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Review article

Megaprosthesis versus Allograft Prosthesis Composite for massive skeletal defects

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ABSTRACT

Massive skeletal defects are encountered in the setting of tumors necessitating excision, failed total hip arthroplasty with periprosthetic bone loss, periprosthetic fracture, complex trauma, multiple failed osteosynthesis and infection. Reconstruction of the segmental defects poses a tremendous challenge to the orthopaedic surgeons. The goal of osseous reconstruction of these defects is to restore the bone length and function. Currently the most commonly employed methods for reconstruction are either a megaprosthesis or an Allograft Prosthesis Composite (APC).

Megaprosthesis, initially created for the treatment in neoplastic pathologies are being used for the non-neoplastic pathologies as well. The longevity of these implants is an issue as majority of the patients receiving them are the survivors of oncologic issue or elderly population, both in which the life expectancy is limited. However, the early complications like instability, infection, prosthetic breakage and fixation failure have been extensively reported in several literatures. Moreover, the megaprostheses are non-biological options preventing secure fixation of the soft tissue around the implant.

The Allograft Prosthesis Composites were introduced to overcome the complications of megaprosthesis. APC is made of a revision-type prosthesis cemented into the skeletal allograft to which the remaining soft tissue sleeve can be biologically fixed. APCs are preferred in young and low risk patients. Though the incidence of instability is relatively low with the composites as compared to the megaprosthesis, apart from infection, the newer complications pertaining to APCs are inevitable that includes non-union, allograft resorption, periprosthetic fracture and potential risk of disease transmission.

The current review aims to give an overview on the treatment outcomes, complications and survival of both the megaprostheses and APCs at different anatomic sites in both the upper and lower limbs

1. Introduction

Massive skeletal defects are encountered in orthopaedic practice because of the bone loss due to tumor, infection, pseudotumor, osteolysis following joint replacement, complex fractures, and, failure of a megaprosthesis. The currently available solutions for the massive skeletal defects include either prosthetic implants (i.e., megaprosthesis) or skeletal allograft prosthesis composite (APC). Each of them have their own advantages and disadvantages.

The mega prostheses have been widely used since the evolution of limb salvage surgery in the late 1970s. The custom-made implants were being used before the development of modular prostheses and their use has been extended to replace the proximal humerus, distal humerus or an entire humerus in the upper extremity. Similar implants have been developed to replace the proximal femur, distal femur, entire femur, proximal tibia, distal tibia and entire tibia as well. Most of them are designed in such a way that the soft tissue sleeve is mobilised and directly fixed over the prosthesis. [1,2] These reconstructions were insufficient due to the lack of muscle strength and subsequent instability of the adjoining joint leading to impaired function. [3] On the other hand, infection and loosening have remained as the main issues following reconstruction with the megaprosthesis.[4]

The Allograft Prosthesis Composites (APC) were introduced to reduce the complications of megaprostheses. The APC basically constitutes a revision type prosthesis inserted inside the skeletal allograft. The residual muscles and tendons can be attached to the

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allograft bone to purportedly reduce the risk of postoperative instability and provide better function.[5] However, the APCs are also not devoid of complications. Periprosthetic bone resorption, non-union at the graft-host bone junction, fractures, infection and risk of disease transmission are the complications associated with this reconstruction method. [6]

The megaprostheses implantations are easy but non-biologic procedures with limited longevity whereas reconstruction with allograft gives an advantage of osteoconduction but with inherent complications. The current review gives an overview of the treatment outcomes, complications and survival of each treatment modality for different anatomic sites in both the upper and lower limbs. At the end, we also discuss the merits of these two procedures by reviewing the recently available literatures comparing them. It is imperative to mention that megaprostheses are in use since a longer duration than the APCs which may be directly related to the availability of bone bank facility in the hospitals as well as the competence of the surgeons as the letter technique is demanding and requires a learning curve.

