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ORIGINAL ARTICLE

The salvage of knee-exposed prosthesis using neurofasciocutaneous sural flap

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Abstract Prosthetic exposure is a severe complication of total knee arthroplasty. Many factors are responsible for failed wound healing, and successful salvage of total knee arthroplasty requires early identification of infection, antecedent events related with wound healing failure, aggressive surgical debridement and early appropriate soft-tissue coverage with local skin, fasciocutaneous, muscle, neurocutaneous or perforator flaps. In this report, we present 15 cases of exposed knee prosthesis treated with island sural neurocutaneous flap. Follow-up showed favorable clinical outcomes: all flaps survived and only two cases of hematoma and one of aseptic phystula occurred. According to our results, the island neurofasciocutaneous sural flap represents a sensate reconstructive alternative for providing fine and dependable soft tissue for covering skin defects around the knee.

Keywords Knee arthroplasty · Skin necrosis · Prosthetic exposure · Sural flap

Introduction

The worse consequence in total knee arthroplasty is wound breakdown with prosthesis exposition. Deep infection and failed wound healing are the chief events in prosthesis exposition, making sometimes critical the patient management. Many factors are responsible and predispose to infection and failed wound healing in knee arthroplasty.

During the preoperative phase, presence of scars around the knee for previous meniscectomy or synovectomy [1], diabetes, tabagism, autoimmune diseases, steroid therapy could lead to complicated wound healing. Plus patients with rheumatoid disorders are more prone to deep sepsis [2, 3]. Patients, with various rheumatologic and inflammatory disease states, who are receiving anti-rheumatics drugs preoperatively may be predisposed to developing surgical site infections. The major classes of anti-rheumatic drugs include nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroids, disease modifying anti-rheumatic drugs (DMARDs), slow-acting anti-rheumatic drugs (SAARDs), immunosuppresive cytotoxic drugs. All these drugs affect inflammation and local immune responses, which are necessary for proper wound healing in the perioperative setting, thereby they potentially result in undesirable post-operative complications. In current literature [4], some important studies investigated the relationship between steroid use and wound infection risk. When administered preoperatively or sufficiently early postoperatively, high corticosteroid levels delay the appearance of inflammatory cells, fibroblasts, the deposition of ground substance, collagen, regenerating capillaries, contraction, and epithelial migration. The steroid treatment was shown to decrease basal levels of TGF-beta and IGF-I and to suppress tissue deposition in wounds [5]. Particularly, transforming growth factor-beta affects all phases of the healing process, including the inflammatory response, angiogenesis, and matrix deposition and insulin-like growth factor I is a major regulator of growth and development of wound healing. Therefore, the depressive effect of anti-rheumatic drugs on wound healing depends on the postponement of the inflammatory reaction, which is essential for the healing sequence to proceed.

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During the operative phase, wrong operation planning and surgical technique (including correct type prosthesis selection; e.g. constrained prosthesis is a predisposing factor in comparison with unconstrained prosthesis) [6, 7] or wrong skin incisions could cause infection and failed wound healing [1]. Also the laminar flow systems in the operative theater should not be underestimated; the original idea was that this kind of air flow should have reduced intraoperative concentration of airborne bacteria and wound contamination. Unfortunately, some authors noticed an increased rate of sepsis in total knee arthroplasty, whereas there was a sensible improvement in infection rates during hip arthroplasty. Their conclusion was that the positioning of personnel around the operating table was an important determinant of the rate of sepsis [8, 9].

During the postoperative phase are very dangerous early mobilization and continuous passive motion, no antibiotic prophylaxis and hematoma.

Development of deep wound infection is also very dangerous. This kind of complication is the most devastating, resulting in pain, discharge and loss of function. The diagnosis, without wound breakdown could be difficult, because pain, swelling, knee effusion and wound inflammation all often occur after arthroplasty. According to the data from the NNIS (National Nosocomial Infections Surveillance) system, *Staphylococcus aureus* (20%), coagulase-negative Staphylococci (14%), *Enterococcus spp*. (12%), and *Escherichia coli* (8%) are the most frequently isolated pathogens in surgical wound infections [10]. An increasing proportion of these infections are caused by antimicrobial-resistant pathogens, such as methicillin-resistant *S. aureus* (MRSA) or by *Candida albicans* [10]. This development may reflect the increasing number of severely ill or immunocompromised surgical patients, and the widespread use of broad-spectrum antibiotics. However, the causative pathogens vary with the type of surgery: in orthopedic procedures, such as total joint replacement, closed fractures repair with nails, bone plates or other internal fixation devices and functional repair, the pathogens more often involved in surgical site infections are *S. aureus*, coagulase-negative Staphylococci and gram-negative bacilli [10]. Pathogens may also originate from preoperative infections at sites distant from the operative site, particularly in patients undergoing insertion of a prosthesis or other implants. Exogenous sources of wound infection pathogens include surgical personnel, the operating room environment, and all tools, instruments and materials brought to the sterile field during an operation. Exogenous flora is characterized primarily by aerobes, especially gram-positive organisms (e.g., staphylococci and streptococci). Fungi from endogenous and exogenous sources rarely cause these infections.

