REVIEW ARTICLE

STEP LADDER ABDOMINAL FLAPS IN HAND RECONSTRUCTION: A REVIEW

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ABSTRACT: INTRODUCTION: There are situations where the skin is lost along with soft tissues on many fingers at the same time. They may or may not be associated with fractures. The reconstruction of such defects is important to regain both form and function. Traditionally, such multiple defects are reconstructed by converting the multiple defects into a single defect by creating a surgical syndactyly and then planning a skin cover for that defect. This method of reconstruction, though appeared simpler, has the disadvantage in that multiple stages are added to the reconstruction process. Hence subsequent procedures like syndactyly release, flap thinning, underlying tendon reconstruction are delayed, ultimately delaying the patient's return to useful work. It not only involves more time, but also results in more scar formation during the intervening period, resulting in more effort required at physiotherapy. The other method of reconstruction is by using multiple flaps at the same time for the coverage of the defects. This may be achieved by the louvre abdominal flaps or the step ladder abdominal flaps. Barring a few reports of isolated cases for whom step ladder abdominal flaps have been used,[(1)(2)] there are no papers in literature reviewing these flaps for hand reconstruction.

KEYWORDS: Hand Injuries, reconstruction, Flap, Surgical recovery of function rehabilitation.

CAUSES: The common situations where we come across such multiple finger defects are road traffic accidents and industrial injuries. Road traffic accidents involve frank loss of skin along with friction burns. These areas of skin loss are usually on the dorsum of the hand or fingers and typically on the radial borders of multiple fingers.

The areas of friction burns must also be taken into consideration and areas of deep II° burns and III° burns must be treated accordingly. III° burns can be recognized by the whitish color or sometimes, charred appearance. These areas must be excised as they denote full thickness skin loss. Even though II° burns may heal on their own, they do so with the following attendant problems.

a) They may heal with hypertrophic scarring that may restrict function and may also be cosmetically unacceptable.
b) They may get converted to full thickness burns in the situation of infection, and result in raw areas that may require further skin cover.
c) These areas of II° burns may heal erratically with some residual raw areas, resulting in healing by secondary healing and the attendant problems of thin adherent scars, or contractures.
d) When a flap cover is planned for the areas of the full thickness loss only, the inset of the flap has to be given to the areas of partial thickness burns only, as these areas of II° burns are contiguous with the areas of full thickness loss. In such situations, a delayed healing of these II^{0} burn areas can compromise the vascularity of the flap.

There may be associated injuries like tendon injuries, fractures or other soft tissue injuries.

EXAMINATION: The examination of such wounds is done in the usual manner and the following points are noted:

- Hand involved
- Fingers involved
- Area and size of the apparent skin loss
- Area and size of the surrounding friction burns/injury and estimating the true skin loss/defect
- Associated injuries like tendon injuries/loss, fractures with or without loss of bone, joint capsule injury leading to instability

DECISION MAKING: The decision making as in the treatment of all skin defects on the hand should start with the management of the vascularity, bone, tendons, nerves and then consider the skin cover. If there is a problem of viability of the finger or fingers, the possibility of re vascularizing the fingers should be done before planning the skin cover. In the process of revascularization, the fractures can be dealt with, the tendons and nerves repaired if there is a loss of a segment of bone or tendon or nerve, two options are available.

A. The tissue defect is made good with either bone/tendon/nerve reconstruction or immediate water tight skin cover may be given in the form of a pedicled regional flap like a radial forearm flap or posterior interosseous flap, or a microsurgical flap in the form of an anterolateral thigh flap or a lateral arm flap. This would be an ideal plan.
B. The second option is to plan for a staged reconstruction. The skin cover can be done first, like a step ladder abdominal flap or an inferiorly or superiorly based abdominal flap, and the individual tissue defects can be reconstructed later when the flaps settle and tissue homeostasis is achieved. This is the less ideal method, but more practical since it may not be always that ideal conditions, like availability of microsurgery infrastructure, time and expertise, are available.

THE OPTIONS FOR RECONSTRUCTION ARE:

- Surgical syndactyly and abdominal flap / bipedicled abdominal flap cover.
- Surgical syndactyly and pedicled regional flap cover.
- Surgical syndactyly and free vascularized microsurgical flap cover.
- Step ladder abdominal flap.

