


Utility of “reposition-flap” in the reconstruction of the avulsed thumb

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Abstract

Injuries that result in thumb amputation cause a loss of 50% of hand function. Microsurgical replantation remains the gold standard of thumb reconstruction techniques. The non-microsurgical technical variants of thumb reconstruction described so far aim to create a neo-thumb of adequate length, stable, opposable, sensitive, and last but not least esthetically pleasing appearance. Avulsion of the distal phalanx and the absence of the nail will determine a functional deficit but also an unesthetic appearance. When replantation is not possible or the patient refuses to “sacrifice” another anatomical region for thumb reconstruction, the “reposition-flap” technique can be used. Although often controversial, this surgical technique deserves proper attention and should be used in some cases. We studied a group of 32 patients with distal thumb amputations. In patients with amputations in zone II according to Tamai, with interphalangeal joint preservation, the thumb was reconstructed using “reposition-flap” with an O’Brien flap in 15 cases. In the remaining 17 cases where the amputation was at the level of the interphalangeal joint, we used the same technique, but the thumb neopulp was reconstructed with the Littler heterodigital neurovascular flap harvested from the ulnar border of the middle finger in 11 cases or radial border of the ring finger in 6 cases. The results were evaluated from a functional (Kapandji score), sensitive (2-point discrimination, Semmes-Weinstein test) but also esthetically (patient satisfaction) point of view. Donor site morbidity, cold intolerance, the presence of nail dystrophy, and bone resorption were also assessed. The disabilities of the arm, shoulder and hand score was evaluated for each patient. Although various surgical and microsurgical techniques for thumb reconstruction are described, when choosing the technique to use we must first consider patient’s wishes. A well-informed patient will be able to make, with the surgeon, the best decision for him concerning the reconstruction option.

Abbreviations: 2PD test = two point discrimination test, DASH = the disabilities of the arm, shoulder and hand, IPJ = interphalangeal joint, P = phalanx.

Keywords: avulsion, flap, reconstruction, thumb

1. Introduction

It is always recommended that the thumb, the most important functional segment of the hand, be reconstructed or replanted in case of complex traumas or amputations.^[1] Trauma to the hand, thumb, and long fingers are common, and the causes are varied.

There are cut, crush, and avulsion injuries as well as their associations produced by various industrial, agricultural, domestic equipment.^[2] In cases of thumb injuries, the goal of surgical treatment is to preserve its length, mobility, opposition, sensitivity, and last but not least its appearance.^[3–5]

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Numerous thumb reconstruction techniques have been described over time.^[6] Of course, in thumb amputation microsurgical transplantation is the gold standard.^[7,8] In cases where this is not possible the result of the selected surgical technique should be a thumb of adequate length, opposable, with possible thumb-digital pinch, that should be sensitive and look as similar as possible to the contralateral thumb.^[9]

The challenge in choosing a reconstructive technique is even greater when the patient refuses to “sacrifice” his/her toe. The most appropriate technique is to be chosen depending on the amputation level, size of the amputated segment, cause of injury, patients’ age, associated conditions, occupation, and especially his/her wish.

“Reposition - flap” is a combined procedure that consists of the association of a free composite graft of the bone-nail bed complex and a homo- or heterodigital island or pedicle flap.^[7] Although this technique is quite “controversial” because it can result in nail dystrophy, joint stiffness, or an inadequate length of the reconstructed finger, it can be used successfully in many cases, especially when there is no other technical solution.^[7]

In Tamai zone II amputations we used the “reposition-flap” technique as a combined technique, using O’Brien flaps and Littler neurovascular heterodigital flaps for thumb reconstruction. This technical variant was chosen when replantation was not possible due to the crush-avulsion mechanism or when the informed patient did not agree with the use of a remote anatomical segment.

