

Sensate Reversed Radial Forearm Flap for Posttraumatic Missing Thumb Reconstruction: Long-Term Results

RAAFAT ABD AL-LATIF ANANI, M.D. and ALAA NABIL EL-SADEK, M.D.

The Department of General Surgery, Plastic and Reconstructive Surgery Unit, Faculty of Medicine, Zagazig University.

ABSTRACT

Since the popularization of microvascular toe transfer, there has been a tendency to relegate the old osteoplastic reconstruction techniques for the thumb to history. Due to cultural reasons, our patients usually refuse thumb reconstruction with sacrifice of one of the toes. The purpose of this study is to present the long-term results of thumb reconstruction with the osteoplastic technique using the sensate reversed radial forearm flap. It includes 9 patients with amputated thumbs. The amputation level was at the distal metacarpal bone in 5 cases and the proximal third of the proximal phalanx in 4 cases. The thumb length was restored by an iliac crest bone graft in 8 cases and the bony skeleton of the amputated thumb in one case. Reversed radial forearm flap was used to reconstruct the thumb skin in all cases. The flap was made sensate by inclusion of the lateral antebrachial nerve in the flap and coapting it to one of the digital nerves of the thumb. A new modification was added by harvesting the palmaris longus tendon within the flap aiming at adding power to the thumb by repairing its proximal end to the stump of flexor pollicis longus tendon and distally to the bone graft. The follow up period ranged from 26 to 61 months (mean: 45.7 ± 11.66 months). The long-term results of the new thumb were studied concerning its sensation, movement and cosmetic appearance. The static 2-point discrimination (S-2PD) of the new thumb approached that of the normal thumb but never reached its value. The prehensile functions of the new thumb were enough to meet the occupational requirements of the patients. The cosmetic appearance was accepted by all except the female patient. Thumb reconstruction with sensate reversed radial forearm flap wrapping an iliac crest bone graft or the skeleton of amputated thumb with inclusion of the palmaris longus tendon is a reliable option in manual workers. Due to cosmetic reasons, its use in female patients should be taken with caution.

INTRODUCTION

The thumb contributes approximately 40% of hand function. In the performance of prehensile functions, the thumb is indispensable, as it allows for both precision and power grips [1]. Thus, reconstruction of the thumb after traumatic amputations has been a subject of considerable importance to hand surgeons for many years [2]. In our com-

munity, toe to hand transfer or pollicization is usually refused by considerable number of patients. That is the reason of choice of osteoplastic reconstruction as a simple method to restore thumb length. However, the other requirements necessary for soft tissue coverage of the newly formed thumb are sensate skin, color match and a thin pliable texture [3-5]. Although various sensate free flaps have been introduced for these reconstructions, much of the time a non-sensate distant pedicle flap has been used with unsatisfactory results [2]. In this study, sensate reversed radial forearm flap wrapping a bone graft has been used for restoration of thumb length. Long-term sensory, functional and cosmetic results in the newly reconstructed thumb have been studied.

PATIENTS AND METHODS

Between June 2001 and May 2005, 9 amputated thumbs were reconstructed with a distally based sensate radial forearm flap with bone graft. Patients' data are summarized in Table (1).

Operative technique:

Allen test was undertaken before the surgery for all patients in order to evaluate the patency of radial and ulnar arteries. All patients underwent general anaesthesia with a pneumatic tourniquet fastened on the arm. Two teams of surgeons were working simultaneously, the first one for flap harvesting and the second for harvesting the bone graft. The flap dimensions were designed according to the size of the thumb to be reconstructed. A skin island was then marked along the axis of the radial artery retaining enough pedicle length and a pivot point of 2cm above the radial styloid process (Fig. 1). The flap was dissected in the usual manner [6]. Once the lateral ante-brachial cutaneous nerve of the forearm was located and identified at the distal

margin of the flap, 5-6cm of the nerve was dissected in the distal direction (to obtain enough length for neurotomy at the recipient site (Fig. 2). The new modification we added is the inclusion the palmaris longus tendon within the flap (Fig. 2). Iliac crest was the donor site of bone graft in 8 patients. In the remaining patient, the amputated non-replantable part of the thumb was available, so, its bony skeleton was prepared as a bone graft. The bone graft was fixed to the bony stump with a K-wire (Fig. 3 A,B). The flap was rotated distally to provide full wrapping of the bone graft (Fig. 4) after anchoring the palmaris longus tendon distally to the bone graft and proximally to the stump of flexor pollicis longus tendon to augment the flexion power of the new thumb. The lateral ante-brachial cutaneous nerve of the forearm was coapted to the digital nerve by an end-to-end microsurgical repair. The donor area in all patients was then covered with a split thickness skin graft from the lateral aspect of the thigh.

