The Use of Megaprostheses in Severe Bone Loss due to Nononcological Indications: Three Case Reports and Literature Review

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Abstract

Reconstruction of severe bone loss and large skeletal defects using biologic materials with autograft or allograft and using tumor endoprostheses (megaprostheses) helped orthopedic surgeons as well as patients in the sparing of limbs. Several types of megaprostheses have been described in the literature for oncological indications with unpredictable outcomes and complication rates. We review single-centered experience of three nononcological cases to assess the safety of using megaprostheses in patients with severe bone loss without malignant disease. In addition, a literature review on the previous use of megaprostheses as treatment modality, their outcome, and complications was done until August 2022. All the participants were found to be good candidates for megaprostheses implants after their refusal of amputation. Their infections were eradicated before the implants, and also, the range of movement and improvements are satisfactory. In addition, according to the literature compared to the alternative of amputation, this operation has proven to be life-altering and revolutionary for many patients. We believe that megaprostheses might be a good limb salvage alternative in patients with significant bone loss and massive skeletal deformities, even in nononcological situations. Future studies should focus on ways to improve the material and design of the megaprostheses and study the long-term complications and survival rate of the implants.

Keywords: Bone loss, endoprostheses, limb salvage, megaprostheses, skeletal defect

Introduction

Reconstructing large skeletal defects or replacing bone of low quality has always been a challenging problem facing orthopedic surgeons, as in the cases of highly comminuted fractures in trauma cases, primary bone malignant tumors, extensive metastatic disease, or end-stage revision arthroplasty.[1-5] In the past, the only solution was amputation of the extremity with all its consequences, since it was difficult to treat these huge defects. Later, the introduction of custom-made large metallic endoprostheses, known as megaprostheses, capable of reconstructing large skeletal defects, aided surgeons, and patients alike by sparing the extremity.

Nowadays, the world is moving toward using megaprostheses in nononcologic cases such as chronic infections, major trauma with large bone loss, or severe osteoporosis, because it was found that the functional outcome after reconstruction with megaprostheses is often very satisfactory and the patient can maintain a good quality of life.[6,7] Concerning chronic infection, the incidence of chronic osteomyelitis following contagious focus of infection has apparently increased, especially in developed countries, making it necessary to find another solution for advanced infection rather than amputation.[8]

Megaprostheses were initially utilized in oncologic orthopedic surgery.[1] The primary usage of megaprostheses material, according to medical literature, was the reconstruction of

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bone abnormalities in cases of bone tumors in the 1940s.[9] Megaprostheses can be a good approach for an orthopedic surgeon when there has been a lot of bone loss.[1,6,10] When it comes to the use of megaprostheses in nononcological cases, the literature is relatively sparse in reports and there is a lack of certainty about the survival rate and any medium to long-term complications that may occur.[11]

This study aimed to investigate the three cases of patients that underwent megaprostheses implantation for a nononcological indication, the final results, and the quality of life after surgery, in addition, to a literature review on the previous use of megaprostheses as treatment modality, their outcome, and complications. We hypothesized that megaprostheses might be a good limb salvage alternative in patients with significant bone loss and massive skeletal deformities, even in nononcological situations, taking into consideration that they are capable of providing a good functional status, long implant survival, and high eradication rates of chronic infections. Patients' informed consent was obtained for this report and Institutional Review Board approval was obtained before the initiation of this study.

Case Reports

In this study, we review three nononcological cases that have been managed successfully with megaprostheses in the Jordan University Hospital.

Case 1

A 60-year-old female, diabetic on oral hypoglycemic agents, whose BMI is 39.3, was diagnosed with breast cancer in 2007 with no metastasis and had undergone a modified radical mastectomy the same year, followed by seven cycles of chemotherapy and five cycles of radiotherapy.

In 2011, the patient started to complain of right thigh pain and was diagnosed to have a right femur metastatic lesion. She was treated with five cycles of radiotherapy, but the pain did not subside.