The purpose of this study is to highlight the effects of the utilization of “reposition flap” technique where microsurgical replantation is not possible and to show the value of the utilization of different flaps for thumb reconstruction, including the neurovascular island flap (Littler), as well as to appreciate the results of this techniques.

2. Materials and methods

We studied 32 cases of injuries to the distal phalanx (P) of the thumb up to the interphalangeal joint (zone II according to the Tamai classification), admitted to the Clinic of Plastic Surgery and Reconstructive Microsurgery of Emergency Clinical Hospital from Iasi, Romania between January 2013 and December 2017. The inclusion criteria were: adult patients, avulsion trauma with complete amputation of the thumb in the Zone II according to Tamai, technically impossible microsurgical replantation, patients that refused other microsurgical reconstruction technique (toe to hand transfer). The exclusion criteria were: patients under 18 years old, other mechanism of trauma than avulsion, incomplete amputations or amputations at other levels than Tamai II, cases in which microsurgical replantation was feasible, cases in which patients accepted other microsurgical technique. All patients were informed about the surgery, so informed consent was obtained from all patients. Twenty-three patients (72%) were men and 9 (28%) women, aged between 25 and 68 years. In 19 of the cases (59.37%) the thumb of the dominant hand and in 13 cases (40.62%) the thumb of the non-dominant hand were involved (Table 1).

2.1. Surgical techniques

All cases had indication for reconstruction and the surgeries were performed under loco-regional anesthesia, an infra-clavicular block with 1% lidocaine with adrenaline in solution 1:400,000 in exsanguinated field using the tourniquet placed on the arm. After

Table 1

The report’s cases.

Number of cases	32
Sex	23M/9F
Age	25–68 y
DH	19
NDH	13
Mechanism of injury	Crush/avulsion
Amputation level	15P2/17IPJ
Agreement of toe transfer	none
“reposition-flap”	15O’Brien flap/ 17 Littler flap

DH=dominant hand, F=female, IPJ=interphalangeal joint, M=male, NDH=non-dominant hand, P=phalanx, y=year.

having been informed, all patients refused to “sacrifice” the toe as well as a longer hospital stay. All patients included in this report with amputation at the level of the interphalangeal joint (IPJ) were informed and accepted they would no longer have mobility in the IPJ, also refusing the transfer of a toe. In this situation, we opted for the reconstruction of the avulsed thumb by “non-microsurgical replantation” using the “reposition-flap” technique. In the 17 cases of amputation at IPJ level (defects over 1.5 cm), after removal of all soft tissue and preservation of the bone and nail apparatus (nail bed and plate) and 3 mm of periungual skin, the bone fixation with 2 crossed Kirschner pins was achieved and then Littler heterodigital neurovascular flaps raised in 11 cases from the ulnar aspect of the third finger (when segment to be covered was large), and in 6 cases from the ulnar aspect of ring finger were used to cover the osteosynthesized distal segment. The size of the used heterodigital neurovascular flaps ranged from the length of one ring finger phalanx to a length equivalent to 2 middle finger phalanges (1.5–5 cm). The design of the Littler flap followed its classic description.^[10] In 5 cases the defect was large (4.5–5 cm) and therefore the flap was harvested from the entire length of both phalanges of middle finger (5 cm). In these situations, after dissection and skeletonization of the neurovascular pedicle, the flap transfer to the recipient sites, was made through the skin incision in the thenar area. In 6 of the cases, tunneling was used when the flap size was smaller (<4 cm). The flap donor site was covered with split-thickness skin graft harvested from the ulnar border of the forearm. The donor site of the skin graft healed by re-epithelialization. Littler flap was brought to the recipient bed and sutured with separate threads to the preserved skin to create roundness of the neothumb pulp (Fig. 1).