Three main portals of entry for infection have been suggested:

- Contamination during operation: here organisms are skin commensal (*Staphylococcus epidermidis*) or are detected in the atmosphere of the operating suite by settle-plate and slit-plate devices (principally Micrococcus species and Diphteroids). In both cases, they can survive, in the wound, hidden in the prosthetic material despite a correct antibiotic prophylaxis [1, 3, 11].
- Postoperative inoculation of the joint by puncture wound or dehiscence of the operative wound [3].
- Hematogenous seeding: this way is linked to distant foci of infection [3, 12]. Urinary tract and gastrointestinal infections, but also dental procedures, are involved [2, 3, 11].

Some Authors even recognized an association between the pathogens and the prosthetic material: *Staphylococcus aureus* and metallic prosthesis [13], *Staphylococcus epidermidis* and polyethylene [14].

Reviewing literature several reconstructive procedures, variable and dependent on the wound requiring coverage size and shape, are described to manage complex wounds around the knee with preservation of the joint and extremity: local skin flaps, local traditional fasciocutaneous flaps, muscle flaps (pedicled or free), neurocutaneous flaps [15–18] and perforator flaps [19, 20].

For superficial damage local skin flaps should be considered, but if deep structures are exposed and a bacterial agent is identified the result could be partial or total flap loss. Traditional local fasciocutaneous flaps, as described by Ponten, have been described for coverage of, even large, but superficial skin loss around the knee [18]. These flaps can be raised in different orientations because of the parafascials vessels supplied by a collateral vascular network around the knee, but can be effective only if the underlying joint capsule is intact. In addition, local fasciocutaneous flaps do not have enough freedom for transfer because the pedicle is short and wide, hence their indication is limited [18]. A reliable method for soft-tissue coverage around the knee is represented by muscle flaps. These flaps offer several advantages providing obliteration of the dead space around the prosthesis and enhancing humoral defense by improving vascularity, draining collections and effusions [18]. Muscle flaps can take the form of local flaps or free vascularized flaps. Local muscle flaps (e.g. Gastrocnemius muscle, Soleus muscle) have the important advantage over free flaps of requiring shorter operative, assuring minimal donor site morbidity, plus microsurgery is not necessary and postoperative care is simple. However, free flaps are more amenable to coverage of massive defects than pedicled muscle flaps [18]. The Gastrocnemius muscle has been a mainstay for soft-tissue coverage over the knee and upper tibia; it is safe, versatile and easy to conform to different size and shape defect, furthermore it may sometimes be unable to provide coverage for large defects around the knee, particularly the supra-patellar region [21, 22]. Perforator flaps represent an another useful method for reconstruction of the knee, resulting in excellent esthetic and functional results [23], but their dissection is tedious and tiring for surgeons, especially for untrained ones, requiring extremely long and sustained pedicle dissection technique. Plus a reliable perforator vessel could not be found during dissection, with considerable anatomical variations [24]. Furthermore, a non-under estimable drawback is the presence of big scars in the distal third of the lower limb and knee.

As reported in literature, and tested in our clinical experience, neurocutaneous pedicled flaps, as described by Masquelet [17], could be a valuable alternative for soft-tissue coverage around the knee providing different advantages over local muscle flaps: greater flexibility of size and shape, longer arc of rotation, provision of skin with protective sensation, less bulk at recipient site and avoidance of a flap twitch [21].

Materials and methods

We describe here our surgical experience in salvaging exposed knee prosthesis using island sural neurocutaneous flaps.