In June 2013, she presented with a right proximal femur fracture due to minor trauma and was treated with open reduction and internal fixation (ORIF). After that, the pain continued, and she was able to walk with a walker only. On follow-up after 4 months, the plate failed (it was broken) with nonunion, so the patient underwent a revision ORIF surgery. An infected nonunion was diagnosed at this stage based on cultures taken intraoperatively. Postoperative intravenous (IV) antibiotics were given, but the pain continued, and she was still unable to walk without a walker. Later, the patient underwent debridement surgery with the appliance of vacuum-assisted closure dressing for 6 months.

In 2014, a second revision ORIF surgery was done with a 6-week administration of IV antibiotics. Unfortunately, the infection was not eradicated, and sinus discharge was noted.

In 2017, patients underwent debridement surgery with 19 cm of bone resection, and an external fixator was applied. The histopathology of the bone resulted in no metastatic lesion and only an infection process with no malignant cells. In February 2017, the external fixator was removed, a bone cement spacer with local antibiotic was inserted, and she was started on a 6-week course of antibiotics [Figure 1]. The bone scan results showed no scintigraphic evidence of bony metastasis; the findings were consistent with osteomyelitis and the swab culture findings were methicillin-resistant *Staphylococcus aureus* (MRSA) and diphtheroid bacilli.

The patient refused amputation at this stage of treatment and in July 2017, proximal femoral replacement (megaprostheses) was applied [Figure 2]. On postoperative day 2, the pain was much less, with no fever or chills, and she started walking with one crutch. In 2019, 1-year and 4-month postoperative, the patient's pain was gone with no fever. On examination, she had full range of motion of the right hip joint, but she still walked with one crutch because of left knee osteoarthritis.

Case 2

A 67-year-old female, smoker with 24 packs/year, has been hypertensive since 2013 on candesartan once daily, diabetic since 2013 on insulin glargine 100 units once daily, metformin 750 mg once daily, and sitagliptin 2 mg once daily. She has also had rheumatoid arthritis since 1983, treated with leflunomide since then and has had osteoporosis on alendronate medication for 15 years.

In June 2012, she had a left femur subtrochanteric fracture. Although no trauma was reported, she complained of severe pain when she was walking that made her unable to bear weight, and ORIF was done in another hospital, as shown in Figure 3. After ORIF, she had severe pain and was unable to walk. After 2 − 3 weeks, swelling was noticed and evacuated by a drain. Antibiotics was prescribed but there was no improvement and dressing was applied for 11/2 months.

In October 2012, the patient presented to our hospital with infected metal, nonunion, sinus, and swab culture resulting in MRSA. Seven debridement surgeries were done, and she stayed at the hospital for 35 days. At the end, a first-stage hip spacer was implanted, and she was prescribed antibiotics for 6 weeks. Then, she was unable to walk but was pain free.

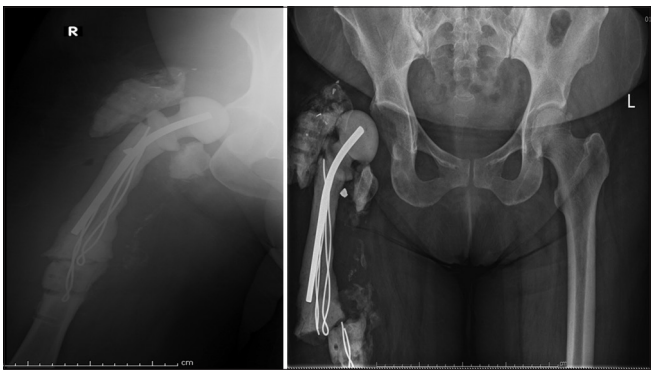

Figure 1: Bone cement with local antibiotic spacer in proximal right femur after resection of 19 cm of diseased bone

In January 2013, she had megaprostheses surgery, as demonstrated in Figure 4. Postoperatively, the patient had no fever, a drain kept for 5 days, and bloody discharge and was prescribed intramuscular antibiotics for 6 weeks, after which she was able to walk independently and pain free.

