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FLAPS COVERING – SIMPLE SOLUTIONS FOR ORTHOPEDIC SURGEONS

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SUMMARY

The forearm and hand traumas are very frequent and have important social and economical consequences for both the patients and the society. Partial or complete amputation of different segments and crush injuries are the most frequent conditions. Most of these traumas are also accompanied by simple or complex tissue defects. It is accepted that in case of very complex and large defects the best way of managing is the use of free tissue transfers performed as soon as possible after the debridement. But, taking into account the main needs of such a reconstruction, i.e. low or absent donor site morbidity, and to realize the reconstruction by replacing like with like, the use of local or regional resources seems to be more reasonable. We will try to demonstrate the advantages of doing the all-in-one reconstruction in simple and complex tissue defects of the forearm and hand by using the most recent described flaps, i.e. local/regional perforator flaps, and to compare them with the traditional flaps.

Keywords: complex forearm and hand traumas, emergency all-in-one reconstruction, free flaps, traditional flaps, local/regional perforator flaps

PRZESZCZEPY SKÓRNE – PROSTE ROZWIĄZANIA DLA ORTOPEDÓW

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STRESZCZENIE

Urazy na poziomie przedramienia i ręki są bardzo częste, mając istotne konsekwencje społeczne oraz ekonomiczne dla samego pacjenta oraz społeczeństwa. Najczęściej są to częściowe lub całkowite amputacje, lub urazy zmiażdżeniowe na poziomie przedramienia oraz ręki. Należy pamiętać, iż takim urazom mogą towarzyszyć uszkodzenia tkanek miękkich. Są dowody, iż w przypadkach rozległych ubytkach tkanek miękkich wskazane są wolne przeszczepy skórne w najkrótszym możliwym czasie, po wcześniejszym oczyszczeniu. Należy wsiąść pod uwagę, że przy takim postępowaniu miejsce pobranie musi być nieuszkodzone, dlatego może bardziej odpowiednim rozwiązaniem jest przeszczep skóry miejscowy lub regionalny. Postaramy się wskazać zalety rekonstrukcji popularnie zwanej „wszystko w jednym" w prostych i złożonych ubytkach tkankowych ręki i przedramienia poprzez stosowanie opisanych przeszczepów: lokalny/regionalny przeszczep skóry na perforatorach w porównaniu do tradycyjnych przeszczepów skórnych.

Słowa kluczowe: urazy ręki i przedramienia, „wszystko w jednym", wolne przeszczepy skórne, lokalne/regionalne przeszczepy skóry

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Introduction

The hand and forearm are the most frequent predisposed to complex injuries involving skin, bones, muscles/tendons, vessels and/or nerves. These complex traumas are susceptible to be severe contaminated, with disruptions of functional elements and, sometimes, associating multiple mechanisms as crush, entrapment, avulsion, torsion (Shieh *et al.* 2006). The complexity and dimensions of the tissue defects require a complex reconstruction which is generally possible by using free flaps transplantation (Godina 1986, Lister and Scheker 1998, Georgescu and Ivan 2003). Moreover, in case of partial or complete amputations with tissue defects, the use of flow-through flaps to solve both the coverage and the revascularization seems to be the method of choice (Parteke and Buck-Gramcko 1984, Brandt *et al.* 1999) (Figure 1).

That IS for sure, that the use of local or regional resources ensures the best and similar material for reconstruction. The use of traditional local flaps, i.e. cross-finger flaps, transposition flaps, advancement flaps, Z-plasty generally work only for simple and small defects. The traditional regional flaps, i.e. axial radial, ulnar or posterior interosseous flap can be used successfully, for the coverage of larger defects, but by scarifying a main source vessel (Figure 3).

The use of the most recent described local/regional flaps as perforator flaps allows the reconstruction by replacing like-with-like but by sparing the main vessels (Weinzweig *et al.* 1994, Hamdy and Zeidan 1997, Jeng and Wei 1998, Georgescu and Ivan 2000, Akn 2003, Kim 2004, Georgescu *et al.* 2007).

