Pilot Evaluation of the Impact of a Mission-Based Surgical Training Rotation on the Plastic Surgery Skills and Competencies Development of General Surgery Residents in Rwanda

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OBJECTIVE: Increasing subspecialty surgical capacity in Rwanda requires innovative approaches to augment the skills of pre-existing surgical providers. Short-term, high-intensity training programs can be effective for surgical education, however, few studies have investigated the quality of skills acquired through a condensed surgical experience. This study aims to determine the efficacy of a 3-week surgical training rotation (STR) to teach plastic surgery skills to general surgery residents in Rwanda.

DESIGN: A survey-based, prospective observational study of general surgery residents and volunteer plastic surgery educators participating in an Operation Smile STR. Resident self-assessment scores of surgical capabilities at the beginning and end of the rotation were compared to surgeon evaluation of resident performance. Progression of resident performance and change in inter-rater reliability between residents and educators were analyzed. Student's *t* test with significance at $p < 0.05$ was used to confirmed statistical significance.

SETTING: This study took place during the Operaiton Smile STR at the Rwinkwavu District Hospital, a primary level hospital in Rwinkwavu, Rwanda.

PARTICIPANTS: All residents (5) and surgeon evaluators (4) who participated in the STR were included in this study. All study participants completed all study surveys.

RESULTS: Residents reported a significant increase in confidence with the majority of procedures performed by the end of the rotation. Surgeons identified significant improvement in all resident skills by 2 weeks ($p < 0.05$). Resident ability to perform self-assessment improved, as determined by a significant decrease in inter-rater error margin from −0.61 to −0.10 over the course of the rotation ($p < 0.01$).

CONCLUSIONS: In this pilot study, a 3 week rotation improved surgical competencies and technical skills of general surgery residents learning plastic surgery. These findings support using the short-term STR as a method for task-sharing education. Further studies are needed to determine durability of skills transfer and long-term impact on surgical capacity. (J Surg Ed 76:1579−1587. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

ABBREVIATIONS: ABPS, American Board of Plastic Surgery ACGME, American College of Graduate Medical Education DALY, Disability-Adjusted Life Year FTSG, full thickness skin grafting SAO density, The number of surgeons, anesthesiologists, and obstetricians in a country per 100,000 population STR, Surgical training rotation STSG split thickness skin grafting

KEY WORDS: international plastic surgery skills education

COMPETENCIES: Practice-Based Learning and Improvement, Patient Care, Medical Knowledge, Interpersonal and Communication Skills

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INTRODUCTION

The WHO list of essential surgeries includes many specialty surgical procedures that have known impact on the physical, psychological, and economic wellbeing of individuals through morbidity reduction and Disability-Adjusted Life Year (DALY) improvement.[1] Nevertheless, the burden of surgical need remains high with over 5 billion people lacking access to safe, affordable surgical care around the world.[2] Based on evidence suggesting improved health outcomes with increasing provider density, the Lancet Commission on Global Surgery recommends 20 general surgeons, anesthesiologists, and obstetricians per 100,000 population (SAO density).[2] This metric, however, does not address provider needs for subspecialty surgery such as reconstructive plastic surgery, which has a high global burden of need.

Increasing the number of plastic surgeons in low and low-middle income countries is challenging for multiple reasons: the lack of trained instructors available, the extensive duration and cost of comprehensive plastic surgery training, and the limited employment and career development opportunities leading to a "brain drain" effect. In Rwanda, an East African country of 12 million people, the surgeon, anesthesiologist, obstetrician (SAO) density is 0.75 in 100,000 population, suggesting the country needs a 26.7 fold increase in overall surgical care providers.[3,4] The surgical specialist availability is even more austere with only 2 credentialed plastic surgeons in the country. With 14% of overall mortality due to injuries, and high volumes of trauma, burns, and tumors, the burden of need for reconstructive surgery in the country is significant.[5] Nevertheless, with no Rwandan plastic surgery training program available, and a minimum 6 years of clinical training necessary to achieve plastic surgery credentialing abroad, the timeline needed to increase the availability of plastic surgery providers in Rwanda through traditional means will likely be extremely protracted.

