complaints of pain in the region of calcaneum of 1-month duration. Physical examination did not reveal anything significant except for tenderness over the calcaneum. There was no history of trauma.

A local part radiograph showed an osteolytic lesion in the calcaneum without any cortical break or periosteal reaction (Fig. 1). A sagittal short inversion time inversion recovery image magnetic resonance imaging showed patchy scattered areas of hyperintensity in the marrow of the calcaneum with hyperintense surrounding soft tissue (Fig. 2). An image-guided biopsy was taken, which was reported as a small round cell tumor and immunohistochemistry showed CD-99 positivity. The biopsy specimen also showed 22q12 translocation positivity. Positron emission tomography-computed tomography was done, which excluded metastasis. The patient was planned for neoadjuvant chemotherapy. She was given six cycles of alternating vincristine/doxorubicin/cyclophosphamide and ifosfamide/etoposide chemotherapy.

The patient then underwent total calcaneal resection with allograft reconstruction. The procedure started with a transversely curvilinear incision which is a modified Cincinnati incision. This incision was first described by Crawford et al. in 1982 and has the advantage of preserving the neurovascular and lymphatic supply of the hindfoot. All the attachments of calcaneum were released, including the Achilles tendon. Calcaneum was completely exposed and then resected in toto. Bone allografts procured from the bone bank was prepared, cut into the shape of the defect, enclosed within a prolene mesh, and placed inside the tumor bed and anchored using metal screws. Talo calcaneal and calcaneocuboid arthrodesis were made. Achilles tendon was refixed to the allograft using a ligament anchor stitch (Fig. 3 and 4). Postoperatively, the foot was kept in plantar flexion for a month and then on neutral position for 2 weeks following which the patient started weight-bearing in the operated limb (Fig. 5). The post-operative histopathology did not reveal any residual disease, and the patient was given adjuvant chemotherapy and is on follow-up.

Review of Literature

Ewing's sarcoma is a high-grade bone tumor that most commonly affects long bones, though it can affect any bone in the body. It is most commonly seen in children and young adults. Ewing's sarcoma of calcaneum has

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Figure 1: Pre-operative radiograph of the right foot showing an osteolytic lesion confined to calcaneum.

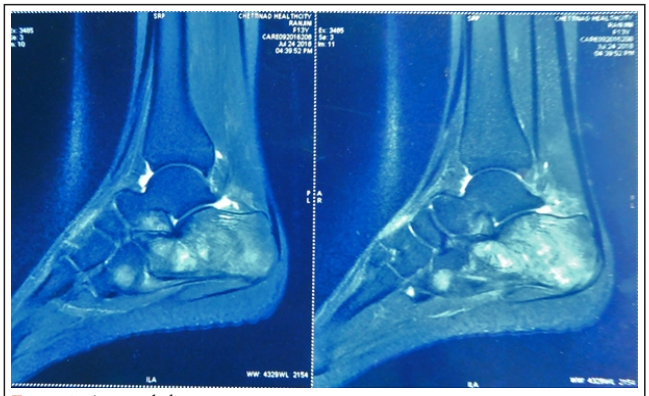

Figure 2: A sagittal short inversion time inversion recover image magnetic resonance imaging showed patchy scattered areas of hyperintensity in the marrow of the calcaneum with hyperintense surrounding soft tissue.

been rarely reported. Resection and reconstruction of calcaneal tumors have been less studied and challenging in view of its rarity and the complex anatomy of calcaneum. Previously below-knee amputation was the only option for calcaneal malignancies. Advances in oncological management have brought in limb salvage as the standard of treatment of calcaneal malignancies.

Patients with calcaneal tumors may be managed by either below-knee amputation or limb salvage resections. Reconstruction options following total calcaneal resections may be biological, including allograft, autografts, or non-biological such as custom-made prosthesis reconstruction [2]. The most important problem with all the reconstructions is that calcaneum is a weight-bearing bone of the foot and hence will be subject to shear stress that might result in fractures and pain. Post-operative functional outcomes should be the best judge in choosing the best reconstruction option in a given setting.

Biological reconstruction

Allograft reconstructions have been one of the most common reconstruction technique used in the few studies that have been reported. Till date, only around 18 cases have been reported with regard to calcaneal reconstruction following calcaneal tumors. No report of allograft reconstruction after total calcaneal resection for Ewing's sarcoma is reported in the literature. Calcaneal resections can be either partial or total. Ottolenghi and Petracchi and Muscolo et al. were the first to report total calcaneal allografts [3]. Post-operative functional result was satisfactory in their reports, but secondary osteonecrosis was reported at a 4 year follow-up period. Allografts can be calcaneal allografts, or other bones may also be used for allografts. There have been reports of calcaneal bone allograft itself being used for reconstruction following total calcanectomy after adjusting for the size of the defect. In case, the calcaneum bone is not available, other bones like femoral head can also be used as in our case. In that case, the bone allografts need to be shaped and anchored to one another and enclosed in a mesh before placing it in the tumor bed. As Ewing's sarcoma occurs most commonly at young age, the patients are more benefited by this mode of reconstruction even though the allografts go in for slow permanent resorption.

