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Original Article

Developing Microsurgery through Experience in Yangon General Hospital, Myanmar

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Although many surgical centers perform microsurgery routinely in developed countries, performing microsurgery is challenging in resource-poor developing countries, such as Myanmar. With the establishment of educational training programs and the assistance of volunteer plastic surgical teams, local plastic surgeons can learn the techniques of microsurgery and apply them clinically. The purpose of this study was to establish baseline data and define the challenges of performing microsurgery in Yangon General Hospital, Myanmar. Sixty-four patients underwent reconstruction with free flaps from January 2015 to January 2018. All clinical records of these cases were assessed. The number of free flap reconstructions performed increased from 11 in the first year to 24 in the third year. The anterolateral thigh flap was the most commonly used (42%). The most common sites of reconstruction were mandible and intraoral defects. Total flap survival occurred in 58 of 64 patients (89%). The total salvageable flap rate for revision surgery was 66.6%; the successful revision rate was highest in 2017, with fewer complications. The flap salvage rates increased and the operative duration decreased as clinical experience improved. Establishing a microsurgical center requires a strong multidisciplinary team, clinical experience, continuous learning, sensible clinical application, and effective interdepartmental and intradepartmental cooperation.

Key words: microsurgery, educational programs, challenges of microsurgical free flaps, reoperation, flap salvageable rate

Microsurgical reconstruction of complex defects was first introduced in the early 1970s with the use of a free omentum flap for the scalp by Mclean and Buncke in 1970 and a free groin flap for a lower limb defect by Daniel and Taylor in 1973.

Successful free flap surgeries require an efficient and motivated surgical team, a supportive anesthesia and nursing team, optimal perioperative management and specialized equipment [1, 2]. Although there are many surgical centers that perform microsurgery routinely in developed countries, it is a challenging field in resource-poor developing countries [2], such as Myanmar.

Microsurgical reconstruction of free flaps was performed in the Plastic, Maxillofacial and Oral Surgery Department of Yangon General Hospital in 1998 with the aid of a visiting Singapore General Hospital plastic surgical team. In 2005, the training of local plastic surgeons was started by the world-renowned Australian microsurgeon, Professor Wayne Morrison. Following

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this training, 3 local plastic surgeons successfully performed five head and neck reconstructions. However, this type of reconstruction had to be stopped because of the lack of surgical personnel and poor resources. In 2010, we tried to initiate the performance of microsurgery again with the support of 2 volunteer plastic surgical teams from Okayama University Hospital, Japan and Australian Interplast. They provided us with great support to help reestablish microsurgery in Myanmar. With the assistance of Australian Interplast, Professor Moe Thuzar (Professor and Head of Plastic, Maxillofacial and Oral Surgical Unit, Yangon General Hospital) formally began to plan the Doctorate of Plastic Surgery Program at the University of Medicine 1, Yangon in 2010, and the program was started at 2014. In 2016, a plastic surgery residency program in Yangon General Hospital was established.

With the establishment of these educational programs, local plastic surgeons are now able to undergo 3 to 6 months of microsurgery training and clinical training supervised by Professor Kimata at Okayama University Hospital, Japan. This program was supported by a non-profit organization (Myanmar-Japan Collaboration Project for Fostering Medical Resources) led by Professor Okada. In addition, local plastic surgeons will spend a period of 3 to 6 months in Melbourne, Australia, supervised by Associate Professor Michael Leung and sponsored by Australian Interplast for advanced plastic surgery training including clinical microsurgery.

During the training period, local plastic surgeons were trained in basic microsurgical skills at the Microvascular Research Center, Okayama University, Japan according to the Microvascular Research Center Training Program (MRCP) [3,4]. After passing the MRCP, they are allowed to scrub into operations followed by participation in vascular anastomosis as well as in flap elevation under supervision.