Following surgery, the operated hand was immobilized in a splint for one week. Immediately after this period, patients were entered into a rehabilitation program.

Follow-up period of the reconstructed thumbs ranged from 26 to 61 months (mean 45.7 ± 11.66 months). At an interval exceeding 26 months after surgery, the following variables were studied.

- 1- Sensation in the new thumb by measuring the static 2-points discrimination (S-2PD) of the reconstructed thumb, the skin of the contralateral forearm corresponding to the donor area of the flap and the volar aspect of the normal thumb for the purpose of comparison after flap transfer. Statistical analysis was done by Friedman non-parametric test for comparison of the three measurements. Paired sample *t* test was used for comparison of two measurements.
- 2- The daily activity of the patient in which the reconstructed thumb is used (prehensile function) including power grip and precision as well as satisfaction of the patient with the function of the new thumb in relation to his or her job.
- 3- The satisfaction of the patient regarding the cosmetic appearance of the reconstructed thumb and the donor site.

RESULTS

All flaps survived completely and the donor site healed without complications.

The values for S-2PD of the measured areas are summarized in Table (2). There was significant difference in the S-2PD between the donor area and the new thumb ($p < 0.001$). The difference between the S-2PD of the new thumb and the normal thumb was significant ($p = 0.001$).

All patients could use the new thumb in their daily activities. The power grips were accepted by all patients and were sufficient in relation to their jobs (Fig. 5). The precision functions like holding a screw driver, pencil, keys etc. were recorded by all patients (Fig. 6). The only complaint the patients suffered from, is the sliding of the skin over the underlying bone.

The cosmetic appearance was accepted by all male patients. They could communicate with the people without the need to cover their thumbs (Fig. 7). The remaining female patient could not expose the thumb and she was always wearing a textile glove. Her thumb was bulky that necessitated liposuction 6 months after the primary surgery to improve the appearance of the thumb (Fig. 8 A,B).

Table (1): Patients' data.

Age in years (Mean and SD)	22-44 (33±7.05)
<i>Gender:</i>	
Males	8
Females	1
<i>Occupation:</i>	
Carpenters	4
Agricultural workers	2
Plumbers	1
Porters	1
Teachers	1
<i>Level of amputation:</i>	
Proximal 1/3 PP	4
Distal MC	5

* Proximal phalanx = PP * Metacarpal = MC

Table (2): The S-2PD of the three measurement areas.

Measured area	S-2PD in mm range (mean ± SD)
Contralateral forearm	20-29 (23.44±3.12)
Normal thumb	4-10 (6.77±2.04)
Reconstructed thumb	8-15 (11.33±2.0)
<i>p</i> value	<0.001

Fig. (1): Design of the reversed radial forearm flap for reconstruction of an amputated thumb.

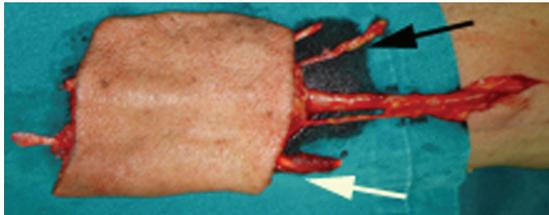
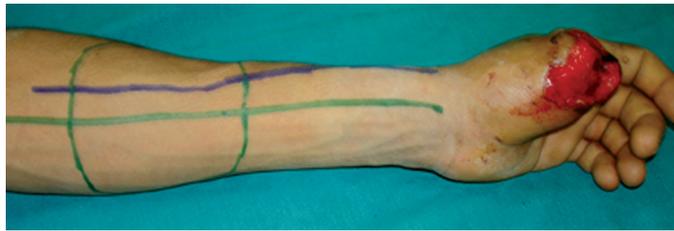


Fig. (2): The flap harvested with the lateral antebrachial nerve (black arrow) and palmaris longus tendon (white arrow) included.



