How to deal with bone exposure and osteomyelitis : An overview

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The authors present an overview of the various techniques which can be used to achieve coverage of exposed bone, particularly in cases of bone exposure associated with an underlying fracture or osteomyelitis. Adequate debridement, possibly in several stages, is necessary in all cases to prepare the receptor site for the next step which is soft tissue coverage, achieved using various types of surgical procedures. Adequate reconstruction can be achieved with pedicled flaps in some cases but in cases with exposure of bone, free flaps usually represent a better option in cases where the condition of the patient is not a limiting factor. Thin fascio-cutaneous free flaps may be used in some cases with small and simple soft tissue loss, so as to minimise donor site mobidity. Free muscle flaps, such as from the latissimus dorsi, are preferable in cases with bone loss in order to fill any dead space ; in cases with major bone loss, a free vascularised bone graft can be used, or composite grafts including bone, muscle and/or skin (fibula or crista iliaca flaps).

Some reconstructions require a functional approach, such as over an exposed joint, or for the weight-bearing area of the foot or the soft tissues over the Achilles tendon.

Survival of a free flap requires perfect, permeable microsutures ; thrombosis of the anastomosis is a major complication which jeopardises flap survival ; close surveillance of the flap is required during the first few days, with hourly Doppler monitoring of the pedicle on the first day.

The success rate can be as high as 90 to 100% in simple cases ; failures may be related to surgical technique, inadequate choice of the flap, or specific features of the patient. In cases with an underlying bone infection, recurrence of infection occurs in 5 to 20%of cases ; this requires additional treatment, possibly with repeat debridement, prolonged antibiotic therapy and sometimes a second free flap.

INTRODUCTION

In lower leg surgery, osteitis, exposure of articulation, bone, tendon or osteosynthesis material, remains a challenging problem for the orthopaedic surgeon as well as the plastic surgeon. Such clinical situations may have various aetiologies ; trauma is the most common. In trauma, soft tissue defects or soft tissue necrosis due to an underlying haematoma may cause exposure of bone, tendons or a joint. Open fractures, especially of the distal one-third of the tibia and the foot, may also be problematic, first because of the need for coverage and protection of the fracture, but also to avoid development of non-union or osteomyelitis. The presence of exposed fixation hardware is a particular situation in which soft tissue coverage becomes urgent. Not only should the exposed fracture be covered, but also the implanted material, in order to

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prevent catastrophic secondary infection of the osteosynthesis (9, 14, 17, 24).

Due to the epidemiology of trauma and the thinness and relative paucity of soft tissue in these areas, defects in the lower leg, ankle and foot represent the vast majority of such cases in our daily clinical practice. Similar defects may also be caused, but less frequently, by resection of soft tissue or bone tumours. Another less frequent, but even more critical clinical situation consists of skin necrosis after multiple re-interventions for arthroplasties, resulting in exposure of bone and prosthetic implants. Finally, patients with peripheral vascular disease or diabetes may also present with large soft tissue defects. They often represent the most difficult subgroup to treat and they require complex reconstruction (24, 27).

In all these challenging situations, perfect harmony has to be found in the combination of debridement, bone reconstruction or fixation and soft tissue coverage (9, 11, 14). Some of the most frequent clinical situations will be presented in this review : 1/ bone exposure, 2/ open fractures, 3/ osteomyelitis. Our personal surgical approach will be presented for simple coverage procedures as well as for functional reconstruction, and the basics of surgical flaps and microsurgery and flap selection will be discussed. Finally, we will present our clinical guidelines to achieve the best possible results.

CLINICAL SITUATIONS

Bone exposure

Cortical bone exposure, without an underlying fracture, may lead to bone necrosis and sequester formation leading to infection and osteomyelitis. Depending on the localisation, bone exposure often goes together with tendon or joint exposure. Tendon exposure will lead to necrosis and rupture while in defects around articulations, the articular cavity is often opened after capsular exposure, resulting in arthritis in most of the cases (17).

There are several clinical situations which may cause bone exposure. **Immediate** loss of soft tissue due to trauma is frequently encountered. In these cases, the tibial crest or the ankle are most often exposed due to the relative thinness and paucity of soft tissue in these areas (19, 33). Nevertheless, skin necrosis or wound dehiscence occurring **several days or weeks after the initial trauma**, are probably the most frequent causes of bone exposure. In crush injuries, resulting from high-velocity trauma and combined or not with bone fractures, full-thickness necrosis of the soft tissues will occur due to the direct trauma and post-traumatic swelling (9, 11, 44). During the hours following trauma, the skin appears oedematous and white at the site of injury, but the “crush” is often underestimated if there are no visible wounds. During the following hours, the teguments will become reddish, phlyctens will appear and eventually necrosis will be clinically apparent after several days. Subsequent debridement of this area will often result in bone exposure. Although there is no risk for bone exposure during the first days, tissue necrosis constitutes an important risk factor for possible infection development. Haematomas, caused by the direct trauma or bone fracture, induce ischaemia of overlying structures owing to excessive tension, which may lead to necrosis of these soft tissues. Even simple wounds occurring in traumatised regions, may eventually lead to secondary bone exposure. Healing of such contused tissues is often problematic, be it for simple traumatic wounds or for surgical incisions. Additional incisions, especially in **secondary surgery** around the knee and the proximal tibia, may cause areas of skin necrosis (30). The typical case is a secondary knee arthroplasty procedure performed through a medial or lateral incision whereas the primary procedure was performed through a midline incision.

Open fractures

Open fractures may be characterised by the combined presence of a primary or secondary wound and an underlying bone fracture. This combination is very unfavourable because it involves several possible risks such as secondary infection with subsequent osteomyelitis and non-union (9, 11). The risk for infection is a very important factor in such clinical situations because it may well jeopardise the limb, or at least the quality of the reconstruction or the flap coverage. In the literature, confusion persists as to when open fractures become "infected" and osteitis can be considered to be present. As clinical guidelines, factors such as the mechanism of injury, the time elapsed since trauma and the degree of contamination of the wound should be considered to evaluate the degree of contamination of the fracture (1, 23, 38). Nevertheless, in several studies all open fractures were treated similarly, even when there was a delay of several months between surgery and trauma (1, 42, 48). It is therefore quite often difficult to separate fresh open fractures from exposed fractures in general. In the eighties, early soft tissue coverage of open fractures has been extensively investigated by such authors as Godina (11), in an attempt to reduce the incidence of late postoperative complications.