Visiting teams from Okayama University led by Professor Kimata and the Australian Interplast team led by Associate Professor Michael Leung made a total of 14 visits to Yangon General Hospital during the study period of this paper, that is, from January 2015 to January 2018. Before mid-2015, foreign surgeons mainly did the operations and local surgeons scrubbed, assisted them, and learned from them. But after that, foreign teams supervised the operations and let local surgeons do the operations (flap harvest, anastomosis, flap inset). Each visit was one week in duration with four days of intense operating and one day of teaching, concentrating on surgical planning, surgical techniques and perioperative care. Therefore, local surgeons had more chances to learn from and be closely supervised by them. Gradually, after multiple missions by visiting teams, the local plastic surgery team at Yangon General Hospital became competent in performing free flap reconstructions.

The purpose of this study was to establish baseline data for future comparisons of outcome variables in the Plastic, Maxillofacial and Oral Surgery Department of Yangon General Hospital and to define the challenges of performing microsurgical free tissue transfer in Yangon General Hospital, Myanmar, from January 2015 to January 2018.

Methods

We retrospectively evaluated all patients who underwent reconstruction with free flaps from January 2015 to January 2018 in the Plastic, Maxillofacial and Oral Surgery Department of Yangon General Hospital, Myanmar. All clinical records of free flap cases in the study period were assessed. The demographic data, underlying pathology, types of reconstructed flaps, length of operation, types and rate of complications, rate of flap survival, salvageable flap rate, and performance status of the patients were recorded. The surgical equipment used in free flap surgery included loupe magnifications for dissection and flap harvesting and an operating microscope (Leica M680) for vascular anastomosis. Systemic low-molecular-weight heparin was administered once per day subcutaneously according to body weight (nadroparin 0.4 ml, 3,800 units for less than 50 kg of body weight and 0.6 ml, 5,700 units for more than 50 kg of body weight) or unfractionated heparin (5,000 units subcutaneously 12-hourly) until the patients were mobilized to prevent postoperative deep venous thrombosis (DVT). For revision flap surgery, we occasionally used 5,000 units of intravenous heparin after the clamps were released. In all cases, we used heparin irrigation. Postoperatively, the flap was monitored by surgeons and trainees through clinical observation and adjuncts such as pin-prick testing and Doppler ultrasound. In patients who had been taking aspirin regularly, we usually had them stop 5 days before the operation and start again after the first postoperative day. All data were analyzed using Microsoft Excel 2010. All procedures were carried out with adequate understanding and were approved by the local ethical committee board at Yangon General Hospital.

Results

A total of 64 patients underwent reconstruction with free flaps during the three-year period. The age range was 14 years to 77 years with a mean age of 45 years. The male-to-female ratio was 1.3 : 1. The age distribution was found to be 4 patients aged ≤20 years (6%), 11 patients aged 21-30 years (17%), 12 patients aged 31-40 years (19%), 14 patients aged 41-50 years (22%), 10 patients aged 51-60 years (16%), and 13 patients aged >60 years (20%).

When analyzed by yearly distribution, the number of free flap reconstructions performed per year increased year by year, from 11 cases in 2015 and 22 cases in 2016 to 24 cases in 2017. In January 2018, the last month of the study period, there were 7 free flap cases. During the study period, the local team performed 39% of all cases independently, while 30% were supervised and done jointly by the Japan team and the remaining 31% of cases were done jointly and guided by the Australian team.

Altogether 65 free flaps in 64 patients were reconstructed. The most common type of free flap was the anterolateral thigh flap, which constituted 42% of the total, followed by the radial forearm free flap, which constituted 34%. Free tensor fascia lata flaps, ulnar forearm flaps, and anteromedial thigh flaps were rarely used, accounting for 1%, respectively (Table 1). A double flap was used in one patient with ameloblastoma; this patient had mandibular, intraoral, and right cheek skin defects where a free anterolateral thigh flap and free fibula flap were inset (Fig. 1). We used radial forearm free flaps in many cases with oral tumors defects, such as lower lip and inner buccal mucosa (Fig. 2). All vascular anastomoses were performed as end-to-end anastomoses under an operating microscope.