This series consisted of 15 patients, 6 men and 9 women. All cases are collected from various hospitals on national territory. As provided in Table 1, relevant associated medical factors, such as diabetes (4 patients), immunologic diseases (2 patients), peripheral vascular disease (3 patients), tobacco use (8 patients), corticosteroids therapies (2 patients) were determined. Antecedent events related with wound healing failure include poor tissue healing/dehiscence in 7 patients, hematoma in 3 cases, plus in all cases wound cultures were positive and bacteria involved were *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Ten patients presented scars around the knee from previous surgical procedures (above all traumatologic operations), but had no history of failed wound healing. These patients underwent orthopedic surgery, which caused limb or knee scars, from 28 to 1 year before knee arthroplasty. All patients had knee prosthesis exposure and in three cases patients also had a tibial bone exposure. In all patients, the knee joint was approached anteriorly through a medial parapatellar access. We treated only cases undergoing total primary arthroplasty, cemented into place with polymethyl methacrylate cement.

In 9 cases, skin necrosis occurred five days after total knee arthroplasty, within 10 days in 4 patients and within 17–18 days for the persistence of hematoma in the other cases. The surgical treatment, based on surgical debridement and early appropriate soft-tissue coverage with local flaps, was performed within 5 days after skin damage on

Table 1 Preoperative and postoperative evaluation

Case	Age (y)	Tipe of prosthesis	Relevant associated medical factors	Interventions (Debridement + Flap coverage)	Wound infection	Antecedent events linked with healing failure	Exposure	Follow up (m)	Final result: evaluation (KSOS)*
1	65	Primary	D/T	1	SA/PA	Dehiscence	Prosthesis	21	Excellent
2	63	Primary	PVD/RA/C	1	SA/PA	Dehiscence	Bone	19	Excellent
3	75	Primary	PVD/T	1	SA/PA		Prosthesis	10	Good
4	66	Primary	T	1	SA	Hematoma	Prosthesis	25	Excellent
5	80	Primary	D	1	SA/PA		Prosthesis	15	Good
6	61	Primary	T	1	SA/PA	Dehiscence	Prosthesis	12	Excellent
7	72	Primary	RA/C	1	PA	Dehiscence	Bone	10	Average
8	69	Primary		1	SA	Hematoma	Prosthesis	28	Excellent
9	77	Primary	D	1	SA/PA	Dehiscence	Prosthesis	20	Excellent
10	71	Primary	PVD	1	SA		Prosthesis	10	Excellent
11	66	Primary		1	SA/PA		Prosthesis	25	Good
12	73	Primary	D/T	1	PA	Dehiscence	Bone	20	Good
13	62	Primary		1	SA/PA		Prosthesis	15	Excellent
14	59	Primary	T	1	SA/PA	Dehiscence	Prosthesis	20	Excellent
15	83	Primary		1	PA	Hematoma	Prosthesis	20	Good

RA Rheumatoid arthritis; *C* Corticosteroid use; *D* Diabetes; *T* Tobacco use; *PVD* Peripheral vascular disease; *SA* Staphylococcus aureus; *PA* Pseudomonas aeruginosa

* Final result evaluation included determination of Knee Society objective score (KSOS), based on pain, stability and knee range of motion (Excellent: scores greater t/o equal to 90; Good: 80 to 89 points; Average: 70 to 79 points; Poor: less than 70 points)

average. Vascular evaluations had not been performed before knee arthroplasty. In only nine cases an angiography of the inferior limb was carried out to evaluate the vascular condition of the inferior limb before the reconstruction with local flap.

Primary management strategy was based on intensive surgical debridement, allowing infection eradication and prosthesis preservation. After surgical debridement in all our cases, we have used for soft-tissue coverage an island fasciocutaneous flap based on the vascular network accompanying the sural nerve. Patients with prosthesis and bone exposure needed a major flap coverage. The flap is raised with a midline axis, the distal margin is incised through deep fascia and the midline neurovascular pedicle identified. The sural nerve and accompanying vessels are ligated and deep fascia is included elevating the flap from distal to proximal, the flap is then tunneled to the recipient site and inset (Figs. 1 and 2). Intravenous antibiotic therapy was instituted with Teicoplanin, Amikacin and Cephalosporins. All patients had postsurgical antithrombotic prophylaxis with low molecular weight heparin (LMWH). Later they were passively mobilized (Kinetec 0–30°) for two weeks and then had active rehabilitation. Mean follow-up was 18 months.

All human studies have been approved by the local ethics committee and have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Results

All flaps survived, no venous congestion was noted, no suffering of the edges of the incision intended for raising the flap was observable. We had two cases of hematoma, which occurred two weeks after surgical procedures, due to heparin, both healed with primary closure after surgical evacuation and one case of recurrence of an aseptic small phystula in a patient with RA treated with steroids (Table 1).

