Reconstruction of the Severely Contracted First Web Space Using the Posterior Interosseous Artery Flap

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ABSTRACT

The creativity of the human hand depends mainly on the presence of the thumb; but for the thumb to act as created, a healthy first web should be present. In severely contracted first web space most of the local flaps fail to produce adequate release. The forearm flaps proved to be the best option for web space reconstruction. The posterior interosseous artery flap has proven superiority than other forearm flaps in this region. It fulfills all the needed requirements and is devoid of the disadvantages of the other forearm flaps. The flap was incriminated for its relatively high failure rate due to inconstant arterial anatomy and the high incidence of venous congestion. In this study the posterior interosseous artery flap was used in 18 cases complaining of severe contraction of the first web space with a high success rate (89%), only two flaps suffered partial loss and an additional flap showed venous congestion that was resolved spontaneously. The released web spaces were wide supple with no recurrence of contracture. This flap is considered to be the flap of choice in first web space reconstruction.

INTRODUCTION

The human hand possesses a unique anatomical structure and shape that made it able to perform numerous precise and gross movements. The thumb, by its opposition movement, is the main structure that enables the human hand to develop these talents.

For proper physiologic thumb opposition function, adequate width of the first web space is required. The normal first web space angle is about 100° in adults and its skin must be supple with adequate sensibility. A reasonable grip and pinch strength are also required. Contracture or deficiency of the first web space contributes much to hand disability and loss of more than 50% of hand function, the same as a lost thumb [1].

Trauma and burns are the main causes of web space contracture; due to loss of skin cover, prolonged immobility in addition to the associated edema. Some pathological conditions as Duputryns contracture or tumor excision may lead to web space deficiency. Sometimes the contractures are secondary to extrinsic causes outside the web itself as in nervous system abnormalities like cerebral palsy or longstanding nerve injuries [2].

Reconstruction of a contracted first web space can be done by different means, starting from a simple skin graft and local flaps to the more sophisticated methods as the use of free flaps. Skin grafts are prone to reconstracture. Local flaps such as the four and five flaps z plasty, which are the most commonly used methods, are only effective in mild to moderate cases and usually leave scars traversing the web margin. Local transposition flaps from the dorsum of the hand do not provide adequate release in severe cases, especially in covering the palmer surface, in addition to their unaccepted scars of the grafted donor sites [3]. For severe cases, larger flaps are needed, in these cases, distant flaps as abdominal or groin flaps were used but they have the significant disadvantage of requiring two stages and they lead to insensible and often bulky skin cover which hinders normal movements or need a third stage of debulking.

Tissue expansion was also suggested but it is associated with high risk of complications and needs good quality skin surrounding the web space so it might be beneficial in congenital cases but not in most of the post traumatic and post burn cases [4].

The introduction of the distally based forearm flaps (the radial forearm flap [5], the ulnar forearm flap [6], the posterior interosseous artery flap [7], the anterior interosseous artery flap [8] and the dorso-ulnar flap [9]) began a new era in hand reconstruction. In a single stage procedure, they provide a good amount of thin and supple skin that is sufficient for release of the most severe contractures. Donor sites of flaps as wide as 4-5 cm can be closed primarily with only a linear scar that is usually accepted.

The radial forearm flap, which is considered as the workhorse for hand reconstruction, is a reliable good option but it has the significant disadvantage of severing a major artery and disturbing the volar lymphatics leading to distal edema. This is also applied for the ulnar forearm flap [10].

The posterior interosseous artery flap has all the advantages of the other forearm flaps without their major disadvantages [11]. Brunelli et al. [12] stated that this flap will replace the other forearm flaps in hand reconstruction. In a study comparing the distally based forearm flaps, Martin et al. [13] considered the posterior interosseous artery flap as the flap of choice in web space reconstruction.

In this paper we will evaluate the use of the posterior interosseous artery flap in reconstruction of the severely contracted first web spaces in different modalities of contractures.

Flap description and anatomy:

The posterior interosseous artery flap is a fasciocutaneous flap based on the posterior interosseous artery and is harvested from the posterior aspect of the forearm. The detailed description of the anatomy is well illustrated elsewhere [7,11,14-17].