Osteomyelitis

Osteomyelitis may result either from haematogenous spread from distant foci or from direct contamination from contiguous septic foci. The latter source of infection is most commonly encountered in clinical practice. Most patients develop osteomyelitis as a result of prior local trauma with an associated fracture or as a result of the ultimate evolution of chronic wounds. There can be a wide variety in clinical presentation of these cases, from a combination of soft tissue and bone loss to purulent discharge from an associated sinus tract. Most patients complain of intermittent pain, aggravated by physical activity (1, 26).

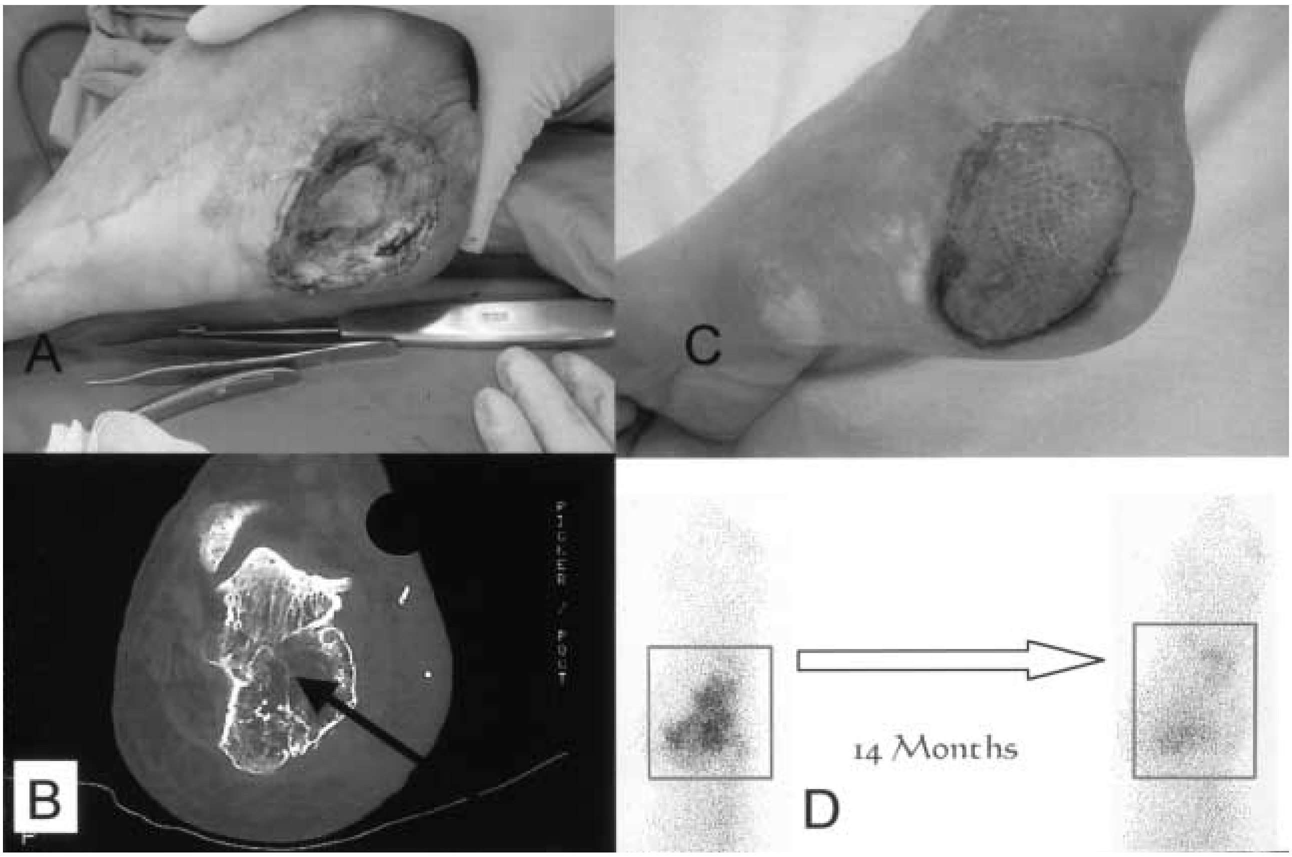

Fig. 1. — Osteomyelitis of the calcaneal bone. Peroperative view after debridement (A). Preoperative osteolysis, diagnosed by CT (B). Early postoperative view (4 months) after free serratus anterior muscle transfer (C). Almost complete removal of the hot spot after 14 months on leucocytes scanning (D).

SURGICAL APPROACH

Although the clinical presentation of all the aforementioned situations may vary widely, their surgical approach follows similar principles. Adequate debridement and careful preparation of the receptor site is needed in all cases. Patients presenting with **osteomyelitis** (fig 1) need an aggressive and complete debridement (13, 17, 42). All dystrophic and inflammatory soft tissues surrounding the open wound should be excised unto healthy tissues. Even if repair with granulating and subsequently fibrous tissue can be accomplished, the resulting scar is not stable but is very sensitive to minor everyday injuries. Bones that heal in a poorly vascularised environment are prone to recurrent chronic inflammation and delayed re-fracture. The occurrence and severity of these complications is directly related to the extent of the original soft tissue damage. Bone involvement is limited in some cases to exposure of a restricted area of bone at the bottom of a small sinus tract, but there may be actual bone loss in other cases. There is seldom a bony discontinuity, but the bone is fragile, appears to be infected and sequester formation may be apparent. In all cases, all pathological and infected tissue should be removed during debridement until healthy, hard and bleeding bone is encountered. An environment, comparable with a clean fresh surgical wound, should be created to decrease the risk of recurrent infection. Nowadays, very aggressive debridement can be performed, as soft tissue coverage is no longer a limiting factor, due to advances in microvascular composite free tissue transfer (13).

