

## Sensory Evaluation of Post Traumatic Thumb after Reconstruction with Reverse Radial Forearm Flap

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### Abstract

**Background:** Thumb is with a special role in hand function. Therefore, in addition to the significance of using thin, pliable, color-matched, and hairless cover in resurfacing the lesion in this area, recovery of sensation should also be taken into consideration.

**Materials and Methods:** Thirteen patients with thumb degloving injuries were candidates for sensate reverse island radial forearm surgery. After transferring the flap, forearm lateral sensory nerve was sewn to the thumb digital nerve. At least for two years, these patients received regular diagnosis, and monofilament, static two point discrimination (S-2PD), and moving two point discrimination (M-2PD) tests were taken from them.

**Results:** Monofilament test did not show normal sensation recovery, at protective sensation threshold, in the patients. The difference between monofilament test and normal thumb was statistically significant ( $p < 0.0001$ ). In spite of this, the protective sensation was restored in all flaps after two years. According to the results from S-2PD and M-2PD tests, the restored sensation was at protective threshold or reduced, and the difference was statistically significant ( $p < 0.0001$ ).

**Conclusion:** Given difficulties of performing free flaps, and also deficiencies of pedicle flaps, the forearm radial island flap is known as one of the primary choices in most of the thumb soft tissue and hand defects reconstruction, due to its advantages, especially restoring the sensation of the injured site.

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## Introduction

Deficiency of soft tissue is very common in hand injuries. There are various methods for the coverage of wound in this area. Choice of the method depends on the site, size, shape, and depth of the lesion, and the skill of surgeon [1]. In this regard, the best technique is early reconstruction of the wound, although mostly it is not possible. In such cases, skin graft is a simple method for lesion coverage. By this method, appropriate hospitalization is required. In addition, when tendon, bone, joint, nerve, and arteries are naked, this method will not be useable [2-4]. Local and regional flaps are less employed due to the small size, being in injured site, and remaining scar [1, 2]. In such cases, most of the surgeons use pedicle flaps, especially groin or abdominal ones. The need for two operations, thickness, and lack of sensation are among drawbacks of pedicle flaps [4-6]. Thumb plays an important part in the hand function and in this regard is the most important finger. A thumb with improper coverage and inadequate strength can severely affect hand functions. In addition, sensation possesses unique position in hand, especially in thumb, in that if recovery of hand sensation was not possible, other reconstruction operations would not have indications. Thumb degloving is one of these injuries, which is accompanied by a large wound and avulsion of skin from

the hand and tendons. In such cases, due to the type and extent of the injury, skin grafting cannot be used. In addition to the significance of using thin, pliable, color-matched, and hairless cover in resurfacing the lesion in this area, recovery of sensation should also be taken into consideration. Although, free flaps possess all of these characteristics, but difficulty of implementation and the need for microsurgery have made it less employed [6, 7]. Forearm radial flap is one of the best choices in that regard.

This flap is at the same organ and so the need for preparation of two areas for operation is eliminated, is hairless in most people, and provides thin coverage for a wide variety of thumb defects. In most cases, this flap is transferred without sensation restoration; while, it is possible to restore sensation to the reconstructed area, by using medial or lateral sensory nerves of forearm and transplant them to the nerves of recipient site, resulting in functionality improvement [6-8].

In this study, 13 patients with thumb degloving, referring to Hazrat-e-Fatemeh Hospital, underwent sensate forearm radial island flap. Then, these patients were evaluated in a two-year follow-up period for the results and complications of reconstruction, and sensation level.

## Materials and Methods

In a clinical trial, sensation restoration level in patients who underwent thumb reconstruction by forearm radial flap was determined and compared with their normal thumbs. From 2001 to 2008, thirteen patients with full thumb degloving and intact forearm, referring to Hazrat-e-Fatemeht education and treatment center, Tehran University of Medical Sciences, stood as candidates for sensate reverse island radial forearm flap (Fig. 1). No age limit was set for flap transfer. Those with injured forearm did not undergo this type of flap surgery, due to the probable failure of radial or ulnar arterial blood flow. In addition, those who smoke more than a pack per day were treated with other pedicle flaps.