In 2013, she lost the ability to move her left lower limb due to a stroke. Since then, she has started taking salicylic acid, and she has had physiotherapy from 2013 to 2016. Now, she walks using an elbow walker.

She had a rib fracture in three ribs in 2015 as a result of trauma, and she still experiences discomfort from time to time, which she manages with local analgesics. In 2016, she started complaining of severe low back pain that was due to L2-3 and L3-4 disc prolapse and was treated surgically, but the pain returned 2 months ago, and she is taking gabapentin 300 mg to relieve the pain. In the same year, she had an index finger infection that resulted in amputation of the distal one-third of the finger that includes the nail. In November 2017, she had an *Entamoeba histolytica* and was treated with paromomycin 250 mg, two tablets three times a day.

Case 3

A 52-year-old female patient presented with diabetes on an oral hypoglycemic agent. In 2010, she started to complain of left lower limb swelling, redness, and pain for 1 month before her definitive diagnosis of lymphoma. On physical examination, she had left inguinal mass. She was given three cycles of chemotherapy and underwent left inguinal lymph node dissection, complicated by femoral artery injury and lymphatic duct injury. Later on, the biopsy was complicated by wound dehiscence. The pain had not subsided, and she was walking with the aid of walking sticks.

In September 2012, she presented to another hospital with a left femur fracture with no previous trauma history. She was unable to bear weight and had severe pain after she felt a click coming from her left thigh while walking. They did a revision of the slides, and a bone biopsy revealed no lymphoma but chronic infection.

The patient presented to our hospital in December 2012 and underwent multiple debridement surgeries. The swab cultures resulted in MRSA, and she was given 6 weeks of antibiotics. In June 2013, she refused amputation, although she had severe pain that interrupted her sleep and was walking with the aid of a walker.

In March 2014, the use of megaprostheses was planned, as shown in Figure 5. Hence, before the surgery, bone debridement and excision of the proximal femur with a spacer were done, a biopsy revealed no infection, and postoperation antibiotics were given. On the last follow-up, the pain was much less, except when she sleeps on her left side. She

