Original article

Feasibility of type III venous flap in coverage of hand defects following trauma and burns

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ARTICLE INFO

Article history:

Received 24 February 2016
 Received in revised form 16 April 2016
 Accepted 5 November 2016
 Available online 15 November 2016

Keywords:

Venous flap
 Trauma
 Burn
 Hand
 A-V fistula

ABSTRACT

Introduction: venous flaps are alternative reconstructive option for coverage of defects. They are nourished by venous blood flow or by arterial blood flowing through the venous network. This study was conducted to assess the feasibility of venous flap in coverage of extremities defects following trauma and burns.

Material and methods: Over a period of one year, 15 arterialized venous flaps were applied to skin defects of the hand. Postoperatively flap were monitored for survival and patients followed up for three months.

Results: In patients with flap area ranging from 6 to 10 cm², all the 6 patients have complete survival (100%). In 11–15 cm² group 3 out of 5 patients have complete survival (60%) and 2 have partial survival (40%). In 16–20 cm² group 1 out of 3 have complete survival (33.3%) and 2 have partial survival (66.6%). In 21–25 cm² group there was only 1 patient who had complete necrosis. This study suggests that small venous flaps have better survival rate as compared to large flaps. Variable degree of congestion was present in all the patients in first post operative week which gradually disappeared in second week.

Conclusion: The venous flap is good alternate for reconstruction of the small defects of hand and digits. It is easy to designed and harvest. It is thin and pliable, without need to sacrifice a major artery at the donor site and with no limitation on the donor site.

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1. Introduction

A flap is a composite block of skin and other tissues that maintains its own blood supply while being transferred from a donor to a recipient site. Flaps range from simple advancements of skin and subcutaneous tissue to composite free flaps that may contain any combination of skin, muscle, bone, fat, or fascia. The standard free flap requires both artery and vein to be anastomosed to those of the recipient area. However donor sites for these flaps are limited and cause morbidity. Since 1981 there have been both clinical and experimental reports of successful new flap transfer that were nourished by venous blood flow or by arterial blood flowing through the venous network.¹ Nakayama, The first one is called venous flap and second one is arterialized venous flap.^{2,3} The arterialized venous flap technique involves the use of two veins in the skin flap, one for arterial flow and one for venous drainage. Historically, an early technique for the rescue of an ischaemic extremity consisted of the creation of an arteriovenous fistula

between the venous and arterial systems of the extremity, following which the venous system served as a route of arterial inflow. The main advantage of an arterialized venous flap is the ease of harvesting a thin flap without the need to sacrifice a major artery at the donor site. The design of venous flaps is very easy because of direct visualization of the venous plexus through the thin overlying skin. There is no limitation of the donor site because it is possible to find the venous network at any place of the body. Despite many advantages, arterialized venous flaps are not commonly selected as the first choice for microsurgical reconstruction. An unstable postoperative course and difficult monitoring of the flap make it a less likely choice as compared with other conventional flaps. As a result, the clinical application is very limited. Aim of this study was to assess the feasibility of venous flap in coverage of extremities defects following trauma and burns.

2. Material and methods

It a prospective study conducted in plastic surgery unit, department of surgery NSCB medical college Jabalpur. All the patients with post burn and post traumatic small to medium sized defect of hand were included. Patient's written and informed

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consent was taken. Institutional ethical committee clearance was taken before starting the study. All cases had either exposed bone, joints or tendons which required flap coverage. Most of the patients fall in 20–40 years age group. All the patients were male. In 9 out of 15 patients, cause of hand defect was electric injury (60%) and 6 patients were post traumatic/crush injury (40%). In 8 out of 15 patients there was left hand defect (53.3%) and 7 patients had right hand defects (46.7%). Dorsal aspect of hand was involved in 8 patients (53.3%) and palmar aspect in 7 patients (46.7%). Proximal half of hand was involved in 7 patients (46.7%) and distal half in 8 patients (53.3%). In 14 patients right hand was dominant hand and in 1 patient left hand was dominant. Nerve, vessel and tendon status were normal in all patients.

