Reconstruction With Modular Megaprostheses for Sarcomas of the Lower Extremity

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abstract

Limb-preserving surgery using modular megaprostheses for the reconstruction of large skeletal defects is currently the preferred treatment for sarcomas. The authors report the postoperative outcomes after skeletal resection for lower extremity sarcomas and the use of the METS cemented modular implant system (Stanmore Implants, Hertfordshire, United Kingdom) for reconstruction. They retrospectively studied 52 consecutive patients operated on from 2003 to 2012. There were 27 distal femur prostheses, 13 proximal femur, 11 proximal tibia, and 1 total femur implants. Patients were followed for a mean of 4.3 years. Overall patient survival, prosthesis survival, limb salvage rate, and secondary complications were documented. Five years postoperatively, prosthesis survival was 79%. Complications warranting implant revision surgery were documented in 15% of patients, whereas complications warranting surgery of any kind were observed in 27% of the patients. Nonmechanical complications, namely local relapse of the tumor and prosthetic infection, were the most common cause of prosthetic failure, accounting for 88% of major revision surgeries and 100% of amputations. Mechanical complications were rare, observed in only 6% of patients. No patients required secondary revision surgery. The limb salvage rate was 89%. Overall patient survival was 79% at 5 years and 71% at 10 years. The low risk for mechanical complications and the high limb salvage rate support the use of the METS modular megaprostheses for the reconstruction of skeletal defects following lower limb sarcoma surgery. [Orthopedics. 2015; 38(5):e401-e406.]
Limb-salvage surgery is the current mainstay of treatment for tumors in the lower extremity because it has a similar overall patient survival and equivalent risk for local tumor recurrence compared with amputation. Modular endoprostheses for the reconstruction of large skeletal defects following sarcoma surgery represented a breakthrough in comparison with previously used custom-made designs, which had a high rate of mechanical complications. Furthermore, the availability of modern modular implants enables the reconstruction of a variety of skeletal defects using in-stock parts that do not need to be modified.

It is a prerequisite that endoprosthetic reconstruction is durable for many years and can be easily revised when needed. Recent advances in implant manufacturing include the use of kinematic knee designs, hydroxyapatite-coated collars, silver-coated stems, and highly cross-linked polyethylene cups. Furthermore, modern surgical techniques entail the routine use of muscular flaps for optimal soft tissue coverage, which further improves the outcome of surgery. Nonetheless, the complication rate of megaprosthesis surgery is high, approximately 10-fold compared with routine prosthetic reconstructions. The complex construction of the implants, major surgical procedures, and concomitant morbidity associated with chemotherapy and radiation are factors that predispose patients with sarcomas to the increased complication rate. Another consideration is that patients with primary bone neoplasms are generally young and active individuals, which stresses the need for implant longevity.

Both mechanical (soft tissue failure, aseptic loosening, structural failure) and nonmechanical complications (local recurrence, infections) are common. However, inconsistent presentation of the complications does not allow for direct correlation of data presented by various authorities. Recently, a classification system has been proposed that can potentially clarify the outcome of endoprosthetic reconstructions in sarcoma surgery.

The authors present their 10 years of experience with the METS cemented modular implant system (Stanmore Implants, Hertfordshire, United Kingdom) in a series of 52 patients who were operated on for sarcomas of the lower extremity and systematically report the complications of using the classification system.

**MATERIALS AND METHODS**

The study was based on a retrospective analysis of all patients (n=52) operated on for bone sarcomas in the lower extremity and subsequent reconstruction with the METS cemented modular implant system from 2003 to 2012 (Figure 1) who had a minimum follow-up of 12 months (range, 12-135 months). Mean follow-up of surviving patients was 52 months, and 31% of patients had more than 5 years of follow-up. The study was compatible with the ethical guidelines of the authors’ institution. Because this was a retrospective analysis of stored data, institutional review board approval was not required.

Twenty-two women and 30 men with a mean age of 35 years (range, 10-84 years) (Table 1 and Table 2) were included in the study. Osteosarcoma (27 patients) was the most common diagnosis. More than half (n=27) of the tumors were located in the distal extremity. According to the Ennekking staging system, three patients had stage IA disease, 6 had stage IB, 7 had stage IIA, 24 had stage IIB, and 12 had stage III. Fine-needle aspiration biopsy was performed to confirm the cytological type of the tumor.

All operations were performed by the 2 senior surgeons (O.B., H.C.F.B.). Wide or marginal surgical margins were achieved in 50 patients (25 wide and 25 marginal, respectively), whereas 2 had an intrasional margin. All endoprostheses were cemented using modern techniques, including pulsatile lavage and vacuum mixing of polymethyl methacrylate. There were 27 reconstructions using the METS distal femur prosthesis, 13 reconstructions using a proximal femur prosthesis, 11 using a proximal tibia prosthesis, and 1 using a total femoral implant.

