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Survivorship of Endoprostheses in Bone Tumor Reconstruction

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Each author certifies that his or her institution has approved or waived approval for the human protocol for this investigation and that all investigation were conducted in conformity with ethical principles of research

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Prior to the 1970s, amputation was the accepted method for the treatment of malignant primary bone tumors. In the ensuing 30 years, reconstruction options for limb salvage have increased in number, including osteo-articular allografts, allograft prosthetic composites, and modular segmental replacement prostheses. This paper will aim to review the most current literature on the outcomes of modular endoprosthetics at specific anatomic locations: proximal femur, distal femur, and proximal tibia.

Introduction

The pioneering work of Dr. Henry Jaffe, entitled *Tumors and Tumorous Conditions of Bone and Joints*, was first published in the 1950s and initiated the modern era of bone pathology. This allowed a more rational approach to the treatment of benign and malignant bone tumors, although not until the 1970's did advances in reconstructive surgery and chemotherapy allow limb-salvage to gain popularity for bone sarcomas[1,2].

Prior to the 1970s, amputation was the accepted method for the treatment of malignant primary bone tumors. During the 1970s, fusions about the knee were utilized for limb salvage by splitting the bone across the joint from the resection and then rotating the split portion of the bone back across the joint to span the resected segment. As such these were termed tibial turn-ups for femoral resections and femoral turn-downs for tibial resections.While these were limb-sparing procedures, little enthusiasm was noted among patients receiving these in light of the functional limitations of a knee fusion.At the same time fusions were being performed, the first modern segmental replacement prostheses were being developed. The Guepar prosthesis (Benoit-Gerrard Company, Caen, France) was a first generation fixed hinge prosthesis, which was adapted for segmental replacement, but few were performed and complications were high (Figure 1)[3]. From roughly 1980 through 1985, non-modular rotating hinge segmental replacement prostheses were available for the knee, and early segmental bipolar prostheses were available for the proximal femur. Most of these prostheses were utilized for aggressive benign and low-grade malignant tumors, such as giant cell tumors and chondrosarcomas. The prostheses were used as well as for patients with advanced metastatic disease, because the absence of effective sarcoma chemotherapy eliminated limb salvage as a safe option for patients with high-grade primary bone sarcomas. This changed during the mid-1980s with the adoption of doxorubicin based neo-adjuvant chemotherapy protocols; during this time limb salvage for bone sarcomas became an accepted treatment option.

The 1980s also saw the advent of modern bone banking techniques and with this, the availability of osteo-articular allografts for the reconstruction of bone resections. Allografts had the theoretical advantage of being a "biological" reconstruction with the hope that creeping substitution would replace the dead bone with living host bone. Dr. Henry Mankin performed much of the pioneering work on osteo-articular allografts for tumor reconstruction in the US (Figure 2). Simultaneous with this was the advent of modular segmental replacement prostheses, which simplified surgical technique and allowed for "off the shelf" flexibility.

The final reconstructive option that became available during this time was the combined allograft/prosthesis, termed allograft-prosthetic composite (APC). While this promised to deliver the durability of a prosthetic joint with the stability of a healed allograft-host junction, the technique proved to be difficult technically, expensive and associated with a high infection rate[4]. As such APC's never gained widespread popularity in the field of tumor surgery.

In the ensuing 30 years, modular segmental replacement prostheses became the standard for tumor reconstructions about the hip and knee in North America and Europe, while osteo-articular allografts have continued as the common reconstructive option in South America[5].

This paper will aim to review the most current literature on the outcomes of modular endoprosthetics at specific anatomic locations: proximal femur, distal femur, and proximal tibia.

Proximal Femur

The proximal femur is the most common location of metastases in long bones[6].

Finstein et al. in 2007 reported on 62 patients who underwent cemented bipolar proximal femoral replacements. At a mean follow-up of five years, there was 86% revision free survival rate with an infection rate of 5%[7]. Potter et al. one year later reported on 61 proximal femoral endoprostheses with a mean follow-up of 55

Figure 1. Guepar fixed-hinge prosthesis, popular during the 1960's.

months.There was a 93% five year revision free implant survival with a 5% infection rate[8]. Most recently, Chandrasekar et al. in 2008 reported on 100 patients who underwent cemented proximal femoral replacement. At five years, there was a 91% revision free implant survival with a mean Toronto Extremity Salvage Score (TESS) of 61% and a 6% infection rate[9].