Several authors propose to perform the debridement in several stages to achieve an optimal

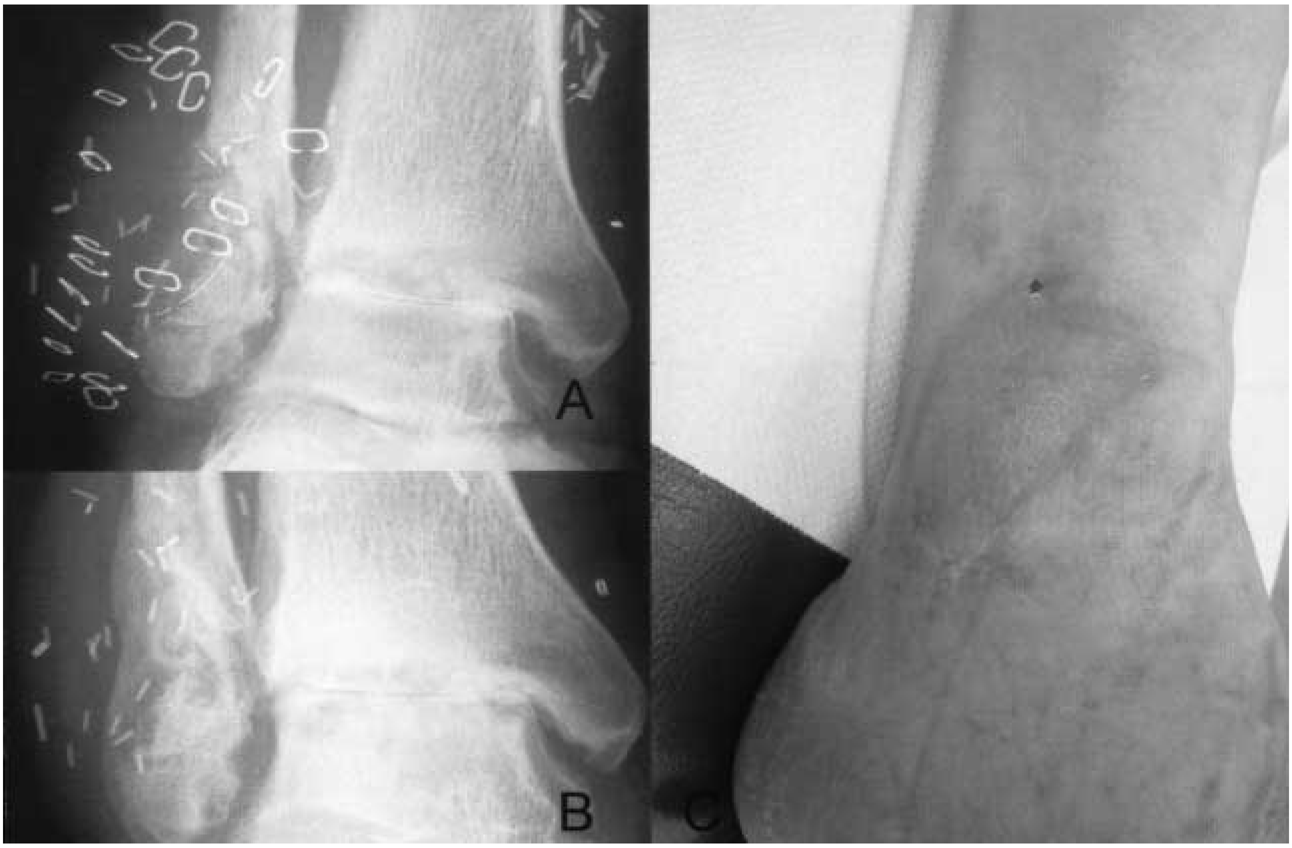

Fig. 2. — Open fracture of the lateral malleolus. Early postoperative (A) and late postoperative radiograph with good callus formation (B). Clinical result 6 months after flap transfer (C).

debridement and thus ameliorate the quality of the receptor site (13, 28, 48). In cases of **simple bone exposure or open fractures**, major attention should be given to the debridement of the soft tissues, while the bony structures only have to be cautiously freshened up and abundantly irrigated. Exposure of **osteosynthesis material or tendons** should be treated in the same way. In cases where screw troughs seem to be infected, resulting in relative mobility, these screws (and in some cases the underlying plate) should be removed and replaced by external fixation.

Whenever the **bone loss** does not impair the biomechanical situation, secondary bone healing will occur under the soft tissue coverage (fig 2). Depending on the amount of bone loss, reconstruction may include auto-or allogenic bone grafts or vascularised bone, harvested with a soft tissue flap. In the literature, guidelines can be found for cortico-cancellous bone grafting in gaps no larger than 5 cm (25, 36). However, in previously infected tissue, vascularised bone grafts are preferred for gaps larger than 1 to 2 cm. It is indeed always possible to include a vascularised bone segment in soft tissue flaps. The indications for the use of impacted bone grafts include small bone defects or larger defects without loss of continuity of the bone. Flap choice thus depends on the type of tissue defect created after thorough debridement.

"Simple" soft tissue coverage procedures

The most important parameters that have to be taken into account are the size of the soft tissue defect, the need for vascularised bone, the topography of the bone loss and the functional issues of the affected region. All these topics will be discussed with flaps. Answers to these questions concerning the defect, will provide enough information to select the appropriate flap. In certain cases, pedicled flaps are still indicated but in the majority of clinical situations, free flaps are the only adequate solution (1, 16, 17). If adequate reconstruction can be performed with pedicled flaps, then these flaps will be first choice in cases where operative times have to be as short as possible. Coverage with a free flap is indeed a more demanding procedure with a prolonged operative time. But if free flap coverage is the better option for a stable patient, then it should be first choice even if a pedicled flap may appear as a reasonable alternative.

During the eighties, Mathes and co-workers have initiated the concept of bone coverage by muscle flaps. They supported their statement on experimental work on animals (7) which suggested that there is an increased resistance to infection of axial supplied myocutaneous flaps, compared with random pattern flaps. This was explained by an increased oxygen tension in the distal part of myocutaneous flaps compared to the distal part of random fasciocutaneous flaps. Moreover, they advocated that muscle flaps 1/ diminish bacterial loads in surrounding tissues, 2/ have an antibiotic carrying capacity 3/ augment the vascularisation not at the expense of surrounding tissue perfusion but on their own proper pedicle and 4/ provide adequate filling of the recipient cavity (if any). All these beneficial effects are due to increased oxygen tension in the tissues, increased supply in leukocytes and phagocytic activity and finally decreased bacterial counts in wounds reconstructed with muscle flaps (15).