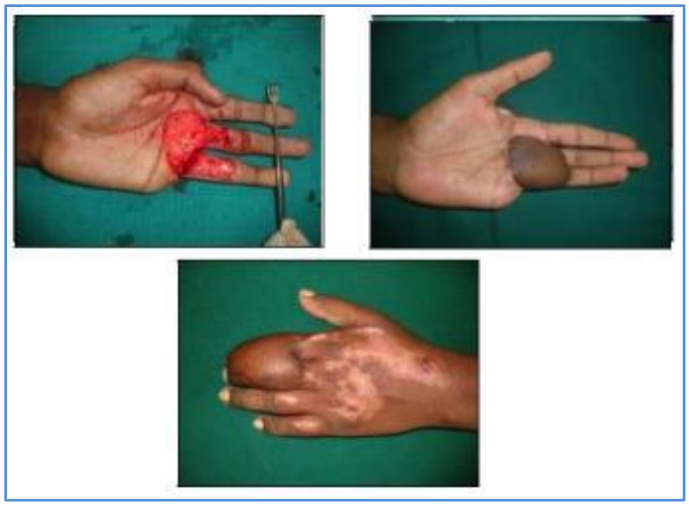

Fig. 1: Patient with defect in the proximal phalanx and distal palm reconstructed With Step ladder flaps and another patient with syndactyly

- If the defect is mainly on the dorsum of the hand and extending on the dorsum of multiple fingers but not extending beyond the interphalangeal joint – surgical syndactyly and flap.
- If the defect is on the dorsum of the hand and extending on the dorsum of multiple fingers and extending beyond the interphalangeal joint – step ladder abdominal flap.
- If the defect is mainly on the palm of the hand and extending on the volar aspect of multiple fingers– surgical syndactyly and flap.

Fig. 2: Final result after release of syndactly

- If defect is only on dorsum of fingers proximal to IP joints, abdominal flap
- If defect is only on dorsum of fingers distal to IP joints – step ladder abdominal flaps
- If defect is only on the volar aspect of multiple fingers – surgical syndactyly and superiorly based abdominal flap cover.
- If the defect is on the distal aspect of the volar aspect of multiple fingers, step ladder abdominal flaps are ideal.

Fig. 3: Four finger injury with 3 step ladder flaps

Fig. 4: Flap inset and final result after flap division

COUNSELING:

POINTS TO BE DISCUSSED WITH THE PATIENT:

- The nature of the injury must be explained to the patient.
- The plan of reconstruction must first be outlined. This must cover all the facets of reconstruction like skin, bone, tendon, joints.
- The number of stages that is being planned must be explained.
- The total expected duration of the reconstruction process and the approximate time that it will take for the reconstruction to be completed
- The anaesthesia that will be required during the procedures must be discussed.
- If an abdominal flap is planned after creating a surgical syndactyly, the patient needs to be informed that the fingers will be sutured together and that skin from the abdominal region will be taken. If a step ladder flap technique is planned, this, too, must be explained.
- The possible complications of anaesthesia and the surgery like flap necrosis, flap dehiscence, wound infection must be explained to the patient. Also, the method in which the complications will be dealt with should also be elucidated.
- The resultant scars on the body that the patient can expect following the reconstruction, and the methods by which these scars can be minimized by further optional procedures should also be explained.
- The approximate period of time that the patient need have to stay in the hospital and the financial aspect should also be discussed.

PLANNING: The hand must be kept on the anterior abdominal wall. It is more comfortable for the patient if we choose the ipsilateral side. A lint pattern must be taken for the defects. Whether we are going to plan superiorly based step ladder flaps or inferiorly based step ladder flaps is dependent on the nature of the defect.

- If the defects extend from one neutral line to the other: it signifies a band dorsal defect. Here, either inferiorly based abdominal flaps or superiorly based abdominal flaps can be used. However, it is useful to remember that when we place the pronated hand on the abdomen, it assumes a mid-prone position due to the effect of gravity and ease. Hence, in such bang dorsal defects, it is ideal to plan inferiorly based step ladder abdominal flaps.
- If the defects are more towards the ulnar side of the fingers: In such situations, the inferiorly based abdominal flaps are comfortable.

