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Orthotopic and heterotopic lower leg reimplantation

EVALUATION OF SEVEN PATIENTS

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Reimplantation is a well-established procedure in reconstructive surgery. This is especially so after amputation of the upper limb since prostheses provide limited function. In unilateral amputation of the lower leg orthotopic reimplantation is the treatment of choice. With bilateral amputation, in which orthotopic reimplantation is not possible because of the complexity of the trauma, heterotopic reimplantation is an option.

We report five patients who received orthotopic and two who received heterotopic reimplantations of the lower leg. We assessed the functional outcome with reference to cutaneous sensation, mobility, pain, and the cosmetic result.

The functional outcome was good, as was the patients' satisfaction. Their mobility, stability, and psychological state were satisfactory. Patients with heterotopic reimplantations preferred the reimplanted leg to a prosthesis. Although reimplantation of the lower leg requires prolonged hospitalisation, delayed mobilisation and secondary operations, we conclude that there is an indication for this operation in order to improve the patient's quality of life.

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With advances in microsurgical techniques, severe injuries and amputation of limbs do not necessarily have to lead to the loss of a limb. In hand surgery, reimplantation of totally or partially amputated fingers is well-established. Since the first successful reimplantations of hands in the early 1960s, reimplantation of whole limbs has become more common.[1-6]

When amputation of both lower or upper limbs with different levels of section and degrees of damage to surrounding tissues occurs, orthotopic reimplantation may not be possible. In these patients heterotopic reimplantation should be considered. For bilateral amputations of the lower limbs with only one reimplantable segment and an ipsilateral stump with gross damage, there are two options, either bilateral amputation or heterotopic reimplantation of one limb to the contralateral stump. To our knowledge reports of heterotopic reimplantation of the lower limb are rare.[7-10]

To justify reimplantation because of the cost, prolonged hospitalisation, secondary operations and complications, the functional outcome and satisfaction of the patient have to be measured carefully.

Patients and Methods

Between 1995 and 2001 we treated seven patients who had had amputation of the lower leg in an accident. In two, both lower legs had been amputated. The mean age of the patients at the time of the accident was 31 years (21 to 43). There were six men and one woman (Table I).

The follow-up ranged from one to six years. Pain in relation to walking distance, sensation, function and patient satisfaction were assessed by a standard questionnaire (Table II).

Results

Two patients, one with an orthotopic and one a heterotopic reimplantation, are presented in detail.

Illustrative case reports

Case 1: orthotopic reimplantation. A 28-year-old student had an amputation of the left foot at the level of the ankle (case 1, Table I). Parts of the tarsal bones were crushed and had to be resected. We transfixed the ankle with three Kirschner wires, and primarily reconstructed the anterior

Table I. Details of the seven patients who underwent either orthotopic or heterotopic reimplantation of the lower leg after injury

