Acta orthop. scand. *54*, 772–776, 1983

THE REPAIR OF SOFT TISSUE DEFECTS IN THE LOWER LEG

A Comparison of Different Flap Techniques

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The results following reconstruction of soft tissue defects in the lower leg in 102 patients with 19 cross-leg flaps, 49 muscle flaps, 17 dorsalis pedis island flaps and 26 free composite island flaps were compared regarding the pattern of primary healing, time taken to heal and costs. The cross-leg flap appeared to be the least dependable method of reconstruction and most expensive way of reestablishing stable soft tissue coverage. Muscle flaps and dorsalis pedis island flaps appeared to be preferable and equal alternatives to cross-leg flaps in the proximal and distal part of the lower leg, respectively. Free composite island flaps also appeared advantageous compared to cross-leg flaps, and seem to be indicated when simpler means of reconstruction are inadequate or would yield a similar result at higher overall costs.

Key words: leg injuries; microsurgery; plastic surgery; transplantation; wound and injuries

Accepted 16.iv.83

During the last decade, considerable progress in reconstructive surgery has been achieved through better knowledge and understanding of flap anatomy and pathophysiology (Daniel & Kerrigan 1979). In particular, the use of one-stage reconstructions with either pedicled island flaps or free composite flaps with microsurgical vascular anastomoses has been rewarding (Serafin et al. 1977, Harii et al. 1980, McCraw 1979, Ohmori 1982).

Fractures of the lower leg are often combined with deep, soft tissue defects and the problem of repair therefore is of interest to both orthopaedic and plastic surgeons. The purpose of this paper is to compare different methods of soft tissue reconstruction in the lower leg regarding healing pattern, time before healing and overall costs.

MATERIAL AND METHODS

One hundred and two patients, 26 female and 76 male (mean age 37 years; range 5–86 years), with soft tissue defects of different aetiology (Table 1), were treated at the Department of Plastic Surgery, Rigshospitalet, Denmark, in the period 1961–1981. The period that elapsed from the accident to the reconstructive procedure varied from 5 days to 10 years.

All defects were localised to the lower leg, including knee and ankle regions. In all cases, reconstruction using a flap was indicated. The following methods of soft tissue repair were employed.

Cross-leg flaps

Nineteen patients had reconstructions using 19 cross-leg flaps following the principles of Stark (1952) and Eriksson et al. (1966). In two cases a delay procedure was performed. Ten crural-to-crural, three lower leg-to-ankle, three thigh-to-ankle and one thigh-to-lower leg transfers were undertaken. The donor sites were grafted with split skin. The pedicles of the flaps were transected after 21 days on average.

Table 1.
The diagnosis indicating flap reconstruction in 102 patients. Three patients are registered twice as secondary flaps were necessary

Aetiology	Cross-leg	Muscle flap	Dors.ped. island	Free island
Primary closed tibial fracture	4	7		5
Primary compound tibial fracture	5	20	5	11
Primary closed malleolar fracture		5	2	
Primary compound malleolar fracture	3		2	1
Primary compound tarsal fracture	4			
Postoperative infection with skin necrosis		4	4	2
Chronis ulceration or hyperkeratosis	3	5	3	1
Tumor resection		4	1	
Burns gr. III				4
Total	19	45	17	24

Muscle flaps

Forty-five patients had reconstructions using 49 muscle flaps. The transposed muscles were covered with a split-skin graft as described by Ger (1968). The muscles used for transposition are listed in Table 2.

Dorsalis pedis artery island flaps

Seventeen patients had a transposition of a composite flap from the dorsum of the foot pedicled on the anterior tibial/dorsalis pedis vessels as described by McCraw & Furlow (1975). The donor sites were covered with split-skin grafts.

