CASE SERIES

UDC: 617.575/.576-089.844
DOI: https://doi.org/10.2298/VSP220721093J

Versatile clinical application of radial artery perforator flap for hand and wrist reconstruction

Višestruke mogućnosti kliničke primene perforator režnjeva radijalne arterije za rekonstrukciju defekata ručnog zgloba i šake

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Abstract

Background/Aim. Radial artery perforator flap (RAPF) is a type of fasciocutaneous or adipofascial reverse pedicle flap, which proved to be a versatile flap for the reconstruction of small and moderate size soft tissue defects of the forearm, wrist, and hand. RAPF provides suitable skin coverage with elastic subcutaneous tissue thus enabling the protection of exposed or damaged functional structures and their simultaneous repair. The aim of this study was to summarize and analyze the results of the treatment of patients with upper extremity soft tissue defects caused by trauma, infection, burn, or tumor removal, which were reconstructed with RAPF. **Methods.** This retrospective study included 20 consecutive patients with skin and soft tissue defects of the hand and wrist, treated at the University Clinical Center of Vojvodina from 2012 to 2022. The design of the flaps and length of the pedicles were determined by the recipient site. Tourniquet-induced exsanguination was used during surgery for better visualization. The flaps were elevated and placed at the site of the defect. Data on patients and flaps were summarized upon their collection. **Results.** Distally based fasciocutaneous RAPF was used in all cases. The average age of the patients was 48 years, predominantly (64%) males. Defects were most often localized on the dorsal part of the hand (60%) and wrist (20%). The most common indications for surgery were trauma (45%) and tumor resection (25%). A satisfactory coverage of the defect was achieved in all 20 patients with no flap loss. Venous congestion was noted in 4 (20%) patients, which resulted in partial necrosis of the flap in 3 (15%) patients. Wound healing was achieved upon conservative treatment by secondary intention in two patients and with a secondary suture in the last one. A surgical site infection occurred in 2 (10%) patients who withdrew after proper local and systemic therapy. **Conclusion.** RAPF proved to be a workhorse flap for soft tissue reconstruction of the upper limb. This surgical solution led to an excellent functional and aesthetic outcome in the majority of patients. Complex surgical procedures could be done simultaneously, together with the reconstruction of tendons, joints, or fracture stabilization. The reliability and safety of these flaps are confirmed through our clinical data.

Key words:
hand; radial artery; surgical flaps; surgical procedures, reconstructive; wrist joint.

Apstrakt

Uvod/Cilj. Perforator režanj radijalne arterije (PRRA) je vrsta fasciokutanog ili adipofascijalnog reverznog peteljkastog režnja, koji je potvrdio svoju višestruku primenu u rekonstrukciji malih i srednjih defekata mekih tkiva podlaktice, ručnog zgloba i šake. PRRA obezbeđuje odgovarajući kožni pokrivač sa elastičnim potkožnim tkivom, i time omogućava zaštitu eksponiranim ili povređenim funkcionalnim strukturama i njihovu istovremenu reparaciju. Cilj rada bio je da se sumiraju i analiziraju rezultati lečenja bolesnika sa defektima mekih tkiva gornjeg ekstremiteta nastalih usled traume, infekcije, opekotine ili uklanjanja tumora, koji su rekonstruisani primenom PRRA. **Metode.** Retrospektivnom studijom obuhvaćeno je 20 bolesnika sa defektima mekih tkiva šake i ručnog zgloba, koji su lečeni u Univerzitetskom Kliničkom Centru Vojvodine od 2012. do 2022. godine. Dizajn režnjeva i dužina peteljki određivani su u odnosu na recipijentnu regiju. Sve operacije izvedene su pod Esmarch-ovom bandažom u bledoj stazi, radi bolje vizualizacije. Režnjevi su podizani i pozicionirani na mesto defekta. Podaci o režnjevima i bolesnicima su neposredno beleženi i sumirani. **Rezultati.** Distalno bazirani fasciokutani

