The Use of Distal Ulnar Artery Perforators in the Coverage of Wrist and Hand Defects

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Abstract

Background: Recent advances in perforator flap design have increased their popularity in coverage of complex wounds. A lot of studies have been made over the use of radial artery perforator flaps in the coverage of hand and wrist defects, however little has been discussed about the usage of ulnar artery perforator flaps. The goal of this study is to discuss the applications of distal ulnar artery perforator flaps in the coverage of hand and wrist defects.

Methods: This study included 10 patients presenting with various defects. Seven patients had defects over wrist and distal forearm, while 3 patients had defects over the hand. Distal ulnar artery perforators were used to design flaps to cover these defects.

Results: Successful stable coverage was achieved in all 10 cases. Seven cases healed uneventfully while minor complications were encountered in the form of partial loss in one case and infection in 2 cases. Five cases were designed as propeller flaps and rotated 180º while 5 cases had a skin pedicle and were rotated 90º.

Conclusion: Distal ulnar artery perforator flaps offer a reliable method for reconstruction of defects in the wrist and proximal hand. They are suitable in the treatment of complex cases with extensive soft tissue loss and associated injuries. The flaps are thin, pliable, and robust. The skin is not hirsute. The scar is relatively inconspicuous. It is also a one stage procedure and does not require the sacrifice of a main vessel.


Introduction

COMPLICATED large wounds over the wrist and proximal hand that are not amenable to direct closure represent a difficult challenge to the reconstructive surgeon. These wounds are usually complicated by the exposure of vital structures in the wrist as tendons, nerves, vessels, or even bone. Successful reconstruction of these wounds depends on coverage with similar tissue to provide stable soft tissue coverage [1].

Traditional flaps that are commonly used to reconstruct forearm and proximal hand defects include local fasciocutaneous flaps for the coverage of smaller defects. Larger defects are commonly covered by local axial flaps like the radial forearm flap, or remote flaps as the groin flap.

The radial forearm flap is a time-honored reliable option that is favored by many surgeons for its thinness, pliability, and ease of dissection. It is a versatile option that can be used to cover various defects over the forearm and hand. However it requires the sacrifice of the radial artery which may result in chronic ischemia of the hand [2].

The groin flap is an excellent back up flap for forearm and hand reconstruction. It provides a large flap with a concealed donor site. However it requires maintaining the hand in an uncomfortable position for weeks, positioning that may not be compatible with orthopedic external fixators. It is also a 2 stage procedure [3].

The introduction of the perforator flap concept has revolutionized reconstructive surgery. It allows the harvest of reliable flaps based on a perforating branch without the need to sacrifice the main vessel. This concept commonly used in microsurgical free flap surgery can be applied in pedicled flaps for local reconstruction. By eliminating the microsurgical component, the applications of perforator flaps can be widespread and the potential risk of flap loss diminished [4].

Perforator flap design depends on the detection of the perforating vessels along the course of the main vessels in the vicinity of the region to be reconstructed, and then choosing the most appro-
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appropriate of these perforators to support the flap. This concept can be applied anywhere along the body [5].

In the forearm perforator flaps can be designed on the radial and ulnar arteries. Many studies have focused on the applications of radial artery perforator flaps. Clusters of clinically significant perforators from the radial artery are found at the distal and proximal ends of the forearm. This allows for the design of distally based perforator flaps to cover the wrist and hand. However, distally they are limited in their reach to the lateral aspect of the hand and palm. They cannot comfortably reach the medial aspect of the hand and cannot reach the metacarpophalangeal joints. In addition the scar from the radial artery perforator flap is obtrusive, being on the distal radial exposed (working) surface of the forearm [6].

Recent anatomical studies on the ulnar artery perforators have shown a predictable distribution of perforators along the course of the vessel [7]. Many studies have been made on the location of the dorsal branch of the ulnar artery, which is considered a large perforator of the ulnar artery emerging from the dorsal surface of the vessel 4-6cm proximal to the pisiform bone [8]. In addition to the dorsal branch there are other perforators emerging from the volar aspect of the ulnar artery. The goal of this study is to describe the clinical applications of the flaps based on the perforators emerging from the distal part of the ulnar artery.

