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Establishing a Microsurgical Practice in a Limited Resource African Setting: The Kapsowar Hospital Experience

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Background: Microsurgical technique is still not readily available in many low- and middle-income countries. Few works in the scholarly literature describe the establishment of microsurgical practice on the African continent, and there are virtually no descriptions of the financial aspects of free flap performance by locally staffed teams in sub-Saharan Africa. The Kapsowar Hospital is a hospital in rural Kenya with 2 plastic and reconstructive surgeons certified by the American Board of Plastic Surgery and has recently expanded clinical practice to include microsurgical procedures.

Methods: A retrospective chart review was conducted on patients who received a free flap at the Kapsowar Hospital in 2022–2023. Captured parameters included age, sex, relevant medical history, etiology of wound, flap performed, intraoperative time, complications, surgical revisions, and length of stay. Billing information for all domestic patients who received free flaps were audited, and disability-adjusted life years was calculated.

Results: Nineteen free flaps were performed on 17 patients. The most common flap performed was the anterolateral thigh flap (n = 11). Flap survival rate was 94.7%. The surgical cost associated with performing an anterolateral thigh flap was $548 ± $35. The total cost associated with other free flap performances was $863 ± $269. The cost per disability-adjusted life years averted was $121, indicating that the procedure was very cost-effective.

Conclusions: Despite obstacles, microsurgical practices can be safely established in limited-resource African settings. Free flaps can be performed with greater cost-efficiency when performed by local teams. Surgical mission trips should emphasize educational components and ultimately transition care to local surgeons. *(Plast Reconstr Surg Glob Open 2024; 12:e6390; doi: 10.1097/GOX.0000000000006390; Published online 20 December 2024.)*

INTRODUCTION

The development of reliable microsurgical techniques has elevated standards of care in plastic surgery and, in some instances, initiated an entire reimagining of the reconstructive ladder.[1–3] Although this is true in high-income nations, the reality is that in low- and middle-income countries (LMICs), such surgical management is still not readily available. This lack of access to advanced surgical techniques is especially concerning given that surgeons in the LMICs of sub-Saharan Africa contend with an increased burden of patients for whom free flaps would be the most appropriate method of management.[4] That the plastic and reconstructive surgeons of sub-Saharan Africa are eager to master and offer microsurgical capabilities to their arsenal, even in resource-constrained environments, is evidenced by a recent survey of plastic surgeons in LMICs in which 97% agreed that microsurgery was essential to their region and cited a desire for increased training and resource allocation for such procedures.[5] Currently, there are few works in the scholarly literature that have described their institution's experience

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in establishing long-term microsurgical practices on the African continent, the lessons they have learned, and the outcomes they have obtained.[6,7] Information regarding the expenses associated with performing free flaps in sub-Saharan Africa is equally sparse and has been primarily reported in the context of short-term mission trips.[8,9]

The Kapsowar Hospital is a 140-bed nongovernmental district-level hospital located on an escarpment of the Great Rift Valley in rural western Kenya. The population that it serves is predominantly agrarian, and it acts as a catchment for approximately 300,000 people. Among the 20,000 patients who receive care at this facility yearly are 4000 inpatients. Despite its rural location, the hospital has a robust surgical staff, which is comprised of both national and expatriate surgeons who are responsible for the management of more than 2000 surgical patients a year. Beginning in 2022, advancements in staff and necessary supplies and equipment enabled the establishment of the first microsurgical practice in this region of Kenya. Our hospital has 2 plastic and reconstructive surgeons certified by the American Board of Plastic Surgery, which uniquely positions us to describe our initial experience and outcomes in establishing a microsurgical unit. We believe this to be the first work to detail the financial aspects and cost-effectiveness of performing microsurgical procedures in rural sub-Saharan Africa with an entirely locally dwelling team.

PATIENTS AND METHODS

This study was jointly coordinated by faculty at Weill Cornell Medicine and Kapsowar Hospital and approved by the institutional review boards associated with both. A retrospective chart review was conducted on all patients who presented to Kapsowar Hospital and were managed with at least 1 free flap from November 2022 to 2023. Eligible patients were identified via a search of the electronic medical record at Kapsowar Hospital via appropriate search terms. All patients who had been admitted for inpatient care and required surgical management with a free flap were included in the study, irrespective of age, sex, or etiology. After identification of eligible patients, charts were reviewed assessing the following parameters as documented for all patients: (1) age, (2) sex, (3) relevant medical history (ie, smoking status, diabetes, human immunodeficiency virus), (4) etiology of wound, (5) localization of wound, (6) flap performed, (7) intraoperative complications, (8) intraoperative time, (9) postoperative complications, (10) postoperative complications and surgical revisions, and (11) length of hospital stay. Further analysis included obtaining billing information for all domestic patients who had received free flap procedures and calculating the cost-effectiveness of free flap performance using disability-adjusted life years (DALYs) based on the database of the Global Health Cost-Effectiveness Analysis Registry using a disability weighting of 0.173 for a long-term untreated amputated lower limb, a discount rate of 0.03, and an age weighting parameter of 0.04. Obtained data were entered into a Microsoft Excel spreadsheet, and patient-specific identifiers were removed.