Table 2. The different muscles used for soft tissue coverage in 45 patients

M. flexor digitorum longus	5
M. flexor hallucis longus	2
M. extensor hallucis longus	14
M. soleus (pedicled proximally)	8
M. soleus (pedicled distally)	2
M. gastrocnemius medialis	5
M. gastrocnemius lateralis	3
M. tibialis posterior	1
M. tibialis anterior (partial)	2
M. peroneus longus	1
M. peroneus brevis	1
M. extensor digitorum brevis	4
M. abductor hallucis	1
Total	49

Free island flaps

Twenty-four patients had reconstructions using transplantations of 26 free composite island flaps with vascular anastomoses to suitable vessels in the recipient area employing a microsurgical technique. Fifteen thoracodorsal (latissimus dorsi) musculo-cutaneous flaps (Maxwell et al. 1979), two saphenous flaps (Acland et al. 1981) and nine iliofemoral flaps (Daniel & Taylor 1973, Taylor et al. 1979) were used. The donor sites could be sutured directly (21 cases) or split-skin grafted (5 cases).

The charts for all the patients were reviewed in retrospect. The time spent in hospital, including the time needed for preoperative wound treatment and the time required to complete the reconstructive procedure, was determined as *period of admission.* The time from the day of flap procedure until wound healing was indicated as *time taken to heal.*

The results of the procedure were evaluated by the pattern of primary healing which was graded in three groups: *Success* indicated an uncomplicated postoperative course with complete survival of the flap. *Partial success* indicated that in spite of partial loss of the flap, it was able to fulfil its intended function with only limited additional procedures (e.g. split-skin graft). *Failure* indicated that a new flap became necessary or that the leg had to be amputated less than 6 months postoperatively.

The average daily cost per bed in Rigshospitalet, Denmark (1980) was D.kr. 1700 (US$ 261) and the combined average salaries for anaesthetists, surgeons and operating room staff amounted to D.kr. 1200 per hour (US$ 184 per hour, based on rate of exchange, mid – 1980).

RESULTS

The patterns of healing are presented in Table 3. The heterogeneity of the material does not permit a proper statistical analysis, but it is obvious that the healing of the cross-leg flaps was complicated by a comparatively high frequency of partial losses and failures, while the use of free composite flaps in this series presented the lowest rate of complications. However, the intended purpose of providing vascularized soft tissue over an avascular area was achieved in more than 90 per cent of all cases.

Tables 4 and 5 present the average number and time of general anaesthesias, including both primary and secondary operative procedures together with the mean time taken to heal and the mean time of admission to hospital. The average overall costs are given relative to the costs of the cross-leg flap.

Summarizing the tables, it appears that the cross-leg flap procedure was followed by a rather high frequency of complications and required more secondary operations in general anaesthesia than the other procedures. Due to the prolonged admission time, the cross-leg flap procedure therefore turned out to be the most expensive way of achieving a stable soft tissue coverage in the lower leg. The muscle flap and the dorsalis pedis island flap appear to be more advantageous procedures, primarily because of a lower rate of complications and shorter time taken to heal, and secondarily due to a milder exploitation of the operation theatre capacities and a shorter hospital stay. Cases in which free composite island flaps are transplanted using microsurgical vascular anastomoses make high demands on operation theatre facilities, resulting in high "operative" costs. However, these expenses are compensated for by a low frequency of complications and therefore a short time taken to heal, which is followed by a reduced period of admission. In consequence, free flaps appear to be an advantageous alternative for reconstruction of soft tissue defects in the lower leg if simpler procedures are not possible, or may be expected to produce a similar end result at higher overall costs.

Table 3. The primary pattern of healing of 111 flaps used for soft tissue repair in the lower leg

Flap procedure	No. of flaps	Success	Partial success	Failure
Cross-leg	19	3	13	3
Muscle	49	26	19	4
Dors. ped. island	17	11	5	1
Free island	26	20	5	1
Total	111	60	42	9

Table 4. The average number and time of general anaesthesias used for the different flap procedures for soft tissue repair in the lower leg

Flap procedure	No. of flaps	No. of general anesthesias	Hours of general anesthesia
Cross-leg	19	2.9	5.8
Muscle	49	1.6	3.0
Dors. ped. island	17	1.1	3.9
Free island	26	1.5	11.0