In distal phalanx amputations (15 cases) we used the same technique, except it was an O’Brien flap that was associated. The amputated distal segment was processed by complete removal of the thumb pulp to the bone, with preservation of the nail complex and bone support, as well as of a 3 to 4 mm strip of periungual skin. The bone was perforated in several places, at different depths, to favor bone nutrition of the flap with which it will be covered. The nail was also perforated in 2 to 3 points to promote drainage. Osteosynthesis was performed with 2 Kirschner crossed pins. The osteosynthesized segment was then covered with an O’Brien flap, the size of the defects being <1.5 cm. The flap was sutured with separate threads in the receiving bed (Fig. 2).

The remaining defect at the base of the thumb due to flap advancement was covered with the skin graft harvested from the hypothenar eminence (Patton graft) (Table 2).



Figure 1. “Reposition-flap” with heterodigital neurovascular flap (Littler). (A) Thumb avulsion, (B) osteosynthesis of the distal segment, (C) defect coverage with Littler flap.

In all cases, the viability of the flap and the “replanted” segment was assessed by monitoring the appearance, turgor, capillary refilling, and nail and periungual skin color. During the first 3 postoperative days, heparinized serum with the role of “biochemical leech” was applied locally, at the level of nail perforations. Length of stay ranged from 3 to 7 days (well below after free transfers or microsurgical replantation).

Patients were followed-up monthly in the first 2 postoperative months, then at 6 months, 1 year, and 2 years by assessing thumb mobility with Kapandji scale, neopulp sensitivity with 2 point discrimination test (2PD), and Semmes-Weinstein monofilaments test, disabilities of the arm, shoulder and hand (DASH) score, cold intolerance, nail dystrophy, radiological evaluation of bone resorption, the morbidity of the flap donor site, and last but not least the degree of patient satisfaction and their socio-professional reintegration assessed by questions from Michigan Hand Outcomes Questionnaire.

3. Results

In terms of flap viability, the results were good, with no recorded cases of ischemia or necrosis.

In one of the cases in which the Littler heterodigital neurovascular flap was used, there was a decrease in venous

return, in which case we used biological leeches (hirudotherapy) for 3 days (2leeches/d) with good results, without the need for reoperation. Leech therapy was initiated at the first signs of venous congestion. This complication occurred when the Littler flap was transferred by the subcutaneous tunneling technique. Neothumb function and sensitivity were assessed monthly for the first 2 months, then at 6 months, 1 year, and 2 years, kinetic therapy being recommended to all patients. It should be noted that some patients showed poor adherence to the program prescribed by the physiotherapist. Thumb mobility was assessed with the help of Kapandji Score (Fig. 3).

The recorded scores ranged from 6 to 9 on the Kapandji scale, obviously with much better results when the O’Brien flap was used, situation in which the IPJ was preserved. The SW test revealed diminished protective sensation in the Littler flap compared with the O’Brien flap at 1 year postoperatively, which was expected, with a slight improvement at 2 years, thus showing a mild adaptation of the receptor system to constant pressure. The two point discrimination test (2PD) test evaluates the innervated density of rapidly adapting mechanoreceptors. One year after surgery, the 2PD test result was 6 to 7mm in the patients in which the Littler heterodigital neurovascular flap was used, which considered as a good result.



Figure 2. “Reposition-flap” with O’Brien flap. (A) Distal amputation of the thumb, (B) osteosynthesis of the distal segment, (C) defect coverage with O’Brien flap.

An improvement was found 2 years after surgery in young patients (up to 35 years old) who adhered to the recommended kinetic therapy program. Thus, in 4 cases the results of the 2PD test at 2 years after surgery ranged from 4 to 6 mm when the neothumb was reconstructed with Littler flap. In cases where the O’Brien flap was used, the results of the 2 PD test were much better, the recorded values being close to normal (Fig. 4).

Regarding the radiologically assessed bone resorption, there was a bone loss between 0% and 30% with both flaps (O’Brien and Littler). Bone resorption of 25% was found in 3 cases (in which O’Brien flap was used, patients over 60 years) leading to

claw nail. In the cases using Littler flap the bone resorption was between 0% and 20%. The patient satisfaction was assessed based on questions from Michigan Hand Outcomes Questionnaire referred to overall hand function, activities of daily living and work, pain, esthetics, and satisfaction (Fig. 5).