With regard to recipient sites and pathology, intraoral tumors were found to be the most common pathology in 26 patients (40.6%). The second most common pathology was post-traumatic lower limb defect, which occurred in 10 patients (15.6%). Other diseases included facial and scalp region tumors, post-burn soft tissue defects on the scalp and neck, post-traumatic soft tissue defects on the head and neck, and post-cancrum oris contracture release defects (Table 2).

In the early period of performing microsurgery at our hospital, we faced postoperative general complications in 7 patients, 2 of whom died post-operatively. Common postoperative complications included chest infection in 2 patients (3.1%) and DVT/pulmonary embolism in 2 patients (3.1%) (Table 3-1). We noted severe chest infection on postoperative day 3 in patients with chest infection, and we treated them with cefipime (fourth-generation cephalosporins) parenterally. Fortunately, they did not require ventilator support and recovered well. Of the 2 patients who exhibited DVT, one elderly female patient had DVT on postoperative day 5. We administered heparin therapy in this case with no adverse outcomes, and this patient recovered quickly.

Two patients died (3.1%) during our study. The first was a young woman with cancrum oris, who died due

Table 1 Types of free flap used for reconstruction

Types of flap	Number of flaps (%)
Anterolateral thigh	26 (42%)
Radial forearm	23 (34%)
Fibular	7 (11%)
Latissimus dorsi	4 (7%)
Groin	2 (3%)
Ulnar forearm	1 (1%)
Tensor fascia lata	1 (1%)
Anteromedial thigh	1 (1%)

Table 2 Distribution of diseases for free flap reconstruction

Diseases and sites	Number of patients (%)
Head and Neck tumor	
Intraoral	26 (40.6%)
Facial and Scalp	7 (10.9%)
Mandibular	6 (9.4%)
Maxilla	3 (4.8%)
Post-traumatic soft tissue defects	
Head and neck	2 (3.1%)
Lower extremities	10 (15.6%)
Post-burn soft tissue defects	
Scalp	2 (3.1%)
Neck	6 (9.4%)
Post-infectious soft tissue defects*	2 (3.1%)

*Cancrum oris

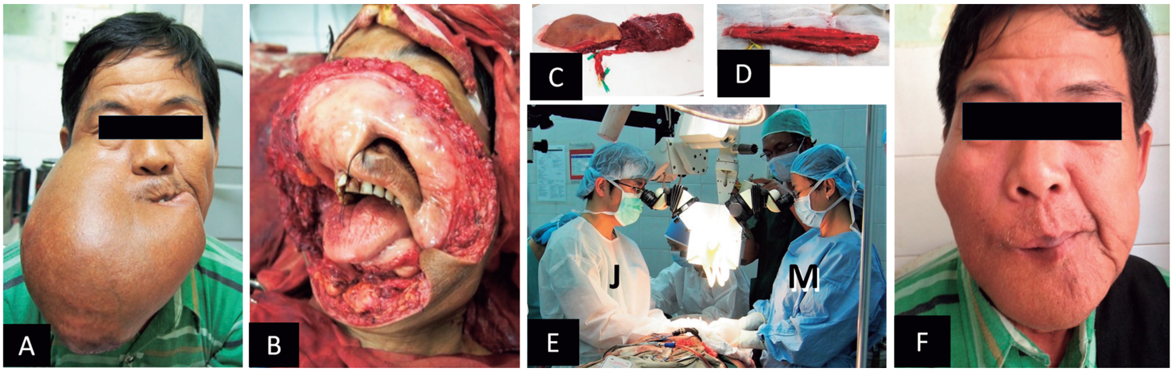

Fig. 1 A huge ameloblastoma mandible tumor, following tumor excision and right extended hemimandibulectomy, reconstructed with a free anterolateral thigh flap and fibular flap. (A) Preoperative view of a huge ameloblastoma. (B) Large defect following tumor removal. (C) Anterolateral thigh flap. (D) Fibula flap. (E) Intraoperative view: Japan team- J, Myanmar team-M. (F) Postoperative view at 4 weeks.