As a provider of plastic surgery services in Rwanda since 2010, Operation Smile desired to improve the surgical capacity of Rwanda and the sustainability of their efforts in the country. In 2015, the organization, in conjunction with the University of Rwanda, initiated a biannual STR during which volunteer plastic surgery faculty instruct midlevel Rwandan general surgery residents on high-yield plastic surgery procedures in a mission based model. This STR experience focused primarily on plastic surgery education needs as expressed by the University of Rwanda and the Rwandan government.

Few studies have investigated the sustainability and expansion of surgical capacity that can be generated through an international mission model. A 2015 study by Bido et al. found that orthopedic missions in the Dominican Republic increased knowledge and skills transfer to other providers in the country.[6] The study, however, did not investigate the quality or durability of the initial skills training experience, and therefore left unanswered the question of how short-term intensive surgical training impacts the development of necessary core surgical competencies. Similarly, Operation Smile has observed that sequential international cleft missions progressively engage more local volunteers, who can be positioned for complete and sustainable transfer of care responsibilities over time.[7] However, the timeframe of engagement and skills transfer requires additional study.

In the United States, resident progression in plastic surgery training is monitored by sequential evaluations of technical skills and core competencies agreed upon by the ACGME and ABPS.[8] Additional validated tools to evaluate surgical skills development exist for multiple surgical specialties.[9] Using these validated tools, this study aims to quantify the impact of a short-term high volume plastic surgery training experience on Rwandan general surgery resident technical skills and core competency development.

MATERIAL AND METHODS

A survey based observational study was performed of resident participants and evaluators for the October 2018 Operation Smile STR program in Rwinkwavu, Rwanda. All residents who participated in the rotation were included in this study. All volunteer surgeons participating as rotation instructors served as evaluators.

Prior to beginning the rotation, residents were administered a prerotation self-assessment survey, which included questions about their prior exposure and comfort level with performing plastic surgery procedures, as well as self-evaluation of their surgical skills and knowledge. Questions were developed based on ACGME and ABPS published surveys of plastic surgery core competencies and reviewed by the University of Rwanda's General Surgery Department to ensure they agreed with the residency's overall learning objectives.[8] At the end of the rotation, residents were administered a postrotation self-assessment survey with the same questions.

Surgeons, who were all board-certified in plastic surgery by the ABPS, were administered a single survey at the end of their volunteer time. For each resident, surgeons were asked to evaluate their overall surgical competencies,[9] core technical plastic surgery skills, and overall performance at the beginning and end of their

experience with them. As surgeons participated in the rotation for only 1 to 2 weeks, results of their pre- and postassessments were organized according to the time point at which they interfaced with the resident rotation schedule: At the beginning, end of week 1, end of week 2, and end of week 3.

All survey questions were designed according to a 5-point Likert scale. Pre- and postrotation resident self-assessment scores for individual procedures were averaged and compared. Surgeon evaluation of resident overall surgical competencies and plastic surgery skills were analyzed over time. Additionally, surgeon evaluation of each resident's overall performance at the beginning and end of the rotation were assessed. Lastly, the reliability of resident self-assessment and surgeon evaluation was determined for plastic surgery technical skills. The difference between surgeon and resident scores was determined to create an inter-rater error margin. The change in magnitude of that margin at the beginning versus end of the rotation was compared.

All data were analyzed in Microsoft Excel (Microsoft Inc, Washington, DC). Statistical significance was determined using students *t* test at Type 1 error of $p < 0.05$.

RESULTS

Five residents from the University of Rwanda participated in the October 2018 STR program. Residents were in their 3 year of a 4-year general surgery residency program and all participated in the full 3 weeks of the program. This rotation marked residents' first experience with Operation Smile educational programming.