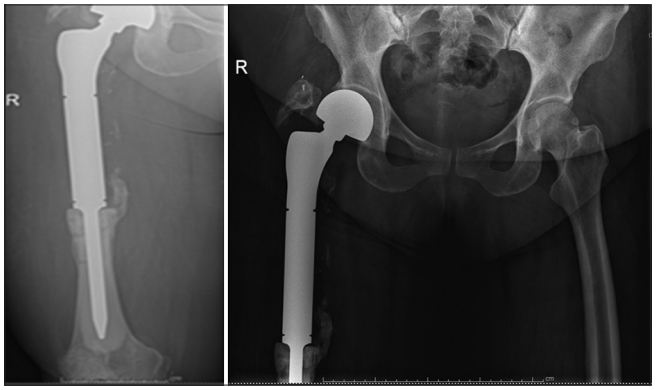

Figure 2: Right proximal femoral replacement after removal of bone cement spacer

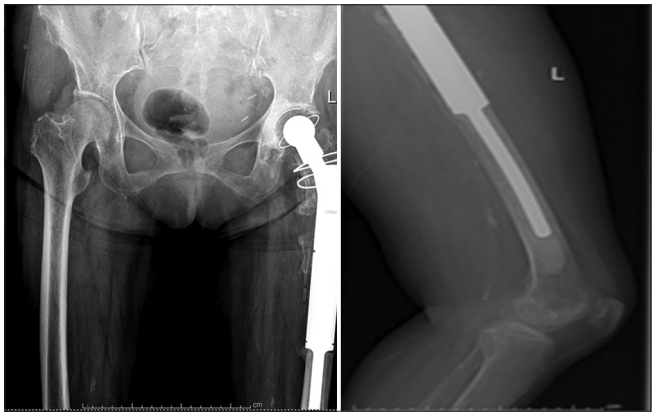

Figure 4: Left proximal femoral replacement (megaprostheses) for case 2

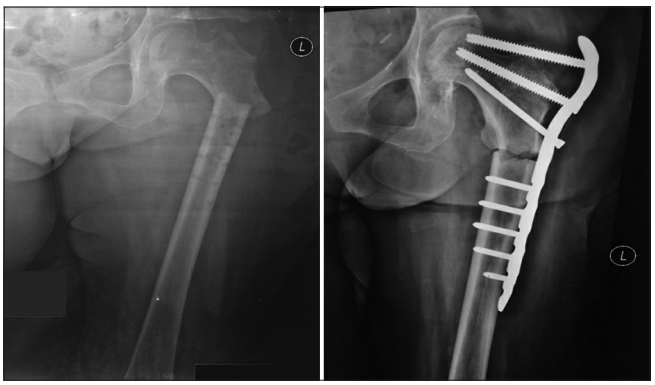

Figure 3: Left femur subtrochanteric fracture treated with open reduction internal fixation ORIF using plate. ORIF: Open reduction and internal fixation

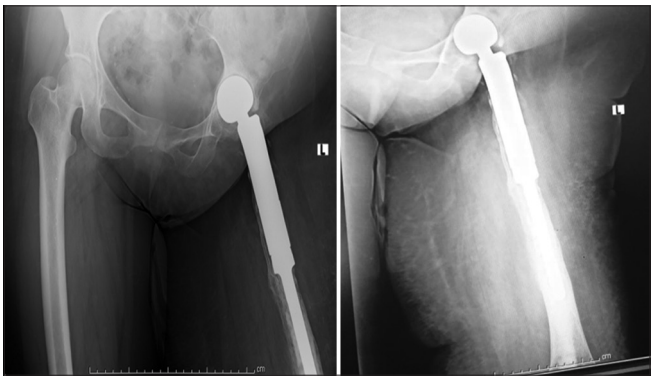

Figure 5: Left proximal femoral replacement (megaprostheses) for case 3

complains of swelling that subsides after a few days, and she reports having infection of her left thigh two to three times per year postoperatively, which she treated in a private clinic with intramuscular antibiotic injections. She now walks using a walker.

Method of literature search

A PubMed search was conducted until the end of August 2022. In addition, a manual search of these papers' references was also conducted. Additional citations of important articles were also added.

Discussion

A megaprosthesis is a metallic device used to replace a large bone segment and the surrounding soft tissue; however, in the operating room, it is a very complex surgical procedure, limiting its use in addition to the cost. Buchman was the first to describe total femur reconstruction in the 1960s,[12] and the term "megaprosthesis" appears to have been originated at the 1981 International Workshop on Design and Application of Tumor Prosthesis at the Mayo Clinic.[1] The use of modular endoprosthesis was introduced in the 1980s as a last resort to salvage the limb before amputation due to excessive bone resection, primarily in oncological cases. Since then, many trails have been improved and evolved to be used in the salvage of limbs.[1]

In addition to the major benefit of its use in saving the limb, megaprostheses also give other advantages, such as immediate weight bearing, a short immobilization period, and good function in the early and mid-term follow-up, which may be of great value for older patients to reduce the complications of immobilization.[13,14] Other benefits include the fact that they are less prone to fracture and nonunion than allografts but are still susceptible to bending stress, which may result in the loss of it.[15,16] However, several risk factor for prosthesis failure should be taken into consideration to predict high-risk patients which include body weight, activity level, prosthetic motion mode, type of reconstruction, type of prosthesis, and length of bone resection.[17,18]

The most well-established indication in the literature is its use in extensive bone resection as a treatment for bone tumors.[2,15,19,20] However, reconstructive failure is somewhat common, and there is a deficiency in recognizing and analyzing it.[16] Metastatic tumors, revision arthroplasty, revision trauma surgery, failed arthroplasty infection, complex fractures in the elderly, recurrent nonunion, and any event that results in massive bone loss that cannot be managed successfully or conventionally are some of the other conditions that have been added to the list.[1-5] Although these indications are known to many orthopedic surgeons, the decision to use them is not usually made, which makes it very difficult to build a literature review. It is noticed that the literature is somehow deficient regarding the treatment of recurrent nonunion, but what is in our hands about modular megaprostheses supports that use of them is a good choice for limb salvage, complication rate, and limb function.[1,21]