The posterior interosseous artery originates proximally from the common interosseous artery and terminates distally in the carpal plexus by multiple branches; the most important one is its anastomosis to the anterior interosseous artery via a direct branch that pierces the interosseous membrane 1 cm above the wrist joint. There might be some reported anatomical variations [14,17-20]. These include: the attenuation or the absence of the middle part of the artery or absence of the anastomosis with the anterior interosseous artery. However, this is controversial as other reports did not mention any vascular abnormality and ensured consistent presence of the artery and its branches [15,21,22].

During its course, the artery lies invested in the fascial septum between the extensor capri ulnaris and the extensor digiti minimi. In the proximal part of its course, the artery is deep and it becomes superficial in the distal part of the septum. It gives off branches that spread on the deep fascia to form longitudinal fascial arcades that supply the superficial skin and the deeper muscles. there are several patterns as regards the distribution of these perforators [21]. The most consistent and important one is termed the medial cutaneous branch that arises 1-2 cm distal to the midpoint of the forearm [16].

The artery is accompanied by two venae commitans along its course and so its perforators as well as its communicating and medial cutaneous branches. In addition to this deep system, there are one to two interconnecting veins that connect this deep venous system to the superficial cutaneous one.

PATIENTS AND METHODS

Eighteen patients with severely contracted first web space were operated upon in the period from January 1998 to April 2001 in the Plastic Surgery Department at Ain Shams University Hospital and El-Nil Insurance Hospital. Thirteen were males and five were females, their age ranged between 9 and 54 years. Nine cases were due to traumatic injuries, seven due to post burn contractures, one due to electric burn injury and one due to firearm injury. Eight cases had previous trials of reconstruction by local flaps.

All patients had severe contractures, web space angle ranged between 15° and 35°. In ten patients there was isolated web space contracture and in the remaining eight patients there was additional skin deficiency over the thumb, index, the palm or the dorsum of the hand that was simultaneously reconstructed (Table 1).

For all patients the contractures were released and the distally based posterior interosseous artery flap was used for reconstruction. Patients follow up ranged between six months and four years.

Operative details:

The operative procedure is done under pneumatic tourniquet without complete exsanguination of the limb for better identification of the vessels.

Release of the web is adequately done including release of the palmer fascia, the adductor pollicis and the first dorsal interosseous muscles and all abnormally situated fibrous tissue. During the release, preservation of the neurovascular bundles to the thumb and index has to be considered. After complete release, a pattern is made and the flap is designed. The detailed description of flap design and elevation is described in many articles [11,12,18,22].

The surface marking of the posterior interosseous artery is drawn on a line between the lateral epicondyle and the ulnar head with the forearm in full pronation. The center of the flap lies on this line at a point 9 cm distal to the lateral epicondyle. The proximal limit of the flap can be safely placed 6 cm distal to the lateral epicondyle and the flap can be extended distally up to the wrist. Its dimensions extend up to 11 cm in width and 20 cm in length, but theoretically, the whole skin of the dorsum of the forearm can be included.

In cases where contracture of the web space is associated with scarring and contracture of the dorsum of the hand (2 cases), a racquet shape design of the flap is utilized by raising a longitudinal strip of skin overlying the pedicle with the flap to use it in resurfacing the dorsal hand defect (Fig. 1).

A longitudinal incision is done overlying the marked course of the artery at the distal forearm 1 cm above the wrist and is deepened exposing the deep fascia. The extensor carpi ulnaris and the extensor digiti minimi are identified, then two linear incisions, 1 cm apart, are made in the deep fascia on both sides of the septum between these two muscles.

The artery is seen invested in the septum with its branches. The dissection proceeds from distal to proximal [11,22] for better identification and tracing of the artery as well as to ensure the presence of the communication between the posterior and the anterior interosseous arteries. The fine branches to the surrounding muscles are carefully coagulated using bipolar diathermy, but those to the fascial strip are preserved.

The skin island is incised to the deep fascia and the loose areolar tissue mesentery between the fascia and the dermis is carefully preserved due to its contents of network of vascular connections using few sutures that will be removed later after insetting of the flap.

Proceeding proximally with the dissection, the fasciocutaneous perforators as well as the medial communicating branch are identified and the least possible number of perforators are included to minimize venous congestion. The posterior interosseous nerve is adjacent to the artery in the middle of the forearm and it is important to preserve it as well as its branches. Sometimes some of the minor branches cross superficial to the course of the artery. If the branch supplying to the extensor carpi ulnaris is encountered, either the artery is divided here if enough number of perforators had been already identified and included or the nerve divided with immediate resuturing. The proximal end of the artery is carefully cut as there might be a possibility to resort to free transfer if the reversed blood flow is not ensured. A wide tunnel is made and the flap is transferred to cover the web space. In cases with the racquet shaped design, the scarred skin bridge between the donor and recipient sites was released and the flap was inset to cover the exposed dorsum of the hand as well as the web space.