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PRRA korišćen je kod svih slučajeva. Bolesnici su bili stari prosečno 48 godina, pretežno (64%) muškog pola. Defekti su bili najčešće lokalizovani na nadlaničnoj strani šake (60%) i ručnog zgloba (20%). Najčešće indikacije za operaciju bile su povreda (45%) i resekcija tumora (25%). Zadovoljavajuće pokrivanje defekta postignuto je kod svih 20 bolesnika, bez izgubljenog režnja. Venska kongestija je zabeležena kod 4 (20%) bolesnika, što je izazvalo delimičnu nekrozu režnja kod 3 (15%) bolesnika. Odloženo zarastanje je postignuto kod dva bolesnika, dok je kod poslednjeg postavljen sekundarni šav. Infekcija na mestu intervencije se razvila kod 2 (10%) bolesnika. Znaci infekcije su se povukli nakon sprovedene odgovarajuće lokalne i sistemske terapije. **Zaključak.** PRRA su se dokazali kao vrlo korisni režnjevi za rekonstrukciju defekata mekog tkiva na gornjim ekstremitetima. Ovo hirurško rešenje dovodi do odličnog funkcionalnog i estetskog ishoda u većini slučajeva. Složene hirurške procedure se mogu uraditi istovremeno, zajedno sa rekonstrukcijom tetiva, zglobova ili stabilizacijom preloma. Naša klinička studija potvrđuje pouzdanost i sigurnost korišćenja tih režnjeva.

Ključne reči:
šaka; a. radialis; režnjevi, hirurški; hirurgija, rekonstruktivna, procedure; ručje, zglob.

Introduction

Reconstructive surgery of the hand is still a challenge in everyday clinical practice. Closure of soft tissue and skin defects, where the functional structures of the hand are often exposed or damaged, must be performed in a timely manner and in the best possible way for the patient. At the same time, it is necessary to enable the simultaneous repair of tendons, joints, bones, nerves, or blood vessels [1].

The radial forearm flap, also called the "Chinese flap", was first described in the literature as a free flap by Yang et al. in 1981 [2]. In the following year, a distally based pedicle flap, whose vascularization is based on retrograde blood flow from the radial artery and accompanying veins (venae comitantes), was presented [3]. Regardless of its wide use at the beginning, the main disadvantage of this reverse flap is the necessary sacrifice of the main artery. This problem was solved by introducing the radial artery perforator flap (RAPF) into clinical practice [4]. Based on the increasing knowledge of the topographic anatomy of the arterial perforators of the forearm and hand over the years, several surgical approaches have been put forward, enabling the versatile use of perforator flaps in reconstructive surgery [5].

Pedicled perforator flap combines the advantages of local (complement skin), regional flaps (arc of rotation up to 180°), and distant flaps (reliable vascularisation) without the need for microsurgical vascular anastomosis. Like-with-like reconstruction is the basic principle in plastic surgery. RAPF matches the surrounding skin with color, texture, and contour, especially for the dorsal aspect of the wrist and hand [6]. It provides suitable skin coverage with elastic subcutaneous tissue to protect exposed hardware and allow all degrees of motion. In some patients, a drawback may be the rich subcutaneous fatty tissue of the forearm, which will require trimming of the flap in the second act [7].

The aim of this study was to present the results of the treatment of our patients with soft tissue defects of the hand and wrist caused by trauma, tumor resection, chronic infection, or deep burn, which were reconstructed with RAPF.

Methods

Data for this retrospective study was collected from the Clinic for Plastic and Reconstructive Surgery, University Clinical Center of Vojvodina, from January 2012 to April 2022. The study was approved by the Ethics Board of the aforementioned institution (No. 00-133). It included 20 consecutive patients for whom we used RAPF. All the obtained data were statistically processed upon their collection.