Although this is true, megaprostheses carry some complications. The early ones are instability and dislocation, which most probably happens when the residual soft tissue cannot protect the metal prosthesis, prosthetic breakage, failure of the fixation, and infection.[16,21,22] None of the participants we discussed had the first three complications, but one of them had multiple infections per year, and it is proposed that this was due to her immunocompromised state and lymphatic resection, but in oncological cases of endoprosthesis failure, which was detected in 18.2%, it is not known whether this failure depends on the indication of surgery or age,[23] because all the cases had recurrent infections before megaprosthesis implantation, but one of them continued to suffer from infections.

It is promising that some of the literature gives hope regarding the management and the 5-year survival rate of megaprosthesis after infection. In a study, 81% had an acceptable functional outcome with the rate of reinfection being only 28%, and it was proposed that the explanation of polymicrobial culture was due to previous procedures done before the use of endoprosthesis.[24] Another study found that the 5-year failure-free survival rate was 71.6%,[20] and the 5-year mortality rate of periprosthetic infection is greater than that of cancer.[25] In a review on 232 patients by Shehadeh *et al*., the limb salvage rate was found to be 92% at 5 years and 90% at 10 years.[26] Pala *et al*. investigated the long-term clinical outcome of 687 cases of distal femur reconstructions with modular prostheses. The results showed that 27% of prostheses failed, the 10-year survival rate of all types of prosthesis was 70% and 50% at 20 years and 91.4% of patients were satisfied with their functional recovery, which had a mean functional score of 23.3.[27]

It is important to bring to light the fact that in all three cases, MRSA was found in the culture. This has been shown by a study that analyzed the infections that happened after orthopedic surgeries and found that *S. aureus* species were the most isolated bacteria, with MRSA making up 79.7% of them.[28] In addition, patients' quality of life and physical activities are negatively impacted by surgical site infections and their hospital stays are extended by a median of 2 weeks.[29] Nonetheless, modular femur prosthesis carries functional and quality improvements.[30] In this case series, all the participants were found to be good candidates for megaprosthesis implants after their refusal of amputation. Their infections were eradicated before the implants, and they were followed after. They can bear weight, two are pain free and all of them can walk using a walker. The range of movement and the improvements are satisfactory.

Conclusion

Although megaprostheses are primarily used in cancer patients where extensive bone loss is present after tumor resection, we can use it in other cases with nononcological indications such as revision arthroplasty, revision trauma

surgery, failed arthroplasty infection, severe osteoporosis, complex fractures in the elderly, recurrent nonunion, and any case where severe bone loss is present. It is a viable and reasonable option, even if unpredictable complications exist. In addition, compared to the alternative of amputation, this operation has proven to be life-altering and revolutionary for many patients.

Future research should focus on ways to improve the material and design of the megaprostheses, as there are many challenging points, such as the attachment of soft tissues to the prosthesis.

Informed consent

Oral consent was taken from the patients to publish data.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, patients have given her consent for her images and other clinical information to be reported in the journal. The patients understand that names and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

Institutional ethical committee approval

Institutional review board approval was obtained before the initiation of this study.

Authors contribution

Ihab Alaqrabawi: Methodology, Data curation, Writing – original draft. Zuhdi O. Elifranji: Conceptualization, Writing – Review and Editing, Investigation. Mohammad A. Alshrouf: Conceptualization, Writing– original draft. Abdulrahman M. Karam: Conceptualization, Writing – Review and Editing. Jihad Al-Ajlouni: Conceptualization, Supervision, Investigation.

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Conflicts of interest

There are no conflicts of interest.

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