Discussion

Early tissue breakdown with exposure of the prosthesis is a severe, but fortunately rare, complication following arthroplasty of the knee [25, 26]. Exposure of the knee prosthesis is due to wound dehiscence, skin necrosis, marginal wound necrosis, skin steeping, sinus tract formation and hematoma [27, 28]. Plus total knee arthroplasty requires major handling and extensive undermining of the soft tissues, followed by early postoperative mobilization, this may damage the skin. The skin breakdown generally occurs in the region of the patella and the tibia, also because of their soft tissue poor vascularization [29]. In this area, the position of the prosthesis straight away under the skin may result in exposure [16]. In addition, wrong skin incisions near and parallel to previous scars could interrupt the arterial transverse anastomotic arcades of the knee and

Fig. 1 **a** Exposed knee prosthesis at 42 days; preoperative view. **b** X-ray aspect. **c, d, e** Intraoperative view after surgical debridement: dissection of a proximally based neurofasciocutaneous flap. **f, g, h** Postoperative and after 9 months follow-up

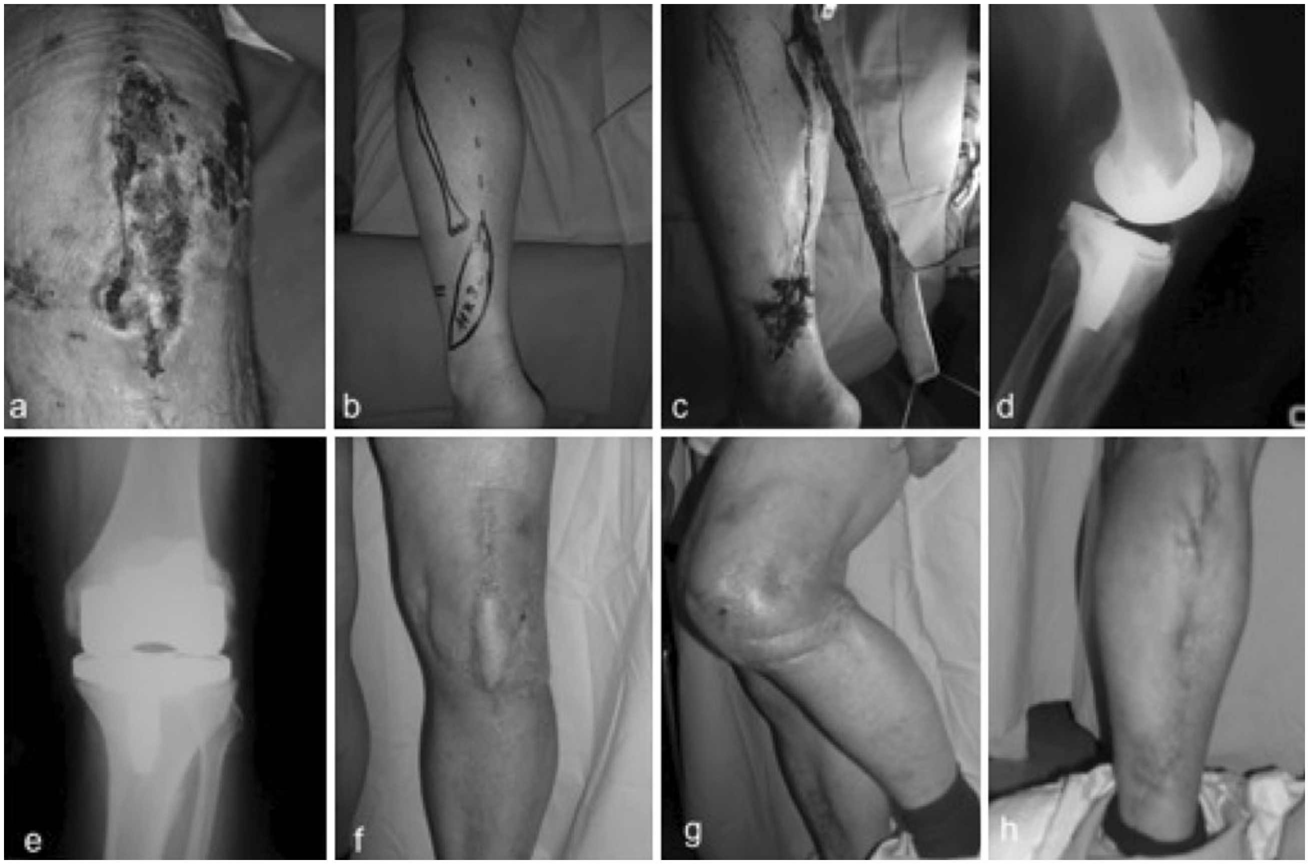

Fig. 2 **a** Cutaneous necrosis. **b** Operation planning. **c** Intraoperative view: sural flap is raised and tunneled to the recipient site. **d, e** Radiographic view. **f, g, h** Postoperative views; a proximally based neuroskin sural flap provided fine and dependable soft-tissue coverage 1 year later