Over a period of one year, 15 arterialized venous flaps were applied to skin defects of the hand. The donor site was flexor or extensor aspect of ipsilateral forearm. Recipient site was prepared first by excision of devitalized tissue in the floor and edges of wound. The size of the defect and length of the vein required were measured. The prospective flap was marked in the fore arm. The venous network in the fore arm is marked and flap is plotted in such a way to keep the one main vein in the centre of the flap. The size of the flap was determined and marked so that flap consisted of a skin, subcutaneous fat, and a vein with one proximal and two distal ends. Under tourniquet the flap is raised keeping the venous network intact. For safety the fascia is also included in the flap. Flap is cut all around to make it an island and proximal and distal veins were dissected in order to gain sufficient length. The vein was irrigated with heparinized saline solution and prepared for anastomosis. The adjacent artery was exposed and arteriotomy was performed at the recipient artery. The proximal end of the vein was sutured to it end-to-side, using 8/0 nylon sutures thus making it an A-V type flap. Radial artery was recipient artery in 13 cases while ulnar artery was recipient artery in 2 cases. All anastomosis of vein and artery was done end to side. The size of anastomosis was 3–4 mm in all cases. In all cases single vein was anastomosed with artery in retrograde manner.

The patency of the anastomosis was assessed immediately by sensation of the thrill on the venous side and the bleeding edges of the skin flap. The flap was sutured to the edges of defect loosely and the donor site was usually closed primarily or by split-thickness skin graft. A light dressing was applied to allow close observation of the flap for colour and venous congestion. Postoperatively heparin 5000 IU was given intravenously for 3 days. Postoperatively flap will be monitored for survival by observing colour and warmth. Any necrosis will be noted and photographs will be taken. Patients will be followed up every week for 4 weeks than every month for three months. Physiotherapy will be advised as per requirement of the patient.

3. Results

We performed type III venous flap in 15 patients over a period of one year. In all patients donor site for flap was forearm. In our study 73.3% patients had flap area of 6–15 cm², 20% patients had flap area between 16 and 20 cm² and only 1 patient (6.7%) had flap area more than 20 cm². Outcome was assessed at the end of 2 weeks. Flap which had marginal necrosis was considered as partial survival. Variable degree of congestion was present in all the patients in first post operative week which gradually disappeared in second week. Complete survival was observed in 10 patients (66.6%) partial survival in 4 (26.7%) and complete necrosis in 1 (6.7%) patient. In our study in patients with electric injury 77.8% had complete survival, 1 had partial survival and 1 had complete necrosis; whereas in post traumatic group 50% patients had complete survival and 50% had partial survival. In patients having defect on dorsal aspect 6 out of 8 have complete survival (75%),

Table 1

Outcome depending upon flap area.

Flap area (cm ²)	No. of cases	Complete survival	Partial survival	Complete necrosis
6–10	6	6	0	0
11–15	5	3	2	0
16–20	3	1	2	0
21–25	1	0	0	1
Total	15	10 (66.66%)	4 (26.66%)	1 (6.66%)

Photograph 1. Post traumatic raw area right hand.

1 have partial survival and 1 have complete necrosis; whereas in palmar aspect defect 4 out of 7 have complete survival (57.14%) and 3 have partial survival (42.85%). In patients with flap area ranging from 6 to 10 cm², all the 6 patients have complete survival (100%). In 11–15 cm² group 3 out of 5 patients have complete survival (60%) and 2 have partial survival (40%). In 16–20 cm² group 1 out of 3 have complete survival (33.3%) and 2 have partial survival (66.6%). All patients with partial survival of flap healed spontaneously with conservative treatment and did not require secondary surgery. In 21–25 cm² group there was only 1 patient who had complete necrosis (Table 1) (Photographs 1–9).

4. Discussion

The first experimental study performed on the arterialized venous flap was described by Nakayama et al.¹ Since then many experimental studies have been performed to evaluate venous

Photograph 2. Flap elevated and sutured.

Photograph 3. Post operative results after 3 months.

Photograph 4. Post electric burn raw area right hand.

Photograph 5. Flap elevated and sutured.

Photograph 6. Post operative results after 3 months.

Photograph 7. Post traumatic raw area right hand.

Photograph 8. Flap elevated.