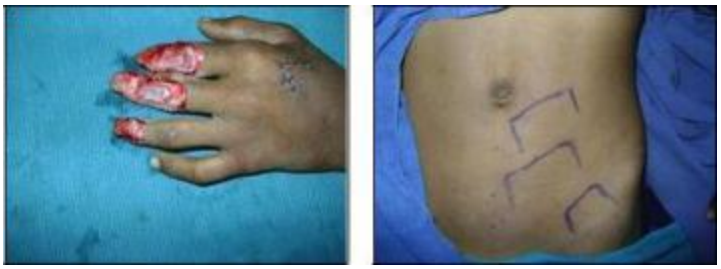

Fig. 5: Defect on the dorsal aspect of the middle three fingers and plan of the flaps

Fig. 6: Flap inset and final result after division of flap

- If the defects are more towards the radial side of the fingers: In such situations, inferiorly based abdominal flaps would have to travel a long distance to reach the radial side to give the leading inset. This is disadvantageous because;
  - Considerable length of the flap is wasted.
  - There is always tension on the suture line, as the position of.

- Comfort of the hand is to get into mid-prone position.
- Since a longer flap is used, the donor scars on the abdomen tend to be more.

Hence, if the defects are more on the radial side, superiorly based abdominal flaps are more practical and useful.

Fig. 7: Defect on the dorsal aspect of the fingers and thumb: covered with step ladder flap for fingers and a superiorly based flap for the thumb and final result

- If the defects are contiguous, i.e., on the adjoining sides of two fingers, it means that one defect is on the radial side and one defect is on the ulnar side. Following the principles that we have already elucidated, the finger with a radial side defect can have a superiorly based abdominal flap and the finger with an ulnar side defect can have an inferiorly based abdominal flap.

Fig. 8: Three fingers injury: defects of index and middle finger covered with Inferiorly based flap and superiorly based flap cover for thumb

- The distance between two flaps must be at least 2-2.5 cm to ensure good vascularity for the flaps and also the intervening skin bridges.

EXECUTION:

Salient points in the execution of step ladder abdominal flaps:

1. Debridement of the defects is the first, most important step. A good debridement will form the foundation upon which to start the reconstruction stages.
2. Mark all the flaps on the abdominal wall. These may not be the final marking for the flaps. If these markings are taken as the final markings, and the flaps are raised, they may move a little with respect to each other, because, the donor sites will be closed primarily. So the original comfort of lie of the flaps may not be present due to the change in the positions of the flaps. Hence, to avoid this discomfort, the most cephalad flap is first raised, donor site closed primarily, the hand is placed again over the abdomen and the next finger defect is re planned.

Fig. 9: Flap is elevated and donor defect closed primarily

The re planned flap may or may not coincide with the original plan marking. This is done sequentially for all the fingers till the ulnar-most finger defect is covered.

3. When marking the flaps for multiple fingers, it must be borne in mind that the flaps should follow the orientation of the fingers and not be planned in a straight line. The diagram below shows the curvature in the design of the position of the flaps, conforming to the orientation of the fingers.

Fig. 10: Four finger injury with 3 step ladder flaps and final result

4. While marking the flaps, it must be remembered that the flaps must climb the side of the finger to reach the defect. So the length of the flap must be comfortably long to avoid tension on the inset suture line. These are random pattern flaps. Hence, they must follow the 1:1 ratio. Generally, the length of the defect on the finger corresponds to the width of the abdominal flap. Hence, the longer the defect on the finger, the wider the abdominal flap and hence the safer the flap. If the length of the defect on the fingers is short, the wounds must be adequately debrided to ensure that safe random abdominal flaps can be used to cover them.

5. Since these stepladder flaps are random pattern flaps, they should be raised in the plane just under the dermis, leaving a single layer of subcutaneous fat, to support the dermal vascular network. This results in thin flaps that are pliable and cosmetically pleasing.
6. The donor sites of the flaps must be closed primarily. This must be done transversely, not longitudinally. By transverse closure of the defect, the width of the flap is maintained. It is done by holding the central point of the side of the defect and applying lateral traction with a skin hook. If the flap donor sites are closed longitudinally, the flap curls transversely and may not adequately cover the skin defect on the fingers.

Fig. 11: Donor site closed transversely

7. Suturing of the flap must be by half buried horizontal mattress sutures, with the knot on the finger side. This technique minimizes trauma to the skin flap.
8. Dressings are important in such surgeries, since we may find it difficult to change the dressings from in between the anchored fingers for a period of two weeks. While applying the dressings, it should be remembered that one portion of the defect is open under the pedicle of each flap. Hence, a non-adherent layer of dressing, followed by a povidone soaked gauze should be placed over the exposed raw area on the abdominal wall, and dressings done. Elbow and arm restraints must be applied.