cause cutaneous necrosis with prosthetic exposure (Fig. 3). According to our surgical experience, in the presence of surgical scars skin incision must be performed on previous incision, if the surgical approach of the knee arthroplasty allows it, otherwise the two incisions must be distant and not parallel. Other risk factors are diabetes, previous local radiotherapy, inflammatory rheumatic diseases and previous scars [16]. Infection ensures if the damage to the skin is not closed.

In the postoperative phase, adequate hydration and analgesia are essential. Analgesia is provided by continuous intraoperative epidural infusion, patient-controlled intravenous analgesia, or oral analgesia. At this early stage, the patients must begin with progressive knee movement using a continuous passive motion machine and under the supervision of a physiotherapist. A too precocious or forced mobilization, especially with 40° or more flexion angle, could cause skin damage.

Different studies reported in literature suggest that revision surgery, rheumatoid arthritis, surgery with conflicting skin incision and postoperative superficial wound infection are all predisposing factors [30, 31]. Insall's and Johnson's studies confirm the association of deep infection with the use of constrained prosthesis [7, 30].

Designs modifications have greatly reduced the incidence of several problems associated with early constrained and semi-constrained total knee prosthesis. Nonetheless, postoperative infections continue to be a serious problem [32].

The management of the infected knee prostheses is often obscure.

Attention should therefore focus on prophylactic measures directed toward gentle handling of the periarticular soft tissues [33]. The most effective and practical way to reduce the risk of deep infection is by achieving first wound healing. For this reason, the parapatellar incision is ideal for the knee prosthesis insertion as it is parallel to the skin cleavage lines of the knee and subjected to considerably minor wound tension during knee flexion [34]. Long-term antibiotics suppress symptoms and reduce discharge but infrequently eradicate deep infection in a cemented prosthesis, with persisting wasting of bone stock, pain and functional disability. Their use is generally limited to cases that are too infirm for surgical procedures and have limited

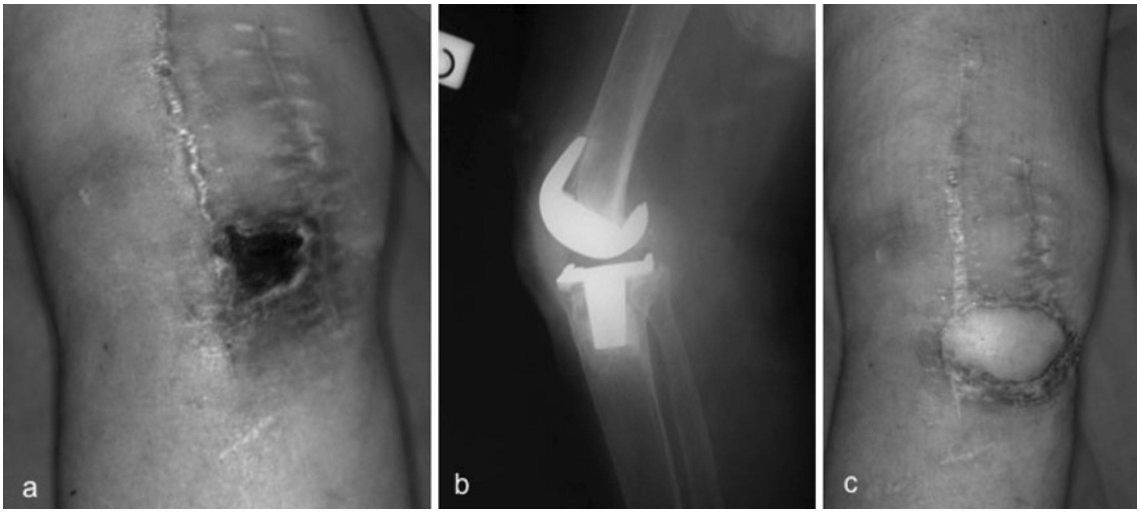

Fig. 3 **a** Cutaneous necrosis after surgical incision near previous scar. **b** Radiographic view of the implant. **c** Clinical aspect at the follow-up

life expectancy [7]. On the contrary, the use of prophylactic antibiotics is crucial for the prevention of infection, establishing the finest preoperative and postoperative conditions for first wound healing [35, 36]. Incorporation of antibiotics, usually gentamicin, into the methyl-methacrylate cement can be undertaken for the prevention of infection [35]. In this way, antibiotics can be effective against organisms resistant to the levels reached by parenteral administration because of their extremely elevated local concentration [35].