Fig. (5): The power grip (the patient can hold an object of about 3 kilograms weight).

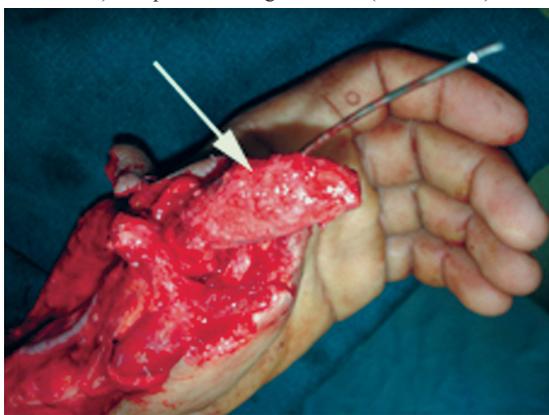


Fig. (3-A): The thumb length is restored with an iliac crest bone graft fixed with a K-wire (arrow).

Fig. (6): The precision function (the patient can hold the key).

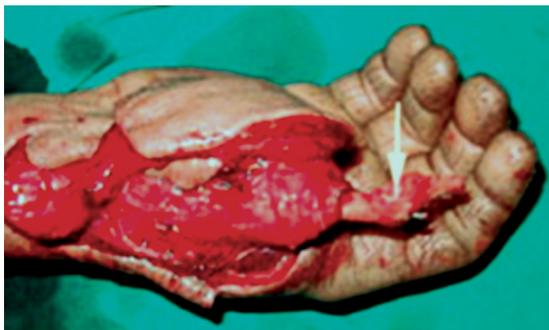


Fig. (3-B): The thumb length in another patient restored with the bony skeleton of the amputated thumb as a graft (arrow).

Fig. (7): The reconstructed thumb and donor site 36 months after surgery.



Fig. (8-A): The bulky reconstructed thumb in the female patient.



Fig. (8-B): The reconstructed thumb after debulking by liposuction 6 months after the primary surgery.



Fig. (4): The flap inset in place wrapping the bone graft.



DISCUSSION

Despite the elegant reconstructive options available for reconstruction of posttraumatic thumb loss [7], the best results are obtained with replantation or revascularization whenever possible. The treatment plan must be always derived from a careful assessment of each patient's posttraumatic function and specific reconstructive needs.

The best options available for thumb reconstruction are either polycization [8-10] or toe to hand transfer [11-15]. Those options are usually refused by the low educated patients in our community like the manual workers who represent the majority of patients with lost thumbs. This may be due to cultural or religious reasons. So, the choice of another option is mandatory, otherwise, the life of these patients will suffer tremendously. Osteoplastic methods of thumb reconstruction were described. The amputated thumb length is restored by addition of a bone graft and wrapping it with a piece of skin to simulate a normal thumb [7]. We agree with Kazuteru et al. [11] that this option will be useful only if there is some muscles are still acting on the remaining part of the thumb. At least the small muscles of the thumb should be functioning. That is why we chose the patients with the level of amputation through the distal metacarpal bone or through the proximal phalanx.

Osteoplastic thumb reconstruction is commonly done with the distant pedicle flap such as the groin and the abdominal flap. These flaps suffer a number of disadvantages such as hand attachment to another part of the body for three weeks, oedema secondary to the dependent position, delay in starting hand rehabilitation program, two-stage surgery and resurfacing with non-sensate skin [16-18].

There is no doubt that foot skin with its sensory modality provides a good option but the operation necessarily requires microsurgical expertise. It also involves some risk of failure and many patients are reluctant to permit harvest of tissue from another part of their body, especially the foot [4,5,18-21].

After introduction of the distally based radial forearm flap, it was widely adopted for hand reconstruction. It is extremely reliable, dissection is relatively easy, large skin paddles can be transferred, microsurgery technique is not required and the donor site is confined to the same extremity [3,6,22]. It has been used as an osteocutaneous flap [3], however, fracture of the remaining part of the radius in the forearm has been reported.