Takeaways

Question: What is the experience of establishing a microsurgical practice in rural Africa?

Findings: We reviewed our first year of free flap cases, including outcomes and a financial audit. Our study demonstrates that despite obstacles, it is possible for local teams to safely perform microsurgical procedures in low-resource African settings with greater cost-effectiveness than has been demonstrated by surgical mission trips.

Meaning: In rural African settings, plastic surgery surgical mission trips performing free flap–based reconstruction should emphasize educational components to ultimately transition care to local surgeons.

RESULTS

Plastic surgeons performed 19 free flaps on 17 patients. Of the 17 patients, 13 were men and 4 were women. The average age of patients was 39 ± 18.5 years. Follow-up period was 2–12 months. A summary of patients in the cohort with flap indication, flap performed, outcome achieved, and relevant patient medical history is provided in Table 1. The most common free flap was the anterolateral thigh (ALT) flap (n = 11). Less common flaps included fibula, radial forearm, ulnar forearm, and free scapular/parascapular flaps. The flap survival rate for all flaps was 94.7%. Operative time was noted for 9 of 18 surgical procedures. The average time of ALT flaps was 11.0 hours. The average time of fibula flaps was 15.8 hours. Complications are summarized in Table 2. Flap failure due to venous congestion was noted in 1 instance and was managed with further, successful free flap transfer. In addition, there were 3 instances of intraoperative thrombosis all of which were successfully managed on the operating table with irrigation and heparinized saline. The costs associated with the performance of an ALT flap are summarized in Table 3. The average surgical cost associated with performing an ALT flap was $548 ± $35; the average cost of inpatient medications was $77 ± $57; the average cost of hospital stay was $238 ± $177. The total cost associated with free flap performance was $863 ± $269. The average DALY per lower extremity reconstruction was 7.14. The cost per DALY averted was $121.

TECHNIQUE

All flaps were raised under surgical loupe magnification. Flaps were flushed using a heparinized saline solution. In cases requiring additional reconstruction, resection of the recipient site would precede raising of the flap and both procedures would be carried out by the same surgical team. Arterial anastomoses were performed using microsurgical instruments and 8-0 or 9-0 sutures using a Zeiss operating microscope. Venous anastomoses were performed using a venous coupler device (Synovis Micro Companies Alliance, Inc.), except when size precluded using this device. Wherever possible, at least 2 veins were coapted. Before closure, adequate flow to the flap was confirmed by visual inspection of bleeding from the flap and verified by the presence of an external handheld Doppler signal. We use the placement of a

Table 1. Case Summary

Case No.	Age, y	Sex	Location	Incident Details	Diagnosis	Chronic Medical Conditions	Free Flap Performed	Flap Survival
1	68	F	Lower extremity	Burn	Gangrene	None	ALT	Yes
2	23	M	Lower extremity	Crush injury	Internal hardware exposure	None	ALT	Yes
3	49	M	Face	Blade (assault)	Traumatic lip amputation	None	Radial forearm	Yes
4	21	M	Upper extremity	Blade (assault)	Internal hardware exposure	None	ALT	Yes
5	72	M	Lower extremity	Neoplasm	Squamous cell carcinoma	None	ALT	Yes
6	30	M	Face	Infection	Noma	None	Fibula	No
							Radial forearm	Yes
7	31	M	Face	Infection	Noma	None	Ulnar forearm	Yes
8	30	F	Face	Neoplasm	ameloblastoma	None	Fibula	No
							Fibula	Yes
9	77	M	Lower extremity	Neoplasm	Marjolin ulcer	Diabetes, hypertension	ALT	Yes/partial
10	31	M	Lower extremity	Unspecified	Internal hardware exposure	None	ALT	Yes
11	49	M	Lower extremity	Burn	Burn	Hypertension	ALT	Yes/partial
12	48	M	Lower extremity	Burn	Chronic wound	Hypertension	ALT	Yes
13	9	F	Face	Infection	Noma	HIV	ALT	Yes
14	25	M	Lower extremity	Motor vehicle accident	Fracture with soft-tissue defect	None	ALT	Yes
15	22	M	Lower extremity	Motor vehicle accident	Traumatic amputation	None	ALT	Yes
16	49	M	Lower extremity	Prick injury	Chronic wound	None	Scapular/ parascapular	Yes
17	65	F	Face	Neoplasm	Squamous cell carcinoma	None	Latissimus dorsi	Yes/partial

