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Original Research Article

Evaluation of free flap surgery with loupe magnification

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ABSTRACT

Background: The role of magnification is paramount in free flap surgery as magnification gives a clear, well-defined, sharp definition to the blood vessels and successful anastomosis of small caliber blood vessels becomes a reality. In the literature, studies have reported that the success rate of free flap surgery under microscope magnification is around 89% to 99% and similar success rate have been achieved with loupe magnification as well in suitable flaps.
Objective: In this study our objective was to determine the feasibility and safety of micro-vascular free flap surgery under 4x loupe magnification, in suitable flaps.
Materials and Methods: This study was a prospective observational case series of 50 adult patients admitted for reconstruction of defects of different etiology at different sites of the body for functional restoration and contour correction from September 2016 to October 2018. The study was conducted in the department of plastic surgery, SCB medical college, Cuttack, Odisha, India. Outcome variables included vascular complications of flaps, re-exploration of flaps, salvage of flap and flap failure. Chi square analysis was performed to find out the significance of association of flap failure at different sites.
Results: Total 50 cases of consecutive free tissue transfer were carried out under x4 loupe magnification in different sites of the body and the re-exploration rate was 10 (20%), the flap salvage rate was 5 (50%) out of 10 cases and revision anastomosis rate was 8 (16%) and success rate was 45 (90%).
Conclusion: We observed that micro-vascular free flap surgery is feasible and safe under optical loupe-4x magnification to reconstruct defects at selected sites of the body with suitable flaps with pedicle and recipient vessel diameter 1.5mm or more in size.

1. Background

Micro-surgery is described as surgery under microscope magnification with micro- instruments and micro-sutures. [1,2] Free flap surgery comes under the purview of micro-surgery. The role of magnification in free flaps surgery is paramount as magnification gives a clear, well defined, sharp definition to the blood vessels and successful anastomosis of small caliber blood vessels becomes a reality, which establishes patent circulation for viability of free flaps. In the literature the success rate of free tissue transfer surgery under microscope magnification is around 89% to 99%. [3–5] Similar success rate has been achieved under loupe magnification as well. [6–12] In this study, we have performed free flap surgery under loupe magnification in suitable free flaps with pedicle vessel diameter and recipient vessel diameter 1.5 mm or more with an objective to determine the feasibility and safety of the loupe magnification in our setup.

2. Materials and Methods

The study design was a prospective observational case series of 50 cases. Only adult patients admitted to the department with suitable defect who needed flap cover for either contour

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correction or functional restoration covered with suitable flaps, were included in this study. Pediatric patients were excluded from this study. Suitable free flap means free flaps with pedicle vessels diameter 1.5mm or more and suitable site means site of defects where available recipient vessel has diameter 1.5 mm or more. The study was conducted in the department of plastic & reconstructive surgery of our institute from September 2016 to October 2018.

Written informed consent was taken from all the patients. The study was reviewed in the institutional scientific committee and approved by the institutional ethics committee.

Micro-vascular procedures were performed using x4 loupe as the sole means of magnification. The procedures performed included reconstruction of extremities, mandible, cheek mucosa, tongue defect, defect over the face and free functioning muscle transfer in brachial plexus injury and facial reanimation surgery. The various recipient vessels selected were, superficial temporal artery, facial artery, thoracodorsal artery and accompanying venous system for venous drainage in head and neck reconstructions. For reconstruction of lower leg defects, anterior or posterior tibial artery and accompanying venous system were used for vascular anastomosis. In cases of upper limb reconstruction ulnar artery, radial artery with accompanying venous system, superficial basilic vein and cephalic vein were selected for anastomosis. Artery to artery and veins to veins anastomosis were carried out with an end to end or end to side technique. Both the primary surgeon and assistant used 4x loupe magnification for the procedures.