All patients were received general anesthesia. Allen test was undertaken before the anesthesia for all the patients to ensure radial and ulnar arterial blood flow. The tourniquet was used in all patients. By measuring the wound size and its distance from styloid process, flap size and also desired pedicle length were determined. Then, flap design was performed using these two factors in proximal forearm, in that the distance between distal flap and styloid process equated to the distance between wound and styloid process plus 3 cm (Fig. 2). Freeing flap along with radial artery and accompanied veins was carried out with loupe -4.5X magnification and according to standard method. In all flaps, first, proximal incision was executed. Then, lateral antebrachial cutaneous nerve of the forearm, with 5-6 cm length, was determined and relocated from proximal to allow neural transplantation at wound site (Fig. 3). After full flap and arterial-venous pedicle detached, it was transferred to the wound site. Through a longitudinal incision from styloid process to the wound, pedicle flap was relocated with perfect vision to prevent strain or sprain. After flap relocation, forearm lateral sensate nerve grafted to thumb digital nerve with 0-10 nylon and microscope magnification.

In two out of thirteen patients, thumb digital nerves were inappropriate or not found due to the extent of avulsion. In these patients, grafting was performed onto the sensory branch of the radial nerve. In all patients, flap donor site or thigh split thickness skin graft was covered. Patient had a plaster splint for 2 weeks, and after this time the suture were pulled and physiotherapy was started.

All patients were followed up for at least two years. During this period, they were examined regularly by occupational therapist and underwent monofilament, static two point discrimination (S-2PD), and moving two point discrimination (M-2PD) tests. The same tests were undertaken for patients' other thumbs and the findings were compared. The results were analyzed with SPSS-16 and significance level at 0.05 was set for *p*-value.

Regarding limited sample size, before using paired *t*-test for drawing comparison between the results from experimental and control groups, the normality of quantitative variables distribution in both groups should be proven first. In order to determine normality or abnormality of distribution, Kolmogorov-Smirnov test was employed. According to this test and regarding the significance level, the distribution was normal and so

paired *t*-test could be used. This test was undertaken for both groups.



Figure 1. Full avulsion of hand soft tissue

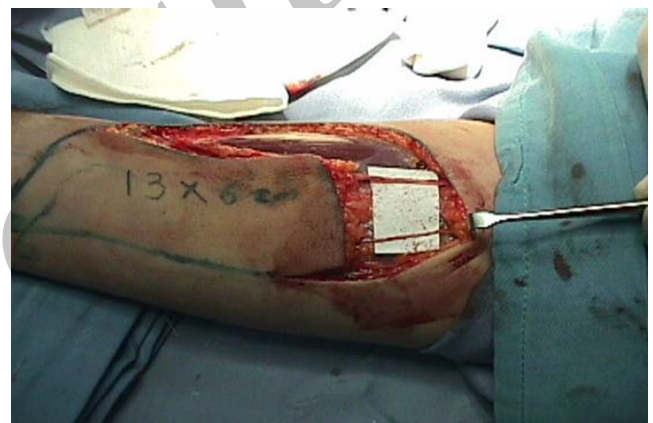


Figure 2. The detached flap along with forearm sensory nerves



Figure 3. Thumb reconstructed by flap

## Results

One of the patients did not show up for follow-up process. Therefore, remaining twelve patients were investigated. All of them were men from 14 to 56 years, with mean age of 28.2 years. In eight patients, the right