Figure 2. Proximal tibia osteo-articular allograft at 10yr followup. Due to arthritic change, patient eventually required a prosthesis.

Interestingly, patients who have primary bone tumors reported better functional scores following proximal femur replacements than those patients reconstructed for extensive metastatic disease. Potter et al. showed that patients with primary bone tumors had a Musculoskeletal Tumor Society (MSTS) function score of 80.2 versus 66.8 for those with metastatic disease[8]. This difference in functional scores is likely due to the high rate of associated co-morbidities in the metastatic carcinoma group, which limit the ability of patients to maximally benefit from their limb reconstruction.

Reported complications are numerous, including dislocations, deep vein thrombosis, pulmonary embolism, infection and prosthetic loosening. The literature reports complication rates ranging from 10 to 20%, when all complications are included[9,10.] The revision rate has been reported to be 7.3% and as high as 57% at 20 years[12,13].

Overall, proximal femoral replacement endoprostheses have a 90% five year revision free implant survival, with TESS scores ranging from 60-75% and an infection rate around 5%.

Distal Femoral Replacement

The distal femur is the most common site of primary bone tumors and the popular therapeutic option is tumor resection and reconstruction with a segmental replacement rotating hinge endoprosthesis (Figure 3). However, long-term data concerning such reconstructions remain limited.

There are however several reports concerning survivability of these prostheses. Myers et al. from the United Kingdom published a series of 335 patients who underwent distal femoral replacement. At ten years, the aseptic loosening rate was 35% for cemented fixed hinge prostheses and 24% for cemented rotating hinge prostheses. There was a 10% infection rate in this series and no functional outcomes were measured[14].

Sharma et al. in 2006 reported on 77 patients who had a mean follow-up of 4.3 years. All patients had cemented stems. They noted 84% implant survival at five years, and 79% at ten years with no stem loosening. The mean TESS was 78%, and all revisions were related to infection or mechanical failure. The reported rate of infection was 8%[15].

There is little functional outcome data on patients who have had reconstruction with these megaprotheses. Malo et al. published a multicenter study of 56 patients who underwent distal femoral replacement prosthetic reconstruction. The mean SF-36 physical component was 43.2, and the mental component score was 54.2. The mean MSTS score was 80.4. Overall, the patients had satisfactory functional outcomes, but those who had pathologic fractures, underwent larger bone resections, or were older experienced worse functional outcomes[16].

Complications, unfortunately, have been reported to be high with the use of these megaprostheses. Aseptic loosening and failure of the hinge mechanism have been reported to be the most common cause of failure, with rates of revision as high as 58%[17]. Infection is also a significant cause of revision, with rates of infection ranging from 8% to 30%[14, 15, 18].