Since these studies, a dogma persists on using muscle flaps for coverage whenever bone is exposed. Recent clinical work however, indicates that other flaps than muscle flaps can be successfully used to cover bone defects after debridement (1, 3, 29). Moreover, muscle harvesting may induce morbidity at the donor site and may have some cosmetic disadvantages at the receptor site. For these reasons, several authors have continued to search for better solutions such as thin fasciocutaneous free flaps, in order to avoid complications in small and simple soft tissue losses (29, 47). In all these studies, aggressive debridement of bone and adjacent soft tissue, removal of all infected, non-viable or fibrotic skin and soft tissue, is performed to reduce bacterial colonisation. Whenever major debridements are performed, all dead space has to be obliterated during the soft tissue coverage procedure to prevent fluid collections, which encourage bacterial colonisation and infection. Moreover, these collections will also preclude optimal tissue contact between the flap and surrounding tissues,

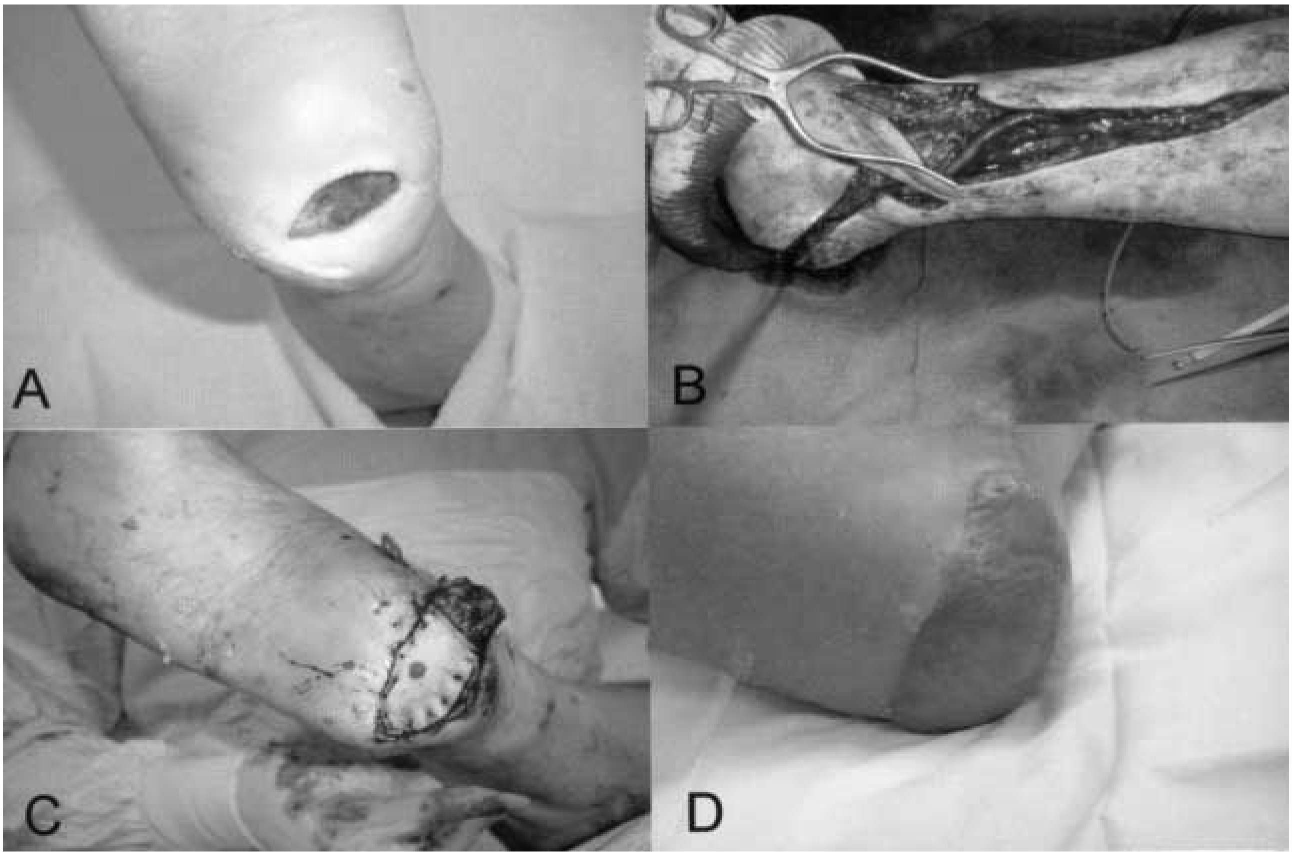

Fig. 3. — A. A heel defect in a vascular compromised patient. B. A combined procedure was performed : arterial femorotibial bypass and radial forearm free flap. C. Intra-operative view. D. Result two years after operation.

thus hindering their optimal interaction in terms of cicatrisation and angiogenesis.

Coverage of exposed tendons or bone, or of a perfectly reduced fracture can be performed with fasciocutaneous or grafted fascial flaps. These flaps, including the neurocutaneous sural flap (10, 18, 33) and anteromedial adiposo-fascial flap of the leg (19, 20), provide an excellent solution in cases of limited soft-tissue loss in a non vascular compromised patient. These flaps however, are considered to be risky in peripheral vascular disease or diabetic patients in which the small vessels are often affected. In these cases (fig 3), free flaps are preferable (34). Secondly, these pedicled fascial flaps are limited in size and free flaps such as the latissimus dorsi are still indicated in large defects. In clinical situations where there is loss of bone but without bone discontinuity, the bone defect has to be filled and it is possible that fasciocutaneous flaps do not provide the ideal solution. Indeed, muscle tissue is bulky but can easily be folded and thus will be better to fill out dead spaces. If bone loss is more important, free bone grafts can be brought in before soft tissue coverage. Several studies have already proven the cosmetic superiority of grafted muscle flaps over musculocutaneous flaps (6, 17, 31). Flaps that are most frequently harvested are the latissimus dorsi, the serratus anterior, the rectus abdominis or gracilis. If bone loss is even more important and continuity is lost, free vascularised bone can be fixed into the defect. Free vascularised bone grafts can be harvested as composite flaps with muscle and/or skin so that the bony reconstruction will be covered by soft tissue (49). The fibular and