**Table 1.** The results of sensory tests undertaken for all patients

Patient	Monofilament test		S-2PD test		M-2PD test	
	Normal thumb [g (N)]	Flap [g (N)]	Normal thumb (mm)	Flap (mm)	Normal thumb (mm)	Flap (mm)
1	2.83 (0.07)	4.56 (4)	4-6	11-12	4-5	10-11
2	2.83 (0.07)	5.07 (10)	6-7	9-10	4-5	8-10
3	2.83 (0.07)	5.07 (10)	6-7	12-13	5-6	8-10
4	2.83 (0.07)	5.07 (10)	6-7	12-13	4-5	12-13
5	3.61 (0.4)	5.07 (10)	6-8	12-15	5-6	10-12
6	2.83 (0.07)	4.56 (4)	7-10	8-10	6-7	8-9
7	2.83 (0.07)	4.56 (4)	6-7	13-14	5-6	12-13
8	2.83 (0.07)	4.56 (4)	4-6	10-12	6-7	10-11
9	2.83 (0.07)	5.07 (10)	4-6	10-12	4-5	8-10
10	3.61 (0.4)	4.56 (4)	7-10	8-10	4-5	12-13
11	2.83 (0.07)	5.07 (10)	6-8	12-13	5-6	8-10
12	2.83 (0.07)	5.07 (10)	6-7	9-11	5-6	8-10
Mean	2.96 (7.5)	2.96 (7.5)	6.54	11.29	5.25	10.25

thumb and in four patients the left thumbs were injured. In addition, in nine patients the hand injury was dominant. In all cases, industrial accidents in the workplace were the cause of injuries. All flaps, except one, were reconstructed without complication. In one case, venous congestion and partial flap necrosis occurred.

The necrotic area was gradually reconstructed after dressing. The donor sites in all patients were reconstructed without complication. In three cases, the patients needed flap size revision or fat reduction. In these patients, at least three months after the first surgery, the flaps were reduced in volume and extra fat was removed. The results of sensory investigation into the relocated flaps and normal thumbs of the patients are presented in table 1. Results from monofilament tests for flap sensation indicated recovery at the level of protective sensation threshold without normal sensation restoration in any patients. The difference between monofilament tests and normal thumb was statistically significant ( $p=0.0001$ ). In spite of this, all flaps possessed protective sensation after two years.

In addition, according to S-2PD and M-2PD tests, the sensation restored in flap was at protective level or reduced, and the difference was statistically significant ( $p=0.0001$ ).

## Discussion

In this study, the degree of sensation recovery in the thumbs reconstructed with sensate flap was studied and it was demonstrated that the maximum level of recovery over a two-year period was at protective threshold. Healing the hand wounds is difficult, due to the presence of important elements such as nerves, vessels and tendons, thin and pliable skin, superficial bones, and strong sense in this area. Reconstruction of soft tissues of hand requires well knowledge of hand anatomy, sensory needs of this area, movement and appearance, reconstruction techniques including different flaps, and relevant clinical skill [1, 2].

Hand defects, especially thumb injuries, are very common. In case of thumb degloving, reconstructions of it with appropriate, color-matched, pliable, and durable cover and on top of that significant sensation recovery causes proper hand function and better appearance.

Without thumb, the majority of hand function will be lost [6, 7]. In the majority of thumb degloving injuries of industrial accidents, a large lesion (approximately 10×7 cm) occurs which cannot be resurfaced with local flaps or skin grafting [6, 9, 10]. In case of large defects, when skin grafting is not feasible, different flaps such as regional, pedicle, and free, introduced for hand reconstruction, are used. Despite several advantages of free flaps, it is technically more difficult than groin or abdominal pedicle flaps, and so less preferred to employ [2, 3, 6].