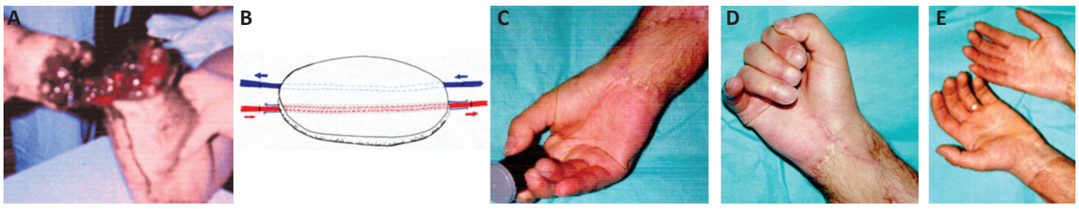

Figure 1. Distal 1/3 forearm amputation with skin defect: A. preoperative aspect; B. squematic representation of a flow-through flap; C, D, E. postoperative aspect after using a contralateral radial artery flow-through free flap showing a very good functional recovery and donor site appearance.

From the desire to diminish the donor site morbidity of the traditional free flaps, the free perforator flaps were developed and allowed the muscles and main vessels sparing (Gedebou *et al.* 2002, Hallock 2004) (Figure 2).

Aim

The simple or complex injuries of the forearm and hand accompanied by tissue defects can compromise the functionality of the upper limb.

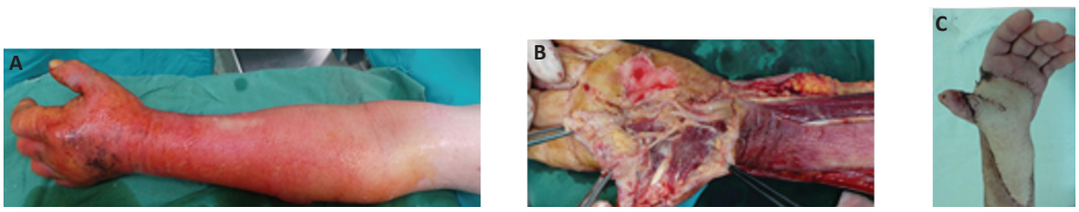

Figure 2. Neglected (3days old) hot press calendar trauma: A. preoperative aspect; B. palmar skin defect remaining after debridement; C. postoperative aspect after coverage with a toraco-dorsal artery perforator free flap.

Figure 3. Post burn sequel: A. preoperative aspect; B. a distally pedicled island radial artery flap harvested, with the sacrifice of the radial artery; C, D. postoperative aspect, with good functional recovery.

In this paper we aimed to present the newest and simplest methods possible to be used in such cases and which can be performed even by surgeons without microsurgical skills. That is why the paper will focus especially to the local/regional perforator flaps.

Materials and methods

Few vascular considerations

The blood supply of local perforator flaps in the forearm is ensured by the septal perforators (direct or septocutaneous) and muscle perforators (indirect or musculocutaneous) (Blondeel *et al.* 2003, Taylor 2003), the last ones are generally of little interest, except the brachioradialis branch derived from the radial recurrent artery. The arterial perforators are accompanied by concomitant veins with a lot of communicating branches between them, the veins drain into both the superficial and deep systems of veins (Timmons 1986, Weinzweig *et al.* 1994, Hamdy and Zeidan 1997, Jeng and Wei 1998, Gumener and Montandon 2004, Kim 2004).

For the hand, in the proximal half of the long fingers, there is a well-represented anastomotic network between the dorsal metacarpal arteries and the palmar common digital arteries and the collateral digital arteries. The perforators emerging from this network give branches, which realize longitudinal anastomoses able to blood supply the dorsal skin over the intermetacarpal spaces.

The digital arteries give also many branches on both lateral and medial aspect of the fingers. After perforating the thin fascia and subcutaneous tissue, these branches end through multiple arterioles into the subdermal layer. There are very rich anastomoses between these perforators at the level of the lateral and medial midline of the fingers. The venous drainage is realized through small venules, which connect to the dorsal and palmar cutaneous venous systems, in the subcutaneous tissue. Small branches of the digital nerves, together with their rich vascular network, are also present and very close to the vascular network.