Topographic anatomy

On its way through the forearm, the radial artery gives numerous septocutaneous and musculocutaneous arterial perforators (range 9 to 16). Two clusters of clinically useful cutaneous perforators arise at the proximal and distal third of the forearm. In the distal part of the forearm, at least six septocutaneous perforators can be found [8]. For planning and elevation of the RAPF, the most important septocutaneous perforators of the radial artery arise within 2 cm proximal to the radial styloid, where the pivot point of the flap is. Circulation is achieved due to a retrograde axial flow from at least two clinically significant (> 0.5 mm) septocutaneous perforators, which anastomoses with the longitudinal chain-link vascular plexus in the overlying deep fascia and subcutaneous tissue. Linking vessels are also connected with an intrinsic superficial vascular network that surrounds the lateral cutaneous nerve and cephalic vein, which altogether provide sufficient blood supply to the RAPF [9].

Surgical technique

Although a preoperative Allen test is unnecessary since flap circulation is independent of ulnar-radial palmar vascular communication, patency of the radial artery at the site of septocutaneous perforator branching is crucial for flap survival. Doppler ultrasound examination was performed in all patients to identify and map the arterial perforators, which can be aggravated by the dominant sound of the superficially placed radial artery at the level of the distal forearm [10].

The patient is placed in a supine position on the operating table with a hand laid on a well-padded arm board. Exsanguination is achieved with a brachial tourniquet. After adequate debridement of the wound or tumor resection site, the size and position of the defect are measured. The design of the flap and the length of the pedicle are determined. Extra pedicle length should be considered in order to rotate the flap without tension or kinking. A lazy "S" shaped skin incision

along the axis of the radial artery is made over the volar forearm with an elevation of thin skin flap equally on both sides to expose the adipofascial pedicle. Lifting the flap starts at its proximal end. Dissection continues towards the distal forearm and pivot point in the subfascial plane. The longitudinal adipofascial pedicle should be 3–4 cm wide and include the cephalic vein and the lateral cutaneous nerve [11]. It needs to be separated from the intertendinous septum, located between the flexor carpi radialis and brachioradialis tendons. Several septocutaneous perforators originating from the radial artery located in the dissection pathway need to be carefully ligated. A small skin bridge is usually kept as a flap extension to minimize pressure on the pedicle following flap transfer. Care should be taken to avoid injury to the sensitive branch of the radial nerve. After elevation to the pivot point, the flap is rotated for 180° to reach the distal defect through the subcutaneous tunnel. In the case of a larger flap or a rich layer of subcutaneous adipose tissue, the intervening skin bridge between the defect and the pivot point should be opened, and, after passing, the flap subsequently closed [12]. Direct closure of the donor site can be achieved if the width of the defect does not exceed 4–5 cm; otherwise, a split skin graft is required. The hand and wrist are immobilized for several days in a neutral position following surgery to promote healing.

Results

Twenty patients underwent reconstruction of the hand and wrist with radial artery perforator fasciocutaneous island flaps. The mean follow-up period was 18 months (range 12–24 months). Coverage of the defect was successful in all cases, with a few minor complications. The average age of the patients was 48 years, with most (65%) being male. The largest size of the fasciocutaneous island flap was 11 × 6.5 cm, and the smallest was 5 × 3.5 cm. The average time duration for the flap elevation and placement was 1 h and 15 min if there was no need for other surgical procedures, including tendon and joint reconstruction or fracture stabilization. The patients usually stayed at the hospital for six days after surgery.

The clinical summary of the patient and flap data is shown in Table 1. The dorsal side of the hand was the most common localization of the defect (60%). In nine (45%) patients, the flap was used entirely for soft tissue defect coverage; however, in all other cases, a complex surgical procedure was required simultaneously with extensor tendons, joint reconstruction, or fracture stabilization. The most common indications for surgery were reconstruction after trauma (45%) and tumor resection (25%).

