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Research Article

Megaprosthesis Revision Caused by Aseptic Loosening and Nonunion of the Structural Allograft in Patients Younger Than 40 Years

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Abstract

Background: The use of structural allografts is aimed to restore the resected bone segment in order to maintain enough bone stock for future revisions. The aim of this study was to describe the mechanical failures of Allograft Megaprosthesis Composite (AMC) revised to Modular Megaprosthesis (MMP) due to nonunion of the structural allograft in patients younger than 40 years.

Material and methods: A retrospective revision in a referral hospital for the treatment of musculoskeletal tumors was performed between January 1st 2009 and January 31st 2012. We looked in the surgical records of the musculoskeletal tumors unit for all of the procedures coded as "megaprosthesis-revision-arthroplasty". We included patients younger than 40 year-old in which primary reconstructive surgery at any segment of the lower limb was performed by means of AMC, and revision surgery was performed by means of MMP. We looked in those records for information regarding integration of the structural allograft to the native bone.

Six revisions from AMC to MMP were performed: 5 knees and 1 hip. The mean age at the time of revision surgery was 28.83 year-old (range 18-38). Primary oncological diagnoses were: 4 osteosarcomas of the distal femur, one Giant Cell Tumor (GCT) of the femoral head and 1 GCT of the proximal tibia.

Results: In none of the cases integration of the structural bone allograft to the native bone was observed, reason why it had to be completely resected in all patients. The reason for revision surgery in all cases was aseptic loosening secondary to nonunion of the structural bone allograft. Mean time elapsed from implantation of AMC to revision surgery to MMP was 103 months. Mean time elapsed from revision surgery to last follow-up visit was 26 months.

Conclusion: Structural bone allografts in limb salvage surgery after massive tumor resection, may not be the best reconstructive option because the high probability that the grafted bone segment might not integrate to the native bone, even in young patients, may lead to prosthetic failure because of aseptic loosening.

Keywords: Allograft; Aseptic; Bone; Loosening; Megaprosthesis; Modular; Nonunion

Level of evidence: IV, case series

Introduction

Advances in the non-surgical treatment of the malign tumors of the musculoskeletal system allow limb reconstructions after big tumor resections without compromising the oncological prognosis [1]. Nowadays, reconstructive surgery after great tumor resections contemplates a series of alternatives: osteoarticular allograft [2], arthrodesis with intercalary bone allograft [3], Allograft Megaprosthesis Composite (AMC) [4] and Modular Megaprosthesis (MMP) [5]. Megaprosthesis (Figure 1) are actually considered the best treatment option because they allow a better preservation of the joint function [6,7].

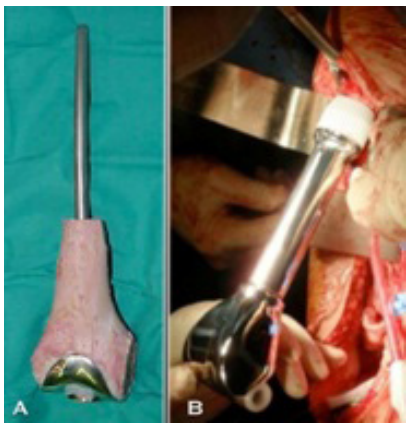

Figure 1: Allograft prosthesis composite before being implanted (A), distal femur modular megaprosthesis once implanted (B).

The published overall megaprosthesis survival is 57-93% at 5 years [8] and 50-88% at 10 years [9]. These implants are usually employed in young patients with high functional demands and a bone quality affected by concomitant radio and chemotherapy, reasons that might suppose a high risk for failure [8]. Infections represent the main reason for revision surgery of these implants, and this issue is mainly due to the immunosuppression secondary to the adjuvant therapies [10].

The development of the prosthetic implants and components modularity have supposed an increase in the use of MMP and a

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decrease in the use of AMC, because MMP suppose a shorter surgical time and intraoperative availability of several modules that allow adaptations when there is to change the planned resection. Likewise, the post-operative period of a MMP does not require long times of non-weight bearing that, in cases of AMC, are indicated in order to protect the integration of the allograft to the host-bone, reason why MMP allow a faster return to function [11,12].

According to some authors, the use of structural allografts in AMC is aimed to restore the resected bone segment, to offer a bed in which musculotendinous structures can be reinserted, and to guarantee enough bone stock for future revisions once integrated to the host-bone [13].