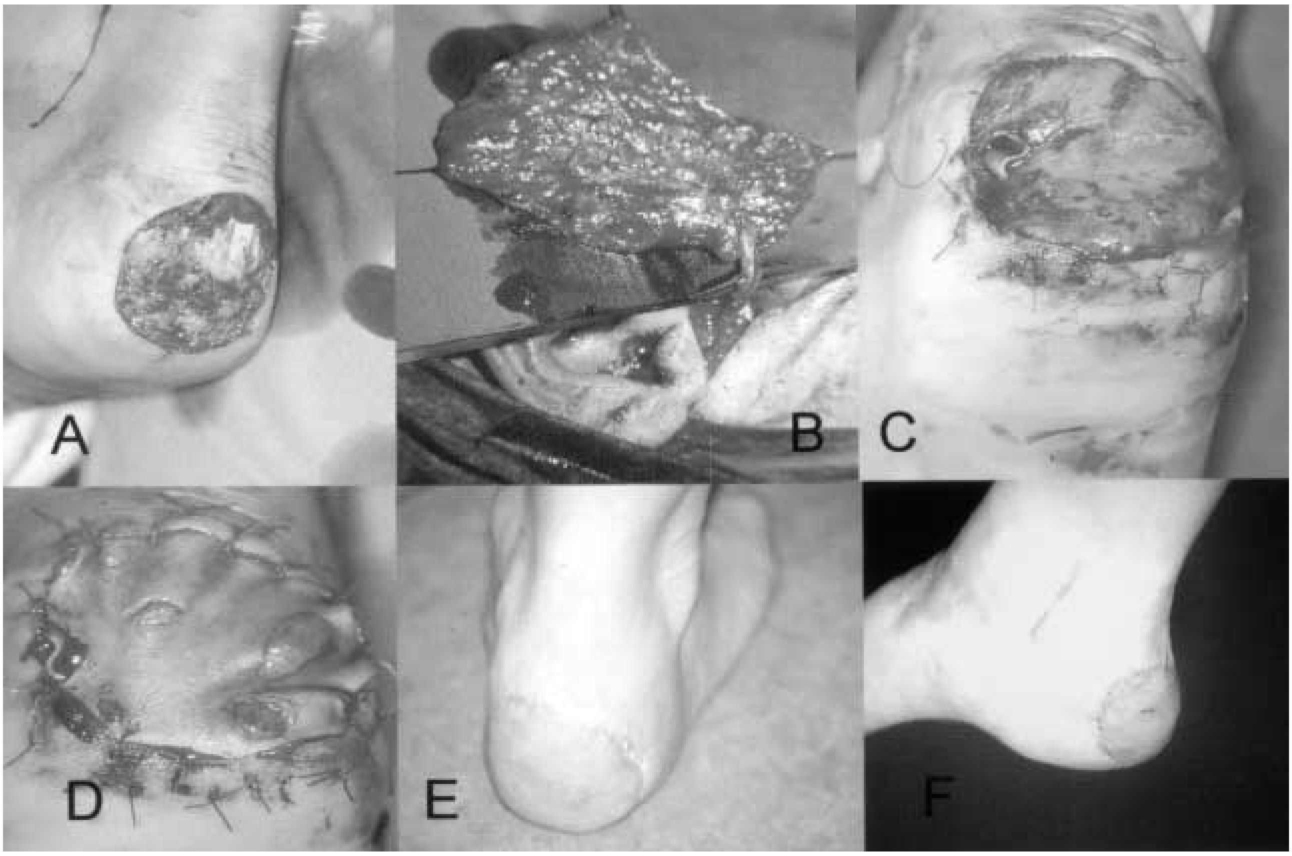

Fig. 4. — A. Exposed calcaneal bone and distal Achilles tendon after debridement of a pressure sore. B. Harvesting of a free temporalis fascia flap. C. Intra-operative view after flap transfer. D. Close up with skin graft on top of the flaps. E, F. Postoperative views after one year.

crista iliaca flap are most commonly harvested for this purpose (36).

Reconstructions that need a functional approach

In selected cases, the only goal is soft tissue coverage, without any functional considerations. A typical example is the exposure of the tibial crest at mid-diaphysis. In other coverage procedures, especially in reconstruction of articular or peri-articular regions or weight-bearing areas, functional issues may be important. Exposure of an articulation entails an important risk of infection and subsequent stiffness. This represents the major motivation to cover the defect urgently. On the other hand, the mobility of the region should not be impaired by any kind of reconstruction ; simple skin grafting is often excluded for this kind of reconstructions owing to the risk of subsequent graft retraction. The use of flaps can often solve the problem but great care has to be taken to import enough soft tissue to avoid late cord formation in flexion zones. The thinness of the coverage often provides a supplementary advantage in avoiding discomfort during movement. In some cases with soft tissue loss, ligaments are also damaged. Coverage including a slip of fascial tissue would be the ideal solution but when only muscular coverage tissue is used, fibrosis on the deep part of the flap will occur, providing some strength in the articular region.

Reconstruction of the weight-bearing area of the foot is still challenging for all plastic surgeons (4). Indeed, a thin but protective coverage has to be achieved, and the flap has to be folded into the defect as perfectly as possible to allow the subsequent use of footwear. However, the tissue characteristics of the plantar region of the foot are very peculiar. The skin overlying the heel for example is attached by numerous septa to the calcaneus, which avoids a "shearing phenomenon". Every other tissue used in reconstructions will be prone to such shearing to some extent, although some tricks can be applied to diminish this. Much discussion remains on the sensitivity of the reconstructed area. It seems ideal to also restore the sensitivity together with the coverage, in order to provide protection and to limit mechanical stress (37, 39, 41).

Not only has the plantar area of the foot special volumetric reconstructive requirements, but the region of the Achilles tendon is also quite particular. The skin covering the non weight-bearing part of the heel and the Achilles tendon has special characteristics with respect to resistance and gliding but also thinness. Soft tissue reconstruction of these areas is seldom an easy procedure. Skin graft take in these areas is often disappointing, especially when the peritendon is not present anymore. Moreover, due to the extreme thinness of skin grafts, consequent ulcerations will occur due to footwear. It would be ideal to use fasciocutaneous flaps in this region, allowing gliding and providing protection but these flaps are often too bulky. It is therefore recommended to perform the coverage procedure in this area with a fascial flap, grafted in a second setting i.e. after granulation tissue formation on the flap (fig 4).

The flaps

Contrary to a skin graft which depends on the vascularity of the receptor site to survive, flaps are tissue transfers including their own vascularity. They can survive without any revascularisation of the receptor site. This offers the advantage that more important tissue volumes can be transferred. The simplest flaps on the reconstructive ladder are the **local flaps** such as rotation or transposition flaps. These flaps are nourished by a non-specific vascular network like the dermal or subdermal plexus (random pattern flaps) or by a direct cutaneous pedicle (axial pattern flaps). Their utility in coverage procedures at the lower leg is limited because of donor site considerations and additional scarring. In head and neck surgery, however, they are still often used to cover defects after tumour resection.

In **pedicled flaps**, a real individual vascular pattern is included al well as a nourishing pedicle. Some of them are skin flaps or fasciocutaneous flaps while others are muscular or musculocutaneous. A **free flap** also contains a tissue unit vascularised by a nourishing pedicle but is usually situated far from the receptor site. Its viability after transfer depends on the micro-anastomosis between the pedicle (artery and vein) of the flap and a receptor artery and vein that is chosen at the receptor site.

