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Free-Tissue Transfer in Hand Surgery

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Schlüsselwörter: Handchirurgie – freier Gewebetransfer – Mikrochirurgie – Gewebedefekt.

Summary: Background: Reconstructing large defects of the hand with free flaps continues to pose difficulties due to the specific anatomical structures and highly sophisticated function of the hand.
Methods: The principles, advantages, disadvantages and current indications for various free flaps to reconstruct defects of the hand are reviewed.
Results: The application of microsurgical tissue transfer has been a major advancement in the treatment of complex defects of the hand. Through the years the approach has changed from one of simply getting the wound covered, to primary reconstruction to preserve or regain function. It is no longer satisfactory to cover hand wounds with unsightly, bulky flaps of tissue. A wide variety of free flaps offers the potential to reconstruct nearly any defect of the hand and has changed the standards for a successful outcome.
Conclusions: Microvascular free-tissue transfer has expanded the options for more refinement in hand reconstruction and has changed the standards for a successful outcome.

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Freier Gewebetransfer in der Handchirurgie

Zusammenfassung: Grundlagen: Die Rekonstruktion von ausgedehnten Defekten an der Hand mit freien Lappenplastiken stellt aufgrund der spezifischen anatomischen Strukturen und Handfunktion ein schwieriges Problem dar.
Methodik: Die Grundlagen, Vor- und Nachteile und Indikation von verschiedenen freien Lappenplastiken zur Rekonstruktion von Defekten an der Hand werden als Übersicht dargestellt.
Ergebnisse: Die Verwendung eines mikrochirurgischen Gewebetransfers brachte einen wichtigen Fortschritt in der Behandlung komplexer Handdefekte. Während der letzten Jahre hat sich diese Technik von einer bloßen Defektdeckung zur Möglichkeit einer primären definitiven Rekonstruktion mit Wiederherstellung der Funktion gewandelt. Dazu steht eine Vielzahl an freien Lappen zur Deckung nahezu aller Defekte im Bereich der Hand zur Verfügung. Diese haben die Langzeitergebnisse entscheidend beeinflußt.
Schlußfolgerungen: Der freie mikrovaskuläre Gewebetransfer hat die Möglichkeiten der Handrekonstruktion enorm erweitert und ist heute obwohl technisch sehr aufwendig ein unverzichtbarer Bestandteil der rekonstruktiven Palette.

Introduction

Techniques for covering large defects of the hand have changed dramatically since microsurgery has become widely applied in hand reconstruction. Digital replantation, first performed in 1968, is likely one of the most significant examples of reconstruction in the hand because it allows exact replacement of the missing part (16). Although the first successful free flap reported in 1973 was to the lower limb, free-tissue transfer rapidly became a popular technique in reconstructive surgery of the hand (9). The pioneering work of *Buncke* et al. (3) and many others in microsurgical free-tissue transfers and detailed anatomical studies of cutaneous circulation have allowed us to refine our treatment of large hand defects so that practically any composite defect of the hand can now be reconstructed with a free-tissue transfer. The goal of treatment of large, open-hand wounds has shifted from simple coverage for salvaging the hand, to the more the culturally sensitive goal of coverage with pliable, sensate, and cosmetically similar tissue to better restore hand function and form. Treatment starts with a thorough analysis of the individual requirements for each particular wound: bone, joint, muscle, nerve, artery, veins, tendon, and last but certainly not least, skin coverage. What type of skin coverage is needed: glabrous or nonglabrous? Is sensation crucial? What are the functional needs and expectations for a particular patient? Should definitive coverage be delayed or provided immediately? These questions and many more need to be considered in the preoperative analysis of any moderate or severe hand defect.