In all the procedures we used optical loupe x4 magnification with 45cm focal length for recipient vessels dissection, flap elevation, pedicel dissection and micro-vascular anastomosis and 8-0 polypropylene was used as micro-sutures for vascular anastomosis. In all the cases two team approach was made to undertake the free flap surgery. One team prepared the recipient vessels, and after being convinced with the status of the vessel, the other team carried out the flap harvest. Other details of micro-surgery principles like delicate tissue handling, in all the stages of free tissue transfer, utmost care was given while dissecting the pedicle both recipient and flap pedicle. Bipolar diathermy was used judiciously for coagulation of small branches near the pedicle and suture ligation with micro-sutures was used for small branches adjacent to anastomosis. Circumcision of the vessel ends, dilation of the vessel ends, irrigation of vessels lumen with heparin solution of 50 IU per milliliter of saline, lie of the pedicle, tension on the pedicle, kinking of the pedicle, rotation of the pedicle was taken care of while performing the micro-vascular anastomosis of free flaps. In cases of free flap surgery in the limbs across a joint, the limb was immobilized in suitable position with plaster of Paris slab. Floppy dressings were applied and provisions were made for clinical monitoring of the flap area by keeping the flap exposed.

Post operatively all the patients received low molecular weight heparin (LMWH) 60 mg / 0.6 ml dose per day and 1500 ml of Ringer's lactate infused at the rate of 60 micro drops per minute over 24 hours.[13,14] The infusion was continued for 5 to 7 days post-operatively. Pre-operative level and post-operative level of prothrombin time and international normalized ratio was measured to monitor the coagulation profile.

Postoperatively Patients were kept in the specialized ward in the plastic surgery unit and they were monitored hourly for first 48 hours and then every four hours for next 48 hours by the post graduate resident. Color, turgor, capillary refill, dermal bleed to needle scratch were used to clinically assess the vascular patency. No special gadgets were used for monitoring of the status of the vascular anastomosis. Quality of dermal bleed to needle scratch like the color of the blood whether bright red or dark red and rate of bleed whether normal, sluggish, rapid or absent were assessed.[15]

In the earliest detection of the signs of congestion or ischemia of the flap, patents were taken back to operation theater for re-exploration of the anastomotic site and observed for obvious kinking, hematoma exerting pressure on the anastomotic site, venous thrombosis or arterial thrombosis and accordingly measures were taken like removal of the tight sutures, evacuation of hematoma or redo-anastomosis of the affected vessels and 5000 IU heparin subcutaneously twice daily doses was added for 5 to 7 days and Ringer's lactate 1500 ml at a rate of 60 micro drops per minute over 24 hours for 5 to 7 days was continued.[13]

Patients demographic data, etiology of the defects, location of the defects, different flap selected, different recipient vessel selected, total time taken for surgery, time of ischemia of the flaps, anastomotic complications, need of re-exploration, flap salvaged, total hospital stay were documented. Analysis of the data was carried out using IBM SPSS version 21 and association of the site of defects, recipient vessels selected and flaps selected to flap re-exploration was analyzed using, Chi square test by cross tabulation. Results with a $p < 0.05$ were considered to be statistically significant.

3. Results

A total of 50 cases of consecutive free flap surgery were carried out with x4 loupe magnification, in different sites of the body like head and neck- 27 (54%) cases, upper extremity-10 (20%) cases and lower extremity-13 (26%) cases, of different etiology (Table 1).

Patient age ranged from 20 years to 69 years with mean age of 34.88 years and standard deviation of 16.24 years. Study included 34 male & 14 females with male to

Table 1: Clinical details of patients

	Number (% of total)
Gender	
Male	36 (72%)
Female	14 (28%)
Co-morbidities	
Diabetes Mellitus	2 (4%)
Hypertension	5 (10%)
Smoking	9 (18%)
Anatomical Area	
Head & Neck	27 (54%)
Upper Limb	10(20%)
Lower Limb	13(26%)
Etiology of the defect	
Ameloblastoma Mandible	4 (8%)
Hemifacial atrophy	2(4%)
Facial Palsy	1(2%)
Post electric burns scalp defect	7(14%)
Carcinoma of oral cavity	8(16%)
Post traumatic Exposed Calvaria	1(2%)
Traumatic soft tissue loss of face.	4(8%)
Post tumor resection upper limb bony defect	3(6%)
First web space defect of hand	1(2%)
Post traumatic bony defect ulna lower half	2(4%)
Pan Brachial Plexus Injury	4(8%)
Post tumor resection defects of tibia	2(4%)
Post traumatic Lower third leg defect	11(22%)