Table 2. Postoperative Complications (14)

Etiology	Frequency (n)
<5% necrosis	2 (10.5%)
Partial flap necrosis	3 (15.8%)
Hematoma	3 (15.8%)
Infection	2 (10.5%)
Donor site dehiscence	3 (15.8%)
Flap failure (venous congestion)	1 (5.3%)

single, simple suture at the site where the Doppler signal was attained to ensure consistent subsequent evaluations at the bedside.

Patients are returned to the surgical ward after surgery. In the absence of more sophisticated methods, such as implantable Doppler or tissue oximetry infrared devices, our local protocol requires nursing staff to perform serial clinical exams for skin warmth and visual inspection as well as Doppler sonography every hour for the first 3 days after the procedure.

DISCUSSION

Although sub-Saharan Africa has unfortunately lagged behind high-income countries (HICs) in microsurgical capabilities, there is much room for optimism regarding the future of the practice on the continent.[10,11] In the wake of the 2015 publication of the Lancet Commissions "Global Surgery 2030: Evidence and Solutions for Achieving Health, Welfare, and Economic Development," there has been both increased interest in the development of microsurgical techniques in LMICs expressed by surgeons in HICs as well as an increase in scholarly output from their colleagues on the African continent.[6,12–14] This small, but growing, body of literature suggests that microsurgery can be performed safely and effectively, even in the low-resource environments that often typify the African healthcare experience.[15,16]

However, that is not to say that there are no significant obstacles to performing microsurgery in LMICs. As a rural facility in an LMIC, our experience in free flap surgery allows us to highlight some of the challenges confronting this frontier of surgical delivery and how our institution has managed them.

The ALT flap has proven to be our workhorse for lower extremity soft-tissue defects. This flap has numerous advantages that are well documented in the literature, including potentially wide skin territory, reliably sized and positioned perforators, and innervation (Fig. 1).[17,18] In addition, as our patient cohort to this point has tended to favor young men after traumatic injury and older patients with chronic lower extremity wounds, notable drawbacks to the flap—such as the frequent necessity of split-thickness skin grafts to the donor site because of the required large flap size—have not been dissuasive to its use.[18] Similarly, as our cohort has had a low obesity rate, we have not had significant issues with ALT flap thickness, which can dissuade its use in other populations.[19,20]

We have had success in using a variety of free flaps for use in facial reconstruction (Fig. 2). For mandible reconstruction, we have favored the use of the fibula flap, which allows for both sufficient length of bone graft and adequate soft-tissue coverage.[21,22] For reconstruction of the

Table 3. Costs Associated With Free Flap Performance

OR	US Dollars	Inpatient	US Dollars (Daily)
Staffing		Staffing	123.6 (4.12)
Anesthetist	64.4	Electricity and food	18.1 (0.60)
Nursing	68.0	Bandages	7.6 (0.25)
Repetitive costs		IV fluids	38.7 (1.29)
Autoclave operation	1.1	Drains and tube	5.0 (0.17)
OR electricity	13.9	Gauze	11.7 (0.39)
Pharmaceuticals		Gloves	12.4 (0.41)
Heparin	4.7	Syringes and needles	21.2 (0.71)
Anesthetics	2.8	Inpatient total	238 ± 177 (7.9)
Consumables			
Anesthesia supplies	6.4	Pharmaceuticals	
Bandages	4.3	Anticoagulants	31.6
Blood transfusion fee	3.9	Aspirin	5.8
Drains and tubes	9.8	NSAIDs	0.7
Gauze	9.5	Opioids	1.7
Gloves	13.7	Antibiotics	35.9
IV fluids	21.8	Nutritional supplements	0.6
KY jelly	2.8	Miscellaneous	0.2
Microclips	25.7	Pharmaceutical total	77 ± 57
Syringes, needles, scalpels	1.8		
Suture (micro)	252.0		
Sutures (standard)	39.7		
Urine bag	1.3		
OR total	548 ± 35		

IV, intravenous; NSAID, nonsteroidal anti-inflammatory drug; OR, operating room.