At the evaluation of the Littler’s flap donor site with 2PD test, we obtained values of 6 to 7 mm at the skin grafted area, which values indicate hypoesthesia. The mobility of the donor finger was maintained normal.

These esthetic results were better when the Littler flap was used because its size made possible a better modeling at the receiving

Table 2

Surgical techniques used.

Surgical technique	“Reposition flap” with O’Brien flap	“Reposition flap” with Littler flap
Cases	15	17
Flap size	1.4–1.7 cm (mean—1.6 cm)	1.8–5 cm (mean—4 cm)
Donor site	Thumb	11 cases—middle finger 6 cases—ring finger
Donor site covering	STSG from hypothenar region (Patton graft)	STSG from forearm
Flap’s transposition to the recipient site	Advancement	11 cases—skin incision 6 cases tunnelization

cm = centimeters, STSG = split-thickness skin graft.



Figure 3. (A–C) Thumb mobility results (Kapandji Score).

area level ensuring adequate roundness of the neopulp. In only one of the 32 patients a re-intervention was requested 1 year after surgery to improve the esthetic appearance of the thumb neopulp (Table 3).

One year postoperatively, the degree of disability of the affected hand was assessed by calculating the DASH score. DASH scores were low with both used surgical techniques, indicating good and rapid socioeconomic reintegration. The most commonly affected DASH score items were: writing, opening a jar, and using a knife in the kitchen.

4. Discussions

Thumb reconstruction or replantation is always indicated. According to Heitmann and Levin, the goals to be considered in thumb reconstruction are stability at the IPJ and metacarpophalangeal joint, sensate and non-tender thumb tip, adequate strength to resist the forces of the fingers, correct posture and positioning of the thumb with a wide webspace, and mobility of the carpometacarpal joint with intrinsic muscles to aid prehension.^[11] All these can be obtained when the chosen surgical technique preserves the length of the thumb as close as possible to the normal one. The pursuit and achievement of the above-

mentioned goals are aimed at ensuring the best possible pinch, fine manipulation, and power grip.^[12]

Injuries to the thumb have various causes, mechanisms of action, and levels of injury. All this will influence the choice of surgical technique for thumb reconstruction. Therefore, replantation is not always possible and the choice of another surgical technique will depend on patient's age, overall health, functional demands, level of injury, mechanism of action, associated lesions (lesions of the long fingers, thenar eminence, other segments of the upper limb) and dominant hand.^[13] Patient agreement should be obtained taking into account his/her requests given the resulting donor site morbidity. In the current report, patients refused a toe-to-hand transfer and in a few cases, the absence of interphalangeal joint, too.

“Reposition-flap” was first described by Mantero in 1975 as a 2-time technique using a cross-finger flap at that time.^[14] In 1992, Foucher was the first to modify this technique to achieve an intervention “all in one-time.” The tissue from the palmar surface of the amputated segment was completely excised followed by realignment of bone and nail complex and its fixation to the proximal stump. For the pulp reconstruction it is recommended to use an innervated flap.^[15] In 1997 Dubert made negative remarks on the “reposition-flap” technique, reporting unsatis-



Figure 4. (A) SW test and (B) 2PD test. 2PD test=two point discrimination test, SW test =Semmes-Weinstein test.

factory results with 100% clubbed nail.^[16] In 2014, Robert reported that in a study of 51 patients only 5 developed nail dystrophy. However, patient satisfaction was maximal.^[7]

Our results support his findings, namely of the 32 patients in only 3 cases (patients aged over 60 in whom O'Brien flap was

used) clubbed nail and nail dystrophy were recorded. However, the degree of satisfaction was maximum among these patients, compared with the appearance of a stump completely deprived of nail. Also, Braga-Silva in 2001 reported 2 cases of clubbed nail in a group of 30 patients. In these 2 patients the soft tissue defect