During the course of the rotation, 214 patients were screened and 99 procedures were performed in 73 patients. Target patient number for the rotation was 60. Residents engaged in a variety of plastic surgery procedures over 13 operative days including wound debridements, superficial mass excisions, scar revisions and contracture releases, split- and full-thickness skin grafting (STSG and FTSG), local and pedicled flaps, unilateral and bilateral cleft lip repair, cleft palate repair, and congenital and traumatic hand surgery. Most common procedures were mass excisions with reconstruction ($n = 26$, 26.3%) and scar revisions and contracture releases ($n = 21$, 21.2%). Both of these categories were frequently combined with other procedures. When procedures were performed in combination, 2 residents participated each with direct surgeon supervision at the respective surgical site. Four out of 5 residents (80%) participated in at least 1 of each of the procedures, with the exception of cleft palate repair (3/5, 60%), traumatic hand surgery (2/5, 40%), and local or pedicled flap (1/5, 20%) (Table 1). Additional days during the rotation were dedicated to patient screening at the beginning and dressing changes when needed at the end. Residents also engaged in a half day of didactic teaching each week.

TABLE 1. Resident Exposure to Different Procedure Types During the Rotation

Procedure Type	Resident Participation in Procedure, *n* (%)
Wound debridements	5 (100)
Skin lesion and tumor excisions	4 (80.0)
Scar revision and contracture release	4 (80.0)
Split thickness skin grafting	5 (100)
Full thickness skin grafting	5 (100)
Local and pedicled flaps	1 (20.0)
Cleft lip repair	3 (60.0)
Cleft palate repair	5 (100)
Congenital hand surgery	4 (80.0)
Traumatic hand surgery	2 (20.0)

On average, residents reported significant increase in comfort level and confidence in the following procedures: superficial mass excisions ($p < 0.05$); scar revision and contracture release ($p < 0.001$); FTSG ($p < 0.01$); unilateral ($p < 0.05$) and bilateral ($p < 0.05$) cleft lip repair; cleft palate repair ($p < 0.01$); and congenital hand surgery ($p < 0.01$). Procedures that were not associated with significant increase in confidence included wound debridements ($p = 0.178$) and STSG ($p = 0.078$), which had the highest prerotation scores, as well as local and pedicled flaps and traumatic hand surgery, which residents had the least exposure to during the rotation (Fig. 1).

Surgeons evaluated residents on their overall performance over the course of 3 weeks. Sixty percent of residents demonstrated significant improvement in overall performance with all 5 residents showing a positive trend (Fig. 2). Surgeons also evaluated residents on overall surgical competencies including: efficiency in time and motion; appropriate use of assistance; handling of intraoperative events or complications; and demeanor, temperament, and team communication. By the end of week 2, residents demonstrated significant improvement in efficiency, use of assistance, and handling of complications. No significant changes were observed in demeanor, temperament, and team communication, with average scores higher than 4 out of 5 from the beginning of the rotation (Fig. 3).