Planning

Timing of surgery

A dilemma for the reconstructive surgeon is deciding the timing of the flap cover. *Byrd* et al. (5, 6) concluded that the key is to provide soft-tissue coverage after all devitalized tissue has been removed but before colonization takes place. He presented superior results with free-flap transfer within 5 days of injury in the lower extremity, and he concluded that wound coverage should be avoided in subacute periods (6 days to 6 weeks) since 50 % of patients underwent infection and flap loss with subsequent osteomyelitis. *Marko Godina* is credited with conceptualizing the use of 'emergency' free-tissue transfer in the early 1980s. His clinical experience, published in 1986 (10), emphasized the extreme importance of radical debridement and 'early' closure (within 72 hours) using free-tissue transfer. *Godina* reported a 1.5 % rate of infection in 134 patients after early coverage and reconstruction versus an infection rate of 17.5 % in 167 patients with delayed reconstruction (between 72 hours and 3 months). The concept of radical debridement and 'emergency' free-flap coverage was further developed by *Lister* and *Schecker* (17) and *Ninkovic* et al. (19) from our unit.

In our experience, timing for flap coverage is based on a fundamental principle of wound closure. We formulated a nomenclature that divides free-flap closure into three categories: 'primary free-flap closure' (12 to 24 hours), 'delayed primary free-flap closure' (2 to 7 days), and 'secondary free-flap closure' (after 7 days). Only surgically clean wounds can be closed within 12 hours to achieve primary healing because every 6 to 8 hours the bacterial count is doubled, and when it is greater than 10^5 it produces clinical infection. Complex, untidy wounds should be converted into surgically clean wounds to allow primary closure. Thereafter, one of the most important parts of the operation is the radical debridement. In this approach, intact neurovascular structures and tendons are left in place and large bone may be cleaned and replaced in their anatomical position if adequate coverage can be obtained. Once the wound has been debrided, flap selection should be considered. In a retrospective study, we analysed 43 patients with large complex hand injuries that were treated with 49 free flaps (22). Our results showed that 'primary

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free-flap closure' (12 to 24 hours) diminished flap failure, infection and multiple secondary surgical interventions. That caused reduced hospital stay thus decreased costs.

Recipient vessels

In most patients, the hand will maintain adequate perfusion if only one of the major arteries (radial or ulnar) is open. If the hand is viable and either one of these pulses is strong, arteriography is not necessary. If there is any question regarding the status of hand perfusion, an arteriogram should be performed, especially if free-flap transfer is being considered. Anastomosis is usually performed to either the radial or ulnar arteries. For the radial side of the hand and dorsum, the radial artery in the snuffbox may be used for end-to-end or end-to-side anastomosis. If both the radial and ulnar arteries are patent, an end-to-end anastomosis at this level should not compromise circulation to the hand. In most instances, however, it is probably safer to perform an end-to-side anastomosis.

Flap selection

Palmar wound coverage

Large and deep soft-tissue defects of the palm of the hand are not very frequent but their reconstruction is extremely difficult due to the special anatomy required. The glabrous skin provides unique support and protection of the underlying structures. The thick palmar skin is resistant to shifting due to the fibrous septa and fat-free skin creases. The high concentration of sensory mechanoreceptors, which increase in number from palm to fingertip, provides a high degree of sophisticated sensibility in the working surface of the hand. The ideal substitute for palmar defects has to be sensate, durable, relatively immobile, hairless and thin (24).

Fig. 1. Explosion injury – soft tissue defect, 2nd interdigital space and palm.

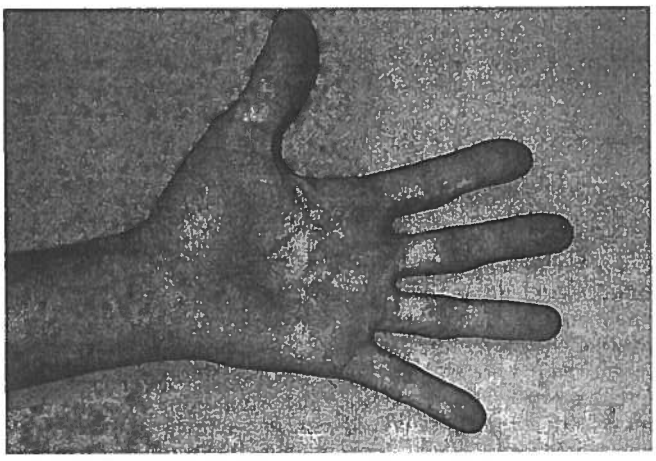

Fig. 2. Defect coverage with an extended lateral arm free flap.