The aim of this study was to describe the mechanical failures of AMC revised to MMP due to nonunion of the structural allograft in patients younger than 40 years at the moment of revision surgery. The secondary aim was to estimate the mean survival of the primary implant (AMC).

Material and Methods

A retrospective revision in a tertiary referral hospital for the treatment of musculoskeletal tumors (HSCISP) was performed. We looked in the surgical records of the musculoskeletal tumors unit for all of the procedures coded as "megaprosthesis revision arthroplasty" between January 1st 2009 and January 31st 2012. We included patients younger than 40 years in which primary reconstructive surgery at any segment of the lower limb was performed by means of an AMC, and revision surgery was performed by means of a MMP. We excluded the procedures in which revision surgery was indicated because of infection or tumor progression. Infection as the reason for failure of the AMC was discarded by means of observation at the microbiological report of the intraoperative samples of the information "no growth of germs". We only included those cases in which the final histological dossier of the tissue samples taken during the revision arthroplasty was reported as "without evidence of malignant cells". In all of the cases scintigraphy was performed before surgery, showing an increased uptake in all cases, so we did not take this pattern into account for discarding latent infections. We looked in the surgical records of the revision surgery for information regarding the integration or not of the structural allograft to the native bone. The Musculoskeletal Tumor Society scoring system (MSTS) [14] was assessed at the immediate visit prior to revision surgery and at the last visit post revision surgery. In the MSTS system, numerical values (range 0 to 5) are assigned to each of the six categories of pain, function, emotional acceptance, supports, walking and gait. The questionnaire gives a total score comprised between 0 and 30, with 0 indicating poor and 30 good.

The total number of cases that met the inclusion criteria was 6: 5 knees and 1 hip (Figures 2-5). The mean age of the included patients at the time of revision surgery was 28.83 year-old (range 18-38). The primary oncological diagnoses were: 4 osteosarcomas of the distal femur, 1 Giant Cell Tumor (GCT) of the femoral head and 1 GCT of the proximal tibia. In all of the primary implants (AMC) structural bone allograft was used. There were 3 men and 3 women. The primary AMC in all cases was a custom made implant Waldemar-link (Hamburg, Germany). 4 of the AMC were cemented and 2 were not. The surgical approaches employed at the primary surgery were: a midline extended approach to the knee joint in cases 1-4 and 6; and an extended posterolateral approach to the hip joint in case number 5. Frozen structural allografts were used in all cases. Revision surgery was performed through the surgical scar of the previous approach in all cases. The revision MMP used in all cases was Waldemar-link, all of them cemented. All of these procedures involved a high complexity, and were all performed by the senior surgeon IG. All of the patients had surgery under general anesthesia and femoral nerve block. In all patients antibiotics were administrated intraoperatively and during the whole period of hospitalization, according to the protocol established in our institution. 2g of cefazolin were administrated during surgery once tissue samples for microbiology examination were taken. 1g of cefazolin was administrated every 8h until discharge. Low-molecular heparin prophylaxis was given from the day of admission until 30 days after discharge. All of the patients had surgery without tourniquet in order to have a better control of the neurovascular bundle.

Figure 2: Aseptic loosening and nonunion of the structural allograft in an allograft megaprosthesis composite. The lysis of the allograft caused a shortening of the femur and extrusion of the stem through the great trochanter (A); distal femur modular megaprosthesis as revision mega-arthroplasty (B).

Figure 3: Aseptic loosening and nonunion of the structural allograft in distal femur allograft megaprosthesis composite (A); distal femur modular megaprosthesis as revision mega-arthroplasty (B).