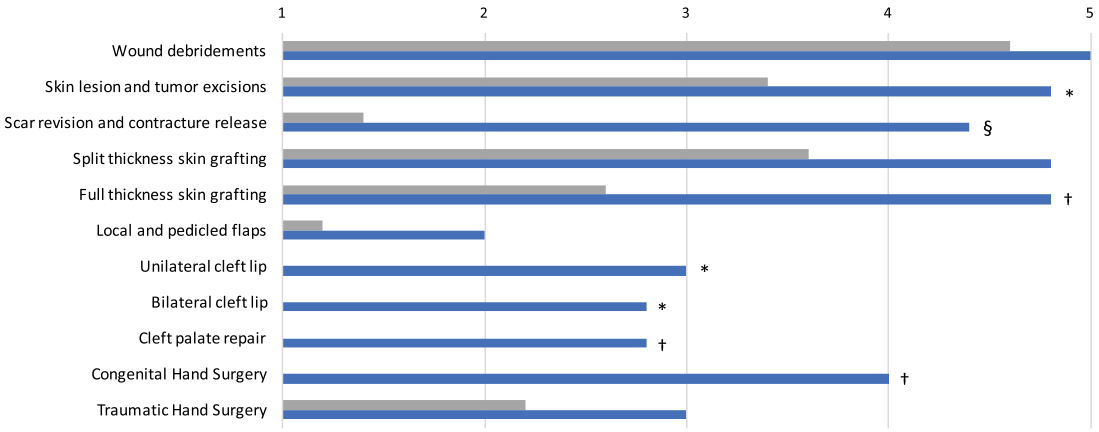

FIGURE 1. Average resident self-reported confidence with plastic surgery procedures at the beginning of the rotation (gray) compared to at the end of the rotation (blue). *$p < 0.05$, †$p < 0.01$, §$p < 0.001$.

Surgeons were surveyed on resident performance in specific plastic surgery skills. Table 2 lists out the series of questions related to plastic surgery skills that were included. On average, residents demonstrated significant improvement in all skills categories over the course of the rotation with earliest significance seen at the end of week one for knowledge of surgical anatomy (question 5) and application of postoperative dressings, splinting, and generation of a postoperative plan (question 8) ($p < 0.01$). All other skill categories achieved significant improvement after 2 weeks (Fig. 4).

Residents also became more accurate at self-assessment of their technical skills with time when compared to surgeon evaluation. Figure 5 demonstrates improved clustering of surgeon versus resident skills scores at the end compared to the beginning of the rotation. Additionally, the average inter-rater error margin between surgeon evaluation and resident self-assessed scores significantly narrowed from −0.61 to −0.10 ($p < 0.01$, Table 3).

DISCUSSION

Rwanda requires a significant increase in the number of surgical providers in order to address the surgical needs of the country. With an over 25-fold increase needed in SAO density, traditional methods of training for comprehensive plastic surgery service delivery will likely require decades to impact provider numbers in the country.[1,2] Surgical task shifting and task sharing, which currently is employed in 33% of countries around the world, can be an effective method of increasing the accessibility of essential surgical services.[10-12] With an existing general surgery residency program in Rwanda, training general surgery residents in the performance of plastic surgery procedures may be an effective method of augmenting the surgical capacity of the country. This study demonstrates that as little as 2 weeks of intensive exposure can increase not only confidence level and skill in performing plastic surgery procedures, but also

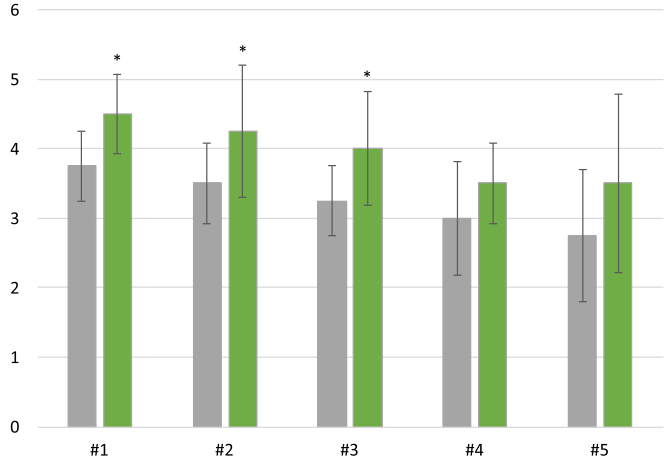

FIGURE 2. Surgeon evaluation of overall performance for each resident at the beginning (gray) compared to end (green) of the rotation. Individual residents are ascribed numbers #1 through #5. *$p < 0.05$.