female ratio of 2.4:1. Smokers represented 9 (18%), diabetes mellitus 2 (4%), hypertension 5 (10%). In our series post-operatively, flap ischemia was encountered in 3 (6%) cases and venous congestion was encountered in 7 (14%) cases that needed re-exploration. Following re-exploration, it was observed that 3 (6%) cases were arterial thrombosis, 4 (8%) cases were venous thrombosis, 2 (4%) cases were hematoma and 1 (2%) case were due to pedicle kinking (Figure 1).

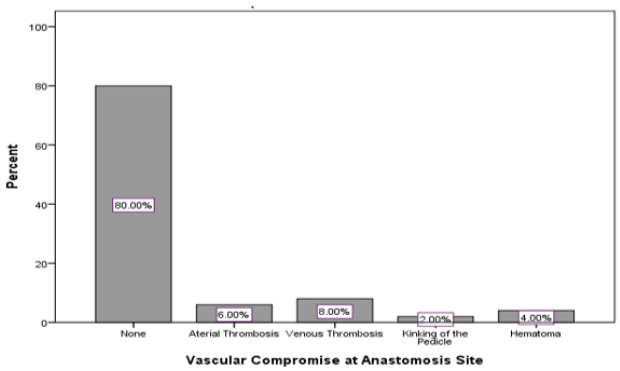

Fig. 1: Bar chart showing rate of vascular complications at anastomotic site.

The average re-exploration rate was 10 (20%) and revision anastomosis rate was 8 (16%) and evacuation of hematoma relieved venous congestion 2 (4%) cases.

Out of the 10 (20%) cases of re-exploration, total 5 (10%) cases (arterial thrombosis-2, pedicle kinking-1, hematoma-2) were salvaged. The overall flap failure rate was 5(10%) cases (arterial thrombosis-1 venous thrombosis-4) (Figure 2).

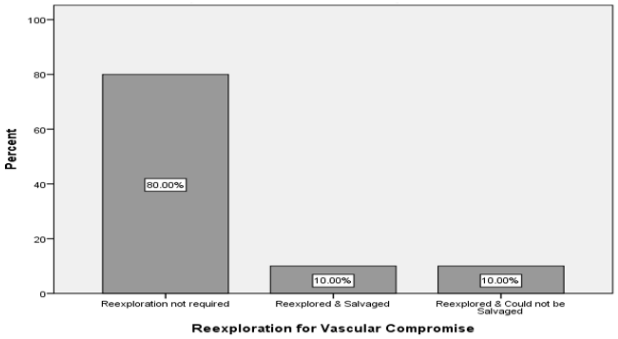

Fig. 2: Bar chart showing rate of re-exploration and salvage.

In our series following re-exploration 50% of the vascular compromised flaps were salvaged due to timely intervention in the form of re-exploration and revision anastomosis and evacuation of hematoma within first six hours of signs of vascular compromise, with an overall success rate of 90%.

There was no statistically significant difference in outcome of reexploration amongst head & neck, upper limb & lower limb defects (Pearson Chi square value 5.488, degree of freedom-4, p = .241) (Table 2).

Table 2, showed that maximum failure of free flaps had occurred in lower extremity, which could be due to improper timing of surgery or altered intrinsic vessel quality due to trauma in lower extremity. Overall outcome of flap survival amongst head and neck, upper limb and lower limb had no significant difference as p= .241. (Pearson Chi square value 5.488, degree of freedom-4, p= .241)

Fig. 3: a: Posttraumatic defects with exposed fronto parietal bone; **b:** Defect covered with anterolateral thigh flap and recipient vessel is superficial temporal vessels.