Fig. 1. Patient from case series. A, A photograph of a female patient who presented with a squamous cell carcinoma. B, A photograph of this patient 8 months after receiving a latissimus dorsi free flap.

oral lining, we have had good success with both radial and ulnar forearm flaps, which provide relatively easy dissection and favorable malleability.[23–25]

Similar to other studies regarding microsurgical outcomes in sub-Saharan Africa, a major challenge confronting our institution is postoperative flap monitoring.[4,12] This has proven especially challenging in buried and deep oral flaps where the veracity of Doppler signaling is more difficult to ascertain. Our 1 failed flap was not recognized as necessitating re-exploration until it was beyond the point of rescue. Therefore, despite the protocol established by our institution for postoperative monitoring, continued improvement in the ability to recognize troublesome signs is necessary to optimize results.[26]

Given that we only have 1 surgical team capable of performing microsurgical procedures, both donor and recipient sites are typically operated on by a single surgeon. Our institution has excellent anesthetists whose presence allows for the safe performance of such extensive procedures. However, to limit the extended operative time, we used time-saving devices whenever possible.[27] This includes avoiding hand-sewing of venous anastomoses by use of anastomotic couplers and skin stapling donor site flaps.[28] Limiting surgical time is especially important

Fig. 2. Patient from case series. A, A photograph of a male patient who presented with a traumatic lower extremity amputation. B, A photograph of this patient 10 weeks after receiving an ALT flap.

in our facility as we do not have access to forced air-warming blankets and limited ability to leave patients intubated after discharge from the operating room. As such, safe practice requires well-trained nursing staff to closely monitor patients in the postoperative period.

Another challenge we have encountered is the absence at our rural institution of a microbiological laboratory capable of delivering cultures and antibiotic sensitivities. The nearest laboratory with the capability of providing culture and sensitivities is more than a 2-hour drive away. It takes approximately 1 week from the delivery of our specimens for this laboratory to provide us with results. This restricts our ability both to identify the causative organism infecting a specific patient and to inform the empiric treatment of others. In addition, our hospital's pharmacy has a limited formulary of antibiotics at its disposal, which presents further difficulty in our ability to combat both pre- and postoperative infections.

Another challenge to the establishment of a microsurgical practice in rural LMICs is the paucity of microsurgical resources available.[29,30] Although many of the supplies necessary for traditional surgical procedures can be obtained in the country, our microsurgical sets, microvascular sutures, and clamps must be purchased out of the country and hand-carried to our facility. This requires the surgical team to plan, organize, and anticipate inventory months in advance. In turn, mindful and judicious use of these limited resources is necessary throughout the course of every microsurgical procedure we perform. At our institution, given the scarcity of microsurgical instrument sets and the delicacy with which they need to be handled, our surgeons personally hand wash each microsurgery set and prepare them for autoclave sterilization.

One final barrier that merits discussion is the economic factors for patients and institutions of providing microsurgical procedures. The country in which we practice has a nationalized healthcare system. However, although free flaps performed by other specialties (ie, maxillofacial surgeons) receive reimbursement, no free flap procedures performed by plastic surgeons currently qualify for this reimbursement. Although our institution has a policy of not restricting care based on a patient's financial capabilities, the performance of free flaps at our institution is not yet profitable and is currently dependent on international charitable partnerships.[31–33] We intend to continue performing free microsurgical procedures beyond the study period for patients for whom such procedures are indicated. We believe that the path to economic sustainability in free flap procedures will be forged by a continued demonstration that microsurgery is not only possible but essential for optimizing patient outcomes in LMICs. We are hoping that our government will also recognize this and include reimbursements for free flap procedures in the national healthcare procedure coding.

Studies reporting on the performance of free flaps during surgical mission trips to Africa have priced the cost of a free flap procedure between $1800 and $2285.[9,34] To the best of our knowledge, there are no published studies that have reported the cost of a free flap procedure in rural sub-Saharan Africa with staff that reside entirely in country. Our audit of the financial records of all resources expended on patients who received ALT free flaps, including donated materials used in surgery (ie, sutures and clips), revealed an average cost of $548 ± $35. The greatest expense associated with the operation is the cost of microvascular sutures ($252 per surgery), followed by staffing anesthetists, 2 nurses, and 1 scrub tech ($132 per surgery). Postoperative pain control is primarily managed with a multimodal regimen consisting of nonsteroidal anti-inflammatory drugs and acetaminophen. When compared with the use of opioids for free flap patients, this treatment has been shown to be as safe, with a decreased side-effect profile and greater cost-effectiveness.[35,36] Pharmaceutical costs contribute an additional $77 ± $57 to our patient costs.