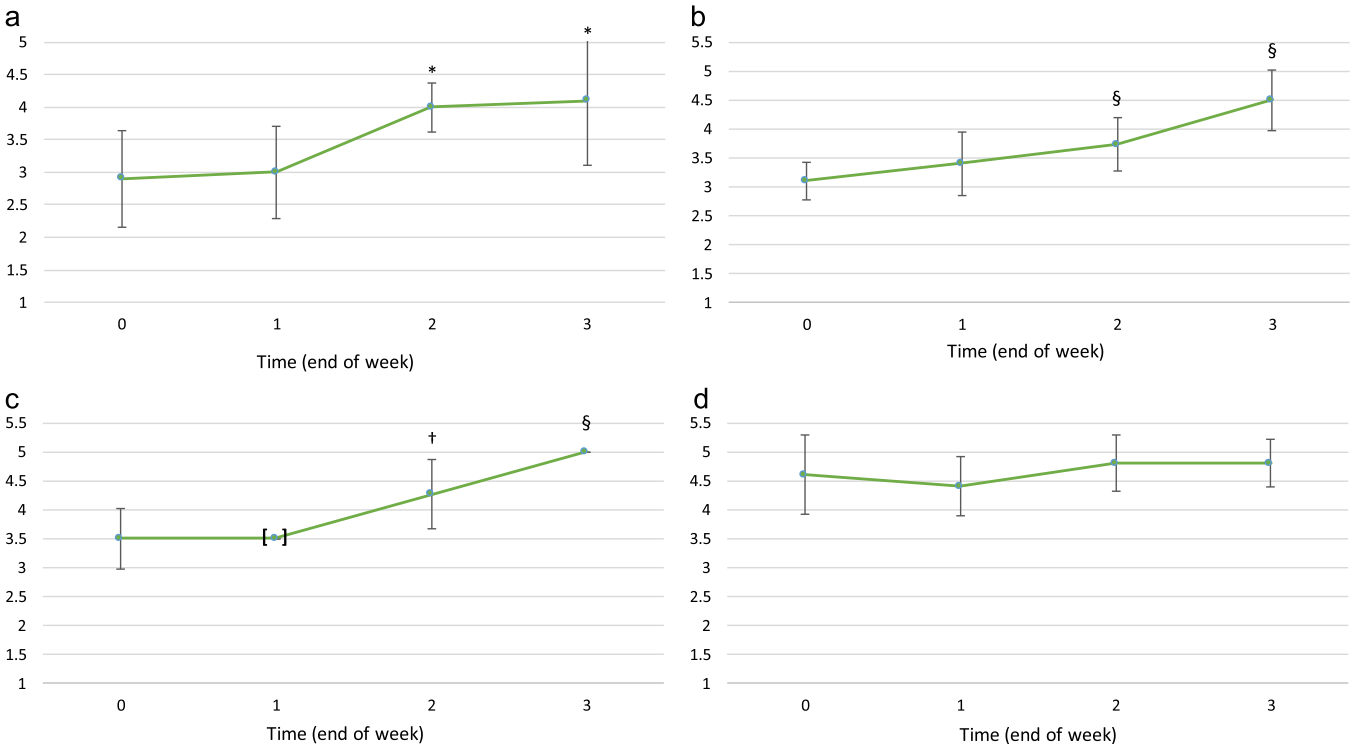

FIGURE 3. Average surgeon evaluation of resident skills over time in (a) efficiency of time and motion, (b) appropriate use of assistance, (c) handling of intraoperative events or complications, and (d) demeanor, temperament, and team communication. *p < 0.01, †p < 0.005, §p < 0.001. [] denotes lack of data (assumption made of no difference from previous).

the acquisition of general surgical core competencies. Skill performance continued to improve from 2 to 3 weeks suggesting that longer durations of exposure can result in ongoing skill development.