Photograph 9. Post operative results after 1 month.

flap's viability, reliability, and haemodynamics, as well as the factors affecting its survival. Isotope perfusion and an infra-red thermo graphic study were performed by Wolf et al.,⁴ showed that in a rat model of epigastric arterialized venous flap the blood flow was 92.7%, while in free venous flap it was 62.4% and in venous island flap 31%. An infra-red thermo graphic study showed that blood in the arterialized venous flap dispersed faster and over a larger area than in flow-through venous flaps. Inada et al.,⁵ studied factors affecting the survival of the arterialized venous flap and found that two venous exits were more effective than one because these flaps could become congested and may die in the presence of a relative excess of arterial blood inflow. They concluded that flap size is important determinant for its survival. Roberts et al.,⁶ also emphasized on venous congestion of flap may lead to necrosis and advised reduced arterial inflow versus reduced venous outflow as a factor affecting flap necrosis.

Arterialized venous flaps differ from conventional flaps in a way that the arterial inflow bypass the capillary network and enter in venous outflow. There are considerable controversies on the real nature of their survivals.^{2,7,8} Noreldin et al.⁷ and Shalaby et al.⁸ in their experimental study demonstrated presence of arterioles and multiple capillaries in the perivenous areolar tissue, which is vital to the survival of venous flaps. On the other hand, Xiu et al.⁹ showed that the profuse venous network in flow-through venous flaps and early invasion of new blood vessels are the mainstays of venous flap survival. There is no conclusive evidence regarding the exact mechanism for venous flap survival. However, it is probable that a combined work of the aforementioned factors is responsible for the perfusion of venous flaps.

The arterialized venous flap was able to survive with just pre-capillary and post capillary venous system while in an ischaemic state.¹⁰ The sudden rise in pressure of the arterialized venous flap right after the anastomosis with the high pressure arterial blood flow causes an active congestion.¹¹ When the draining by means of the efferent vein is not efficient, deoxygenated haemoglobin accumulates in the flap, causing an ischaemic condition and swelling, discoloration, bullae formation, and finally results in partial necrosis. Therefore more number of draining vein facilitates

more efficient exchange of oxygen and nutrients and enhances the chance of flap survival. Sasa et al.¹² also reported that if the efferent vein is well maintained, the rearterialisation process of the flap can be accelerated. Also, if the arterialized venous flap has a healthy recipient vascular bed, this hastens the neo vascularization from underneath the flap, which can also improve the chance of flap survival.

In our study out of 15 flaps complete survival was observed in 10 patients (66.6%) partial survival in 4 (26.7%) and complete necrosis in 1 (6.7%) patient. When the flap size was <10 cm² than chances of flap survival is 100% and when flap size was between 11 and 20 cm² than survival goes down by 50% and flaps more than 20 cm² unlikely to survive. In complete necrosis the flap area was more than 20 cm² and patient had electric burn of hand where chances of venous damage was more which had lead to flap necrosis. Therefore this study also support that size of venous flap is important determinant for its survival. Conventionally defects of hand and fingers are treated with pedicle flaps like groin or abdominal flaps. These flaps have problem of being two stage and problem of immobilization for weeks with oedema and stiffness. The arterialized venous flap is good alternate for reconstruction of the small defects of hand and digits. It is easy to designed and harvest. It is thin and pliable, without need to sacrifice a major artery at the donor site and with no limitation on the donor site. It's a single stage procedure and there is no need to immobilize hand for 3 weeks and physiotherapy can be started early reducing oedema and stiffness.

Inoue et al.¹³ observed that the survival status of arterio-venous flaps appeared to be influenced by the donor site and size of the flap. When a small flap from the forearm was used, the success rate was almost 100%. However, there was a 50% success rate when a large flap from the leg was used. Recently, Kakinoki et al.¹⁴ performed a retrospective analysis of the free arterialized venous flaps showed that the size of the flap was correlated statistically with a successful result and flap surface area less than 767 mm² were less likely to develop necrosis. The influence of donor site on the survival of arterialized venous flaps may be attributed to the configuration of venous network of different donor sites. In practice larger flap can be harvested using the concept of delay or pre-arterialization of flap.^{15–17}

5. Conclusion

Small venous flaps have better survival rate as compared to large flaps. Variable degree of congestion was present in all the patients in

first post operative week which gradually disappeared in second week. The venous flap is good alternate for reconstruction of the small defects of hand and digits. It is easy flap to do without need to sacrifice a major. The survival status of arterialized venous flaps is acceptable; however these cannot completely replace the conventional flaps in the reconstructions of the hand and digits.

Conflicts of interest

The authors have none to declare.

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