Principles of microsurgery

The microsurgical anatomosis remains one of the most important steps during the free tissue transfer procedure. During this procedure, the vessels of the pedicle which nourish the flap are sutured to receptor vessels in order to restore an adequate blood flow into the transferred tissue. These sutures are most frequently performed on vessels with diameters from one to three millimeters. Because the major vessels in the lower leg should be preserved whenever possible, most sutures in lower leg reconstructions are performed in a termino-lateral fashion for the artery, and termino-terminal for the vein (fig 5) (12). While this nourishing pedicle is, in the first days after transfer, the only blood supply to the flap, perfect permeable microsutures are essential for flap survival. It is generally accepted that the microsutures are most at risk for thrombosis during the first five days, after which endothelialisation of the anastomosis occurs. These flaps will indeed undergo necrosis after thrombosis of the pedicle, although some case reports have been published where a free flap survived on the lower leg after early pedicle section or thrombosis.

Thrombosis may develop in the artery or vein (or both) impairing in all cases the flap survival (21). It

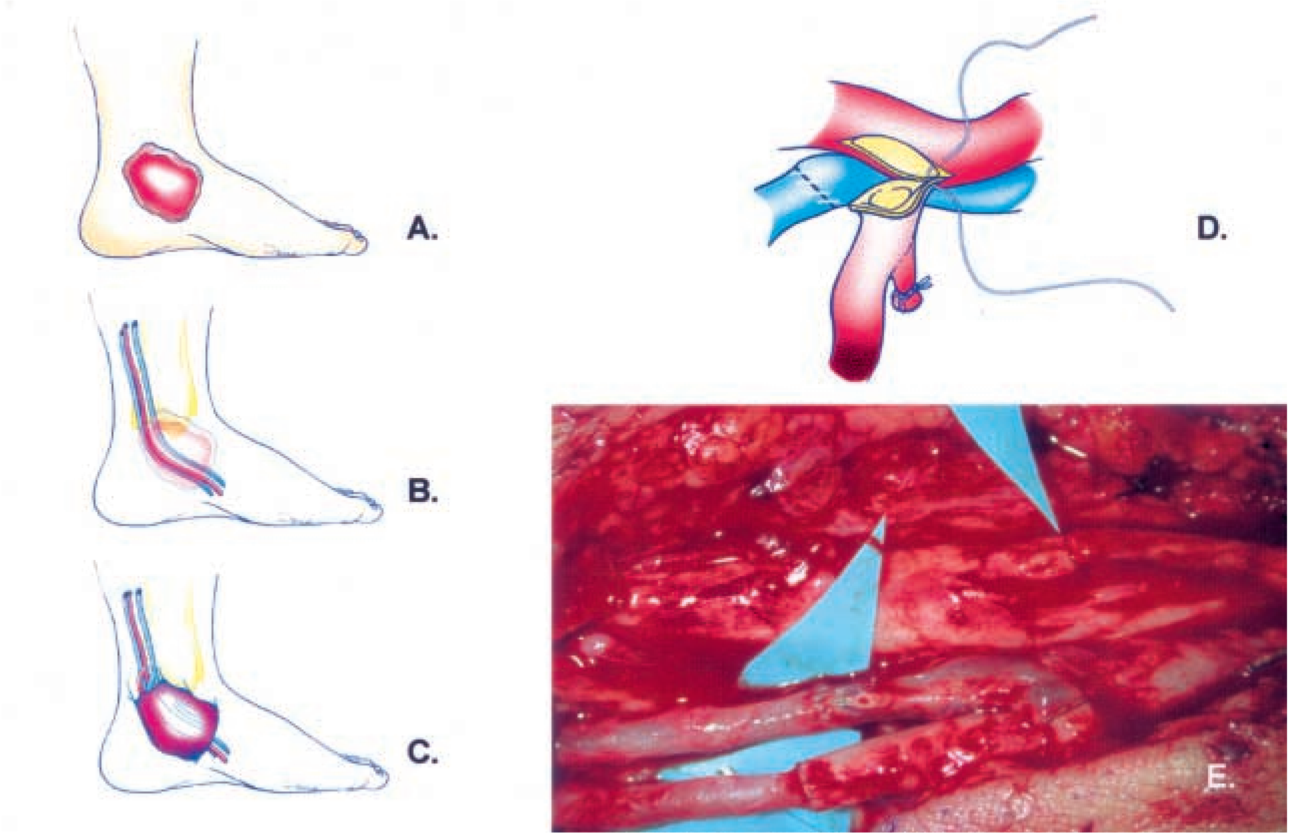

Fig. 5. — Schematic drawing of a free flap procedure.
A. Defect on the medial malleolus. B. The donor vessels. C. Hooking up of the free muscle transfer by end-to-side anastomosis. D. Close up of an arterial end-to-side anastomosis and a venous end-to-end anastomosis. E. Clinical view of an arterial and venous end- to- end anastomosis.

is well known that the surgical technique is the most common cause of thrombosis (35). Whether adventitial tissue is included, the intima is traumatised, or subintimal structures are exposed, all these events may lead to microsurgical failure by thrombosis. External compression by a haematoma, torsion of the pedicle or closure under tension, are other possible causes. There are some more factors, still often discussed in the literature, which may signify supplementary risks for failures : preoperative infection of the operation site, a hypercoagulation status, interposition of vein grafts,… (43). All these microsurgical risks force most microsurgical teams to install a particular postoperative surveillance program (8). Most frequently, surveillance of the colour of the transferred tissue as well as Doppler monitoring of the pedicle is performed hourly on the first day. These measures enable the surgeons to react swiftly in case of suspicion of a microsurgical thrombosis. Five to twenty percent of these patients will undergo surgical re-interventions only to verify the microsurgical sutures or to perform a thrombectomy (46). Whereas microsurgery was still in the experimental stage during the late seventies, it has now become a routine tool in the armamentarium of the plastic surgeon. In microsurgical centres, success rates of 90 to 100% can be achieved (4, 22, 43, 45). The rates may vary with the type of reconstruction (e.g. free flaps for breast reconstruction are more successful than free flaps in lower leg reconstruction), the type of flap (osteocutaneous less successful than muscular) and the experience of the surgical team.