The breadth of plastic surgery exposure during the rotation was extensive with 99 procedures performed over 13 operative days in a 3-week period (average 19.8 procedures per resident). Each resident's surgical exposure during the rotation was dependent on individual patient presentations, with most common procedures including burn reconstruction and mass excision with reconstruction. Overall, the majority of residents had at least 1 and often more exposure to: wound debridements, superficial mass excisions, secondary burn reconstruction with STSG or FTSG, congenital hand reconstruction, and cleft lip repair. Improvement in self-reported comfort and confidence occurred in almost all procedures with the exception of those which residents had the least exposure (traumatic hand surgery and local or pedicled flaps) or the highest prerotation confidence (wound debridements and STSG). These findings suggest that a short surgical training experience can be a key component to developing diagnostic and treatment skills as well as confidence building.

A high volume, intensive surgical training experience is known to improve both general technical as well as procedure-specific skills in surgeons pursuing additional training in cleft surgery.[13] Through self-reports, 94.7% of residents in surgical training have also found that surgical mission experiences positively impact core competencies, specifically professionalism and leadership.[14,15] However, the objective impact of short term intensive

TABLE 2. Survey Questions Assessing Plastic Surgery Skills in Surgeon Evaluations and Resident Self-Assessments

Question Number	Question Description
1	Performs comprehensive preoperative patient evaluation and communication
2	Provides justification for procedure selected and knowledge of possible alternatives
3	Pays attention to safety (confirmation of consent, site marking, participation in time out)
4	Correctly places surgical markings, positions patient, and prep/drape
5	Consistently knows relevant surgical anatomy
6	Consistently knows surgical steps and flow of operation
7	Appropriately handles tissue, instruments, and devices
8	Correctly applies dressing, splint, and generates a postoperative plan

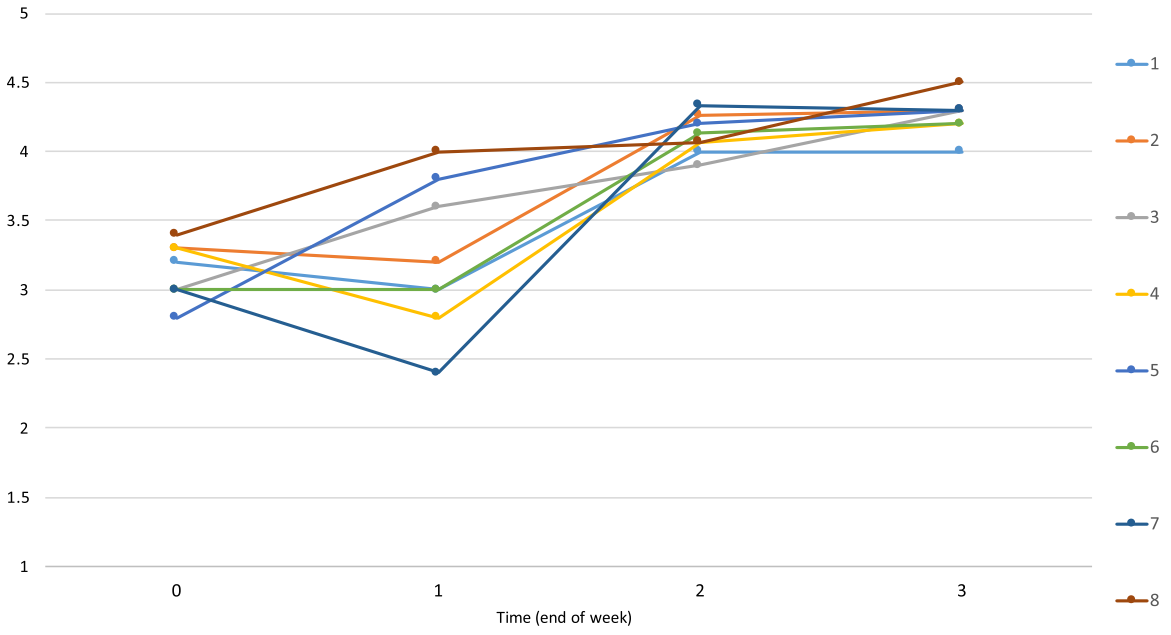

FIGURE 4. Surgeon assessment of resident plastic surgery technical skills over time. Each line represents a single question assessing a technical skill. Legend on the right identifies question numbers. Questions can be found in Table 2.