Table 1

Clinical summary of patient and flaps' data

Features	Values
Number of flaps	20
Age, year, mean (minimum-maximum)	48 (26–77)
Gender ratio	2.9
male/female	13 (65)/7 (35)
Localization	
dorsal side of the hand	12 (60)
wrist	4 (20)
thumb	3 (15)
palm	1 (5)
Etiology	
trauma	9 (45)
tumor	5 (25)
chronic infection	3 (15)
burn	3 (15)
Type of reconstruction	
only soft tissue coverage	9 (45)
tendon	7 (35)
bone	3 (15)
joint	1 (5)
Time of reconstruction	
delayed	12 (60)
immediate	9 (45)
Size of the flap in cm^2, mean (minimum-maximum)	24 (17.5–71.5)
Tunneling of the pedicle	17 (75)
Skin extension harvesting	11 (55)
Donor site	
split-thickness skin grafts	13 (65)
primary closure	7 (35)
Complications	
distal venous congestion	4 (20)
partial necrosis	3 (15)
infection	2 (10)
Follow-up in months, mean (minimum-maximum)	18 (12–24)
Long/Wide ratio, mean (minimum-maximum)	3.7 (3–5)

All values are given as numbers (percentages) except age, size of the flap, follow-up, and long/wide ratio.

Tunneling of the pedicle under a skin bridge was performed in the majority (75%) of patients. Small skin extension of the flap in order to relax the tension on the pedicle was used in 55% of patients.

The immediate pedicled flap was performed in 9 (45%) patients, for acute traumatic defects with exposed bones and tendons or for planned operations after malignant tumor resection. A delayed procedure was performed on most patients, mostly as they arrived at our institution from other departments or regional hospitals as unsolved cases.

Distal venous congestion was the most common (20%) complication in the early postoperative period. Spontaneous recovery of the flap occurred in one patient. Three cases resulted in marginal necrosis of the most distal part of the flap. Wound healing was achieved upon conservative treatment by secondary intention in two patients and with a secondary suture in the last one. This kind of complication did not develop in patients in whom the cephalic vein was ligated at the base of the flap pedicle during the operation.

A surgical site infection occurred in two patients in whom delayed reconstruction had been performed. Signs of infection withdrew spontaneously after adequate local treatment and antibiotic therapy according to the wound swab antibiogram.

Primary closure of the defect was possible in 7 (35%) patients, while a split-thickness skin graft was used in 13 (65%) patients. There was no significant donor site morbidity.

All patients had stable scars and soft tissue coverage with a satisfactory color, texture, and contour of the flap in the follow-up period. Hypoesthesia and tingling were noticed in several patients at the area of skin, which was innervated by sacrificed lateral cutaneous nerve but without further consequences. Patients who underwent physical therapy showed significant improvement in the function of the involved fingers, with a good or satisfactory outcome. Two patients required flap trimming in a second surgical procedure due to a bulky appearance and aesthetic refinement.

Case report 1

A 55-year-old male patient was referred to our Clinic with a pigmented skin lesion on the volar aspect of the wrist. The tumor was first noticed by the patient two years prior. Vertical tumor growth started with intermittent secretion four months before he was admitted to the Clinic. Wide surgical excision (margins of 2 cm) was made all the way to the transverse carpal ligament. Reconstruction of the defect was achieved with a RAPF (size 4.5 × 4.5 cm). The donor site defect was closed with direct sutures. The histopathology report confirmed the clinically established diagnosis: melanoma, nodular type, Clark V, Breslow 4 mm, with ulceration. The function of the wrist was fully preserved with a satisfactory aesthetic outcome. In the two-year follow-up period, the patient was without local or systemic recurrence of the disease (Figure 1).

Case report 2

A 50-year-old male patient was admitted to our Clinic with soft tissue necrosis of the dorsal side of the right thumb. Three weeks earlier, the patient sustained a chainsaw injury with a dislocation fracture of the base of the proximal phalanx and section of the extensor tendons of the thumb. The patient was initially treated at another healthcare facility where fracture stabilization with a Kirschner wire was done. Radical surgical debridement was performed. Reconstruction of the tendon defect was achieved with an interposition tendon graft of palmaris longus. Soft tissue defect was covered after planning and elevation of the RAPF (size 6.0 × 3.5 cm). Direct closure of the donor site was done. The wound healing was completed with mild venous congestion of the flap in the first week after surgery. Six months later, a good functional result was achieved with a satisfactory range of motion in the right thumb (Figure 2).

Fig. 1 – a) Nodular type of wrist melanoma; Clark V, Breslow 4 mm, with ulceration; b) Planning the elevation of radial artery perforator flap (size 4.5 × 4.5 cm); c) Early postoperative result (two days post-op); d) Late postoperative result (one year post-op).