RESULTS

The posterior interosseous artery as well as its communicating branch to the anterior interosseous artery was present in all cases. The dimensions of the flaps used ranged between 6 x 4 and 18 x 9. The operative time for flap elevation ranged between 75 & 90 minutes (Table 1).

All flaps survived completely (Figs. 2-13) except two flaps (11%) that showed partial loss due to venous congestion.

Venous congestion occurred in three flaps (16%). It resolved completely in one and led to partial flap necrosis in the other two. These were managed by frequent dressings, with spontaneous healing in one case and skin grafting to cover the palmer aspect of the web in the other one. Edema was observed only in one flap, 5.5%, that resolved slowly by elevation (Fig. 10).

The reconstructed web spaces were thin and supple with wide dimensions that allowed free

mobility. the released webs could reach an angle as wide as 75-85º. None of the patients developed motor deficits in extension. All donor sites healed nicely, 7 were closed primarily and

11 required skin grafts, that was esthetically accepted (Fig. 8). None of the patients showed recurrence of the contracture during the follow up.

Fig. (1): Racquet shaped design of the posterior interosseous flap.

Fig. (4): Post traumatic contracted first web in a 24 year old male.

Fig. (2): Post traumatic contracted first web, side of the thumb, palm and dorsum of the hand in a 36 year old male.

Fig. (5): Defect after release and the flap is raised.

Fig. (3): Post operative results with release of the web, palm and covering of part of the thumb.

Fig. (6): Late post operative results with release of the web, palmer aspect.

Fig. (7): Late post operative results with release of the web, dorsal aspect.

Fig. (8): Accepted appearance of the grafted donor site.

Fig. (9): Post traumatic contracted first web in a 54 year old male.

Fig. (10): Early post operative result with flap edema.

Fig. (11): Late post operative result with spontaneous resolution of the edema with elevation.

Fig. (12): Post operative result of reconstructed first web space after gun shot injury.

Fig. (13): Post operative result of reconstructed first web space and adjacent sides of the index and thumb.

Table (1): Summary of patient's data and results.

No.	Age	Sex	Side	Cause	Diagnosis	Size	Donor	Complication	End result
1	25	M	Rt.	Firearm	Web & index proximally	10 x 8	Graft	-	Good
2	54	M	Rt.	Post tramatic	Web only	7 x 5	Direct	Flap edema	Resolved
3	23	M	Lt.	Post burn	Web & adjacent part of the thumb	9 x 5	Direct	-	Good
4	19	F	Rt.	Post burn	Web only	6 x 4	Direct	-	Good
5	9	M	Lt.	Post electric burn	Web & adjacent part of the thumb	8 x 5	Graft	Venous congestion	Loss of half of the flap
6	17	M	Rt.	Post burn	Web only	9 x 5	Graft	-	Good
7*	12	M	Lt.	Post traumatic	Web & dorsum of the hand	17 x 6	Graft	-	Good
8	27	F	Lt.	Post burn	Web only	9 x 6	Direct	-	Good
9	40	M	Rt.	Post traumatic	Web, adjacent part of the thumb & palm	13 x 7	Graft	Venous congestion	Loss of half of the flap
10	18	F	Rt.	Post burn	Web only	7 x 5	Direct	-	Good
11	24	M	Rt.	Post traumatic	Web & adjacent part of the thumb	9 x 6	Graft	-	Good
12	43	F	Lt.	Post burn	Web only	9 x 6	Graft	-	Good
13	15	M	Rt.	Post traumatic	Web only	15 x 6	Graft	Venous congestion	Resolved
14	28	M	Lt.	Post burn	Web only	7 x 4	Direct	-	Good
15*	36	M	Rt.	Post traumatic	Web, side of the thumb, palm & dorsum of the hand	18 x 9	Graft	-	Good
16	27	F	Rt.	Post traumatic	Web only	8 x 6	Graft	-	Good
17	24	M	Lt.	Post traumatic	Web only	10 x 6	Graft	-	Good
18	35	M	Rt.	Post traumatic	Web & adjacent parts of the thumb and index	11 x 5	Direct	-	Good

* Racquet shaped flaps.