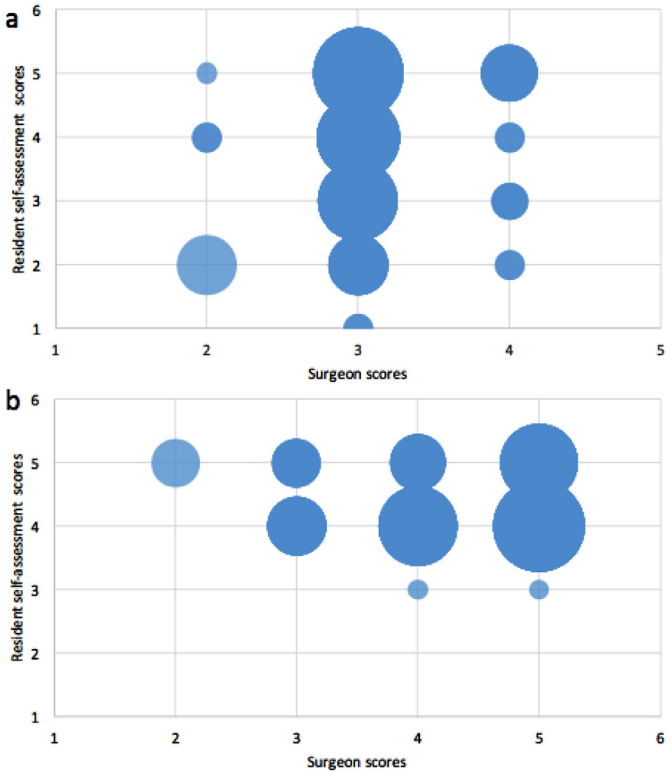

FIGURE 5. (a) Graph of surgeon evaluation versus resident self-assessment scores of technical skills performance at the beginning of the rotation. (b) The same comparison at the end of the rotation. Circle size represents the number of matched scores with larger circles denoting combinations of surgeon and resident scores that were more common.

TABLE 3. Inter-Rater Error Margin for Resident Self-Assessment Versus Surgeon Evaluation of Plastic Surgery Skills

	Question Number								
	#1	#2	#3	#4	#5	#6	#7	#8	Overall
Average prerotation error margin (SD)	−0.80 (1.48)	−0.50 (1.27)	−0.80 (1.30)	−0.50 (1.18)	−0.80 (1.32)	−0.40 (1.43)	−0.80 (1.03)	−0.6 (0.97)	−0.61 (1.22)
Average postrotation error margin (SD)	−0.40 (1.17)	−0.10 (0.99)	0.125 (0.83)	−0.40 (1.17)	0.00 (0.94)	0.00 (0.94)	−0.10 (0.99)	0.1 (0.99)	−0.10 (0.99)
p value	0.511	0.444	0.206	0.851	0.137	0.471	0.140	0.128	0.005

training experiences on resident skills development is a novel assessment. This rotation model differs from standard surgical missions in that the primary objective is to optimize resident education through the delivery of safe surgical care rather than maximize the number of patients who can receive care. In the latter model, while residents may be able to participate in surgeries, their efficiency level often is not high enough for them to participate beyond an assistant or observational role due to time constraints. In this experience, the target patient number was kept intentionally low in order to allow residents the time to actively participate in the surgical procedure with hands on experience under direct supervision. This program structure element likely contributes to the success of skills transfer through a short-term mission model.