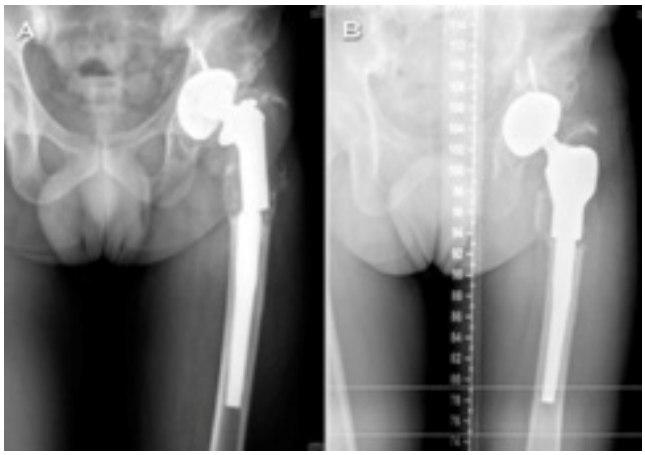

Figure 4: Aseptic loosening and nonunion of the structural allograft in proximal femur allograft megaprosthesis composite. Polyethylene liner wear and primary stem breakage (A); proximal femur modular megaprosthesis as revision mega-arthroplasty (B).

Figure 5: Nonunion of the structural allograft in proximal tibia allograft megaprosthesis composite (A); proximal tibia modular megaprosthesis as revision mega-arthroplasty (B).

Results

The mean time elapsed from implantation of the AMC to revision surgery to MMP was 103 months (range 39-216). The mean time elapsed from revision surgery to the last follow-up visit was 26 months (range 24-49). In none of the cases integration of the structural bone allograft to the native bone was observed, reason why it had to be completely resected in all patients.

Radiographic follow-up

The reason for revision surgery in all cases was aseptic loosening secondary to nonunion of the structural bone allograft. Table 1, depicts the details of all cases and the specific reasons for revision surgery.

Clinical follow-up evaluations

At the last follow-up visit 50% (3/6) of the patients were pain free. All of the patients had at a functioning limb and they were all able to walk without crutches. The mean MSTS score assessed at the immediate visit prior to revision surgery was 18.48±1.53, and at the last visit post revision surgery was 21.73±2.42.

Complications related to revision surgery

There was no evidence of infection in any of the patients of this series. Germ growth was not observed in any of the intraoperative tissue samples taken during revision surgery. We did not take scintigraphy into account for discarding latent infections, because it usually shows an increased uptake in this type of cases. At the last follow-up visit, 1 patient was having a tibial stem tip pain, and other patient referred a clicking during walking, and also had radiographic signs of loosening of the MMP.

Discussion

The implantation of structural allografts after great tumor resections is still being recognized as a good reconstructive strategy, because it is considered that the allograft has a good capability of integration to the host bone and to the biomechanics of the reconstructed limb [13]. Nonetheless, all of the reconstructions with structural allografts performed in our series of young patients, failed because of aseptic loosening of the megaprosthesis because none of the structural allografts integrated to the native bone.

Megaprosthesis are big constrained implants with long lever arms that confer a high stress at the interface "implant-cement-bone", reason why they can be considered with propensity to eventual mechanical failure [15]. Regarding the reasons for failure of these implants, a retrospective multicentric revision published by Henderson et al., in 2011 describe 5 types of failure [16]. They describe that aseptic loosening is the second reason for failure in terms of frequency, and infection is the main one. According to this classification, all of the AMC of our series belongs to the type II (aseptic loosening).

Aseptic loosening is considered as the final consequence of a series of mechanical factors common to all the megaprosthesis. It has been attributed to: a long interface "implant-cement-bone" [17], to the stresses generated by the important lever arms of the constrained hinges [15], by an altered transmission of the axial loads when walking [7], and high functional demands of young patients [18]. Besides these reasons, we believe that the fact that the structural allograft did not integrate in any of the cases of our series had a determinant role in the development of the aseptic loosening and the subsequent failure of the megaprosthesis.

In our series the mean age of the patients at the time of revision surgery was 29 year-old, while in other published series of megaprosthesis revision surgery, the mean age of patients at the moment of implantation of the primary megaprosthesis was 41 [16] and 27 year-old [19]. Despite our series have a low number of cases, it is confirmed by patients in which revision surgery was performed with a mean age lower than the mean age at the moment of the primary surgery of other published series. We believe that the fact that the structural allograft had to be removed in all of the cases of our series (despite the theoretical biological advantages of the young patient in terms of bone consolidation and integration, and despite the five-year survival of massive allograft reconstructions has been described to be 80.8% [20]) denotes that the reconstructive strategy with AMC could be at least questionable.