Case	Age (years)	Gender	Nature of injury	Preoperative ischaemia (hrs)	Accompanying injuries	Primary treatment and reconstructive surgery	Secondary procedures	Duration of hospitalisation (days)
1	28	M	Crush injury by a 2-ton metal weight Amputation of the left foot through the ankle	4.5	Contusion of the right thorax	Partial resection of ankle Arthrodesis of the ankle by Kirschner wires Anterior and posterior tibial vessels Insertion of the extensor tendons into the metatarsals and the posterior tibial tendon at metatarsal I	Reconstruction of tibial nerve (with sural nerve grafts) and free latissimus dorsi flap Revision of flap anastomosis Split skin mesh graft Transposition of muscle flap Removal of Kirschner wires	83
2	42	M	Crush injury by industrial press Amputation of the right foot above the ankle Multilevel amputation of the left leg from the thigh downward with intact distal lower leg and foot	2	None	Left lower leg to right leg by external fixator Proximal anterior to distal posterior tibial vessels and *vice versa* Reconstruction of anterior tibial, extensor digitorum, peroneal tendons, and triceps surae tendons	Reconstruction of tibial nerve (with sural nerve grafts) and free latissimus dorsi flap split skin mesh grafts New external fixator after fracture of callus Removal of external fixator Shaping of latissimus dorsi flap	225
3	43	M	Crush injury by train Amputation of both lower legs below knee Destruction of the right foot	3.5	None	Left lower leg to right leg by external fixator Proximal anterior to distal posterior tibial vessels and *vice versa* Tibial nerve	Free latissimus dorsi flap Removal of external fixator	64
4	21	M	Crush injury by train Amputation of the right foot Fracture of the tibia Destruction of talus and calcaneus	1.5	None	Partial resection of talus and calcaneum Arthrodesis in the ankle by Kirschner wires and external fixator Anterior and posterior tibial vessels Tibial nerve	Split skin mesh graft Correction of position of external fixator Removal of external fixator	108
5	17	M	Crush injury by train Amputation of the right lower leg Intact flexor hallucis longus and tibialis posterior tendon	3	None	Partial resection of the ankle Arthrodesis of the ankle by external fixator Anterior and posterior tibial vessels Anterior tibial and triceps surae tendon Tibial nerve	Split skin mesh grafts Removal of external fixator	94
6	35	F	Motorcycle accident Amputation of the distal right lower leg through the ankle	2.5	None	Arthrodesis of the ankle by external fixator Anterior and posterior tibial vessels Anterior tibial and triceps surae tendon Tibial nerve	Free latissimus dorsi flap Split skin mesh graft Removal of external fixator	73
7	29	M	Crush injury by industrial press Amputation of the right foot through the ankle	3	None	Partial resection of ankle Arthrodesis of the ankle by external fixator Anterior and posterior tibial vessels	Reconstruction of tibial nerve (with sural nerve grafts and free latissimus dorsi flap) Split skin mesh graft Removal of external fixator	87

and posterior tibial vessels. The posterior tibial nerve was left for secondary repair. After two weeks a soft-tissue defect around the medial malleolus was covered with a free latissimus dorsi flap and the nerve reconstructed with ipsilateral sural nerve grafts. The flap was revised the next day because of an arterial thrombosis. Four weeks later the residual defect in the skin was covered by a split skin mesh graft. In all, the patient was in hospital for 83 days. Two years after the injury the patient is fully mobile (Fig. 1).

Table II. Details of the questionnaire given to the patients (pain, 1 = none, 6 = intolerable; function, 1 = excellent, 6 = insufficient; + = yes, - = no). The influence of the convalescence period on the quality of life was rated pleasant, not bothersome, moderately bothersome and severe

Quality	Mean values
Pain	
At rest	1.4
Walking distance < 50 m	1.9
Walking distance > 50 m	2.1
Cold temperature	2.6
Sensitivity	
Sharp/blunt differentiation	2 × (+), 5 × (-)
Two point differentiation < 2 cm	2 × (+), 5 × (-)
Cold/warm differentiation	3 × (+), 4 × (-)
Vibration	6 × (+), 1 × (-)
Mobility	
Knee	7 × full range
Ankle	5 × no active movement
	1 × 10/0/20 ex./flex.
	1 × 15/0/30 ex./flex.
Toes	5 × no active movement
	1 × active ex./flex.
	1 × active ex., no flex.
Function	
Walking up stairs	2.7
Walking down stairs	3.0
Walking on uneven ground	4.0
Walking backwards	2.9
Running	5.3
Maximal walking distance	2100 m
Patients' satisfaction	
Aesthetic result	2.4
Overall function in daily practice	2.7
Influence of the convalescence period on quality of life	4 × moderately bothersome
	3 × extremely demanding
Patients satisfaction with heterotopically reimplanted limbs	
Preference of prosthesis or reimplanted leg	2 × (+)

Case 2: heterotopic reimplantation. A 42-year-old engineer had bilateral multilevel amputations caused by an industrial metal press (case 2, Table I). The left thigh down to the distal lower leg had a 30 cm defect of bone and soft tissue. The left foot was amputated about 10 cm above the ankle and was intact. The right foot was amputated 5 cm above the ankle and at a second level through the metatarsal bones and severely crushed. An orthotopic reimplantation was not possible. The patient had no other injuries.

The left leg was amputated above the knee and the left foot was reimplanted to the right lower leg. The bone was stabilised by an external fixator. The proximal anterior tibial vessels were anastomised to the distal posterior tibial vessels. The tendons of the extensor and peroneal muscles were reconstructed. One month later a free latissimus dorsi muscle transfer was required to cover a soft-tissue defect over the tibia and the posterior tibial nerve was reconstructed with sural nerve grafts taken proximally from the lower leg. One year later the latissimus flap was reshaped to improve the appearance. He was in hospital for 225 days (Fig. 2).