In a survey of resident participation in surgical missions, 58% of experiences were under 10 days.[16] This study, however suggests that a minimum of 2 weeks is necessary to improve general surgical competencies such as operating efficiency, appropriate assistant usage, and handling of complications with improved skills development continuing up to 3 weeks. A similar trend was seen in specific skills, with earliest improvement occurring after 1 week in postoperative management and knowledge of surgical anatomy. However, multiple skills performances deteriorated in this time as well. The overall divergence in technical skills performance at 1 week transitioned into significant improvement by 2 weeks suggesting that rotations a minimum of 2-weeks duration is needed to generate reliable technical improvements. Additionally, the exposure to preoperative screening and didactic sessions during the surgical experience likely contributed to development of more conceptual skills including patient assessment and communication as well as generating an appropriate postoperative plan. A 2 to 3 week long intensive surgical training experience is consistent with many residency training models, were subspecialty rotations last a minimum of 1 month.

Three out of 5 residents demonstrated significant improvement in their overall performance over the course of the rotation. Interestingly, the 2 residents who began with the lowest scores did not achieve significant improvement, although they demonstrated a positive trend. This finding likely reflects that more rapid skill transfer can occur in individuals with higher baseline skill level, a phenomenon more starkly appreciated when comparing residents in their last compared to first year of training. In this rotation, residents were in their third of 4 years of general surgery education, which is likely the appropriate level for a 3-week long rotation. If more junior trainees are to be educated through this model, a longer duration of exposure would be recommended.

The ability to accurately self-judge performance is a skill that develops over time, with studies showing that residents in their fifth year of surgical training evaluate their own technical skills more reliably than more junior residents.[17,18] However, unlike years of surgical training, residents in this study were significantly more accurate in assessing their technical skills when compared to surgeon evaluation after only 3 weeks as demonstrated by a decrease in the average magnitude of inter-rater error margin from 0.61 to 0.10. This degree of improvement may reflect an early learning curve of self-assessment as a novel skill or highlight the power of high-volume concentrated surgical training.

One of this study's limitations lies in the survey methodology. As international volunteers, surgeons first encountered the general surgery residents on the first day of the rotation. As a result, surgeons were only able to retrospectively evaluate resident performance after having spent time with them. This may have introduced some recall bias into surgeon evaluations of early resident performance. Nevertheless, this recall bias would have been consistent across all time points of evaluation, as surgeons began and ended their participation in the rotation at each time point.

This study also does not address the longevity of skills improvement. Residents demonstrated significant ability to acquire novel skills and build core competencies in 3 weeks, but the durability of the learning experience and how it translates to the increased delivery of plastic surgery care is an area needing further study. This current study provides a foundation for a subsequent long-term study by confirming that plastic surgery skills can be acquired through the short term STR experience and providing a starting point from which to judge long term performance. If this skill level can be maintained and utilized in the future professional career of residents, the additional training may potentially impact the availability of plastic surgery services for the Rwandan population. Additionally, plastic surgery as a specialty encompasses a diversity of procedures that require different levels of skill to perform. Given the breadth of procedures performed in this study, disparate lengths and volumes of exposure may be required to both master and maintain technical skill depending on procedure complexity. Nevertheless, findings suggest that for specific procedures, a short high-intensity training experience can successfully result in surgical skills acquisition.

CONCLUSIONS

As countries attempt to increase their surgical capacity, creative ways are needed to transfer technical skills from educators to trainees in a rapid fashion. Through a 3-week plastic surgery training rotation, Operation Smile has demonstrated that general surgery residents in Rwanda can improve their overall surgical competencies, acquire novel plastic surgery skills, and increase their ability to accurately reflect on their performance. This method of education is an effective way to increase the number of providers capable of performing plastic surgery procedures even in the absence of a comprehensive plastic surgery residency program. Ultimately, repetitive training rotations through this model could have the potential to significantly increase the surgical capacity of the country.

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