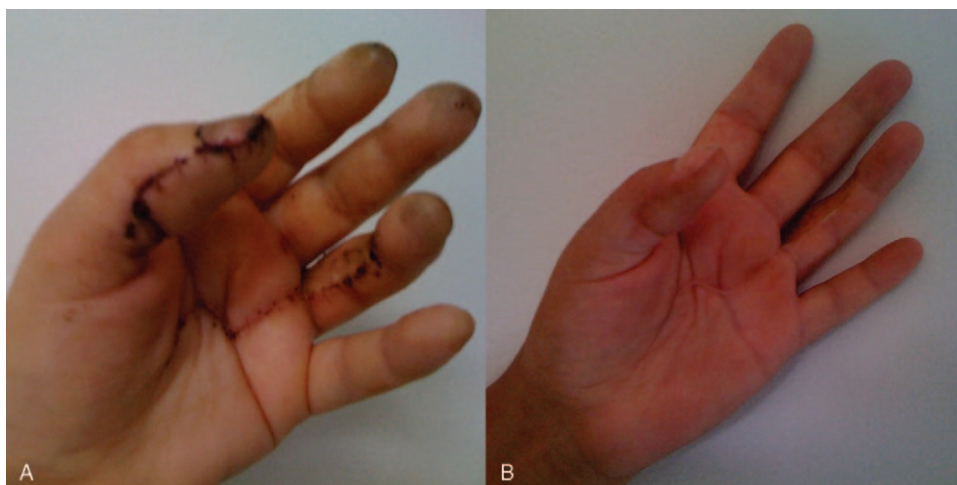


Figure 5. (A, B) Esthetic results in "reposition flap" with Littler flap reconstruction.

Table 3
Results.

Surgical techniques	“Reposition flap” with O’Brien flap	“Reposition flap” with Littler flap
Number of patients	15	17
Flap survival	15	17
Kapandji score	8–9	6–8
Cold intolerance	0	0
Claw nail	3	0
Bone resorbion	0–20%	0–25%
SW test	Green-blue	Blue-purple
2PD test, mm	Mean—4 mm	Mean—6 mm
DASH score	Mean—4.8	Mean—5.6
Patient satisfaction	+++	+++
Return to work/daily life activity (weeks)	Mean—6	Mean—6

2PD = two point discrimination, DASH = disabilities of the arm, shoulder and hand, mm = millimeters, SW = Semmes-Weinstein.

was covered with Atasoy flap, flap which can achieve only a slight advancement.^[17] Given all the above, we can conclude that the possible occurrence of clubbed nail or claw nail using the “reposition-flap” technique is far from being a sufficient criterion to contraindicate it.

To prevent the claw nail when using reposition-flap techniques, we believe that the quality and vascularization of the flap intended to revascularize the replanted fragment are of utmost importance. For these reasons we strongly recommend the use of the Littler heterodigital neurovascular insular flap with this technique, as no such complication as nail deformities, bone resorbion, or deficient fracture site consolidation occurred in the cases in which this flap was used.^[18] In our report we also used the O’Brien flap in cases with large defects, for better coverage of the pulp, the esthetic outcome being better than the “controversial” Littler heterodigital neurovascular insular flap.^[19]

The Littler flap is relatively “controversial” due to its disadvantages. Although at the time of its description by Littler in 1960 it was an effective way of covering large thumb pulp, later, donor site morbidity and cortical reintegration of the neopulp became topics of debate.^[10] The advantage of using this flap is the possibility of providing (for thumb pulp reconstruction) a sensitive skin island, with texture and qualities similar to the lost one, the functional and esthetic sequels compared with the advantages of this flap being insignificant.^[20] The rotation arch of the flap is large and thus it can be oriented to cover the receiving area properly and can be shaped as needed. The main disadvantages of the technique, detected over time, were related to the possibility of cortical reintegration of the neopulp, which is often slow, its tactile sensitivity remaining at the level of the donor site.^[21] Donor site morbidity is also a topic of debate. Overtime, attempts have been made to reduce these disadvantages. A division of the digital nerve innervating the flap and reanastomosis of this nerve to the proximal nerve end of the ulnar digital nerve of the thumb was attempted.