Patients and Methods

The study included 10 male patients who presented to the casualty Department of the Kasr Al-Ainy Hospital between July of 2013 and December of 2014. Three cases were due to burns, 3 cases were due to road traffic accidents, 2 cases were lacerations caused by sharp objects while 2 cases were due to firearms injuries. The patients were aged 10 to 51 with an average age of 24 years.

The defects included in the study were judged to be in need for stable coverage by flaps due to the complicated nature of the injuries. All of the defects had other associated injuries. Seven patients had exposed or injured tendons, while 2 of the patients had associated underlying bone fractures. Three patients had associated median nerve injuries.

Two patients had post burn contractures. One case had contracture over the dorsum of the wrist, while another case had contracture over the dorsal aspect of the 5th metacarpophalangeal joint. The release of these contractures resulted in defects that needed stable coverage by a flap to avoid recurrence of contracture.

Four patients had defects over the volar aspect of the wrist, while 3 patients had defects over the dorsum of the wrist. Two patients had defects over the dorsum of the hand, while one case had a defect over the palm. Patients' details regarding age, mechanism of injury, type and location of the defects, associated injuries, flap type and postoperative result are shown in (Table 1).

Doppler and Duplex studies were used to detect the location of perforators over the course of the ulnar artery in the distal third of the forearm.

Operative technique:

The flaps were based on the distal ulnar perforators. Their positions were confirmed preoperatively with duplex or by an exploratory incision before flap elevation.

The flaps were raised in a supine position with the forearm stretched on a table. A tourniquet is applied with minimal exsanguination. The flaps were outlined on the ulnar aspect of the distal forearm. The skin is incised longitudinally on the palm while the flap is elevated. The incision extends down to the deep fascia between FDS and FCU muscles. The ulnar artery and nerve are explored until the perforators of the ulnar artery are identified. In some cases volar perforators were identified, in others the dorsal branch was localized as it emerges under the FCU with the dorsal branch of the ulnar nerve. The site at which the perforator pierces the deep fascia is marked on the skin with a simple suture. The thread of this simple suture is left long and used to measure the distance between the perforator and the distal edge of the defect, then the same length of suture line is used to mark the proximal edge of the flap.
The flap is harvested in a proximal to distal direction. The flap is rotated to cover the defect. A distal skin pedicle is usually preserved, unless it limits the insetting of the flap in which case the flap can be completely islanded. The donor site can be closed primarily if the flap width is less than 4cm otherwise a split thickness graft is used.

This flap can be safely and reliably used to cover large defects. The largest flap in this study was 15 X 7cm.

The patient's hand and arm were elevated. Special precaution was made to ensure that there is no pressure applied over the site of the pedicle. Light dressing was applied to all flaps, with a window for flap monitoring. The skin paddle of the flap was observed starting at 6 hours post operatively, then every 12 hours for the first 48 hours, then once every day.

All patients were followed-up for a period of 6 months postoperative.

### Table (1): Characteristics of the studied cases.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Sex</th>
<th>Etiology</th>
<th>Associated injury</th>
<th>Site of defect</th>
<th>Size of defect in cm</th>
<th>Flap size in cm</th>
<th>Degree of rotation</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>M</td>
<td>Burn</td>
<td>Post burn contracture affecting little finger</td>
<td>Medial dorsal of hand</td>
<td>9 x 6</td>
<td>15 x 7</td>
<td>180°</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>35</td>
<td>M</td>
<td>Firearm injury, shotgun</td>
<td>Flexor tendons of 4th and 5th fingers</td>
<td>Medial palm</td>
<td>6 x 4</td>
<td>11 x 5</td>
<td>180°</td>
<td>Infection</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>M</td>
<td>Lacerated wound</td>
<td>Scar e Adherent extensor tendon</td>
<td>Dorso of wrist</td>
<td>4 x 3</td>
<td>11 x 3</td>
<td>90°</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>M</td>
<td>Burn</td>
<td>Post burn contracture</td>
<td>Dorso of wrist</td>
<td>6 x 3</td>
<td>8 x 3</td>
<td>90°</td>
<td>–</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>M</td>
<td>RTA</td>
<td>Fracture ulna</td>
<td>Dorso of wrist</td>
<td>3 x 2</td>
<td>7 x 4</td>
<td>90°</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>51</td>
<td>M</td>
<td>RTA</td>
<td>Median nerve, FDS 5th finger</td>
<td>Volar wrist</td>
<td>7 x 7</td>
<td>12 x 8</td>
<td>90°</td>
<td>Infection</td>
</tr>
<tr>
<td>7</td>
<td>19</td>
<td>M</td>
<td>Electric burn</td>
<td>Exposed FCU tendon</td>
<td>Volar wrist</td>
<td>4 x 3</td>
<td>8 x 5</td>
<td>90°</td>
<td>–</td>
</tr>
<tr>
<td>8</td>
<td>22</td>
<td>M</td>
<td>Shotgun</td>
<td>Fractured metacarpals, exposed extensor tendon</td>
<td>Dorso of hand</td>
<td>6 x 5</td>
<td>12 x 7</td>
<td>180°</td>
<td>–</td>
</tr>
<tr>
<td>9</td>
<td>19</td>
<td>M</td>
<td>RTA</td>
<td>Exposed ligated radial artery, median nerve</td>
<td>Volar wrist</td>
<td>9 x 8</td>
<td>14 x 6</td>
<td>180°</td>
<td>–</td>
</tr>
<tr>
<td>10</td>
<td>18</td>
<td>Laceration</td>
<td>Exposed cut median nerve, FCR</td>
<td>Volar wrist</td>
<td>4 x 3</td>
<td>14 x 4</td>
<td>180°</td>
<td>Partial loss of distal 2cm</td>
<td></td>
</tr>
</tbody>
</table>