Case report 3

A 74-year-old male patient was admitted to our Clinic with a soft tissue defect on the dorsal side of the right hand. Two months before, he was treated at the hematology department for Hodgkin's disease as an outpatient. A local chemotherapy agent induced perivenous extravasation injury, which led to necrosis. After radical surgical debridement, reconstruction of the defect was achieved with RAPF (size 8.5 × 5.5 cm). The donor side defect was covered with a split-thickness skin graft. In the early postoperative period, epidermolysis occurred in the most distal part of the flap without further complications. During the rehabilitation period, a full range of motion of all fingers was achieved (Figure 3).

Case report 4

A 57-year-old female patient was referred to our Clinic from another hospital after a compression injury of the right hand. The patient had a skin defect on the dorsal side of the hand and volar aspect of the wrist with the inability to actively extend the second, third, and fourth finger due to injury of the extensor tendons. After surgical treatment, delayed primary repair of extensor tendons was possible for the third and fourth fingers. An interposition tendon graft of *indicis communis* was used to reconstruct the extensor *indicis proprii* tendon. Soft tissue defect on the dorsal side of the hand was covered with RAPF (size 5.5 × 3.0 cm), while the skin defect on the volar side of the wrist was resolved with a split-

Fig. 2 – a) Soft tissue necrosis of the dorsal side of the right thumb with dislocation fracture of the base of the proximal phalanx and extensor tendons injury; b) Wound after radical surgical debridement; c) Tendon reconstruction with interposition graft of palmaris longus and elevation of radial artery perforator flap (size 6.0 × 3.5 cm); d) Fully preserved vitality of the flap with mild venous congestion (two weeks post-op).

Fig. 3 – a) Local chemotherapy drug-induced perivenous extravasation injury which led to necrosis of the dorsal side of the hand; b) Reconstruction of the defect with radial artery perforator flap (size 8.5 × 5.5 cm); c) Appearance of the flap two weeks post-op; d) Donor side defect covered with a split-thickness skin graft.

Fig. 4 – a) Soft tissue defect on the dorsal side of the hand after compression injury with a lesion of extensor tendons for the second to fourth finger; b) Planning the elevation of radial artery perforator flap (size 5.5 × 3.0 cm) with mapping of arterial perforators with Doppler ultrasound; c) Delayed primary repair of extensor tendons for third and fourth fingers and with interposition graft for *indicis proprii* tendon; d) Good functional result with full extension of involved fingers (one year post-op).

thickness skin graft. Direct closure of the flap donor site was done. The good functional result with full extension of involved fingers and the satisfactory cosmetic outcome was accomplished four months later (Figure 4).

Discussion

RAPF allows the reconstruction of small- and medium-sized defects on the dorsal part of the hand up to the level of the metacarpophalangeal joints of the second to fifth finger and the proximal phalanx of the thumb. On the palmar side, it may reach a proximal or even distal transverse crease. According to most authors [8, 11], the maximum flap size that can be reliably planned is 8–12 cm wide and 15–20 cm long. The largest size of fasciocutaneous island in our patients was 11 × 6.5 cm. Localization of the top edge should be limited at the lower 2/3 of the forearm because of the perforator vascular cutaneous territory. Further increase in flap length would not be safe and reliable [13]. Relative contraindications for RAPF could be in patients at risk for microvascular arterial disease or venous insufficiency or thrombosis in the affected limb, smokers, diabetics, skin or systemic disorders, and others.

In 75% of cases in our series, a subcutaneous tunnel was used for positioning the flap at the recipient site. Dissection of the tunnel should be sufficiently wide to prevent compression or kinking of the vascular pedicle. This method of trans-passing the flap was not used only in cases of a thick layer of subcutaneous fatty tissue or unsuitable condition of the skin bridge. Otherwise, a longitudinal skin incision was performed through the shortest pathway of the flap with linear wound closure afterward. Small skin extension of the flap toward the pedicle was done in 11 (55%) patients. That is recommended to reduce tunnel tightness and avoid traction injury. Numerous authors believe these procedures can reduce the risk of possible complications [12, 14, 15].