The sensate radial forearm flap has been reported for the reconstruction of the hand [19,21]. In our study, the S-2PD in the reconstructed thumb changes significantly and approaches that of the normal contra-lateral thumb but it never reaches the normal measurements (Table 2). Although the S-2PD of the new thumb is less than that of the normal thumb, the sensation of the thumb was enough for the daily requirements of our patients. This agrees with previous reports [19,21]. The results suggest that sensory return in the innervated flaps is influenced not by the donor nerve in the flaps, but by the recipient digital nerve. A point to be mentioned here is that we harvested the lateral antebrachial cutaneous nerve of the forearm starting from the distal margin of the flap. Others harvested the nerve from the proximal margin of the flap [19,21]. The final sensory outcome was comparable. We found that the size of the nerve distally is comparable to that of the digital nerve which makes the coaptation better. Harvesting the nerve from the distal margin of the flap leaves enough length after flap rotation that makes nerve repair easier without any tension.

The S-2PD reported with the more sophisticated techniques like wrap around toe skin transfer [11] or whole toe transfer [15] lie around 10 mm. The S-2PD of the reconstructed thumb in our report lies in the range of 8-15 mm which approaches this figure. In a trial to increase the S-2PD of the reconstructed thumb, Omokawa et al. [5] combined the innervated radial thenar flap with the radial forearm flap.

Although the majority of patients in our study were manual workers, no one of them complaint of trophic changes or ulcerations. However, with the start of recovery of sensation, all patients complaint of cold intolerance that disappeared by time.

The function of the newly reconstructed thumb was enough to meet the needs of the daily activity of the patients in this series. Being manual workers, they do not need the ultrafine functions of the thumb that are needed by more fine jobs like computerists, surgeons, pianists etc. The power grip function is the main function needed for this group of patients and this was reported by all patients. All the patients could lift heavy weights of 2-3 kilograms against gravity between the thumb and other fingers. The new modification we added by anchoring the harvested palmaris longus tendon within the flap to the bone graft distally and to the stump of the flexor pollicis longus tendon proximally may add power to the newly reconstructed thumb.

Even, the more fine function of the thumb, the precision, could be reported by the patients. They could use the screw driver in their jobs, pencils in writing, comb their hairs, hold the keys, hold spoons and knives etc. Similar results were reported by Sabapathy et al. [23]. However, the reconstructed thumb could not be used in some daily activities of our patients like dealing with buttons of clothes, tie of shoes. However, they were generally satisfied with the thumb function.

A notice to be mentioned is the sliding of the skin overlying the underlying bone of the newly reconstructed thumb that was reported by all patients. This is obviously due to the different quality of the skin of the forearm from the glabrous skin of the volar aspect of the fingers. However, all patients were adapted to this problem and learnt how to overcome it by holding the objects firmly to stabilize the skin over the underlying bone.

Except the female patient, all patients exposed their thumbs and they found no problems with the communication openly with the people. Only, the female patient found the reconstructed thumb unpleasant in its appearance, that is why, she was always wearing a textile glove. Except in obese patients, the radial forearm flap is thin and needs minor revision after transfer [3]. The female patient needed debulking of the flap by liposuction to decrease the size of the reconstructed thumb to be comparable to the normal one. This resulted in delay of the final recovery of sensation in comparison to other patients.

In General, this modality of reconstruction can not be considered equal to that of toe to hand transfer [15] either from the functional or cosmetic aspect, but it gives a simple alternative in a selected group of patients in our community.

Conclusion:

In selected group of patients, the distally based sensate radial forearm flap wrapping a bone graft is a relatively good option for reconstruction of the amputated thumb at a level through the distal metacarpal or the proximal part of proximal phalanx. It provides reliable skin cover, useful sensation, reasonable power grip and precision function that meet the needs of manual workers. The inclusion of palmaris longus tendon to reconstruct the flexor pollicis longus tendon seems to add power to the newly reconstructed thumb. In spite of the good functioning outcome, this modality of reconstruction seems to be not accepted aesthetically by female patients.

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