Table 2: Re-exploration versus outcome at different anatomical locations crosstabulation

Re-exploration	**Head & Neck**	**Upper extremity**	**Lower extremity**	**Total**
Not required	21 (77.8%)	9 (90.0%)	10 (76.9%)	40 (80%)
Salvaged	4 (14.8%)	1 (10.0%)	0(0.0%)	5 (10%)
Failed	2(4%)	0(0.0%)	3(23.1%)	5 (10%)
Success	25 (92.6%)	10 (100%)	10 (76.9%)	45 (90%)
Total Reconstruction (N-50)	**27 (54%)**	**10 (20%)**	**13 (26%)**	**50 (100%)**

Fig. 4: a: Post Electric burn defect over the face with exposed frontal & malar bone with loss of left eye; **b:** Defect covered with Anterolateral thigh flap and recipient vessel is facial artery and vein.

Fig. 5: a: Case of ameloblastoma of mandible; **b:** Post of view reconstructed mandible with free osteocutaneous fibula and recipient vessel facial artery and common facial vein.

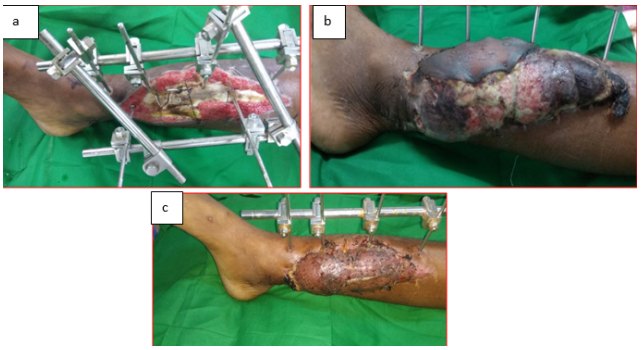

Fig. 6: a: Post traumatic defect of leg with exposed & fractured segment of tibia; **b:** Reconstructed latissimusdorsi musculocutaneous flap with partial necrosis and recipient vessels are posterior tibial artery and accompanying vein and adjacent cutaneious vein. **c:** Three months follow up with resurfaced skin graft.

In our series 2 (4%) cases of flaps developed infection which responded to conservative treatment of higher antibiotics and resulted in partial flap loss and latter on covered with split thickness skin graft. The mean Ischemic time of flap was 74.60 minutes and mode were 75 minutes with standard deviation of 26.28 minutes. The mean duration of surgery was 274.70minutes (4 hrs 34

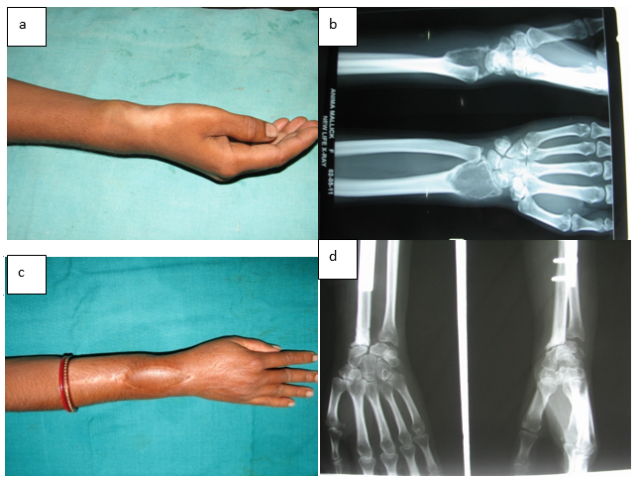

Fig. 7: a: Clinical photographs of bony swelling of the distal end of the forearm right side; **b:** Preoperative X-ray pictures showing giant cell tumor distal end of radius; **c:** 1 year follow up clinical photograph of right forearm and hand with well settled skin paddle of vascularised free osteo-cutaneous fibula and recipient vessels are radial artery and accompanying vessel and cephalic vein; **d:** Post operative X-ray picture showing reshaped distal end of the reconstructed radius.