Fig. 3. Functional result, 1 year postoperative.

In our clinical practice the most useful free fasciocutaneous flap is the extended lateral arm flap (ELAF), which is thin distally with skin relatively well anchored to the underlying fascia (11, 18, 19) (Figs 1–3). Furthermore, the restoration of sensation is obtained after coaptation of the posterior cutaneous nerve of the forearm to a recipient nerve of the hand. The main disadvantage of the ELAF is related primarily to the donor site, because if large areas of skin are taken it can result in a wide, unsightly scar. Larger fasciocutaneous flaps such as groin (8), scapular, and parascapular flaps may be used, but with the disadvantage of not being sensible and of being too bulky (4). A satisfactory alternative for palmar coverage may be the temporoparietal fascial flap (TPF). This flap provides very thin, vascular fascia, which can be covered with a full-thickness skin graft to provide satisfactory coverage of large hand defects. Temporoparietal fascia has the advantage of being one of the body's few 'spare parts' because of its minimal donor site morbidity. In addition, tendons are surrounded by smooth fascia that allow them to glide. Some sensation can be provided to the flap by taking the auriculotemporal nerve with the flap (13).

In our experience, an ideal functional and cosmetic reconstruction of the palmar surface can be achieved with the free instep flap (19, 20). The free instep flap is firmly adhered to the underlying structures without the problems of shifting. Two-point discrimination of the palm after reconstruction with a free instep flap is 7 to 8 mm and demonstrates that a high degree of sophisticated sensibility can be achieved. The free medialis pedis flap, which represents the very medial part of the free instep flap, is highly suitable for resurfacing small soft-tissue defects of the hand due to its similar anatomical structure. However, it is an insensate flap that is limited in size (15).

Dorsal wound coverage

Recommended flaps for coverage of the dorsum manus are the fasciocutaneous lateral arm flap (11), the gracilis muscle flap (12), the temporalis fascia flap (2) and the free groin flap (23). The dorsalis pedis flap is used less often because of the concern of donor-site morbidity; in patients with multiple extensor tendon defects, however, this flap taken as a composite flap with tendons (3, 14) is a good alternative to a free-tendon transfer in combination with a muscle flap. The dorsalis pedis flap can be raised with the overlying tendons, the second metatarsal bone, and the metatarsophalangeal joint, enabling a wide range of reconstruction options. *Caroli* et al. described three cases of dorsalis pedis flap transfers to the dorsum of the hand and reported excellent aesthetic results (7). *Asko-Seljavaara* et al. published one case of a dorsalis pedis flap transfer to the dorsal hand and attested an excellent skin texture (1).

In a retrospective study, we analysed the aesthetic aspects of dorsal hand defect coverage by comparing fasciocutaneous flaps or skin flaps with muscle flaps with a skin graft. Between 1992

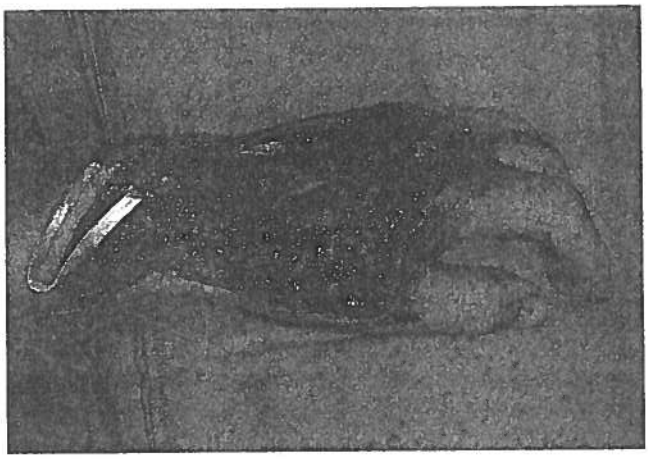

Fig. 4. Soft-tissue and tendon defect, dorsum of hand.