Hemiarthroplasty with a monopolar cup was undertaken for the majority of patients operated on with proximal femoral implants, with total hip replacement reserved for patients who presented with engagement or erosion of the acetabulum. The hip joint was accessed through a posterior approach, and the short external rotators were readapted whenever possible. In the case of proximal tibia tumors, medial gastrocnemius rotation flaps were routinely used for proper soft tissue coverage of the implant. The patellar tendon was readapted using a variety of techniques, including suture with metal wire or the use of a Trevira tube (Implantcast, Buxtehude, Germany). A knee brace in extension was used for approximately 6 weeks to protect healing of the extensor mechanism. Immediate full weight bearing was encouraged in all cases.

Intravenous antibiotics with 3 doses of clindamycin taken on the first operative day was the most common antibiotic course, with clindamycin reserved for patients who had a hypersensitivity to penicillin. Active deep wound drains were routinely applied. Mean operative time, including both primary resection and reconstruction, was approximately 119 minutes (range, 73-172 minutes). Mean blood loss was
1058 mL (range, 150-3200 mL). Standard deep vein thrombosis prophylaxis consisted of 5000 IU of dalteparin administered subcutaneously for 4 weeks postoperatively. All patients had radiographs taken immediately postoperatively to ensure appropriate placement of the implants.

Mean hospital stay was 9 days (range, 4-37 days). Additional wound controls were scheduled if needed, and overall performance was typically estimated 2 to 3 months postoperatively.

Patients records were reviewed for the occurrence of potential complications, which were categorized either as mechanical (Type I-III) or nonmechanical (Type IV-V), as previously proposed. Failure endpoint for the endoprosthetic reconstruction was defined as replacement of the cemented parts of the prosthesis, implant removal, or amputation of the limb. Kaplan-Meier survival curves were compiled using SPSS version 18 software (SPSS, Inc, Chicago, Illinois), with the date of the primary surgery as the start date and prosthesis failure as the end date. In cases where the implant did not fail, the end date was the date of death or last follow-up.

RESULTS

Complications warranting surgery of any kind were observed in 14 (27%) patients, and the rate of major revision surgery resulting in implant failure was 15% (8 patients). Complications are summarized in the Table 2. None of the patients who underwent revision of the implant for any of the causes listed above required secondary revision surgery. Implant survival was estimated to be 83% at 3 years and 79% at 5 years (Figure 2).

Nonmechanical events were the dominant cause of failure and were observed in 7 patients (absolute incidence of 13%). They accounted for 88% of major failures and 100% of the amputations. More specifically, local relapse of the tumor (Type V failure) was observed in 4 patients (absolute incidence of 8%) at a mean of 32 months after the primary surgery. Two patients who presented with tumor relapse were diagnosed with osteosarcoma, 1 with chondrosarcoma, and 1 with undifferentiated pleomorphic sarcoma of the bone. All 4 patients underwent amputation. Two implants (absolute incidence of 4%) failed as a result of deep infection (Type IV failure). One of the patients was successfully treated with revision and antibiotic treatment and the prosthesis was salvaged after being autoclaved and reinserted; the other patient underwent amputation as a result of uncontrollable infection. Both deep infections were located in the distal femur, and mean time to implant failure was 18 months. One patient was treated with minor surgical revision and antibiotics for a superficial soft tissue infection.

Mechanical complications were observed in 3 patients (absolute incidence of 6%) and did not result in any amputation. One distal femur implant (with a self-expanding mechanism) was revised due to aseptic loosening after 28 months (Type II failure) (Figure 3). The tibial bearing mechanism of 1 distal femur implant failed and had to be replaced 40 months after

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<td>Classification</td>
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Figure 2: Line graph showing Kaplan-Meier survival analysis of the 52 implants. Implant survival was 83% at 3 years and 79% at 5 years.
The current authors re…t treated with mobilization in general anesth…

In total, 6 amputations occurred in the current series, and the limb salvage rate was 89%. As stated above, local recurrence was the leading cause of amputation, whereas infection and intractable pain were the indications for the other 2 amputations. None of the patients who presented with mechanical complications had to undergo amputation.

Nine deaths occurred in the current series. Two patients had persistent disease and 1 had lung metastasis. All other patients (n=40) had no evidence of disease after their primary operation. Overall patient survival was 79% at 5 years and 71% at 10 years.

**DISCUSSION**

Introduction of modular megaprostheses for the reconstruction of large skeletal defects has been a major improvement compared with previous custom-made designs, allowing for intraoperative versatility in case a more extensive resection is needed, easy revision of parts that have failed, increased availability, and, hopefully, lower complication rates and costs.