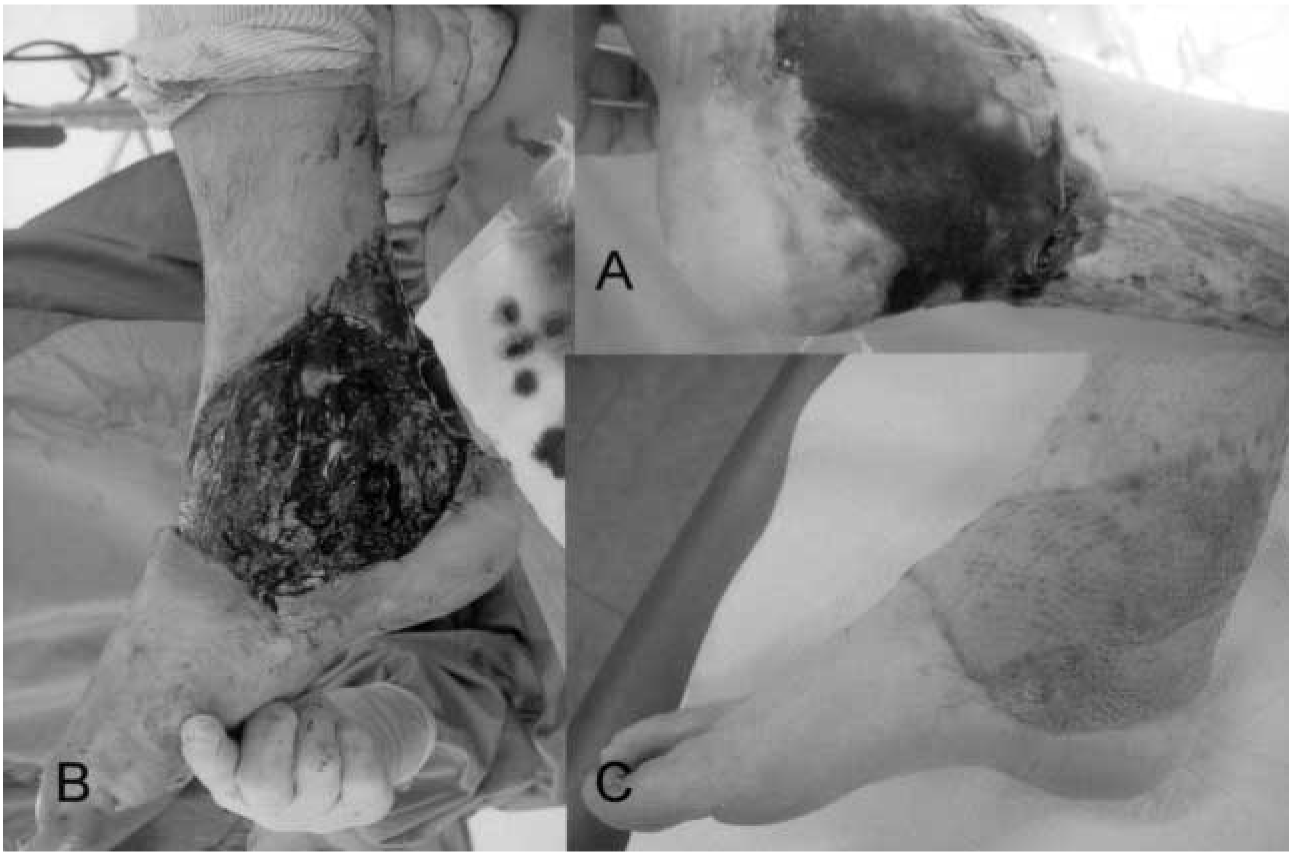

Fig. 6. — A. Skin necrosis after a degloving injury. B. Soft tissue defect after debridement. C. Postoperative view after free latissimus dorsi transfer.

Flap selection

Following the rules of the reconstructive ladder, simple local flaps should be used before pedicled flaps, which on their turn, should be used before free flaps. However, we will not discuss the use of skin grafts and local flaps because their indications are quite restricted in lower leg reconstruction.

Pedicled flaps are often the first type of flaps that have to be considered for lower leg defects. Unfortunately, they cannot provide coverage for all types of defects in all kinds of patients (9). The gastrocnemius flap, nourished by the sural artery and vein, branches from the popliteal vessels, can be used to cover up defects from the anterior aspect of the knee to the first one-fourth of the lower leg. Harvesting this muscle however results in a certain functional and cosmetic impairment and moreover, the size of defects that can be covered is limited. The soleus muscle can be harvested to cover defects over the middle one-third of the lower leg. It is nourished by branches from the fibular artery and has the same limitations : donor site morbidity (loss of the deep venous pump) and a limited size (20). The anteromedial adiposofascial flap can cover defects from the knee down to the heel. It is nourished by perforators from the posterior tibial artery as well as by the saphenous pedicle. However, its use is limited to coverage of defects up to 30 to 40 cm^2. Moreover, it is not a muscular flap, which is often needed to obliterate dead space. Although it can be very useful in selected cases, it is not first choice in patients with diabetes or peripheral vascular disease or in patients who