Fig. 2 Defect at the lower lip and inner buccal mucosa reconstructed with a radial forearm free flap. (A) Lower lip defect following tumor removal. (B) Radial forearm free flap. (C) Immediate postoperative view. (D) Postoperative view at 6 weeks.

to pulmonary embolism on postoperative day 3. The cancrum oris defect was so extensive that we had performed reconstruction with a radial forearm free flap, supraclavicular flap, and cheek rotation flap. Possible contributing factors to her pulmonary embolism were malnutrition and dehydration. The second patient was a middle-aged man who died due to postoperative encephalitis. The underlying pathology was a scalp and skull bone defect following skull fracture and extradural haematoma-removal surgery. These defects were treated with delayed reconstruction (one year later) with an anterolateral thigh flap after wound debridement by neurosurgeons. The onset of encephalitis was on postoperative day 1, and we lost him on day 5 despite resuscitation attempts.

Total flap survival was achieved in 58 patients (89%). The number of flaps free from local complications was 46 (71.9%) (Table 3-2). Regarding flap-related complications, wound infection was the most common, occurring in 6 patients (9.4%). Total flap necrosis occurred in 5 patients (7.8%) and partial flap necrosis in 2 patients (3.1%). Another noted complication was postoperative bleeding in 2 patients (3.1%) (Table 3-2).

We assessed the preoperative performance status of all patients. They were categorized from 0 to 5 according to the WHO performance status score [5]. Nine patients were found to be in status 0 (14%), 20 patients in status 1 (31%), 15 patients in status 2 (24%), 11 patients in status 3 (17%), and 9 patients in status 4 (14%). Obviously, we noted that a great number of general and flap-related complications (57.1% of general complications and 27.8% of flap-related complications) were detected in patients with a high preoperative performance status score (Table 4).

Therefore, in some cases that received compromised flaps, re-exploration was necessary. In total, 18 cases had to be re-done. When analyzed by year, there were 2 cases in 2015, 8 cases in 2016, 8 cases in 2017, and no cases in 2018. In 2016, 4 out of these 8 were salvageable, but in 2017, a higher proportion (7 out of 8 cases) was salvageable. The total flap salvage rate was 12 out of 18 patients (66.6%). The remainder of the cases were unsalvageable, and we had to debride the necrosed flap and perform reconstruction with another regional flap in 3 patients. The life boat flaps used were the pectoralis major myocutaneous flap and supraclavicular flaps. Some failed flaps were corrected with skin grafts after serial debridement in 3 patients.

Among the reasons for reoperation, suspected flap congestion was noted in 3 patients (16.7%). We were able to save all congested flaps at postoperative day 1. These cases were all found to be due to venous occlusion. However, we could not save flap necrosis in 6 out of 7 patients (38.9% of reoperation cases). These failed flaps occurred due to arterial problems in 2 cases and due to venous thrombosis in 4 cases. Other reasons for reoperation were postoperative bleeding in 2 patients and wound infection in 5 patients, and in these cases we were able to control the infections and bleeding and salvage the flaps. Most patients who developed wound infection underwent debridement after day 7 postoperatively (Table 5).

In contrast to revision surgery, the highest success rate for flap salvage was found to be on postoperative days 1 to 3 in cases with flap congestion (Table 5). In cases reopened after postoperative day 5 for flap necrosis, we could not save the flap, and the non-viable flap had to be debrided and another loco-regional flap was used for reconstruction. The earliest day of reoperation for wound infection was found to be from day 4 to day 6 (one patient); most patients with wound infection were operated on after postoperative day 7 (Table 5).