One of the theoretical advantages of an AMC in those cases of resection of the proximal tibia, is that the structural allograft allows

	Anatomic location	Onchological diagnosis	Gender	Age (years-old) at the moment of revision surgery	Time (months) elapsed from primary surgery to revision surgery	Reason for failure	Integration of the structural allograft	Cementation of the primary megaprosthesis	Particularities	Pain	Ability to walk
Case 1 (Figure 2)	Distal femur	Osteosarcoma	Woman	18	96	Aseptic loosening of the femoral component because of nonunion of the structural allograft.	No	Yes	None	No	Yes
Case 2 (Figure 3)	Distal femur	Osteosarcoma		20	50	Aseptic loosening of the femoral component because of nonunion of the structural allograft.	No	Yes	The femoral stem of the modular megaprosthesis is convertible to future hip arthroplasty	No	Yes
Case 3	Distal femur	Osteosarcoma		31	216	Aseptic loosening and breakage of the femoral component because of nonunion of the structural allograft.	No	No	Neuropathic pain in the territory of the common peroneal nerve.	Yes	Yes
Case 4	Distal femur	Osteosarcoma		38	39	Aseptic loosening of the femoral component because of nonunion and osteolysis of the structural allograft	No	Yes	Body weight=152kg. Tibial stem tip pain. Waiting for re-revision.	Yes	Yes
Case 5 (Figure 4)	Femoral head	Giant Cells Tumor		34	168	Nonunion of the structural allograft. Polyethylene wear and particle disease causing loosening and untethering of the metaphyseal module. Breakage of the primary stem.	No	No	None	No	Yes
Case 6 (Figure 5)	Proximal tibia	Giant Cells Tumor		32	48	Aseptic loosening of the tibial component because of nonunion of the structural allograft.	No	Yes	Failure of the extensor mechanism in the revision modular megaprosthesis because of nonunion of the remanent bone block of the allograft. Waiting for re-revision.	Yes	Yes

Table 1: Details of the 6 cases of patients with failed custom-made allograft prosthesis composite because of nonunion of the structural allograft and aseptic loosening.

a reinsertion of the extensor mechanism when the resection compromises the Anterior Tibial Tuberosity (ATT). Donati et al., reported a survival of 78% at five years in cases of resection of the proximal tibia managed with AMC as a primary Surgery [21], reporting that 12.9% of their patients underwent additional surgery to promote union of the graft. They also describe that union of the graft could be negatively conditioned by the use of radiotherapy. Our experience has led us to believe that in this kind of patients, structural allografts behave as a temporary spacer, so union to the native bone is something that rarely occurs. In case number 6 of our series, the proximal segment of the tibia had to be completely resected at the moment of revision surgery, but a bone block with the ATT could be preserved. The primary reconstruction strategy consisted in an AMC in order pretend integration of the bone block with the ATT to the structural allograft. In this case, neither the structural allograft integrated to the host-bone nor the ATT integrated to the structural allograft.

In regards to the mechanical failures and the mean survival of the AMC and the MMP, Biau et al., described in their series of 91 megaprosthesis that mechanical failures were more frequent in AMC (10/33) than in MMP (10/58), and that the mean survival of AMC was 117 months and of MMP 138 months [19]. In another series of 75 knee megaprosthesis, Wunder et al., described that the failure proportion was greater in the group of AMC when compared to the group of MMP (6/10 vs 10/64 respectively) [22]. It could be considered that nowadays there is enough evidence to establish that a MMP is a superior reconstruction strategy than an AMC. Based on the mentioned premises, actually in our unit all of the primary and revision megaprosthesis are MMP.

Our study has the limitation of being a retrospective revision with a low number of cases, with a heterogeneous pathology and with several anatomic locations. However, our revision has the strength of being conformed by a series of young patients in which all of them had a revision of the megaprosthesis only because of mechanical failures, when they were younger than 40 year-old.

The results of our revision allow us to conclude that the use of structural allografts in limb salvage surgery after massive tumor resection, may not be the best reconstructive option because the high probability that the grafted bone segment might not integrate to the native bone, even in young patients, may lead to prosthetic failure because of aseptic loosening.

The study was performed in accordance with the ethical standards of the Declaration of Helsinki (amended in October 2013); and the level of confidentiality concerning the protection of personal data was as required by the Spanish laws (LOPD 15/1999). All patients gave their written informed consent, and they accepted that data from their electronic medical file could be used for purposes of this scientific research.

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