However, several reports have shown that reconstructions in the lower extremity, specifically around the knee joint, are associated with a high complication rate.\(^{5,9,12,14}\) Moreover, patients with sarcomas are generally more prone to complications compared with those treated for other causes (trauma, pseudarthrosis, failed conventional prostheses) and have somewhat lower implant survival rates because they are operated on with the intention of good surgical margins, which implies extensive soft tissue resection. Furthermore, they are generally young and physically active individuals, which predisposes the implant to wear. Lastly, they are treated with high-dose chemotherapy and radiotherapy, which renders them prone to biological complications, such as infection and necrosis.

One previous study reported good short-term results of the Stanmore modular megaprostheses in lower extremity sarcoma surgery.\(^{17}\) The current authors report a larger series of patients with a longer follow-up and advocate the use of the METS system for reconstruction of large skeletal defects. Indeed, the overall failure rate in the current series was 15%, which is lower than previous studies reporting complication rates warranting major revision surgery ranging from 20% to 35%.\(^{5}\) The 5-year implant survival rate of 79% is comparable with the recently published results of Coathup et al.\(^{7}\) Gosheger et al\(^{11}\) reported a somewhat inferior prosthesis survival in patients with lower extremity sarcomas that were treated with Mutars megaprostheses (Implantcast), although direct comparisons are difficult to draw because the case-mix of the series is different.

Nonmechanical events were the dominating cause of prosthesis failure in the current series. Furthermore, major complications in this category resulted in an 86% amputation rate, accounting for all amputations in the current series. Tumor relapse was a complication that inadvertently led to amputation. Excision with adequate surgical margins is known to lower the risk for recurrence,\(^{18}\) even though in all patients in the current study who relapsed had clear margins after resection (3 wide, 1 marginal). Advances in the medical treatment of this group of patients are further expected to lower the risk of local relapse.

The failure rate due to infection was 4% in the current study, which is in the lower range of the 2% to 12% rate reported in the literature.\(^{5,11,13,19,20}\) Importantly, the current authors observed no secondary infections in the subgroup of patients who were reoperated on as a result of mechanical failure, in contrast to a previous study that reported a striking increase of infection after revision surgery.\(^{5}\) The current authors attribute this result to proper use of antibiotics, short operative time, and
meticulous surgical technique to avoid dead-space and hematoma formation, compliance to hygiene routines during patient hospitalization, and short hospital stays. Indeed, mean operating time and hospital stay in the current series do not differ remarkably from standard endoprosthetic surgery. However, the current results also suggest that the risk of amputation is considerable once an infection occurs and corroborate previous reports showing a 25% to 100% amputation rate in this setting.10,19,22

Regarding mechanical failure, the current data compare favorably to published results, which report a mechanical complication rate between 5% and 48%.5 Aseptic loosening, previously reported in 5% to 48% of megaprosthesis reconstructions,5,19 was only a minor complication in the current series, with a rate of 2%. The porous collar that allows osteointegration of the prosthesis, along with modern cementation techniques, is a likely explanation of this low rate. Thus, the current authors advocate the use of cemented implants even in young patients, an issue that has been previously questioned,11 because this allows immediate weight bearing, shorter recovery, and less risk of perioperative fractures in comparison with noncemented implants. However, the current authors acknowledge that longer follow-up is necessary to detect problems that result from stress shielding. The design of the prosthesis used proved durable because the current authors did not observe any fatigue fractures of the stems, which have been frequently reported by other authors.

Biological and biomechanical complications were documented, with the most frequent being the need to convert to total hip arthroplasty due to erosion of the acetabular cartilage. The current authors routinely performed hemiarthroplasty when there were no macroscopical signs of cartilage erosion of the acetabulum, taking into account the relatively poor prognosis of the patients and the lower risk for dislocation of the prosthesis. In select patients who have a favorable prognosis (an expected survival of more than 5 years), total hip arthroplasty should be considered. Because megaprosthesis reconstruction has a higher risk for dislocation due to extensive resection of soft tissues, dual mobility cups or analogous implants are probably indicated currently.23 The overall limb survival rate of 89%, which is in line with previous studies that report rates ranging from 87% to 97%,5,9,11,19,20 demonstrates that most complications could be efficiently addressed with limb-preserving surgery. This favorable result reflects the good prognosis of the patients who present with mechanical complications.

The fact that the current study is retrospective is recognized as a major limitation. Moreover, the patients had different sarcoma types and variable adjuvant treatments. However, this is the case with almost all studies published thus far due to the rarity of the primary tumors. The current authors consider the following strengths of their study: use of a single implant type, elimination of the heterogeneity of diagnoses by excluding metastatic disease and benign tumors, and performance of the operations by the same surgeons. Furthermore, follow-up was standardized and did not differ considerably between patients.

Conclusion
Collectively, the current results support the use of modular megaprosthesis for the reconstruction of skeletal defects caused by sarcomas of the lower extremities because it is accompanied by a low risk for mechanical failure and allows for a high limb survival rate. The authors suggest that efforts to prevent nonmechanical complications, such as infections and local tumor relapse, should further improve the outcome of surgery.

References
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