Deep prosthetic joint infection remains an uncommon but serious complication of total hip replacement. We reviewed 24 patients with recalcitrant hip wounds following infected total hip replacement treated with either pedicled rectus femoris or vastus lateralis muscle flaps between 1998 and 2009. The mean age of the patients was 67.4 years (42 to 86) with ten men and 14 women.

There had been a mean of four (1 to 8) previous attempts to close the wound. A total of 20 rectus femoris and five vastus lateralis flaps were used, with one of each type of flap failing and requiring further reconstruction. All patients had positive microbiology. At a mean follow-up of 47 months (9 to 128), 22 patients had a healed wound and two had a persistent sinus. The prosthesis had been retained in five patients. In the remainder it had been removed, and subsequently re-implanted in nine patients. Six patients continued to take antibiotics at final follow-up.

This series demonstrates the effectiveness of pedicled muscle flaps in healing these infected wounds. The high number of previous debridements suggests that these flaps could have been used earlier.

Total hip replacement (THR) is cost effective with more than 50,000 procedures carried out in England and Wales annually. Deep infection remains an uncommon but serious complication with rates of 0.2% to 2.2% and 1.1% to 3.7% quoted for primary and revision procedures respectively. The management of infection requires antibiotic treatment, either with debridement and retention of the prosthesis or with revision of the components. Revision may be immediate or staged with two-stage revisions considered to be the standard with reported success rates of 94% to 98%. With this optimistic assessment, there will be approximately 250 cases of infected THR that are refractory to revision each year in England and Wales. These patients often have prostatic loosening causing pain and decreased mobility. They may also have chronically discharging wounds. Following debridement, any resultant defect can be treated with a pedicled muscle flap which provides vascularised soft tissue to manage the dead space and cover the hip wound. This study reports on a cohort of patients with a persistently infected THR managed using a multidisciplinary approach and a pedicled muscle flap. Our primary aim was to assess whether this management resulted in healed wounds with control of the infection.

Patients and Methods
This is a retrospective review of all patients with a recalcitrant infected THR treated with a pedicled muscle flap between April 1998 and September 2009. Patients in whom these muscle flaps were used for infected pressure sores, hip stabilisation, tumour reconstruction or femoral osteomyelitis, were excluded. All patients were treated at the Nuffield Orthopaedic Centre, Oxford, by a multidisciplinary team of plastic surgeons, orthopaedic surgeons, and infectious disease physicians specialising in bone infection. Patients were identified by searching theatre registers, surgeon’s logbooks and the computerised operation note system. We believe all patients were identified as each was represented in at least two of the three potential sources. Patient medical records were then retrieved and analysed against a 22 point pro forma.

In all, 30 patients were identified with non-healing wounds of the hip region, in which 31 pedicled muscle flaps were performed; five patients were excluded as they did not
have joint-related wounds. One patient died in hospital and was also excluded from the analysis. This resulted in 24 patients, comprising ten men and 14 women, in whom 25 flaps were performed (one failed flap required reconstruction with an alternative flap). Their mean age at the time of reconstruction was 67.4 years (42 to 86). The right hip was operated on in 15 cases and the left in nine.

The patients were instructed to cease their antibiotics for at least two weeks prior to surgery. These patients had open wounds extending down to an infected hip prosthesis or, where this had already been removed, wounds extended down to the infected femur or acetabulum. The wounds were widely excised removing any fibrotic scar tissue. The prosthesis was removed if it was loose. If it was implanted within the last six months or if removal would be overly destructive it was left in situ. Replaceable modular components were exchanged. A total of five or more separate deep microbiological samples were taken, before intra-operative Vancomycin (1 g twice per day) and Meropenem (500 mg to 1 g three times per day) were administered. The flap was chosen depending on the site and extent of the defect.

**Rectus femoris flap.** Through the lateral hip incision the rectus femoris was harvested by approaching its fascial compartment laterally. This dissection is uncomplicated as it has no intra-compartmental connections other than its vascular pedicle, which enters the muscle inferomedially approximately 15 cm from the anterior superior iliac spine. The tendon is divided 10 cm above the patella and the origin is divided leaving the muscle only attached by its neurovascular pedicle. It is then transferred into the acetabular fossa medial to vastus lateralis, and pulled laterally towards the hip wound. It fills the acetabular fossa, around the proximal femoral stump and the hip wound (Fig. 1). The fascial layers are closed and the skin is often primarily closed. Where that is not possible the muscle is covered by a skin graft or an overlying local paddle of skin on the rectus femoris flap is used.

**Vastus lateralis flap.** The vastus lateralis has one major and many minor vascular pedicles, as well as an extensive origin from the femur making the dissection slightly more complex. The flap is raised through the same incision commencing at the junction between vastus lateralis and rectus femoris. The two proximal pedicles that run deep to rectus femoris heading medially to the origin of the superficial femoral artery are retained, but the more distal branches from the profunda are divided. The distal tendon is divided and the muscle released from the underlying vastus intermedius, dissecting proximally and in so doing elevating vastus lateralis from its origin on the femur. A complete release may not be necessary. It is a much larger, bulkier muscle than rectus femoris making it ideal for larger defects but harder to transpose unless completely mobilised on its pedicle.

Data collected included: patient demographics, original treating hospital, confirmed date of infection, date of prosthesis removal, total duration of wound breakdown, number of previous surgical attempts at debridement/closure, flap losses, healed wounds (whether primarily or by secondary intention), requirement for re-operation, donor site morbidity, culture positive infection, polymicrobial infection, responsible organisms, antibiotics and their duration of use. Re-implantation of the THR was recorded and the mobility of the patient at final follow-up.