With respect to the operative duration, most cases

Table 3 Distribution of postoperative complications

3-1. General complications

Complications	Number of cases (%)
Chest infection	2 (3.1%)
DVT/pulmonary embolism	2 (3.1%)
Post-op encephalitis	1 (1.6%)
Post-op psychosis	1 (1.6%)
Uncontrolled hypertension	1 (1.6%)
Death*	2 (3.1%)
No complications	57 (89.0%)

DVT- Deep Venous Thrombosis
*One case died of encephalitis and another case died of pulmonary embolism

3-2. Flap related complications

Complications	Number of Cases (%)
Flap congestion	3 (4.7%)
Partial flap necrosis	2 (3.1%)
Total flap necrosis	5 (7.8%)
Wound infection	6 (9.4%)
Bleeding/Haematoma	2 (3.1%)
No flap related complications	46 (71.9%)

Table 4 Distribution of preoperative performance status of patients and complications

Performance status (WHO score)	Number of patients (%)	General complications (%)	Flap related complications (%)
0	9 (14%)	0	1 (5.5%)
1	20 (31%)	0	3 (16.7%)
2	15 (24%)	1 (14.3%)	4 (22.2%)
3	11 (17%)	2 (28.6%)	5 (27.8%)
4	9 (14%)	4 (57.1%)	5 (27.8%)

WHO score for performance status of patients[5]
0: Fully active, able to carry pre-disease performance
1: Restricted on physically strenuous activity but ambulatory and able to carry out works of a light or sedentary nature e.g. - light house work, office work
2: ＜50% in bed during the day (ambulatory and capable of all self-care but unable to carry out any work activities; up and about more than 50% of working hours
3: Capable of only self-care limited, confined to bed or chair ＞50% of waking hours
4: Completely disabled, cannot carry on any self-care. Totally confined to bed or chair
5: Dead

Table 5 Data for postoperative reoperation

Reasons of reoperation	Number of patients (%)	Postoperative day of reoperation			Salvage number of flaps
		D1–D3	D4–D6	≥D7	
Bleeding	2 (11.1%)	2	0	0	2
Flap congestion	3 (16.7%)	3	0	0	3
Flap necrosis	7 (38.9%)	1	1	5	1
Wound infection	5 (27.8%)	0	1	4	5
Donor site morbidity	1 (5.6%)	0	0	1	1
Total	18 (100%)	6	3	9	12 (66.5%)

D1～D3- Day 1 to day 3, D4～D6- Day 4 to day 6, ≥D7- more than Day 7.

Table 6 Mean operative duration according to year distribution

Year	2015	2016	2017	2018
Anterolateral thigh flap	10.6 h (S.D ± 1.08)	10.8 h (S.D ± 4.1)	8.9 h (S.D ± 1.7)	8.3 h (S.D ± 1.5)
Radial forearm free flap	8.3 h (S.D ± 1.8)	8.6 h (S.D ± 1.9)	7.8 h (S.D ± 0.6)	7 h (S.D ± 0.5)

*Operative duration includes total operation (tumor removal, neck dissection, flap raise, inset and anastomosis).

(26 patients, 41%) were completed in between 8 to 10 h. Very few operations (2 patients, 3%) were completed in between 14 to 17 h. The average operative duration was 9.15 h. The remainder of the operations were completed as follows: 9% in ≤6 h, 27% within 6 to 8 h, and 17% within 10 to 12 h.

The fastest operation was a radial forearm free flap for tongue reconstruction, completed in 5.5 h. The longest operation lasted for 17 h; it involved anterolateral thigh flap reconstruction for recurrent squamous cell carcinoma at the nose, upper lip, and buccal mucosa. The tumor was so extensive that a prolonged operative period was required for a difficult neck dissection, tumor resection, and difficult anastomosis due to arterial thrombosis during the operation. However, no adverse outcomes occurred in the postoperative period.