Studies reported in literature suggest that in most cases careful, early and adequate surgical management can be an effective choice of salvaging an exposed knee prosthesis [32]. Surgical management must plan to achieve a painless knee [35]. There are many different surgical techniques provided for management of exposed prosthesis: arthrodesis [34], surgical debridement without prosthetic removal [32], spacers positioning, reimplantation of a new prosthesis [16, 32, 35] and, in exceptional cases, amputation [35]. Following arthrodesis, fusion is reachable in a small proportion of cases as suggested by Hageman, Woods and Tullos [35, 37]. Different studies reported in literature [35, 38] confirm that the technique of immobilization with Charnley compression clamps is inadequate for arthrodesis following infection. A two-stage intra-medullary nail, combined with additional bone grafting, appears to be the most effective technique in order to obtain fusion [31, 35, 39, 40]. Bigliani suggested the addition of pulsing electromagnetic fields to raise the rate of fusion [35, 41]. Immediate exchange prosthesis following radical debridement has proven to be unpredictable [35]. A radical debridement including prosthetic components and cement as the first stage of a two-stage reimplantation arthroplasty appears to be more promising [32, 35, 42, 43]. It's Rand's, Bryan's and other authors' opinion [32] that a two-week interval between removal of the prosthesis and replacement is inadequate [7, 35, 42]. In most cases, when the prosthesis is replaced after six weeks, painless walking is obtainable [7, 32, 35, 43]. Usually antibiotic-impregnated methylmethacrylate beads are positioned in the knee cavity from the time of debridement and removal of the prosthesis and the reimplantation [32]. The antibiotic selection is based on organisms' sensitivities and indexes of phlogosis. During the period following removal of the prosthesis, length is sustained with an external fixation-device or a long-leg cast [32] or a spacer.

Generally antibiotic-impregnated cement is used for the reimplantation; however, there is some indication from a small number of cases reported in literature that the treatment of infected un-cemented knee prosthesis could be more successful than the cemented one [33].

In spite of positive results of revision surgery, the prospect of amputation or even death remain a distinct possibility as suggested by Poss [15], Hood, Insall [44] and Grogan [45]. It seems that in most cases early coverage of the soft tissue defect with a flap could avoid and neutralize exposure and infection [15, 16].

According to our surgical experience, the fascioneurocutaneous sural flap is a good and dependable flap for salvage of knee prosthetic exposure, offering several distinct advantages: it is capable of covering large defects; the flap can be tailored to the defect size and shape, providing less bulk at the recipient site and outlined anywhere on the suprafascial course of the nerve; it provides skin with protective sensation as reported by Masquelet [17].

Other advantages of this flap include ease of re-elevation from the recipient site for subsequent orthopedic procedures and the absence of a flap twitch at the recipient site; it is possible to raise either a proximally or distally based pedicle flap [16].

The most significant drawback for this flap is the cosmetic deformity at the donor site, plus the sural nerve is divided and an area of sensory loss in the lateral aspect of the foot is produced and a risk of neuroma formation is reported [16, 21]. We have found none of the aforementioned complications to be observable in our patients.

Time passing between knee arthroplasty and flap reconstruction runs from two to three weeks, in the meanwhile necrotic and healthy tissues separate. While the borderline between necrotic and healthy tissue gets clearly detectable, antibiotic therapy, whenever signs of infections are present, and dressings are started. The operation must be carefully planned and vascular conditions precisely examined. Flap reconstruction involves as a first step a surgical debridement of necrotic tissue, which removes potentially infectious substance and creates a suitable recipient site, and then the reconstruction plan is completed by soft-tissue coverage with local flap.

In our opinion, the island neurofasciocutaneous sural flap represents a sensate reconstructive alternative for providing fine and dependable soft tissue for covering skin defects around the knee.

Conflict of interest None.

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