In such cases, as hand can be moved close to the abdomen or groin it is a simple operation with little complications. Despite these, this method has several drawbacks. These flaps are bulky, having unmatched color with recipient site. Moreover, it requires at least two surgeries along with secondary operation for volume reduction. In addition, hand should remain attached to abdomen or groin for three weeks which is extremely annoying to the patients [3, 6]. Over this period, the hand would have downward position and become inflamed. In addition, physiotherapy and occupational therapy are not feasible, which may cause joints stiffness. Consequently, these flaps are not recommended for elderly. For similar reason, groin and abdominal flaps are not recommended for children. One of the main drawbacks of these flaps is the lack of sensation recovery, even at protective threshold. Forearm radial flap was first developed in China in form of free flap for improving neck attachment and to reconstruct oral cavity after tumor resection. Then, this flap was used in antitrade and retrograde fashions in reconstruction of upper limbs [11]. In retrograde model, flap is perused by retrograde flow through the connection between radial and ulnar arteries. Additionally, flap vascular discharge is in retrograde fashion through bypass and crossover [1, 2, 12]. Despite several flaps introduced for hand reconstruction, forearm radial reverse flap is still largely preferred for hand reconstruction [13]. This is a very reliable flap, with easy and quick detaching process and chance of preserving sensation. Moreover, vascularized bone and tendon transfer, along with the flap, is possible [2]. Likewise, surgery is performed on single site, and so there is no need for preparation of other regions and prolongation of anesthesia and surgery durations. This flap is adequately large, thin and pliable and color matched. Removing the flap requires great care



to prevent damage to sensory radial nerve. If the flap pedicle was designed with proper length, it could also cover the fingers [2, 4, 14, 15]. Detaching radial artery is a drawback of this flap, which in some cases can cause malperfusion of hand. Undertaking Allen test for patients before performing this flap is obligatory. Some experts have recommended reconstruction of radial artery with a vein graft in all patients. Obviously, in case of ischemic symptoms in hand after detaching the flap, radial artery should be reconstructed. In addition, flap transfer in perforator flap fashion without removing radial artery is possible [2, 3, 5, 13, 16]. The second disadvantage with this flap is an ugly scar over the forearm, so it is not recommended for young women. It is possible to transfer this flap in fascia fashion alone, resulting in acceptable scar over donor site. In such cases, when the flap is transferred, it would be resurfaced with skin graft [1-3]. If the flap width was less than 4 cm, the donor site could probably be closed primarily. Otherwise, skin graft should be introduced [1, 8]. The most common acute complication of this flap is venous congestion. In such cases, leeches or anastomosis of superficial veins can be used for better drainage [2, 5]. In some patients with flap surgery for palm coverage, depilatory cream or laser hair removal is required for removing hair [2].

Posterior interbone artery flap is a good alternative for reverse radial forearm flap. However, it requires considerable skill and more challenging surgery, leading to higher risk of vascular injury. There is also the possibility of damage to the posterior interbone nerve [16, 13-18].

Free flaps are the best choice in several cases. Anterolateral thigh flap and cross-leg flap are the most applicable techniques in hand reconstruction. The possibility of transferring exactly similar tissues from less important and less exposed regions, possibility of sensation recovery, simultaneous bone, tendon, and muscle transfer, appropriate perfusion, and not being on injury site are among significant advantages of this technique.

However, the possibility of failure and the need for remarkably skilled surgeon for performing microsurgery inhibit the extensive use of this method [17, 18]. In this study, forearm radial flap in retrograde fashion with simultaneous forearm lateral nerve grafting was undertaken for 13 patients in order to resurface large thumb degloving injury. The results demonstrated that not only this flap provides adequate coverage but also when it was transferred in sensate form caused protective sensation. In spite of the fact that the sensation degree of flap site is considerably different from that of normal thumb, but recovery of sensation even at protective level in hand, and especially in thumb, considerably impacts the patient's hand function. This flap possesses its special position in reconstruction of upper limbs. In addition to trauma, this flap is useable in burns, infections and congenital malformations, especially in the first web space [19].

Regarding the difficulties of free flaps, the lack of surgeon with microsurgery skills, inaccessibility of required facilities, and pedicle flaps deficiencies mentioned earlier, it seems that forearm radial flap is the first choice for most cases of thumb soft tissue reconstruction and also hand defects, for following reasons: appropriate coverage, pliable skin, durability, relative color match, simple and quick surgery, applicable for all ages, acceptable donor site morbidity, and recovery of protective sensation.

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### Authors' Contributions

All authors had equal role in design, work, statistical analysis and manuscript writing.

### Conflict of Interest

The authors declare no conflict of interest.

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