POSTOPERATIVE PERIOD: Absolute immobilization is advised only for 24 hours or as long as the patient feels diffident. Since there are multiple flaps inset to the fingers of the hand, the construct is quite stable. Daily cleaning the suture line with an antiseptic solution will keep it clean. There may be some exudate from the exposed raw areas on the undersurface of the flaps near the pedicle. These must be cleaned by removing the soiled gauze and replacing with clean gauze with antibiotic ointment.

STAGE OF FLAPS DIVISION: The flaps are divided at the end of the second week. The following points must be considered during this stage:

- The exact line of division of the flap must be marked carefully before division. This must be done, taking into account the remaining raw area on the finger involved, the position of the neighboring flap. It is usually advisable to mark a gentle curvilinear line across the pedicle as the elective line of division of the flap.
- After the flap division, the wound on the abdominal wall is closed. In most of the cases, it may be possible to close these wounds primarily. If it is not possible, a skin graft would be prudent.
- The final flap inset must now be done on the fingers. A good debridement of the remaining edge of the skin defect on the finger must be done to remove the macerated edges and provide a healthy skin for the flap to inset into.

FOLLOW-UP:

- After the flap division, a full dressing and a volar POP slab with the wrist in neutral position or 200 extension, with the metacarpophalangeal joints of fingers in 900 position, and the interphalangeal joints in neutral position. If the thumb also has been involved, a dressing on the thumb must be followed with a volar POP slab for the thumb with the CMC joint of the thumb in a position of palmar abduction, and the metacarpophalangeal joint of the thumb in 100 flexion and interphalangeal joint in neutral position.
- After the wounds have stated drying up, in a week to 10 days, it is advisable to discard the full POP slab. Individual fingers dressings are advised and active movements encouraged. If the wrist has also been involved, this phase of starting therapy should be supported with a wrist stabilization splint, which can counter the pain and lack of wrist stability.
- When into 3 weeks, the need for straightening splints for the fingers arise, since there may be scars running across the volar aspects of the fingers, and may lead to flexion contractures.

COMPLICATIONS AND PROBLEMS:

a) **Axial instability of the finger:** Sometimes, when the joints of the involved fingers have been injured and stability is not good, providing a flap may cause the finger to rotate on its own axis in response to the force given by the weight of the skin flap, gravity, and the hand's inherent nature to settle in its position of ease. If it happens, it must be recognized and at the time of flap division, must be corrected. This correction must be continued further, by providing deviation correction splints, when mobilization is started.

b) **Flap necrosis:** Some portions of the flap or flaps may undergo necrosis. The cause is usually one of the following, either faulty design of the flap of faulty technique. Early removal of sutures may help to control the damage. If there continue to be raw areas, they must be dealt with at the time of flap division with a skin graft if needed.

c) **Suture line dehiscence:** May occur if the positioning of the patient is not comfortable, as occurs when the planning is faulty. If there is extensive dehiscence, it may require advancement of the flap after redebridement. However, if the dehiscence has occurred due

to faulty planning, advancement of the already faulty flap may not help. Damage control with a skin graft is the best option in such cases.

HIGHLIGHTS:

a) Make a detailed examination about the different structures involved in addition to the skin loss on the multiple fingers.
b) Make a decision about the reconstructive option for the skin – either do a surgical syndactyly and then cover with a large single abdominal flap or consider the multiple finger defects individually and plan for multiple step ladder abdominal flaps.
c) If having decided for multiple abdominal flaps, counsel the patients about the various aspects of the reconstruction options and get a full consent for the procedures.
d) Plan the reconstruction protocol carefully – take into account the vascular injuries, bone, tendon and nerve injuries, and also the skin injuries and plan accordingly.
e) Execute the different steps of the step ladder abdominal flaps carefully.
f) Take good postoperative care of the patient and the flaps and complete the procedure with a neatly executed flap division and final inset.
g) Follow-up of the patient is very important for achieving good function in the reconstructed hand and fingers.
h) Complications and problems may occur in the step ladder abdominal flaps, but deal with each complication as best as possible, keeping in mind the ultimate goal of achieving a fully functional hand and fingers.

Fig. 12: Complications - contractures of the fingers

REFERENCES:

1) M Neumeister: The Reconstruction of the Mutilated Hand, Semin Plastic Surgery: Feb 2010; 24 (1) 77–102.
2) Degloving injuries of the hand: R Krishnamoorthy and Karthikeyan Indian J Plast Surg. 2011 May-Aug; 44 (2): 227–236.

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