The esthetic and functional outcomes did not differ much from those obtained using the classical Littler technique.^[22] The phenomenon of “double sensitivity” was solved by nerve reanastomosis. According to mean values of 2PD test, the results were better when using the classical Littler technique. Attempts have also been made to modify the technique at the same time as

reanastomosis, nerve reanastomosis being done to any digital collateral nerve of the traumatized thumb.^[22] Paresthesias were found to be more common when the classical Littler technique was used. The Semmes-Weinstein and 2PD static and dynamic tests showed no significant differences in the case of nerve reanastomosis compared with the classical technique. Cortical reintegration of the neopulp was much better when using the modified technique.^[23]

With its advantages and disadvantages, the Littler flap remains one of the most used techniques in thumb pulp defect coverage, with the above mentioned indications.^[21,22] The results of the current report were satisfactory in terms of cortical reintegration of the neo-thumb. The most common and feared complication is compromising vascularization, as it is the case with all flaps used at hand level. The Littler flap has a low rate of vascular complications, <1%.^[24–26] The arterial supply of the flap is based on a robust artery that will not usually cause deficient perfusion, but being an island flap the venous return is only through the comitant veins, which can be twisted or compressed when the flap is placed over the defect. Thus, venous congestion, although extremely rare, is the most common complication of the Littler flap reported in the literature. Also for these reasons, several authors suggest avoiding subcutaneous tunneling of the flap.^[27–30] Venous congestion has been present in only one of the case studies and has been managed by applying leeches since the first signs of venous congestion. The condition of the flap had improved in 3 days, without necrosis or need for flap revision.

All 32 patients of current report were fully satisfied with neothumb function and appearance although in 8 patients, the IPJ mobility was not recovered. As in the study by Choo et al^[7] in which 5 of the 51 patient studies developed claw nail, this did not diminish patient satisfaction at all. Similarly, in our report, the presence of nail dystrophy did not influence patients’ full satisfaction with the esthetic appearance of the nail and, implicitly, with the reconstructed finger. Socio-professional reintegration was 100%, not requiring changing the job or the current activities done by patients before the accident.

5. Conclusion

Finger injuries are common. Replantation remains the gold standard for digital reconstruction. When replantation is not possible, various reconstructive techniques can be used. Selecting the right reconstructive technique is a real challenge for any surgeon, even more so when the patient refuses to “sacrifice” another anatomical region. There are techniques which although “controversial” at one time, when used have the best results. The use of Littler’s flap has the advantage of a better blood supply, avoiding or minimizing the bone resorbion or claw nail. Also, the Littler’s flap brings enough soft tissue to shape a neopulp with best esthetic result. The cortical reintegration of the neopulp is possible and with satisfactory results when the patient respects the recovery program. The aspects considered by the surgeon “disadvantages” (claw nail) do not influence in any way patient satisfaction, and thus cannot be considered contraindications to the use of a certain surgical technique (“reposition-flap”) according to the results of this study. Although numerous and varied surgical techniques are described, the selection process has to take into account, first of all, the needs and desires of the patient previously informed as completely and correctly as possible.

Author contributions

Mihaela Pertea and Bogdan Veliceasa contributed in the manuscript drafting and critical revision, Petru Ciobanu contributed in the analysis and interpretation of patient data, Mihaela Pertea, Natalia Velenciu, Sorinel Lunca, and Vladimir Porocho contributed in the conception and design of the report. All authors read and approved the final manuscript.

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