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Role of staged endoprosthetic revision with flap cover for limb salvage in endoprosthetic failure

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Abstract Endoprosthetic replacement (EPR) is commonly required for limb salvage in bone malignancies. Endoprosthetic failure is a term used to denote mechanical failure or infection usually requiring removal of the prosthesis. Treatment of infection consists of EPR revision with or without placement of a temporary spacer. Flap cover (either local or free) may be required if the overlying soft tissues are of concern. It is claimed that the investment of the endoprosthesis in well-vascularised soft tissue facilitates the eradication of infection. This series included nine patients with endoprosthetic failure due to chronic infection who needed flap cover. These patients underwent revision of the EPR in two stages. The first stage of revision included removal of the endoprosthesis, insertion of a spacer and soft tissue reconstruction. If serial sampling of the periprosthetic space failed to demonstrate microbial growth, the spacer was exchanged for an endoprosthesis.

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A total of nine patients underwent staged revision of endoprosthesis. In five patients cover was provided by a local pedicled flap and in four by a free flap. Patients undergoing cover by a broad flat musculocutaneous flap (i.e. free/pedicled latissimus dorsi) performed better. This study reports the results of attempted limb salvage in endoprosthetic failure due to infection in nine cases. Initial findings in this small series indicate that staged revision and soft tissue reconstruction in the form of muscle flap investment of the endoprosthesis carries a higher rate of successful limb salvage.

Résumé Le remplacement prothétique est fréquemment utilisé pour la chirurgie conservatrice dans les tumeurs osseuses. La faillite de ces prothèses correspond à un échec mécanique ou à une infection qui nécessite habituellement l'ablation de la prothèse. Le traitement de l'infection consiste en la revision chirurgicale de la prothèse avec ou sans mise en place temporaire d'un espaceur. Une couverture par lambeau (local ou libre) peut être nécessaire selon l'état des parties molles. Il semble que la mise en place de la prothèse au sein de parties molles bien vascularisées facilite l'éradication de l'infection. Présentation d'une étude de 9 patients ayant une faillite de prothèse par infection et ayant besoin d'un lambeau de couverture. La revision a été faite en 2 temps, le second étant réalisé si une série de prélèvements dans l'espace péri-prothétique ne montraient plus de prolifération microbienne. Dans 5 cas la couverture était réalisée avec un lambeau local et dans 4 cas avec un lambeau libre. Les patients avec un lambeau musculo-cutané libre (grand dorsal) avaient un meilleur résultat. Les résultats précoces de cette petite série montrent que la reprise en 2 temps avec couverture prothétique par un lambeau musculaire donne un taux élevé de réussite dans la préservation des membres.

Introduction

Endoprosthetic replacement is extensively used for limb salvage in patients with bony malignancies. Infection is one

of the major complications of this procedure and if not controlled leads to failure of the endoprosthetic replacement. In most cases infection is treated by revision of the prosthesis in combination with prolonged course of antibiotics. Multiple revisions of the endoprosthesis lead to extensive scarring which we believe predisposes to further infection and possible loss of the prosthesis. In such patients, we believe the use of flap cover of the prosthesis facilitates salvage in two ways, firstly by providing robust and supple skin cover and secondly by introducing well-vascularised tissues for the control of infection. We aimed to evaluate the role of flap cover for limb salvage in patients with failed endoprosthetic replacement. Additionally, the advantages and disadvantages of free flaps over pedicled flaps were reviewed.

Methods

We studied eight patients who underwent endoprosthetic replacement due to infection and one patient with mechanical endoprosthetic failure. The patients were treated at the Birmingham Sarcoma Service in the Royal Orthopaedic Hospital (ROH), Birmingham. The Royal Orthopaedic Hospital at Birmingham is one of the tertiary centres for sarcoma referral. All patients were under follow-up at the ROH for endoprosthetic replacements done for bone tumours.

All the patients underwent staged revision of the endoprosthesis.

Stage I The first stage of the revision consisted of removal of the prosthesis and introduction of an antibiotic-impregnated cement spacer. A mixture of vancomycin and gentamycin-impregnated cement was used in all the cases. This was also accompanied by application of flap cover around the spacer which was either done at the same time at ROH or within a few days after spacer insertion at Selly Oak Hospital, Birmingham. In the postoperative period all the patients received antibiotics for 6 weeks based on the preoperative antibiotic sensitivity assays. Antibiotic cover was continued till two consecutive culture-negative aspirates were obtained.

Stage II Six weeks following the first stage of endoprosthetic revision the patients were admitted for aspiration and culture from the periprosthetic space. After the results of two consecutive aspirations were negative, the patients were admitted for second-stage endoprosthesis revision in which replacement of the spacer was done with a regular endoprosthesis. The patients were discharged after it was clear that there was no infection of the endoprosthesis, following which they were followed up regularly.