The patients with limbs reimplanted orthotopically had satisfactory function. In two there was moderate pain on

Fig. 1

Case 1. Photograph showing the appearance of the left foot of a 28-year-old man after a crush injury. Two years after orthotopic reimplantation the patient is able to stand on his replanted foot.

Fig. 2

Photograph showing the appearance two years after heterotopic reimplantation.

walking more than 50 m. Their maximum walking distance without a break did not exceed 200 m. The others were able to walk between 1 and 2 km without resting or pain. Climbing and descending stairs as well as walking backwards were comfortable, but they could not run. Walking on uneven ground caused major problems.

The ankle could only be moved passively. Two patients reported lack of sensation distal to the line of reimplantation. Three had protective sensation of the sole. The patients were satisfied with the cosmetic result and function. None would change the reimplanted limb for a prosthesis. All five would agree to have their legs reimplanted again under similar circumstances.

The patients with heterotopic reimplantations had mild pain when walking more than 50 m. Climbing stairs was easy but descending stairs was difficult. This was due more to their prosthesis than to the reimplanted leg. Walking on uneven ground caused major problems as well as walking backwards. They could not run. There was no active movement of the ankle. The maximum walking distance ranged from 1 to 2 km, depending on the terrain. In both patients, the dorsum of the foot was insensitive. The sole had complete protective sensation in one patient and nearly so in the other. Both patients described the functional result of the reimplanted leg as satisfying and superior to a prosthesis. At first they were unhappy with the cosmetic result, but later became adjusted to it. They both declared that despite the difficulties which they encountered they would have the procedure again under the same circumstances.

Discussion

The indications for reimplantation depend on many factors such as the general condition of the patient. For multiply-injured patients the principle ‘life before limb’ is indicated. Sometimes definitive amputation, or so-called ‘limb banking’, by temporary vascularisation in the axilla, groin or distal forearm and secondary reimplantation are options.[11] In certain cases parts of the amputated limb may be used to improve the stump primarily or secondarily by temporary ‘flap banking’. If this is not possible the stump can be improved by microvascular tissue transfer or distraction.[12,13]

If the patient’s general condition allows reimplantation, assessment of the amputated limb and the residual stump is a key factor. Where there is extensive damage or contamination, the loss of length after adequate debridement is a limiting factor. Secondary lengthening is possible even after shortening of more than 6 to 8 cm.[14,15]

The preoperative period of anoxia should not extend beyond four to six hours. The more proximal the site of amputation, the shorter the time available if necrosis of muscle is to be avoided. Septicaemia and multiorgan failure may occur from the systemic effects of toxic metabolites released from the limb.

Another important precondition for successful reimplantation is the patient’s compliance. This must not be underestimated, especially bearing in mind the long and demanding period of rehabilitation.

In our patients a reimplanted limb fitted with orthopaedic shoes, serving as a ‘vital prosthesis’, provides better function than a prosthesis. Protective sensation should be possible from secondary nerve reconstruction or transplantation, but is not essential for a functioning limb. In order to avoid injury and recurrent infection of the reimplanted limb without protective sensation, patients should be taught how to care for it with instruction on cutting toenails and cleanliness. They should avoid risks to the foot from heat or cold (walking barefoot etc). This is comparable to instructions to diabetic patients with foot problems.

The patients described the function of the reimplanted leg as sufficient. For the patients whose limbs were orthotopically reimplanted the function of the reimplanted leg was inferior to that of their normal leg. The patients with heterotopic reimplantation allowed direct comparison between the prosthesis and reimplanted leg. This showed a clear superiority for daily function of the reimplanted leg to the prosthesis. They were mobile with a walking distance of at least 200 m and were able to work. The patients felt intact in ‘body-length’, which they described as extremely important for their psychological integrity. They adjusted to the alienating aspect of the ‘wrong’ foot on the leg and declared that they would not change it for a prosthesis. It was important for them to ‘stand on their own foot and still touch the ground’.

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