### Results

Successful stable coverage was achieved in all ten cases. Seven cases healed uneventfully while minor complications were encountered in 3 cases in the form of partial loss in one case and infection in two cases.

In 6 cases the flaps were designed based on the known location of the dorsal branch of the ulnar artery. In 4 cases a flap was designed on a perforator of the ulnar artery other than the dorsal ulnar branch. All perforators used in this series were clinically significant (size > 0.5mm).

In 5 cases that had defects over the wrist the flap needed to be rotated only 90° to cover the defect. However in all the 3 cases that had defects over the hand and in 2 of the cases that had a defect over the distal part of the wrist, the flap needed to be rotated 180° to reach the defect.

In the cases in which only 90° was done the flap design allowed the preservation of a skin pedicle, while in the cases where the flap was rotated 180° the flap was completely islanded and changed to a propeller design. This allowed more distal flap reach and better inset. All the flaps in this series had just one perforator at their base.

One case suffered from partial loss of the distal aspect of the flap. This later healed by secondary intention without the need for a surgical intervention. Two cases suffered from post-operative infection that was managed by repeated dressing until complete healing.
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Fig. (2): A 10 year old patient presented with post burn contracture over the dorsum of the hand (A). A large flap (15 x 7cm) was designed over the dorsal branch of the ulnar artery and rotated 180º to cover the defect (B).

Fig. (3): A 51 year old male patient presented with a lacerated wound over the wrist (A) a flap 12 x 8cm was designed over the dorsal branch of the ulnar artery and rotated 90º to cover the defect (B).

Discussion

Much has been discussed about the distal radial artery perforators and their use in radial artery perforator flaps to cover the wrist and hand, however little has been discussed about the use of distal ulnar artery perforators [6].

Ulnar artery perforator flaps can be designed anywhere along the course of the forearm as long as a perforator has been detected or identified. Ulnar artery perforators are distributed along the course of the ulnar artery, with clinically significant perforators found in the distal, middle and proximal parts of the forearm [9].

In the current study it was found that in the distal forearm an average of 1-2 clinically significant (size >0.5mm) perforators were found. They were found at an average distance of 5.8cm from the pisiform bone. These include a constant branch, the dorsal ulnar branch, described by Becker and Gilbert in the design of the Becker flap [10].

Vergara-Amador described the location of the dorsal branch of the ulnar artery as a constant finding at 4-6cm from the pisiform bone [8]. Based on this anatomical information, in this study the location of the dorsal branch could be identified intraoperatively through surgical exploration. However the location of other perforators of the ulnar artery needed to be identified preoperatively.

Preoperative identification of perforator location was attempted by Doppler study in all patients. In our experience Doppler mapping was not helpful in identifying perforator location in the distal forearm as the signal from the underlying ulnar artery masked the signal from the perforating vessels due to the subcutaneous course of the vessel.