Venous congestion is the most common complication of this surgical procedure [16]. When it is transient, it will not leave permanent consequences. Epidermolysis, marginal or complete flap necrosis may be a complication of a severe circulatory disorder. Intense venous blood inflow from a one-way magistral valvular system of the distal part of the hand may exceed the capacity of the smaller concomitant bypass veins that surround the cephalic vein. It remains controversial whether the cephalic vein should be ligated at the base of the flap pedicle. According to our clinical experience, it is necessary to consider this procedure if the cephalic vein is tense and voluminous with the presence of obvious venous stasis after tourniquet release during surgery. This procedure was not performed in any of the four patients from our series in whom partial flap necrosis was manifested. Some authors purpose “flow-through” venous flow by supercharging the free end of the vein on the distal part of the flap to a recipient’s vein [17]. Novel research suggests a hybrid perfusion mode by anastomosing the distal vein of the flap with the recipient artery [18]. An option for flap salvage can still be to apply medicinal leeches (*Hirudo medicinalis*). Despite the proposed solutions, venous congestion remains a challenge in distally based perforator flaps on both the upper and lower extremities. It has been shown that there is no positive role of the cephalic vein in the venous drainage of this flap [13]. On the other hand, the vascular plexus accompanying the cephalic vein contributes to the flap perfusion and should not be sacrificed [9, 19].

The lateral cutaneous nerve should be an integral part of the pedicle. Longitudinal intrinsic and extrinsic perineural vascularization of this nerve enhances flap nutrition [9]. The sacrifice of this nerve does not lead to a significant sensory

deficit and has never been emphasized by our patients. If there is a need for a greater degree of protective sensation return, such as in palmar reconstructions, the sensate flap can be achieved by the same nerve [20]. Neurorrhaphy of transected end of the antebrachial nerve should be done with a suitable recipient sensory nerve. Neurotization of the flap is not necessary in the majority of cases since the protective sensibility is established to a lesser or greater extent in all patients over time.

In over half of our cases, a more complex reconstruction was done, which included tendons [7 (35%)], bones [3 (15%)], and joints [1 (5%)]. Smooth tendon gliding can be obtained under this kind of flap. The palmaris longus tendon graft is most often used in secondary tendon repair. This tendon can be included and elevated together with the flap. In addition, the possibilities of using the tendon flexor carpi radialis and brachioradialis as part of the composite flap are described in literature [21, 22]. During the operation, it is necessary to ensure the appropriate tension and quality of the tendon sutures, which must be strong enough to withstand early protected motion. Excessive shortening of the tendon can result in loss or reduction of flexion mobility. On the other hand, insufficient tension on the suture will not allow complete extension of the fingers [23]. Adequate and timely physical therapy will certainly contribute to the best possible postoperative result.

Trauma [9 (45%)] is the leading etiological factor in our series. In addition, versatile clinical usage of RAPF is possible. Five (25%) of our patients underwent tumor surgical resection – three with squamous cell carcinoma, and two with melanoma, which are, together with basal cell carcinoma, the most common primary hand malignancies. In six (30%) patients, necrosis of the skin and soft tissue of the hand occurred after subdermal burn [3 (15%)] and chronic infection [3 (15%)]. Delayed reconstruction was performed in all of these patients. Hand infection is often encountered in clinical practice. Severe infections are more likely to develop in risk groups of patients such as drug addicts, patients with diabetes or immunodeficiency, oncologic patients, etc. [24]. As a complication of such conditions, deep necrosis can develop, with possible consequent tendon rupture. Successive necrectomy, adequate dressings, topical and systemic therapy according to the findings of wound swab antibiogram, as well as the use of a vacuum-assisted closure system, led to the optimization of the wound state [25]. After proper wound conditioning, complete reconstruction is most often performed in a single-stage procedure, using a RAPF, which is in line with the reference studies [1, 26]. In this group of patients, surgical site infection occurred in only 2 (10%) patients after delayed reconstruction. Signs of infection withdrew spontaneously due to appropriate topical wound care.