The year distribution shows that the mean duration of the total operation for cases of reconstruction with an anterolateral thigh flap ranged from 10.6 h (S.D ± 1.08) in 2015 to 8.3 h (S.D ± 1.5) in 2018, while that for radial forearm free flaps ranged from 8.3 h (S.D ± 1.8) in 2015 to 7 h (S.D ± 0.5) in 2018 (Table 6).

Regarding anticoagulation therapy in microsurgery, prostaglandin infusion was used in only one patient (a woman with a free groin flap reconstruction for a defect after the release of a facial acid burn contracture with flap congestion in the immediate postoperative period) and resulted in subsequent flap survival. We used heparin irrigation at the time of vascular anastomosis in every patient. Nonetheless, although we did use systemic heparin in all patients, it is indicated for the prevention of systemic deep vein thrombosis due to immobilization, not for anastomotic patency. In cases of revision surgery for thrombosis, we occasionally used intravenous heparin (5,000 units) after the release of the vascular clamps.

The average hospital stay was 16.8 days (range, 8 to 63 days). More than half of our patients (49 patients) were hospitalized for less than 20 days. A few (4 patients) had to stay in the hospital for more than 50 days due to wound complications. Five patients stayed for 21 to 30 days, and the remaining 4 patients stayed for 30-50 days.

Discussion

Microsurgical free flap surgery requires very strong cooperative teamwork [6]. Previous reports have described the microsurgical training of surgeons from low-resource countries by surgeons from developed countries [6-8]. Craig *et al.* reported a 15-year experience of successfully introducing microsurgery in Vietnam with the aid of Operation Smile international missions [7]. In this paper, we have described the gradual introduction of microsurgery in Yangon General

Hospital, Myanmar, with training from Okayama University Hospital, Japan, and with the support of Australian Interplast. In this endeavor, plastic surgery trainees were given the opportunity to undergo microsurgery training. The clinical experiences of local surgeons were enhanced with combined free flap transfer operations undertaken with the Japanese and Australian teams. The education and training of nurses and other supportive personnel are equally important for the success of free flap surgeries, and both were supported by Australian Interplast.

In the past, establishing microsurgery in resource-limited developing countries such as Myanmar has been challenging [9]. But using the approaches described herein, hospitals in developing countries may be soon be able to meet the basic requirements of microsurgery, such as operative techniques and perioperative management.

In our study, intraoral tumors and lower limb trauma defects were found to be the most common causes of microvascular reconstruction. In Myanmar, intraoral tumors accounted for 3.5% of whole-body cancers, which makes them the sixth-most prevalent cause in males and the tenth-most prevalent in females [10]. Lower limb defects due to trauma are also a common problem, accounting for 25.3% of the trauma patients admitted to Yangon General Hospital [11]. Before we could perform free flap reconstruction, these defects were reconstructed with loco-regional flaps. However, the outcomes were not satisfactory in some cases.

In this series, the anterolateral thigh flap was most commonly used for various donor sites. At the start of the study, we used the radial forearm free flap frequently because it is a relatively quick and easy way for beginners to harvest a long pedicle with large diameter vessels. Later, the anterolateral thigh flap became the most common because it involves a wide and long skin area, several perforators, a long pedicle, and an acceptable hidden donor site scar. Ultimately, the choice of flap was dependent on the location and size of the defects.

Perioperative flap monitoring is also crucial for flaps to be successful [12]. We educated junior trainees and nurses on how to monitor the flap clinically. Monitoring was performed by them as well as by surgeons using the pin-prick test and Doppler ultrasound.

However, the greatest challenge we faced was in being able to return to the operating theatre for compromised flaps, especially at night, due to limited hospital resources, anesthetists, and manpower. We were only able to reorganize the team and re-explore in the morning. If we were suspicious of congestion, we sometimes released some sutures at the bedside. Therefore, there was always a delay in reoperation on compromised flaps, and that would partly explain the problem of flap necrosis. To cope with this, the surgical team had to exercise great caution to ensure flap survival. Thus, another need is to increase personnel such as young surgeons and other staff members.