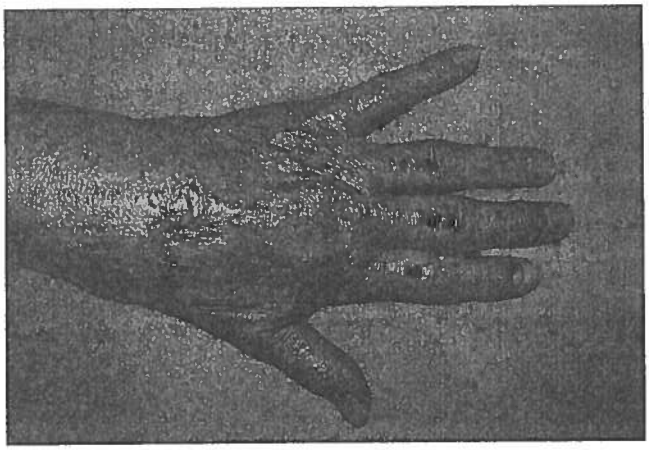

Fig. 5. Tendon reconstruction and defect coverage with a free gracilis muscle flap and unmeshed split-thickness skin graft.

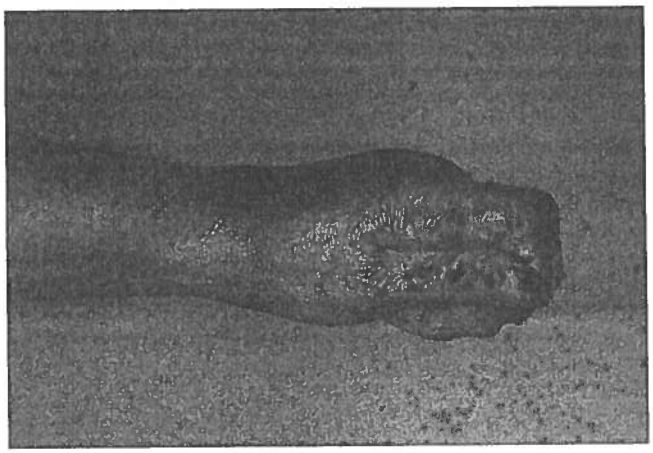

Fig. 6. Functional result, 2 years postoperative.

and 2002, in nine patients, a dorsal hand defect was covered with a fasciocutaneous flap (n-9 lateral arm flap); in seven patients, with a muscle flap (n-4 gracilis muscle, n-3 latissimus dorsi muscle) with a split-thickness skin graft (n-3 meshed, n-4 unmeshed). Our results showed that muscle flaps with an unmeshed skin graft provided a better colour match and skin texture than fasciocutaneous flaps for defect coverage of the dorsum manus (Figs 4–6). Furthermore, combining a free-muscle flap with a tendon graft spares taking a tendinocutaneous dorsalis pedis flap with its high donor-site morbidity (21). Thus, muscle flaps with an unmeshed skin graft offer the better aesthetic result at the dorsal hand and support a fast convalescence.

Summary

The application of microsurgical tissue transfer has been a major advancement in the treatment of complex defects of the hand. Through the years the approach has changed from one of simply getting the wound covered, to primary reconstruction to preserve or regain function. It is no longer satisfactory to cover hand wounds with unsightly, bulky flaps of tissue. A wide variety of free flaps offers the potential to reconstruct nearly any defect of the hand and has changed the standards for a successful outcome.

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