Fig. 8: a: Pre operative clinical photograph of bony swelling of the distal end of the tibia right side; **b:** Preoperative X-ray pictures showing recurrent giant cell tumor distal end of tibia; **c:** MRI pictures showing recurrent giant cell tumor distal end of tibia; **d:** Intra operative photograph showing excised tumor specimen; **e:** Post operative X-ray picture showing double strut of osteo-cutaneous fibula at the distal end of tibia; **f:** 9 months follow up clinical photograph with well settled skin paddle of vascularized free osteo-cutaneous fibula and recipient vessels are posterior tibial artery and accompanying vessel and long saphenous vein.

minutes) with standard deviation of 75.80 minutes (1 hr 15 minutes). Mean hospital stay was 11 days, with standard deviation of 6.30 days, mode was 7days, minimum hospital stay was 6 days & maximum hospital stay was 30 days. We have encountered seroma in 1 (2%) case at latisimus dorsi musculo cutaneous flap donor site and wound dehiscence 1 (2%) cases at anterolateral thigh flap donor site and not encountered any complications at the free osteocutaneous fibula harvest site.

4. Discussion

Julius Jacobson & Suarez's 1960 pioneered work on micro-vascular anastomosis on 1.5mm to 3mm diameter vessels with successful result with the aid of an operating microscope encouraged surgeons to venture into microsurgery and established a new discipline in the surgical field. [1–6]

Subsequently the role of operating microscope became indispensable in micro-vascular free tissue transfer and success rate of around 89% to 99%was achieved in free tissue transfer surgery under microscope magnification. [3–5] However, in the literature, studies reported comparable results of micro-vascular free tissue transfer with loupe only methods in comparison to microscope methods, when the vessel diameter was 1.5 mm or more in size. [6–12]

In our series of50 cases of consecutive free tissue transfer carried out with x4 loupe magnification in suitable flaps with vessel diameter of 1.5 millimeters or more, the average re-exploration rate was 10 (20%) and revision anastomosis rate was 8 (16%) and overall flap failure rate was 5(10%) cases (arterial thrombosis-1 venous thrombosis-4) and salvage rate was 50%, due to timely intervention in the form of re-exploration and revision anastomosis and evacuation of hematoma within first six hours of signs of vascular compromise, with an overall success rate of 90%. That was within the acceptable range of free flap success rate with loupe magnification method of 89% to 99% mentioned in the literature. [6–12]

Shenaq S.M. et al, in a series of 251 (199+28+24) cases of free tissue transfer performed under loupe magnification encountered a total loss of 7 (2.8%) cases, 3 flaps were due to arterial thrombosis despite re-exploration, 1 case of toe to thumb transfer was lost out of 28 cases and out of the 24 digital re-plantation they encountered 3 total loss and 2 partial loss of distal phalanx loss with an overall 97.2% success rate, 1.2% partial flap loss and 8.3% revision rate. They advocated loupe magnification on the grounds of cost-effectiveness, portability and operator freedom. [6]

Our result of 10 (20%) cases of re-exploration and 8 (16%) cases of revision anastomosis with 50% salvage rate, was much below the findings reported by Shenaq S M. et al due to our learning curve and limited experience in microvascular surgery. In our series re-exploration surgery was done within first six hours of notice of signs of vascular compromise. In the literature, the re-exploration rate range between 6% to14%, and salvage rate range from 33% to 81%.[5,6] In our series the re-exploration rate was 20% and salvage rate was 50%, which was within the range.

Serletti et al in a series of 200 consecutive free tissue transfers (loupe 3.5x – 119 cases and microscope – 81 cases) reported that their study showed no difference in outcome between the operating microscope and loupe only method with success rate of over 99% for both groups. They recommended loupe only methods for micro-vascular anastomosis in vessels 1.5mm or more. For children and in vessels less than 1.5mm diameter they have contra indicated the use of loupe and strongly recommended use of microscope for micro-vascular anastomosis.[7]

Ehanire et al, in a series of 116 cases of loupe method of micro surgery and 148 cases microscope method of micro surgery reported that no difference of statistical significance was found in the outcomes of free tissue transfer when safety under loupe magnification compared with the operating microscope. Loupe magnification group had statistically significant shorter setup time (20 minutes, $P < 0.01$). They propose microsurgery training module with both loupe and microscope. They reported anastomotic revision rate of 27% and flap failure rate of 3.6% in the loupe performed microsurgery and anastomotic revision rate of 17% andflap failure rate of 2.2% in the microscope performed surgery. In our series anastomotic revision rate was 16% and flap failure rate was 10% was due to poor case selection and improper timing of reconstruction in post traumatic lower limb defects and the learning curve contributed for higher failure rate.[11]