Another problem we faced was delayed referral from other units. This made the surgery a lot more difficult, as it was usually performed in the subacute period, which has a much higher failure rate for microsurgical free tissue transfer.

In this study, the flap survival rate was 89%, which is comparable to that in other studies. Kim *et al*. reported that their overall flap survival rate was 90.7% in June, 2015, in South Korea [13]. Nangole *et al*. reported a flap success rate of 89% in 2015 in Kenya [2].

During the study period, we had to face some free flap failures (11%). Free flap failure is a traumatic experience for the patient and surgeon alike, and causes the surgeon to reappraise the wisdom of performing the operation [14]. The flap salvage rate was found to be highest within the early postoperative period (3 to 5 days) for compromised flaps; after that period, salvage was impossible. This means that early awareness of flap changes and early re-operation are vital for flap salvage [15].

The flap salvage rate was found to be 66.6% for cases with vascular problems, bleeding, and wound infections in this study. This is relatively comparable to the study by Kim *et al*, in which the salvage rate was 63.2% [13]. In our study, the outcomes tended be better when we become aware of the infection as early as possible. Therefore, early awareness and a high index of suspicion are crucial to avoid the worst situations from occurring.

We have noted that the number of compromised flaps decreased last year (2018); the flap salvage rate was low at the beginning of this study, but it became higher in 2017. This increase in the salvage rate and reduction in complications are related to increased experience in the clinical detection of compromised flaps as well as improved hospital resources and human resources. On the other hand, we still cannot create a second free flap at once in compromised cases due to constrained resources.

There were 2 patients who died in this study period. One death was due to pulmonary embolism and the other was caused by intracranial infection. Contributing factors to these deaths may include inadequate perioperative optimization and a sub-optimal time of reconstruction. The preoperative performance status of patients has been validated as a prognostic indicator of postoperative outcomes [5], and the ECOG (Eastern Cooperative Oncology Group)/WHO (World Health Organization) performance score is effective for making this preoperative determination [5,16]. Indeed, a high WHO score has been significantly associated with prolonged hospital stay and complications [17]. We had to learn from that bitter experience to avoid complications in subsequent patients.

The routine usage of intravenous heparin for prophylactic vascular thrombosis in free flap surgery has been stopped due to bleeding and haematoma in some patients, and in many centers this treatment is only used in cases of difficult anastomosis for intraoperative vascular thrombosis [18-20]. Although we use heparin routinely, its main indication is for the prevention of DVT.

Our study has shown that improved clinical experience has led to a relative decrease in the operating time and a possible decrease in the complication rate of free flap microsurgeries at our hospital. The mean operative duration was reduced year by year. This indicates that we have steadily progressed along the learning curve. In our view, there is no better way to learn microsurgery than through operative experience.

In a resource-poor developing region like Myanmar, establishing a microsurgery program is not easy. First, we need personnel who are strongly motivated, appropriate minimum resources like operating microscopes, ICU care and perioperative management, and effective training programs. There are two ways to obtain the needed education: trainees can go abroad to learn or volunteer teams can visit developing countries. We have taken both approaches. After obtaining their training, trainees can share their experiences with juniors and eventually become trainers. In this way, we believe a larger microsurgery team will be developed soon.

In conclusion, while it is clear that the microsurgery program in Myanmar has begun, free flap reconstructions remain difficult to practice and establish in resource-limited environments such as ours. The experiences at our hospital underscore that fewer complications, better flap salvage rates, and shorter operative durations develop in parallel with improved clinical experience. A well-established microsurgery center requires a strong multidisciplinary team, clinical experience, continuous and effective educational programs, learning, practicing, and effective interdepartmental and intradepartmental cooperation.

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