Table 5. The average time taken to heal and length of stay in hospital necessary for the different flap procedures for soft tissue reconstruction in the lower leg. The overall costs are given in relation to the cross-leg flap

Flap procedure	No. of flaps	Time taken to heal (days)	Length of admission (days)	Overall relative costs
Cross-leg	19	60	80	100%
Muscle	49	38	42	52%
Dors. ped. island	17	13	32	41%
Free island	26	24	35	50%

DISCUSSION

By its very location the tibia is exposed to frequent injury. Compound fractures of this bone are more frequent than of any other major long bone (Rittmann et al. 1979) and are often complicated by loss of soft tissues (Rozner & Ashby 1965, Haertsch 1981) in high energy trauma

(Hoaglund & States 1967, Rittman et al. 1979) or following open reduction of closed fractures (Brown 1973). Fractures of the tibia have an unpredictable rate of healing (Ellis 1958, Hoaglund & States 1967) and when complicated with infection or necrosis of the overlying soft tissues such fractures are often followed by pseudarthrosis and/or osteomyelitis (Boyd et al. 1961, Tønnesen et al. 1975, Clancey & Hansen 1978), resulting in prolonged and expensive treatment.

It is generally agreed that meticulous debridement is important for the successful outcome of the treatment of compound fractures. This is of fundamental importance for successful early closure of traumatic wounds in general and is essential for early functional recovery, especially in cases with exposed vessels, nerves, tendons or bone (Brown 1973, Gustilo & Anderson 1976, Olerud et al. 1978, Byrd et al. 1981).

The blood supply of the traditional cross-leg flap is of the random pattern type which limits the dimensions of the flap (McGregor & Morgan 1973). The ultimate healing of the flap after the transection of its pedicle depends on capillary connections between the flap and the recipient area and adds no further vascularity to the recipient area. This may explain the high rate of complications and failures in this series, which corresponds with those reported by, for example, Jayes (1950). Moreover, in the young female the cross-leg flap leaves an unsightly donor scar and in the elderly may possibly impair mobility of the knee joints. Nevertheless, this procedure is still in use (Hodgkinson & Iron 1979) and may be recommended for primary wound closure in special cases (Hueston & Gunter 1967).

Muscle flaps, dorsalis pedis artery flaps and free flaps used in this series are of the axial pattern type (McGregor & Morgan 1973) which retain their blood supply after transfer. This fact may be important for the healing at the recipient site as Holden (1972) demonstrated that devascularized bone fragments were dependent on invasion by new vessels derived from the surrounding soft tissues, principally the muscles. Axial flaps then are versatile and may be applied not only as a stable cover of bones and joints but also as a suitable material for revascularization of denuded areas and for controlling chronic infection or even as a carrier for living bone grafts (Medgyesi 1973, Pers & Medgyesi 1973, Taylor & Watson 1978, Krag & Riegels-Nielsen 1982).

The majority of the patients in the present series had chronic fistulas exposing infected bone. Ninety of ninety-six cases with primary infections were "cured" after establishing a viable soft tissue cover, while six patients had recurrent infection which in two cases required amputation. However, a longer observation period, including more patients, is needed to establish the long-term value of aggressive reconstruction.

In order to avoid chronic cases like those described in this series, we would advocate close cooperation between the orthopaedic and plastic surgeon, in many cases even in the acute stage, planning the steps of treatment for salvaging the extremity. In the present series, some of the cases were so severe that we feel convinced that amputation would have been indicated in at least seven cases if reconstruction of the soft tissues could not have been performed (5 free flaps, 1 dorsalis pedis artery island flap and 1 muscle flap).

In the treatment of deep soft tissue defects in the lower leg, including the knee and ankle regions, repair with ipsilateral axial flaps or free flaps is advantageous compared to cross-leg flaps regarding versatility, healing complications and overall costs. Close cooperation between orthopaedic and plastic surgeons is recommended.

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