Stranix et al, reported the short operative time and improved operating room efficiency of loupe only microsurgery, in comparison to operating microscope. The constraints of having operating microscope in multiple operation room could also be obviated by loupe only method. They have also demonstrated loupe only microsurgery to be safe and effective alternative to the operative microscope in free tissue transfer reconstruction of traumatic lower extremity defects. Overall peri-operative complication rate 14% in loupe group compared to 16% in microscope group, with total flap failure rates of 4.9% and 6% respectively and the re-exploration for vascular compromise were lower in loupe groups than the microscope group (5.3% versus 9.4%).[12]

Ashwork et al, reported the outcome of orofacial reconstruction with radial free flap in a series of 97 cases under loupe magnification method with 2.5x to 3x magnification, with a 97.9% success rate. They proposed loupe as a method of magnification for training and teaching the surgical trainee for better perception of depth of field, variety of viewing angle and enhanced illumination.[16]

In our series with strict clinical monitoring of the flap with needle scratch technique and studying the rate and quality of bleed, we were able to assess the cause of the vascular compromise like flap ischemia or flap congestion and within first 6 hours of detection of signs of vascular compromise patient were taken back to operation theater for re-exploration. This finding also showed, close post-operative monitoring of the flap helped in early detection of vascular compromise. We also observed that salvage rate was more when pedicle kinking or hematoma was the cause of venous congestion, than intrinsic quality of vein. In 3 (6%) cases of venous thromboses that occurred in the lower extremity group post traumatic defect re-construction, where the chance of post traumatic vessel disease was high.

Lorenzo AR. et al, reported that the intensity of flap monitoring and early detection of circulatory compromise were the best predictors in salvage outcome of free flap transfers that was particularly relevant in flaps with venous insufficiency with clear identifiable causes like kinking of the pedicle, hematoma exerting pressure and compression on the pedicle. They also reported that the magnitude of traumatic insult was the single most important factor related to the incidence of micro-vascular thrombosis and following trauma, the widespread changes that occurred in the walls and the perivascular tissues of the major vascular bundles was identified as post traumatic vessel diseases that lead to post operative thrombosis. They also observed that the recipient vein condition like intrinsic vein quality and spatial orientation were the best predictors of flap outcome in lower extremity reconstruction.[15]

Pieptu and Luchian observed in their review article that free flap surgery under loupe magnification is gaining popularity for its convenience, portability, surgeon's freedom, comfort of viewing angle change, working at depth of field, wider orientation, operator friendly and above all low cost and less operative time with loupe and concluded with a quote thatless magnification should not be considered as less quality.[9]

Though, studies advocated that use of loupe should be a natural progression for the experienced micro surgeons after extensive experience operating under the microscope, we appreciated from our study that the art and science of free tissue transfer could be learned and practiced without the fear of flap failure and increase morbidity when loupe magnification is used for micro-vascular anastomosis in free tissue transfer surgery. At the same time, we would like to propose to use loupe as magnification method for training of micro surgery skills of free tissue transfer technique with reasonable success rate in large size vessels more than 1.5mm diameter, so that free tissue transfer surgery can be

generalized and the patients will get the benefit of getting treated by a right method providing form, function and aesthesis all together in one surgery.

The microscope has been recommended for pediatric patient, digital re-plantation, major peripheral nerve repairs and digital nerve repair and in supra-microsurgery.[6–12]

5. Conclusion

It was observed from our study that micro-vascular free flap surgery is feasible and safe with optical loupe-4x magnification to reconstruct defects at selected sites of the body with suitable flaps with pedicle and recipient vessel diameter 1.5mm or more in size with acceptable result. Small sample size was the limitation of the study. Magnification is one of the essential parameters for successful outcome, however experience plays pivotal role.

6. Author's Contributions

Ahmed AM, data collection and management, analysis of data and manuscript drafting; **Singh P**, design of the study, data interpretation, critical revision and editing of the manuscript and producing final version of manuscript; **Nayak BB**, Conception and design of the study and final approval of the version to be published.

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9. Conflicts of Interest

No conflicts of interest.

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