DISCUSSION

A healthy first web entails the presence of supple adequate skin cover in both the palmer and dorsal web surfaces with a deeply embedded skin creating the web as well as absence of scars in its peripheral border.

For adequate reconstruction of severe cases of contracted first web space, there is a need for a single procedure that offers a well vascularised skin flap to help prevent infection, minimize fibrosis and enable early mobilization and physiotherapy [22]. Commonly, the adjacent borders of the index and the thumb are also involved and need to be simultaneously reconstructed. This is best achieved by the use of regional forearm flaps.

The posterior interosseous artery flap provides all the requirements for proper reconstruction. It also overcomes most of the drawbacks of the other forearm flaps that include: severing of a major limb artery in a previously compromised limb and the dissection in the val-

or aspect of the forearm with interruption of the major lymphatic of the hand.

We found this flap to be of special importance in web space reconstruction as it has a pedicle length sufficient to reach the first web space without tension, unlike other areas in the hand where the pedicle has to be stretched to reach more distal defects. Also, for web space coverage, the pedicle of the flap is rather rotated in a smooth curve than turned over in a 180° as in dorsal hand cover.

In cases associated with scarring and contracture of the dorsum of the hand, the racquet shaped design proved to be useful in simultaneous reconstruction. This is another advantage of the flap that adds to its versatility in different modalities of web space reconstruction.

Many authors [11-13,20,22] agree with this opinion and recommend the use of this flap and consider it the flap of choice in hand reconstruction in general and web space reconstruction specifically [12,22].

Opponents to the liberal use of this flap claimed that its dissection is technically difficult, less reliable as the posterior interosseous artery has inconstant anatomy and it has a high incidence of flap loss due to arterial abnormality or the development of venous congestion [23]. There is also a possibility of injury of the branches of the posterior interosseous nerve during flap elevation [24].

In this series, the well documented difficulty in raising the flap was progressively diminishing with the cumulative experience with repeated elevation of the flap. In the late cases, the time needed for flap elevation ranged between 75 and 90 minutes with a high success rate.

During flap elevation, we did not encounter any anatomical abnormalities in the posterior interosseous artery or its anastomotic branch.

Venous congestion which is known to be responsible for flap loss, was seen in 16% of our cases. So some authors advised the performance of an additional venous anastomosis in selected cases [11,25]. Shibata et al. [23] included a large cutaneous vein with the pedicle but this did not successfully eliminated flap.

The percent of venous congestion is greatly reduced in comparison to other reports [11,18] and this high success rate might be due to many factors:

1- In this series we no longer harvest a cuff of subcutaneous tissue with the pedicle as advised previously [11]. The reason is that its content of superficial veins is not ensured and the bulk of this subcutaneous pedicle may be the cause of this congestion as it compresses the pedicle especially if the flap was tunneled. So, incision of the tunnel that was previously advised [11] was not performed in any patient in this study, except in the two cases of contracted dorsum of the hand where the racquet shaped design was used.

2- In the early cases in this study and in an earlier study [11], we observed that venous congestion was common with the flaps that had a large number of perforators. We also noticed that flaps that bleed profusely after release of the tourniquet usually develop venous congestion. On this basis, we used the least number of perforators to restore the balance between arterial inflow and venous outflow.

No nerve injury was encountered due to the meticulous preservation of the branches of the posterior interosseous nerve and utilizing the perviously described techniques for its preservation.

The edema with the use of the flap was also minimal in comparison to that reported with the radial forearm flap [15], due to the uninterruption of the volar lymphatics.

Conclusion:

The reconstruction of the severely contracted first web space is best done using the posterior interosseous artery flap. It is an excellent flap in reconstructing different modalities of severe contractures of the first web space. It provides a wide thin supple web space with additional skin sufficient to reconstruct adjacent defects of the thumb, index, palm or the dorsum of the hand in one stage. In addition of having all the advantages of the other regional forearm flaps, it is devoid of their major disadvantages, severing of a major artery and interruption of hand lymphatics.

Certain precaution during flap elevation: careful dissection, using the least possible number of perforators, preserving the motor nerve to the extensor carpi ulnaris, the use of thin pedicle, avoidance of pedicle kink and the use of wide tunnel, improves the outcome of the flap and reduces the incidence of unfavorable results.

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