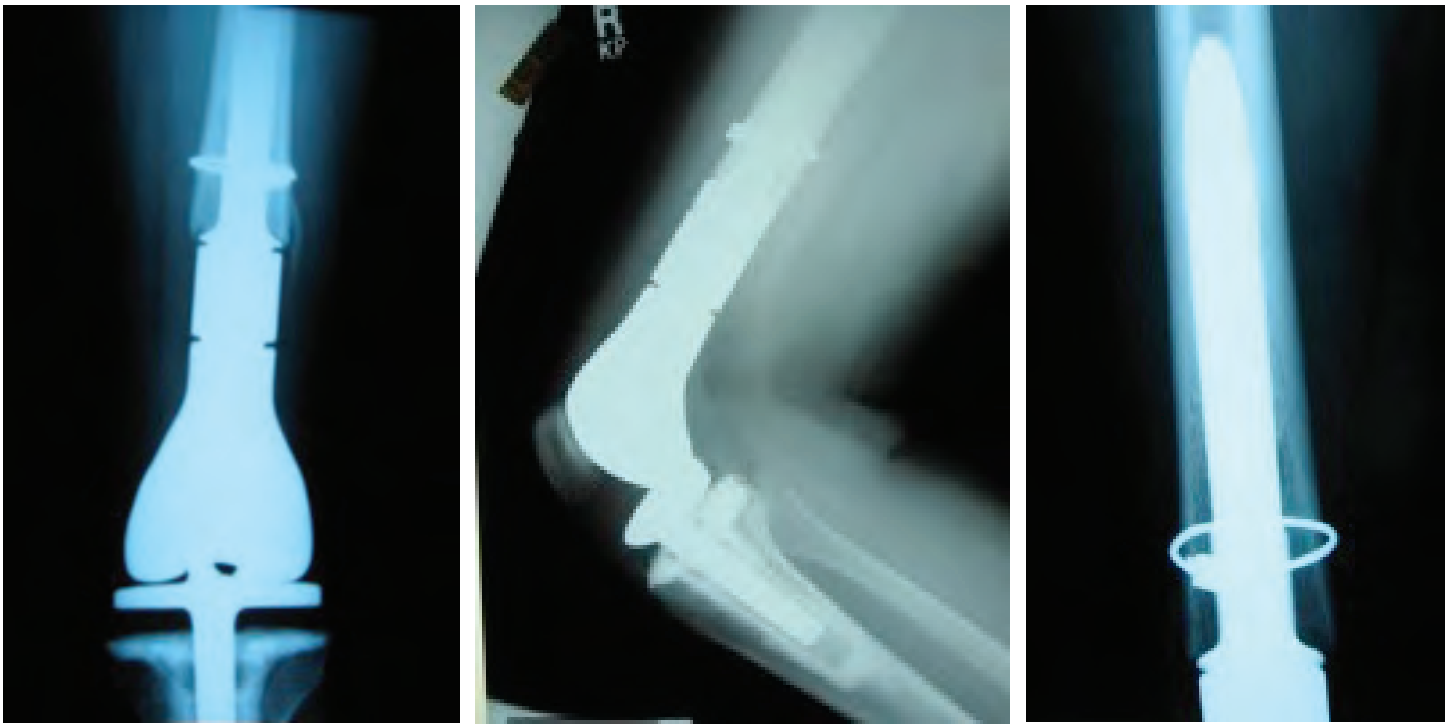

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Figure 3. Distal femoral replacement rotating hinge knee at 6-year followup

Proximal Tibia Replacement

The proximal tibia is another common site of tumors, but the literature concerning the long-term results of the use of these prostheses is limited.

Myers et al. reported on 194 patients who underwent 99 cemented rotating hinge proximal tibia replacement prostheses. The rate of revision was high: 11% at five years, 18% at ten years, and 30% at fifteen years. Furthermore, the rates of infection were 31% without a flap, and 14% with a flap. Unfortunately, there was no data concerning functional scores or extensor lag[14].

Flint et al. reported on 44 fixed hinge prostheses which at five year follow-up had a 27% revision rate secondary to infection, fracture, instability, or vascular compromise. The mean TESS was 77%. There was a 15% infection risk with muscle flaps[19]. It is notable that many authors describe the need for muscle flaps whenever a proximal tibial segmental replacement prosthesis is utilized, in order to minimize the risk of infection about the prosthesis. This was contradicted by a study by Abboud et al. who performed rotating hinge, cemented proximal tibia replacements in 22 consecutive patients. None of these patients had flaps and, at 38 months, there were no deep infections[20].

One of the major factors associated with clinical outcomes after proximal tibia replacement is function of the extensor mechanism. There have been described many methods for reconstruction, including direct reattachment of the patellar tendon to the prosthesis, reinforcement with autologous bone-graft, and attachment of an overlying gastrocnemius flap. Bickels et al. reported that 87% of patients achieved good to excellent results with all three methods[19, 21].

Overall, proximal tibia endoprosthetics remain a viable option for reconstruction after proximal tibia resection, but there are few series reporting long-term follow-up and functional outcomes.

Conclusion

Endoprosthetic reconstruction after tumor resection about the hip and knee has evolved as a practical treatment option. The survivability of these reconstructions is reasonable but with a higher rate of complications than is seen with routine arthroplasty. In the future, advancements in stem fixation, hinge joint design and infection prevention will further refine these techniques and further enhance the success of prosthetic limb salvage surgery.

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