Harvesting technique

Forearm

Pedicled adipofascial flaps: they are harvested through and S-shape incision over the projection of the source artery (Figure 4). The edges of the incision are undermined in the depth of the hypodermis, leaving some subcutaneous tissue on the skin flaps. It is better to tailor the flap with the long axis centered on the source artery's path. Both the cutaneous nerves and the great superficial veins are identified and preserved. Along the margins of the flap, the incisions are deepened to include the deep fascia. The flap is severed proximally and the dissection proceeds from the free end of the flap to its pedicle, stopping 4–5 cm proximal to the radial/ulnar styloyde. It is not mandatory to identify the perforators, which enter the pedicle, to avoid damaging the flap blood supply. The flap can be tunneled through the defect, but it is better to do an incision between the donor and recipient site. After the direct suture of the

donor site and the suture of the flap, this one is covered with moist dressing. Because a flap edema is present for two-three days, it is preferable to delay its skin grafting.

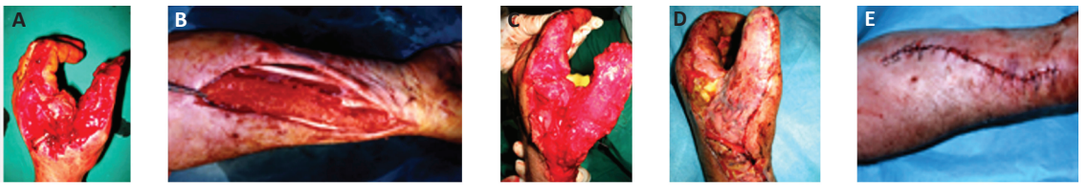

Figure 4. Complex skin defect: A-C. preoperative aspect; harvesting a distally pedicled fascioadipous radial artery perforator flap; first postoperative day; D. the flap skin grafted 7 days later; E. donor site represented by a sinuous scar only.

Pedicled fasciocutaneous flaps: their pedicle is represented by the deep fascia and some subcutaneous tissue between the distal edge of the flap's fasciocutaneous island and the distal group of perforators (Figure 5). The pedicle is better to be centered on the source artery path, and its width is of about 4–6 cm (2–3 cm on the both sides of the source artery path). After the skin island is incised, another longitudinal S-shaped incision is made from its distal end over the projection of the source artery. The skin island is dissected in a subfascial plan, and then the pedicle is prepared in the same manner as for the harvesting of an adipofascial flap. The skin island donor site has to be skin grafted.

Propeller perforator flaps: regardless if a Doppler preoperative investigation was or wasn't done, for the beginning only one edge of the flap is incised, followed by a very careful subfascial dissection under magnification that will allow the identification and isolation of one or more perforators. Only after the identification of a patent perforator the flap incision and its harvesting is completed. The length of the flap must be 2 cm more than the distance between the perforator and the most distal edge of the defect (Figure 6).

Hand Pedicled flaps: they are designed over an intermetacarpal space (Figure 7); the proximal end should not overpass the wrist joint. From the distal end of the flap an S-shaped incision is made to the 1/2–1/3 of the first phalanx of one of the adjacent digits; the edges of the resulted wound are undermined for a width equal to the flap width by leaving some subcutaneous tissue both on the skin and deeper. Then, two parallel incisions are made on the undermined limits, delimitating the pedicle of the flap. The dissection of the flap proceeds from proximal to distal in subfascial plan. The donor site is closed by direct suture. The flap is rotate 180 degrees and can reach very distal defects in the fingers, both palmary and dorsally.

Figure 5. Skin defect over the first intermetacarpal space with retraction: A. preoperative aspect; B. the flap is harvested; C. immediate postoperative aspect; D. final result.

Propeller perforator flaps: they are also designed over an intermetacarpal space, but more distally and with their distal end over the middle of the lateral aspect of one of two adjacent fingers (Figure 8). The flap is harvested from proximally to distally in subfascial plan by keeping deep connections of about 1 cm width only over the junction