Scoccianti et al. and Kurvin et al. Anacak et al. have done en bloc resection of the tumor and intraoperative extracorporeal irradiation of the bone and re-implanted the involved bone [4, 5, 6]. It was considered as a useful and cheap reconstruction method in appropriately selected patients. There have been reports of composite grafts, including both allograft and autograft (iliac crest) or in combination with pedicled osteocutaneous flaps. Li et al. have used distally pedicled osteocutaneous folded fibular flap with or without allografts. (Capanna technique) [7]. Biological reconstruction using a distally pedicled osteocutaneous fibular graft showed good oncological outcomes with regard to local control and functional restoration of the limb. This was described by Li et al. in his

Figure 3: Post-total calcaneal resection.

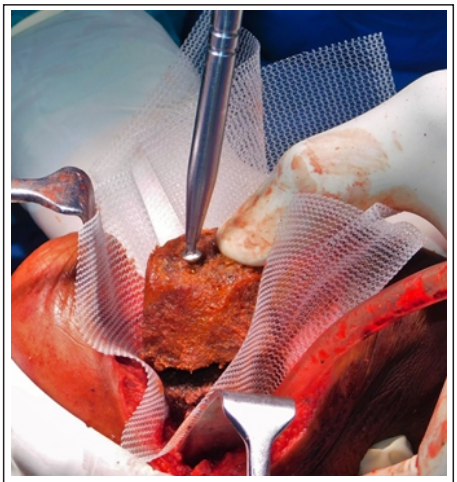

Figure 4: Allograft wrapped in prolene mesh and fixed with a screw.

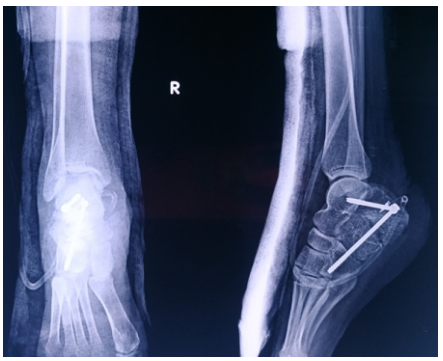

Figure 5: Post-operative radiograph showing the allograft and the screws.

series of five cases. Brenner et al. demonstrated that the vascularized rib is not a good choice for total calcaneal reconstructions in view of the morbidity associated with the donor site and relatively insufficient bony reconstruction [8].

Bone allografts function by augmentation of bone healing at the recipient site by various mechanisms such as osteoconduction, osteoinduction, and osteogenesis [9]. An ideal bone graft functions by all the above-mentioned mechanisms. The bone graft also supplies bone-forming cells to the recipient site. There are no standardized techniques for the incorporation of allografts to sites as calcaneum. The advantages of allografts include availability in large quantities, no need for donor surgery. However, the disadvantage includes antigenicity and a rare risk of disease transmission in case of inadequately sterilized grafts. The rate of disease transmission is very negligible if tissue banking protocols are strictly adhered. Bone allografts are incorporated in the tumor bed using screws after placing the allograft in a synthetic mesh. In the case of calcaneum, talocalcaneal and calcaneocuboid arthrodesis are made. The mesh provides the scaffolding required for the allograft. Most of the time, the allograft does not match the shape of the tumor bed which is also taken care of by the mesh. Furthermore, the mesh holds the allografts in place during microfractures that might occur after weight-bearing.

Non-biological reconstructions

The non-biological reconstruction option includes that of custom-made prosthesis by three dimensional printing. Imanishi and Choong and Chou and Malawer in 2007 used a custom-made titanium prosthesis [2, 10]. They had reported a case of calcaneal resection with custom made prosthesis reconstruction with good functional outcomes at the end of 12 years in a patient with osteosarcoma of calcaneum. In this case, the prosthesis was made by measurements form the contralateral calcaneum of the patient.

There are quite a few advantages of using non-biological prosthesis for calcaneal reconstruction. Some of them include, better post-operative functional outcomes (though no enough studies to prove the same), anchor point provisions made in the prosthesis helps in fixation of tendons, and less weight of titanium prosthesis. The infection rates with regard to biological and non-biological reconstructions have not been studied extensively. Post-operative functional outcomes, as measured by various scoring systems, are also not adequately studied in calcaneal resections in view of its rarity. However, as for any other non-biological prosthesis, the longevity of the prosthesis needs to be questioned. No studies have ever compared biological and non-biological reconstruction options after calcaneal resections.

Conclusion

Ewing's sarcoma of calcaneum can be treated by total calcaneal resection with reconstruction. The reconstruction options include both biological and non-biological and the choice of it depends on the availability of the graft or the prosthesis and other factors, including costs, involved. However, more studies need to be done to document post-operative functional outcomes which should be the ideal parameter for choosing the reconstructive option.

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