Follow-up information was based on clinic letters and contact with patients who had less than two years of post-operative review.

The primary outcome measure was a healed wound. A wound was considered to be healed if it showed absence of erythema, induration, collection, sinuses or further breakdown.

**Results**

The rectus femoris flap was used in 20 hips, one with a skin paddle, and five vastus lateralis flaps were used. There had been a mean of four (1 to 8) attempts at wound closure prior to flap surgery. In five patients the prosthesis was retained, nine patients had subsequent re-implantation of their prostheses, and ten did not undergo re-implantation. At the time of flap surgery 18 patients had already undergone removal of their prosthesis, five patients had the flap procedure carried out at the time of single-stage revision and one patient had the flap as the first of a two-stage procedure.

There were two flap losses (one rectus femoris and one vastus lateralis) and one flap experienced partial necrosis of the overlying paddle of skin. The rectus femoris flap
failure was discovered at re-exploration for failure of wound healing. Suction drains were inserted and the wound closed directly; healing was achieved by secondary intention with no detrimental effects to the underlying muscle or outcome. The vastus lateralis flap failure presented with persistent wound drainage which was successfully treated with a rectus femoris flap leading to primary healing. No other patients required additional intervention for wound healing.

The mean follow-up was 47 months (9 to 128). A total of 19 patients (79%) obtained primary wound healing and three healed by secondary intention. Two had a draining sinus with ongoing infection at follow-up; one of these had eight previous debridements, the other had three.

One patient experienced transient quadriceps spasm post-operatively. No other donor site morbidity was identified. Positive bacterial cultures were obtained in all cases, with polymicrobial infection found in 22 patients (92%). The most common organism was Staphylococcus aureus, which was methicillin-resistant in eight patients (32%).

At final follow-up 21 patients (87.5%) were able to walk but only those who had retained prostheses could do so unassisted. Of the remainder, two patients were already wheelchair-bound prior to admission and one patient was very frail requiring assistance to stand. At the time of operation six patients (25%) were smokers and three (12.5%) had diabetes mellitus, of whom one was insulin-dependent and the other two were controlled by diet. The insulin-dependent patient had six previous debridements, whereas the patients with dietary-controlled diabetes had one and three previous debridements respectively.

At final follow-up six patients remained on antibiotics; three of these had retained prostheses, two had no prostheses in place and one had undergone re-implantation. Oral and intravenous antibiotics were given for varying periods of time according to the extent of the infection and the patient’s individual response to treatment.

Discussion

Deep infection following THR is uncommon but associated with considerable morbidity, loss of mobility and repeated surgery. An intervention which can expedite healing is therefore desirable.

Pedicled rectus femoris and vastus lateralis muscle flaps are a potential solution in recalcitrant hip wounds, with good results reported previously, albeit with prosthetic explanation as part of the treatment. Good results have also recently been reported following the use of a vastus lateralis flap in the treatment of patients with chronic infection after resectional arthroplasty. The mechanism of action of these flaps is not understood. However, the use of flaps encourages more radical excisional debridement of the wound and they obliterate dead space providing well-vascularised tissue to the defect to deliver oxygen, leucocytes and antibiotics to the infected tissues. We also suggest that the flaps reduce tension on the surrounding tissues to improve perfusion. These flaps are relatively quick to perform in comparison to free tissue transfer. This results in shorter anaesthetic times and avoids the risks associated with microvascular anastomoses. Furthermore, pedicled flaps have been shown to be dependable in patients with pre-existing renal dysfunction, cardiac conditions, peripheral vascular disease and also in smokers. Donor site morbidity has been reported with decreased quadriceps strength following harvest of rectus femoris, although post-operative physiotherapy restores the strength of the donor leg.

The number of primary THRs undertaken annually was projected to rise by 40% by 2026 in the United Kingdom (based on 1995 to 1996 figures), to an absolute value of 64 957 procedures. This figure has already been exceeded with 71 021 THRs and 8309 revisions taking place between 2009 and 2010. The number of revisions are also expected to double from 8309 to 16 618 during the same period. Preventative measures to combat infection may improve, but the number of patients with recalcitrant wounds is clearly likely to increase. This study is consistent with other literature, demonstrating that pedicled muscle flaps can successfully treat these difficult wounds, and allow either retention or re-implantation of prostheses in over 50% of cases and allow mobility in over 80%. These previous studies showed success only following prosthetic explanation, whereas this study shows it is possible to retain the prosthesis if it is stable. Our study also shows it is possible to re-implant a prosthesis following this technique. The muscle is easily dissected from the pelvis to allow insertion of the acetabular component. It is acknowledged, however, that three of 14 patients with retained or re-implanted prostheses still required antibiotics at follow-up.

The main limitation of this study was the retrospective design. Some patients were excluded from this series due to insufficient data, a prospective design would have reduced the number of exclusions.

Our study had clear inclusion criteria: patients with persistent wound and infected THR despite prior debridement and/or removal of prosthesis. It was felt that using a healed wound as an outcome measure was reliable as both surgeons and infectious disease physicians could be expected to assess this correctly. Most wounds (92%) had healed at final follow-up. The majority of flaps were rectus femoris, a future study making a direct comparison between both these flaps would be useful.

Increased awareness of the usefulness of pedicled flaps for treatment of these defects is desirable. Early referral for reconstruction is recommended, rather than repeated attempts at debridement, although even after delay successful reconstruction can be achieved. However, early intervention with a flap may reduce hospitalisation and associated morbidity. In conclusion we believe that pedicled rectus femoris and vastus lateralis muscle flaps provide an excellent management option for patients with persistent infection after THR.

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References