In this study the principles of free style flaps, first introduced by Wei and Mardini, were utilized to tailor flap designs according to; the site of the defect and the site of nearby perforators [11]. The free style concept was used to design local pedicled fasciocutaneous flaps that include a perforator at the base to ensure adequate blood supply to the flap. If the arc of rotation of the flap transfer was more than 90º this resulted in a kink at the flap base that limited flap reach. In these cases the flap was converted to a propeller flap design to increase the flap reach.

The dorsal branch of the ulnar artery is a large vessel with an average size 1-1.5mm. It has a
predictable location that can be predictably located during surgical exploration. Flaps based on this branch are very reliable with the largest in this series measuring 15 X 7cm. The other distal perforators of the ulnar artery are less predictable in size and location. There are usually at least one or more clinically significant perforators emerging from the volar surface of the ulnar artery. They are smaller in size than the dorsal branch therefore they are more suitable in designing smaller flaps than those supplied by the dorsal branch.

Flaps based on the distal ulnar artery perforators can reliably reach defects over the volar and dorsal aspect of the wrist as well as the volar and dorsal surface of the hand as far as the metacarpophalangeal joints of the 4th and 5th fingers.

It was not possible to close the donor site primarily as most of the defects were >5cm in width and needed the harvest of large flaps so split thickness skin grafts were used to cover the donor area.

Ulnar artery perforators that were used in flap design in this study varied in size from 0.8 to 1.5 mm, with an average of 1.2mm. This allowed the successful design of flaps up to 15 X 7cm in size based on a single perforator.

There was only one case that suffered partial loss to the distal edge of the flap. This was a large flap 14 X 4cm and the partial loss affected the distal 2cm of the flap. This later healed by secondary intention and did not require further surgery and did not affect the final outcome.

Two cases suffered post-operative wound infection. This was due to the nature of the trauma. One case was following a shotgun injury with dead necrotic tissue at the zone of injury, while the other case suffered a RTA with a lacerated wound to the wrist. Both cases were debrided and dressed repeatedly before surgery for coverage.

**Limitations:**

- Flap size; in flaps that were greater than 14cm there was a risk of flaps loss to the distal edge.
- Reach; flaps based on the dorsal ulnar branch can cover most defects over the volar and dorsal surface of the distal forearm, wrist and hand. However they cannot reach the lateral aspect of the hand or the fingers.

**References**


الملخص العربي

التطورات الحديثة في تصميم السدائل المعتمدة على الأوعية الثانوية زاد من شعبيتها في تغطية الجروح المعقدة. تم نشر عدة أبحاث عن السدائل المعتمدة على الأوعية الثانوية للشريان الكبير، في حين أن السدائل المعتمدة على الأوعية الثانوية للشريان الزندي لم تلق نفس الاهتمام.

الهدف من الدراسة هو تقييم التطبيقات الأكليتية للسدائل المعتمدة على الأوعية الثانوية للشريان الزندي في تغطية العيب اليد والمعصم.

شملت هذه الدراسة 100 من المرضى يعانون من عيب مختلف. وكان منهم سبعة مرضى يعانون من جروح على الرسغ وآخر الساعد، في حين أن 3 من المرضى كانوا يعانون من عيب على اليد. استخدمت السدائل المعتمدة على الأوعية الثانوية للشريان الزندي في الجزء الأبعد من الساعد لتغطية تلك الجروح.

قد حقق تغطية مستقرة ناجحة في جميع العشرين الحالة، في حين عانت حالة واحدة من فقدان جزئي للسديئة لم يؤثر على النتيجة النهائية.

حالتين عانتا من عيب بالجرح. وقد صممت خمس حالات على شكل السدائل المروحيه وتدويرها 180 درجة في حين أن في 5 حالات كانت الاستدارة 90 درجة مع الاحتفاظ بوصلة جلدية.

السدائل المعتمدة على الأوعية الثانوية للشريان الزندي في الجزء الأبعد من الساعد توفر طريقة موثقة بها لإعادة بناء العيب في الرسغ واليد وهي مناسبة في علاج الحالات المعقدة مع فقدان واسع للأنسجة الرخوة مع وجود إصابات أخرى. وتتميز بسجية رفيعة، قليلة الشعر، النتيجة الناجحة منها في مكان منطقي بالساعد، والجراحة تتم على مرحلة واحدة.