The choice of the type of flap was influenced by local tissues and general condition of the patient. In those patients in whom the main problem was a single sinus with low-grade infection, a fasciocutaneous/myocutaneous local flap was used. Free flaps were the first choice in patients with a knee endoprosthesis with a tight scarred skin.

Results

Nine patients underwent staged revision of the endoprosthesis with application of local/free flap. Four patients underwent free flap cover for salvage of the endoprosthesis. Free latissimus dorsi myocutaneous flaps were used. There was 100% flap survival in all these patients. Control of infection after the first stage was satisfactory in this group.

Five patients underwent staged revision with pedicled local/regional flap cover at the first stage while the remainder underwent free flaps. In two of these patients a pedicled latissimus dorsi myocutaneous flap was used to cover a proximal humeral endoprosthesis. These patients had a satisfactory control of infection.

Three patients underwent fasciocutaneous flaps for cover of the endoprosthesis. The first stage revision for control of infection was unsatisfactory in all these patients. In one patient infection was satisfactorily controlled by a washout and change of the temporary spacer (repeat first stage). In the other two patients an above knee amputation was done after removal of the prosthesis.

Microbiology

The most common isolate on preoperative culture was coagulase-negative staphylococci in three patients. Another common isolate was *Staphylococcus aureus* in two patients. Antibiotic therapy following the first stage depended on the antibiotic sensitivity of the isolate. In order of decreasing frequency flucloxacillin and coamoxycylav were the most common antibiotics used. The mean period of antibiotic cover was 5.8 months.

One patient grew methicillin-resistant *Staphylococcus aureus* (MRSA) preoperatively, but the infection continued unabated despite long-term administration of vancomycin and rifampicin. This patient underwent amputation 4 months after the first stage.

One patient had mixed infection with coagulase-negative staphylococcus and group A streptococcus. Infection in this patient continued after repeat first stage (change of spacer and washout), leading to an amputation after 7 months.

Site of endoprosthesis

Two patients underwent cover of the proximal humeral endoprosthesis. In both patients a pedicled latissimus dorsi myocutaneous flap was used with a successful result.

The remaining seven patients had endoprosthetic replacement of the lower femur or upper tibia. Among these three patients who underwent pedicled local flaps for coverage of the endoprosthesis, only one limb was successfully salvaged. Four patients underwent microvascular free flap cover of the endoprosthesis and limb salvage was possible in all these patients. Free flap cover also

resulted in a reduced time to the second stage in comparison to pedicled flaps (Table 1).

Following are detailed examples of our patients.

Patient 1 A 30-year-old male with a right-sided proximal tibial endoprosthetic replacement for an osteosarcoma excised 14 years earlier (1988). He had undergone closure of a sinus by gastrocnemius flap in 1989. He had undergone three revisions of the endoprosthesis, twice due to loosening and once due to infection. On presentation he had an unhealed wound with a sinus over his leg and had been on long-term flucloxacillin. He underwent (as first stage) replacement of the endoprosthesis with a temporary cement-impregnated spacer, followed by free latissimus dorsi myocutaneous flap transfer 3 days later. The flap vessels were anastomosed to the medial genicular artery and the long saphenous vein. Following this the patient was placed on long-term flucloxacillin and underwent the second stage of endoprosthesis revision 8 months after the first stage. On follow-up at 1 year after the second stage the flap was well settled with no evidence of any infection.

Patient 2 A 43-year-old female with an endoprosthetic replacement of left proximal tibia done at the age of 24 years. She underwent one revision of the endoprosthesis earlier (11 years after the initial replacement because of infection). She presented with a sinus over the middle one-third of her leg and underwent first-stage endoprosthe-

sis with excision of sinus and cover with distally based medial fasciocutaneous flap. Aspiration after 6 weeks was positive for *Corynebacterium* spp. as a result of which the first stage was repeated including a washout and change of spacer. Following this she was placed on long-term teicoplanin and was admitted for a second (third) stage 7 months after the first-stage surgery. She received long-term prophylactic antibiotics again after the procedure and did not develop any further infection. At approximately 2 years following her first stage the endoprosthesis is still uninfected and the flap is well settled.

Patient 3 This 22-year-old male was diagnosed with Ewing's sarcoma in his left proximal humerus at the age of 14 years, following which he underwent endoprosthesis replacement. He had persistent discomfort with loosening of the endoprosthesis 3 years after the operation. He underwent revision of the endoprosthesis, during which cultures were positive for *Staphylococcus epidermidis*. The second stage was undertaken 6 weeks after the first stage. Infection unfortunately continued after the second stage. He was admitted for a repeat endoprosthesis revision 2 years later due to continuing infection. He underwent revision of the endoprosthesis in one stage with pedicled latissimus dorsi myocutaneous flap cover. The wound healed well without any complications and 6 months after operation the prosthesis remains well covered (Figs. 1, 2, 3).