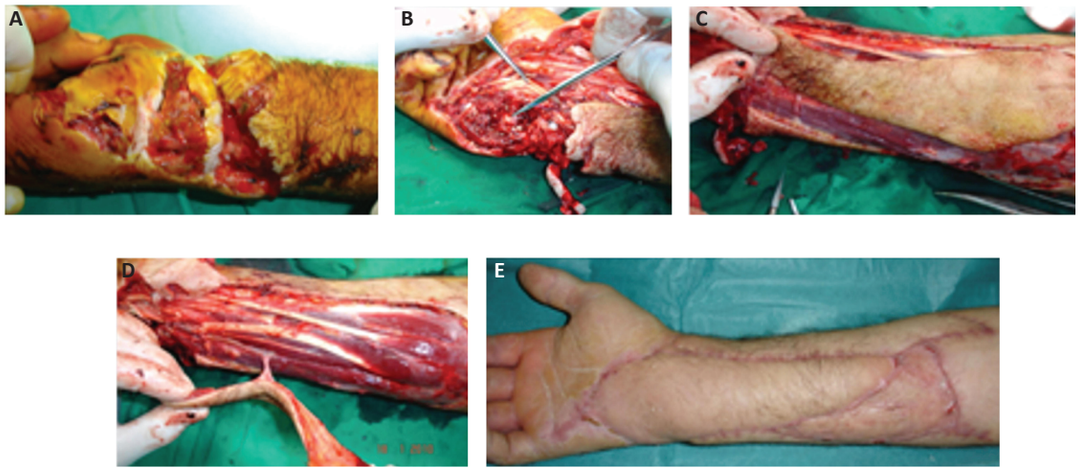

Figure 6. Circular saw trauma with skin defect, pisiform fracture, ulnar nerve lesion: A. preoperative aspect; B. after debridement, C. a propeller ulnar artery perforator flap was harvested; D. the flap is redy to be rotated; E. final aspect.

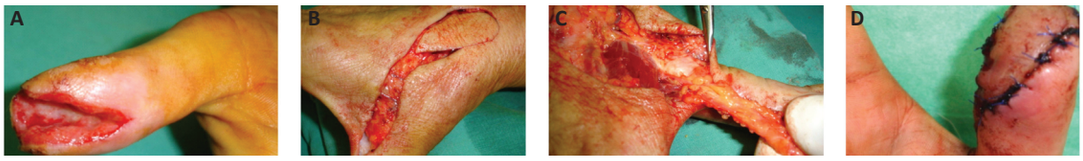

Figure 7. Palmar defect second phalanx of the thumb: A. preoperative aspect; B. a pedicled flap based on a commissural perforator in the first web space was harvested; C. the flap ready to be transposed; D. final aspect.

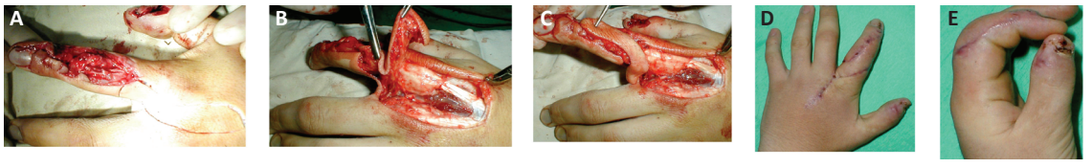

Figure 8. Posttraumatic skin defect over the dorsal aspect of the index finger: A. Preoperative aspect; B. the flap is harvested based on distal commissural perforator; C. the flap is rotated 180 degrees over the defect; D, E. final result.

of the proximal and middle third of the first phalanx. These flaps, very useful in covering the first phalanx and interphalangeal joint are to be rotated for 90–180 degrees to reach the defect. The donor site can also be closed by direct suture.

To harvest a digital artery propeller perforator flap, for the beginning, only one margin of the flap is incised (Figure 9). Then, the flap is undermined in a subfascial plan. Only after finding a good perforator as close as possible to the defect, the final design of the flap and its complete incision are done. It is better to leave a small cuff of subcutaneous tissue around the vascular pedicle, to avoid the possible spasm. If possible, a small branch of the digital nerve, close to the vascular pedicle, is to be included in the flap. For small flaps, the donor site can be closed by direct suture, but for larger defects it should be skin grafted.

To avoid the skin grafting of the donor site, a bi-lobed flap can be harvested. This one is also a perforator flap but is a pedicled one and allows the direct closure of the donor site (Figures 10 and 11).