Applications of these flaps are varied. Adipofascial variation of RAPF also has widespread clinical use [11]. The advantage of this flap is that donor site morbidity is minimal because of the primary wound closure, although a split skin graft is needed to cover the adipofascial flap at the recipient site. Complications such as partial necrosis are slightly more common compared to standard RAPF. Wilson et al. [27] have used this flap to create a fascial tube to treat recurrent de Quervain's tendonitis. A similar surgical technique has been described for flexor tendon sheath reconstruction at the level of the wrist and distal forearm [8]. Recently, recurrent carpal tunnel syndrome has been treated by wrapping or padding the median nerve [28].

Based on the topographic anatomy of the perforators along the axis of the radial artery, several more surgical approaches have been put forward, such as the proximal RAPF, the posterolateral mid-forearm perforator flap, and the snuffbox radial perforator flap. The proximal RAPF, which enables the reconstruction of the elbow and antecubital fossa defects, stands out for its clinical importance [29].

Propeller perforator flap as a free-style flap is based on vascularization by only one septocutaneous or myocutaneous arterial perforator, which can be chosen along the course of the radial artery [30]. The limits of such flaps cover only small defects in the surrounding area.

Clinical use of the RAPF as a free flap has been described in only a few cases [8]. Contemporary knowledge about the vascular contribution of major perforators along the radial artery axis could enable the design of chimeric or segmental radial artery flaps with multiple skin islands that can be based on different clusters of perforators [31].

The most important flaps that can be a replacement for RAPF are certainly the ulnar artery perforator flap and retrograde posterior interosseous artery flap. Nutrition of the ulnar artery perforator flap is based on distal septocutaneous perforators of the ulnar artery [32]. It is suitable for covering defects on the ulnar side of the wrist and hand. The main disadvantage of this flap is the shorter pedicle length. The posterior interosseous flap is also very useful for hand reconstruction [33]. Technically demanding dissection and perfusion, which is dependent on adequate distal communication between the anterior and posterior interosseous arteries, are the reason why it is less often used in daily clinical practice.

In our series, RAPF was used for small and moderate-sized defects. For the minor defects on the specific localization of the hand, suitable alternative perforator flaps may be used, such as the reverse thenar perforator flap, the ulnar palmar perforator flap, and the dorsal metacarpal artery perforator flap [34, 35]. For each of them, the proper indication can be found in hand surgery. In the case of large defect reconstruction or if a regional flap could not be planned because of the poor condition of the wound environment and adjacent tissue, we mostly opted for distant pedicle flaps such as the groin and thoracoabdominal flap. These flaps are not technically demanding and can give satisfactory results. The main disadvantages are mandatory arm immobilization for three weeks and that the procedure has to be carried out in two stages [22]. With the development of microsurgery, the application of free flaps in hand reconstruction, particularly for large and composite defects, is gradually increasing [36]. Anterolateral thigh flap, tensor fascia lata flap, lateral arm flap, paraumbilical perforator flap, and *latissimus dorsi* flap are mostly used [37]. These demanding and time-consuming surgical procedures require an experienced microsurgical team with appropriate conditions and equipment.

Conclusion

Algorithms and timeliness for coverage of the hand following various disease states will depend on the characteristics and localization of the soft tissue defect and the general condition of the patient. The versatile and frequent clinical application of RAPF proved that it became a workhorse flap for soft tissue reconstruction of the upper limb. This surgical solution yielded an excellent functional and aesthetic outcome in the majority of patients with limited donor site morbidity. Complex surgical procedures could be done simultaneously, together with the reconstruction of tendons, joints, or fracture stabilization. Straightforward elevation and perfusion based on cutaneous perforators alone, without the need to sacrifice the radial artery, are the main advantages of this flap. The reliability and safety of their versatile clinical application are confirmed through our clinical data.

Acknowledgement

We are grateful to Boris Jovanović for helping with the English translation and preparing the illustrations.

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Received on July 21, 2022
Revised on October 16, 2022
Accepted on October 17, 2022
Online First October 2022