Table 1 Brief summary of the patients in this series

No.	Age	Sex	Endoprosthesis	Time	Previous revisions	Type of cover	Bacteriology	Antibiotic	Time to second stage	Limb salvage
1	30	M	Proximal tibia	14 years	3	Free lat. dorsi	<i>Staphylococcus aureus</i>	Flucloxacillin	8 months	Yes
2	43	F	Proximal tibia	19 years	1	Fasciocutaneous flap	<i>Corynebacterium</i> spp.	Teicoplanin	7 months	Yes
3	31	M	Proximal tibia	21 years	1	Free lat. dorsi	<i>Citrobacter koseri</i>	Cefuroxime	4 months	Yes
4	14	M	Proximal humerus	5 years	0	Pedicled lat. dorsi	<i>Staphylococcus aureus</i>	Flucloxacillin	4 months	Yes
5	24	M	Proximal tibia	8 years	2	Fasciocutaneous flap	Coagulase -ve staphylococcus + group A streptococcus	Flucloxacillin, penicillin, teicoplanin		No
6	58	M	Distal femur	5months	0	Fasciocutaneous flap	Methicillin-resistant <i>Staphylococcus aureus</i>	Vancomycin, rifampicin		No
7	22	M	Proximal humerus	8 years	0	Pedicled lat. dorsi	Coagulase -ve staphylococcus	Flucloxacillin, teicoplanin, cefuroxime	2 years	Yes
8	23	M	Distal femur	7 years	1	Free lat. dorsi	Mixed coliforms	Augmentin	5 months	Yes
9	20	M	Proximal tibia	7 years	1	Free lat. dorsi	<i>Enterococcus</i> spp.	Augmentin, cefuroxime	7 months	Yes

Following are detailed examples of our patients

Fig. 1 Preoperative photograph showing an infected proximal tibial endoprosthesis with a sinus

Fig. 2 Postoperative photograph of the same patient (Fig. 1) after replacement of the endoprosthesis with a spacer and flap cover

Fig. 3 Photograph of a patient 1 year following second-stage revision, showing stable painless weight bearing

Discussion

Endoprosthetic replacement is extensively used for limb salvage in patients with bone cancers [3]. Failure of the endoprosthetic replacement is defined as a complication that necessitates removal of the endoprosthesis [2]. In a series of 278 endoprosthetic replacements reported by Wirganowicz et al. 19.5% of the patients developed failure of the endoprosthesis [7]. The major causes of failure of endoprosthesis are mechanical failure, infection and recurrence [8]. Mechanical failure is the most common cause of endoprosthesis failure and causes as many as 60% of the failures [4]. Infection causes approximately 15% of endoprosthesis failures but results in a much higher amputation rate [2, 6]. The standard treatment of endoprosthetic infection is a revision of the endoprosthesis. In the series reported by Wirganowicz et al, 40% of the patients with infection ultimately underwent amputation. In such patients infection is often complicated by lack of good soft tissue cover over the endoprosthesis.

Our experience shows that infection needs to be tackled by a multipronged approach. This would include:

- (a) Insertion of spacer with antibiotic impregnated cement
- (b) Provision of well-vascularised soft tissue preferably muscle
- (c) Long-term antibiotics tailored to preoperative and periprosthetic aspirate cultures

Flaps containing muscle have also been shown to have a beneficial effect in infection. Muscle and musculocutaneous flaps have been used for cover of exposed prostheses [1, 5]. In this series the patients who underwent muscle or musculocutaneous flaps had better result than patients with other flaps. All the patients who underwent myocutaneous flaps had latissimus dorsi flap. Latissimus dorsi is particularly well suited for cover of the endoprosthesis, being broad and flat. In this series the skin paddle was designed over the middle portion of the muscle and the muscle was as far as possible wrapped around the spacer. During the second stage of the revision the muscle was dissected away from the spacer and redraped around the endoprosthesis. Pedicled latissimus dorsi myocutaneous flap is well suited for cover of an endoprosthesis of the proximal humerus. Both the patients in this series who underwent this procedure for proximal humeral endoprosthesis had a favourable outcome with limb salvage.

All the patients who underwent free latissimus dorsi flap cover to a lower limb endoprosthesis had a good result, with good control of infection before the second stage. In contrast to this patients having fasciocutaneous flaps had a poorer outcome. Two patients underwent fasciocutaneous flap cover over a lower limb endoprosthesis. One of these patients underwent amputation because of failure of control of infection; the other patient had a delay before the second stage due to persistent infection and had to undergo a repeat first-stage revision.

Based on this series, there is evidence that reconstructive surgery in the form of flap cover is important for limb salvage in patients with endoprosthetic failure due to

infection or soft tissue problems. This series confirms that musculocutaneous flaps achieve good control of infection and help in limb salvage. For a humeral endoprosthesis a pedicled latissimus dorsi musculocutaneous flap is the flap of choice. Infected endoprostheses around the knee are best treated with a stage revision and free latissimus dorsi flap cover for limb salvage.

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