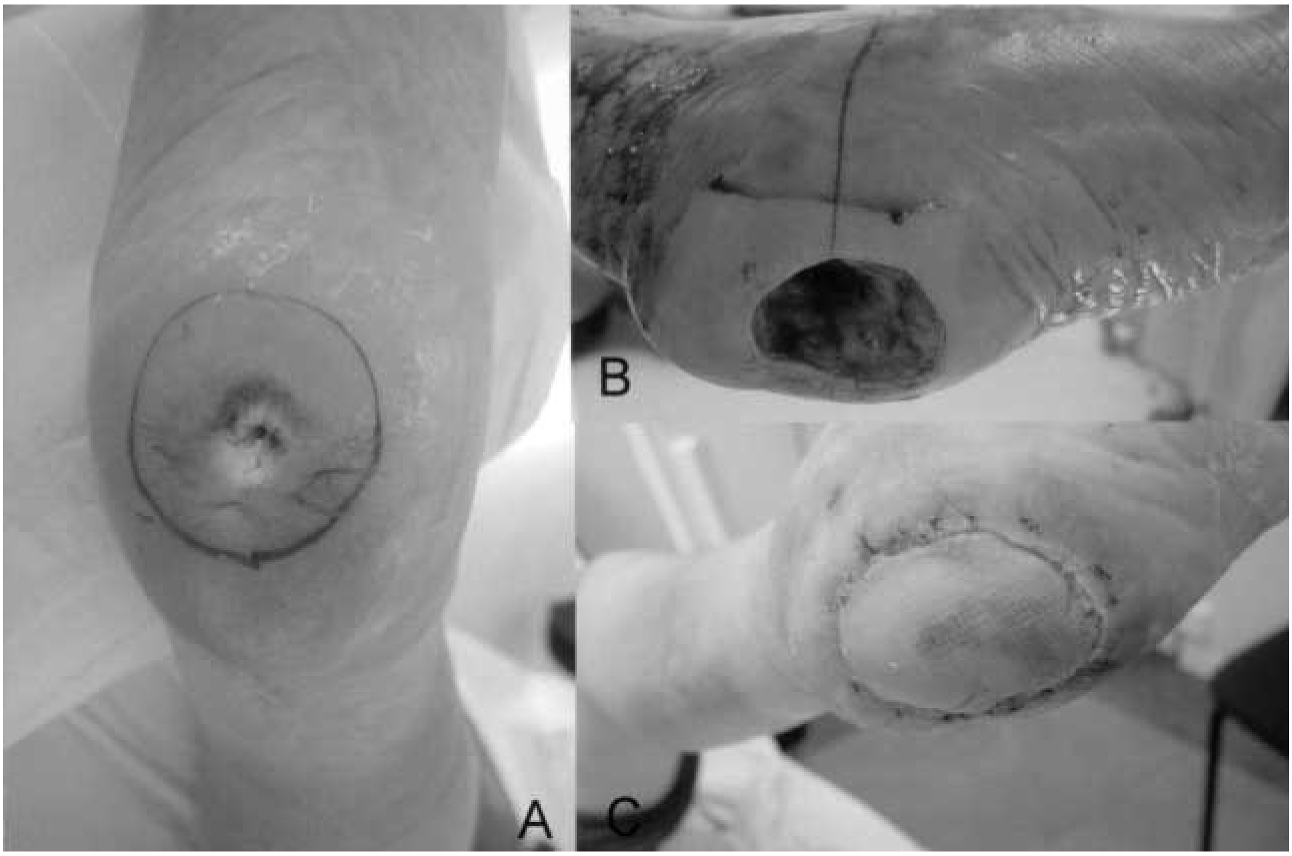

Fig. 7. — A. Osteomyelitis of the calcaneus. B. Clinical view after a first debridement, before a second transfer and free flap transfer. Early postoperative result after free radialis flap transfer.

suffered from severe lower leg trauma. In these cases, the use of free flaps is often the only solution (34).

Concerning **free flaps**, different types of tissue can be harvested on their own pedicle. The choice of free **muscular** flaps depends essentially on the quantity of tissue needed and the desired pedicle length. Indeed, muscles like the *latissimus dorsi*, *serratus anterior* and *gracilis* provide different characteristics ; they all give low donor site morbidity (11, 32, 40, 45). The *rectus abdominis* muscle has been a workhorse for a long time but nowadays, it has been abandoned because of its more important donor site morbidity. All muscle flaps are harvested as pure muscle flaps and will be skin grafted in order to enhance the cosmetic result of the reconstruction. This will also limit donor site morbidity. The *latissimus dorsi* muscle (fig 6) is capable to cover large areas, what makes it unique. It has a long pedicle with large diameter vessels (1.5 to 2.5 mm, thoracodorsal vessels). The *serratus anterior* muscle (2 or 3 inferior digitations) has the same pedicle as the *latissimus dorsi* but its volume is much smaller. The *gracilis* muscle is also a relative smaller muscle with a shorter pedicle (6-8 mm, art. circumflexa femoris med.) with a smaller diameter (1 to 1.2 mm).

If a free **fasciocutaneous** flap is required, the radial forearm flap (fig 7), nourished by the radial artery, is frequently used because of its reliability, thinness and long, large calibre pedicle (29, 47). If harvested as a fasciocutaneous flap, then the donor site has to be covered with a skin graft, often resulting in an unsightly scar. Mainly for this reason, we currently tend to use pure fascial flaps that will be grafted once applied to the receptor site. The donor site can be closed primarily without impairing the cosmetic and functional result of the reconstruction. Some examples of pure fascial flaps that can be harvested are the *fascia radialis*, the *fascia temporalis* (superficial temporal vessels), the fascia of the *serratus anterior* or the fascia of the anterolateral thigh.

Whenever **bone** is needed as a free flap, the fibular flap remains the workhorse. It is harvested on the fibular artery and can provide a long segment of bone. Together with the bone, fasciocutaneous or muscular tissue (*m. soleus*) can be harvested on the same pedicle (49).

This arsenal of about ten flaps, allows us to treat most of our healthy patients. However, in certain cases, other flaps can be harvested to address special situations or because of donor site concerns.

RESULTS AND DISCUSSION

By following the aforementioned guidelines, including an aggressive and adequate debridement, followed by obliteration of any dead space with well-vascularised soft tissue, results should be excellent. In the literature, effective coverage of about 90-100% can be achieved by free tissue transfer, if only tissue viability is considered (22, 45). Most free flap failures are due to microvascular thrombosis of the microanastomoses leading in the majority of the cases to total flap loss. Distal but partial necroses are also well described in the literature, and may lead to the same result i.e. ineffective coverage of the lower leg defect (5). The percentage of failures varies widely according to the experience of the surgeon, the flap choice, the type of reconstruction that has to be performed but also to the medical history of the patient (22).

Recurrence of infection, possibly with abscess formation, fistula or recurrent osteitis occurs in 5-20% of the cases. This discouraging situation is essentially related to ineffective debridement or to a wrong choice of soft tissue coverage. It will inevitably lead to amputation in some cases, whereas in other cases, complementary therapies such as repeat debridements, prolonged intravenous antibiotic therapy, and a second free flap may eventually solve the problem (2).

The most "simple" clinical situations represent the uncomplicated coverage of bone, tendons, articulations or fracture fixation hardware. Global success rates for these situations range from 95 to 100%. Osteomyelitis however, is far more difficult to treat, not from the point of view of microsurgery but because of the need to totally eradicate infection. In such cases, amputation is more often related to reconstruction failure due to infection recurrence. Open fractures represent a particular clinical situation in which all the above-mentioned complications may occur together with complications of fracture healing (14, 45). It is therefore no surprise that in some of these difficult cases, complementary procedures and bone grafting have to be performed to obtain a satisfying result.

CONCLUSIONS

Coverage of soft tissue defects in the lower leg remains a challenge for both the orthopaedic and the plastic surgeon. They are confronted to very heterogeneous clinical situations, where a patient can present with a pathology with widely differing characteristics. It ranges from simple bone exposure with tissue necrosis to osteomyelitis of several years duration.

In all cases, treatment should start with aggressive debridement, followed by coverage with well-vascularised tissue obliterating all dead space. Good results in lower leg reconstruction are not related to the use of a pedicled or free flap but to the conscientious application of the proposed guidelines.

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