Results

By using the above described methods, in all the cases the extremity can be salvaged and an useful functional recovery can be obtained. A very good evolution, with complete survival of the flap is recorded in about 90% of cases. The completely loose of such a local perforator flap is very rare. Minor complications could be registered

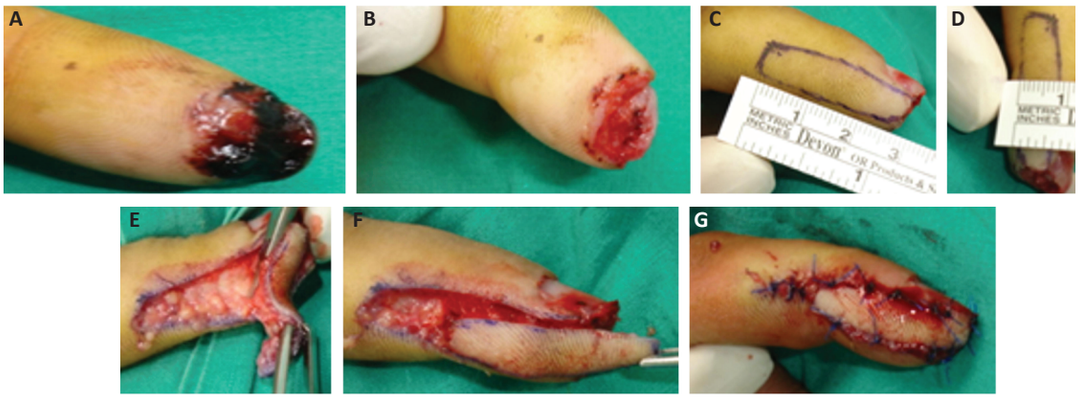

Figure 9. Tip amputation of the index finger: A. preoperative aspect; B. after debridement; C, D. design of the flap; E. flap undermining: a perforator surrounded by a small cuff of soft tissue is seen; f.the flap is rotated 180° and covers the defect; G. postoperative aspect.

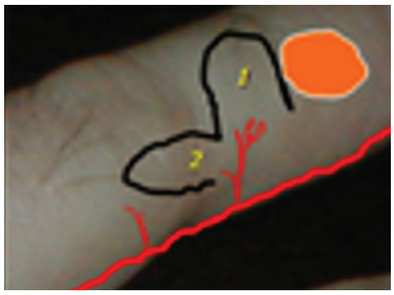

Figure 10. Schematic design of a bilobed flap.

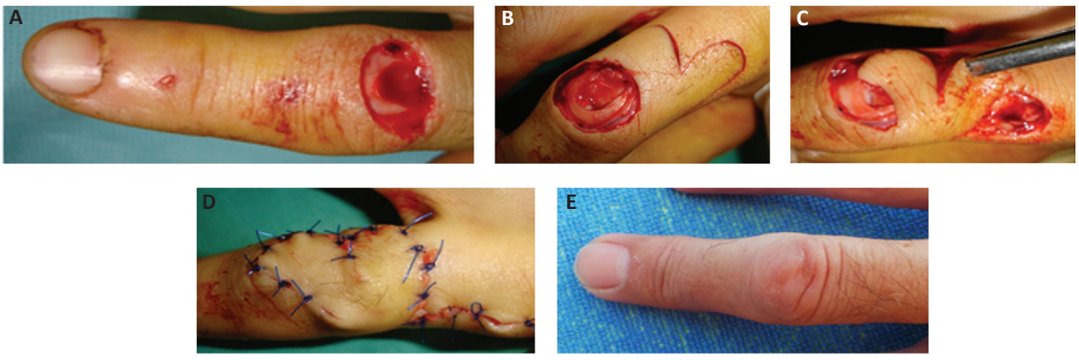

Figure 11. Skin and extensor tendon defect on the PIP joint: A. preoperative aspect; B. design of the flap, which includes also a small extensor tendon segment; C. transposition of the flap; D. immediate postoperative result, with direct suture of the donor site; E. final result.

and consist in partial distal necrosis, which can be solved by secondary epithelialization, and superficial necrosis, which can be managed until granulation and then grafted.

Discussions

The use of free perforator flaps in the last three decades improved very much the results, especially from the donor site point of view (Gedebou *et al.* 2002, Blondeel *et al.* 2003, Hallock 2004). The local or regional perforator flaps respond also to other features, i.e. sacrifice of a main vascular pedicle at the recipient site, the replacement of like with like and the shortening of the evolution and recovery period (Georgescu *et al.* 2007). These flaps need a microsurgical dissection of the perforator but do not

need microvascular sutures, and so they can be defined as “microsurgical non-microvascular flaps” (Georgescu *et al.* 2007).

Conclusion

Local or regional perforator flaps can be successfully used for coverage of small and medium sized defects in the forearm and hand. Moreover, because they can be harvested as composite flaps, by including bones, tendons, sensitive nerves, it is possible to be also used in covering complex defects.

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