2. Megaprosthesis for massive skeletal defects

2.1. Upper limb

2.1.1. Proximal humerus

The reconstruction of the proximal humerus for massive bone defects depends on the type of resection as well the intactness of functional abductor system i.e. the rotator cuff and the deltoid muscle. Kassab et al. [7] advocated that if the resection removes the rotator cuff and the deltoid muscle (axillary nerve) then one can go either for a megaprosthesis or scapulohumeral arthrodesis. However, if the resection preserves the rotator cuff and/or the deltoid muscle, the reconstruction can be done with an allograft prosthesis composite and attaching the cuff muscles to the allograft bone. In their own study, Kassab et al. have mentioned that glenohumeral instability remains the most frequent complication following the reconstruction of proximal humerus which was seen in 37.9% of their 29 cases. The results of megaprosthesis in proximal end of humerus are affected by the fact that majority of the bone defects in the proximal humerus occur due to neoplastic lesions which are commonly seen in the paediatric patients who almost invariably require revisions. Although, the advancement in surgical technique and metallurgy have shown the improvement in functional outcome with the newer prostheses, the complications especially the neurovascular injuries, loosening of the component, instability and infection, and the need for repeated surgical procedures remain major challenges.[8] The outcomes of use of megaprosthesis in different studies are summarized in Table 1.

Recent developments include silver-coated megaprosthesis to reduce the rate of infection and, trevira tube combined with the megaprosthesis to allow attachment of the remaining muscles and tendons by using fibre-wire sutures. Schmolders et al.[10] found only one case of infection at a mean follow up of 26 months in their series of 30 patients treated with silver-coated megaprosthesis for proximal humeral reconstruction. Fifteen of the 30 megaprostheses were combined with trevira tube. Three patients (10%) had subluxation of which only one had to undergo a revision surgery. However, the authors failed to mention whether the subluxation occurred in the cases with trevira or without it. Marulanda et al.[11] used aortograft mesh to facilitate soft tissue attachment and provide mechanical constraint, and improve the stability of shoulder reconstruction following tumor resection. There was no incidence of shoulder dislocation reported in their series of 16 patients at a mean follow up of 26 months. Further, only one patient had a superficial wound infection and none had deep infection necessitating removal of the graft and/or the prosthesis.

2.1.2. Distal humerus and elbow

The distal humerus and the elbow joint are the uncommon sites for bone tumors or the metastasis. In majority of the cases, megaprostheses are indicated in the setting of failed previous arthroplasty, complex intraarticular fractures or failed osteosynthesis with bone loss. Arthrodesis is least acceptable in case of elbow. Although the survivorship of majority of the reconstruction options available is very much limited, the patients invariably want their elbow to be functioning to carry the activities of daily living. Also, successful reconstruction of the elbow gives more satisfaction to the patients.

Megaprostheses are required when even the conventional revision elbow prosthesis becomes insufficient to address the massive skeletal defects. Both modular as well as custom made prostheses have been described in the literature. However, there are only few published studies and majority of them are retrospective analysis with few number of subjects that too with broad spectrum of indications including both neoplastic and non-neoplastic conditions. The outcomes reported in different studies are summarized in Table 2.

Megaprosthesis using principle of compressive osteointegration have recently been introduced to enhance osteointegration by stable compression, preventing stress shielding and hence reducing the incidence of aseptic loosening. This technology involves compressing a porous-coated spindle at the implant-bone interface by a premeasured amount of force through washers and a traction bar, which in turn is secured in adjacent bone with pins. It has been used in cases with large osseous defects with remaining small segment of bone. Goulding et al.[12] retrospectively reviewed 13 such prostheses in 9 patients of which seven were implanted in

Table 1
Summary of the data from the recent studies on the use of megaprosthesis for the management of massive skeletal defects in proximal humerus.

Authors	Diagnosis	No of patients	Average age (years)	Average Follow up	Clinical outcome	Radiological Outcome	Complications	Result	Survival
Dubina et al.[9]	Tumors	761 (30 studies)	45	70.5	MSTS = 74%	–	17% mechanical failure* 4% infection	10% revisions	–
Schmolders et al.[10]	Primary tumors and metastasis	30 (15 with trevira tube)	41	26 m	EFS = 20	12 cranial migration of prosthesis	2 subluxations 1 luxation and infection 1 RNP 1 recurrence 3 fractures	3 revisions	83% at one year, 63% at 2 years
Marulanda et al.[11]	Malignancy	16 (Aortograft mesh)	51	26 m	–	–	1 superficial wound infection	1 death from disease	–

Abbreviations: EFS = Enneking Functional Score, RNP = Radial Nerve Palsy, m = months, *Mechanical failures including prosthetic loosening, fracture, and dislocation, CPS = Compliant Pre-stress Device, GH = Glenohumeral,PH = Proximal Humerus, SOH = Shaft of Humerus, DH = Distal Humerus.