The length of stay for an ALT flap in the literature is reported at between 7 and 17 days.[37–39] Our patients with ALT flaps are admitted for 30 days on average. This increased time can be primarily attributed to 2 factors. First, our rate of postoperative complications (76.8%), while similar to those reported in other studies in Africa (33%–95%),[40,41] is greater than 18%–27.5% rate often reported in the literature from HIC counties.[42–44] This leads to further procedures and resource allocation. Second, as many of our patients come from remote locations and the ability to return to our institution for follow-up care is limited, we are conservative in our discharge plans. In comparison to the United States, where 1 recent study found the average cost per day of hospital admission to be $1425–$4337,[45] our cost for housing a patient is less than $8 per day. All told, inpatient costs for an ALT flap contribute an average of $238 ± $177 to the cost of performing a free flap. The total per-patient admission cost related to ALT free flaps at our institution was $863 ± $269.

DALYs are the standard unit used by the Global Burden of Disease Study to describe the morbidity and mortality due to disease.[46] The World Health Organization recommends that for an intervention to be considered cost-effective, it cost no more than 3 times the gross domestic product (GDP)/capital per DALY, and for an intervention to be considered very cost-effective, that it cost no more than the GDP/capital per DALY.[47] The average DALY per lower extremity reconstruction was 7.14. The average cost per DALY averted at our institution was $121. As the most recent GDP/capital for Kenya was $2,070,[48] the cost per DALY averted by performing an ALT flap for lower extremity reconstruction was a very cost-effective intervention at our institution.

Similar to other studies, which have compared treatment costs between international missions teams and local teams, our findings suggest that locally led teams provide more cost-effective care than do surgical missions.[49,50] Given the scarcity of plastic surgeons capable of performing microsurgical procedures, volunteer mission trips are still warranted. However, as has been demonstrated in other areas of global plastic surgery, the purpose of these surgical trips should not be solely the provision of surgical care for specific procedures in what has been termed the "vertical model" of healthcare delivery.[51] Rather, emphasis should be placed on training components whenever possible, in what has been described as the "diagonal model" of healthcare delivery, which improves efficiency and sustainability.[52,53] In addition, increased funding and efforts to provide fellowship opportunities in HICs for surgeons practicing in LMICs should be pursued.

Despite the challenges in establishing a microsurgical unit in our rural setting, there are several factors that have proven advantageous to our early success which bear mentioning. First, our institution is well established and trusted in our local community and there are few, if any, other options for microsurgical techniques within reasonable distance. It has not, therefore, proven difficult to attract patients who necessitate free flaps for their reconstructive management. Second, our institution benefits from having excellent anesthesia coverage, which allows us to operate to the full extent of our surgical capacity. Third, although short-term mission trips are, by their nature, limited in their ability to provide long-term care for their patients, as our plastic surgery team practices at our institution full time, we do not have restrictions with regard to time course that would otherwise limit our ability to perform reconstructions that may require multiple stages or revisions.[54,55] Fourth, we as a plastic surgery department are committed to finding creative ways to fund these procedures where expenses exceed the patient's ability to reimburse.

There are limitations of our study that warrant mentioning. First, given the great distances that patients often traverse to receive our services, compliance with follow-up appointments is low. Although we attempt to combat this with more conservative discharge dates than would be typical in HICs, we are unable to speak to the long-term morbidity our patients face. Future prospective studies would benefit from a longer follow-up period or enrolling only patients from the local catchment with whom regular follow-up could be more easily ensured. A second limitation of our study is that the relatively low number of cases analyzed in this study restricts the strength of our cost and DALY analyses. Furthermore, as plastic surgeons at our institution receive stipends from their respective sponsoring nongovernmental organizations and not the hospital, the generalizability of our cost analysis is limited by the absence of a surgeon's fee. Future studies involving a greater number of patients receiving treatment in rural environments under similar economic factors is warranted to allow for a more robust evaluation of the cost-effectiveness of microsurgical procedures in rural settings.

CONCLUSIONS

The microsurgical technique is a powerful tool in the skillset of a reconstructive plastic surgeon. Patients requiring reconstructive surgery in sub-Saharan Africa have not frequently been able to receive the free flaps necessary for

adequate function and cosmesis. The experience of our institution in establishing a microsurgical practice with a flap survival rate of 94.7% through its first year of operation demonstrates that the challenges of performing and managing these patients is both possible and cost-effective in a rural, low-resource setting.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

Patients provided written consent for the use of their images.

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