A Facial Plastic and Reconstructive Surgery Training Module Using Surgical Simulation for Capacity Building

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OBJECTIVE: To introduce 3 novel intensive facial plastic and reconstructive surgery teaching modules for surgical capacity building using simulation in a low-middle income country.

DESIGN: Prospective cohort study.

SETTING: University-based medical center in Quito, Ecuador.

PARTICIPANTS: First- and second-year otolaryngology residents in Quito, Ecuador.

RESULTS: Residents participated in an intensive 3-day teaching program focused on microtia, nasoseptal abnormalities, and facial paralysis that included didactic lectures, simulation workshops, and live surgery. Residents underwent rigorous pre- and postmodule testing including written, oral, and practical examinations in each subject area. All participants completed anonymous feedback surveys with ratings on a Likert scale from 0 (very poor) to 10 (excellent). Nineteen residents completed both pre- and postmodule testing. The training module was successfully implemented and testing performance across all 3 subject areas significantly improved. Resident feedback was exceedingly positive, with average scores for each component ranging from 8.9 to 9.8, with highest scores given to the simulation workshops. The postmodule survey indicated that all residents found the course helpful and they desired additional courses covering more subject areas.

CONCLUSIONS: Implementation of an intensive surgical training module combining didactics, surgical simulation, and live surgery resulted in the successful transfer of both skills and knowledge. While the long-term benefit of this program is yet to be determined, this model of training may prove to be a useful tool to help address surgical capacity building in the developing world. (J Surg Ed 76:274–280. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: capacity building, education, low-middle income countries, surgical simulation

COMPETENCIES: Patient Care

INTRODUCTION

The field of global surgery is undergoing rapid transformation due to an increased awareness of the urgent need to improve surgical capacity worldwide. Several recent landmark "call to arms" publications have cast surgery as a greatly needed and essential component of global health, capable of relieving significant disease burden in a highly cost-effective manner.[1-4] The Lancet Commission on Global Surgery's *Global Surgery 2030* reported that only 6% of all surgical cases performed take place in low-middle income countries (LMICs) where one third of the world's population lives, leaving an astounding 5 billion people worldwide without

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access to safe, affordable surgical care.[1] To increase surgical capacity, the Lancet Commission highlighted the critical need for surgical workforce growth as the severe shortage of trained surgeons and anesthesiologist in LMICs creates a significant barrier to surgical access.

In response, surgeons interested in global health who operate in resource poor countries have shifted toward models that incorporate training of local surgeons. Traditional service-oriented or "vertical" mission trips, while capable of providing essential short-term care, are criticized for lack of sustainability and poor follow-up.[5] These antiquated models are being replaced by models, which emphasize local sustainability and capacity building. These diagonal systems incorporate local healthcare worker education and surgical training.[6,7] To this end, the global surgeon must envision a new model that provides long-term educational knowledge and support.

Despite this shift toward in-country training of local surgeons, quantitative data establishing the effectiveness of surgical teaching in these settings are lacking as are structured forms of teaching and educational modules. As surgical simulation gains esteem in the United States, we propose that surgical simulation may be the means of more efficiently teaching surgical procedures in LMICs. Herein, we describe a novel intensive facial plastic and reconstructive surgery teaching module that incorporates didactics, surgical simulation, and live surgery training in an LMIC, and assess the quantitative improvements in local surgeon knowledge and skill following completion of this course.

METHODS

This educational program was conducted in April 2017. A newly established 4-year residency program in otolaryngology was identified in Quito, Ecuador with an interest in academic partnership and a need for facial plastic and reconstructive surgery capacity building. An agreement was made to provide surgical accompaniment and training in facial plastic surgery, with rigorous pre- and postmodule testing. Participant data were collected from the tests and surveys administered, and were reviewed only by members of the responsible educational team. This was performed as an educational program and as such did not require Institutional Review Board approval. Written photography consents were obtained from the program participants.

The training module consisted of a 3-day intensive course with 1 day focused on each of the following: microtia, nasoseptal deformities, and facial paralysis. Each day the residents spent a half day listening to relevant short lectures, practicing pertinent facial analysis, and participating in a practical simulation workshop. The lectures given included a review of relevant anatomy, disease processes, facial analysis, and surgical management for each subject. In the microtia simulation workshop, residents planned, carved, and assembled an auricular framework from a synthetic rib (Fig. 1). The nasoseptal workshop used a novel nasal model simulator on which the residents performed a septoplasty, carved and placed columellar strut grafts, spreader grafts, and tip grafts, and practiced placing a nasal splint. In the facial paralysis workshop, residents practiced taking proper photography series and facial paralysis videos, and were offered an opportunity to practice the eFACE assessment. All residents were given a flash drive with relevant reading materials, lectures, and videos to review. If a resident missed a portion of the day's activities due to clinical obligation, the missed material was reviewed separately with them.

The second half of each day was spent in the operating room participating in the relevant live surgery. Residents participated in functional septorhinoplasty through an open approach, microtia repair, and static facial reanimation alongside the senior authors. Potential surgical cases were identified by a local surgeon prior to the team's arrival and these patients were screened by the visiting team the day prior to the start of the course. Each resident participated in at least 1 of each type of surgical case. Residents were taught proper photo documentation for rhinoplasty as well as intraoperative record keeping through use of Gunter diagrams.

Testing took a half day to complete and was performed on Monday prior to and Friday following the 3-day intensive course. The second half of the testing days was spent in the operating room observing and participating in surgery. Testing consisted of written, oral, and practical examinations in each of the targeted subject areas (microtia, facial paralysis, and nasoseptal abnormalities). The written examination consisted of 15 multiple choice questions, with 5 questions from each subject area, provided in both Spanish and English. The oral examinations consisted of oral board-style case scenarios for each of the 3 subject areas in which the residents were asked to analyze various nasal, facial, and ear deformities, and provide a treatment plan. A standardized grading system was used. Two versions of the written and oral questions, with similar levels of difficulty, were generated and randomized among the residents to be administered either pre- or post-training, such that no resident received the same pre- and postmodule test. Practical examinations included application of a nasal splint, performance of a detailed facial paralysis assessment using the eFACE scale,[8-10] and proper assembly of an auricular framework from 3 segments of precarved

simulated cartilage. A standardized grading system was used for each practical examination.

At the conclusion of the program, residents completed anonymous surveys evaluating the program in which the residents were asked to rate the quality of each portion of the module on a scale from 0 (very poor) to 10 (excellent) and were asked to provide feedback on what they liked and did not like about the program for improvement of future training modules.

Pre- and postmodule testing data were analyzed using paired and unpaired Student's *t* test, as appropriate, under the hypothesis that the educational module would improve testing performance in all 3 areas.

RESULTS

Nineteen otolaryngology residents initially enrolled in the training program. Twelve participants were in the second year and 7 were in the first year of surgical training. While this is a 4-year training program, the residency had only been in existence for 2 years and thus these were their most senior residents. A single second-year resident was excused from the module secondary to medical issues. Ten residents were present for every teaching opportunity, 6 residents missed 1 half-day session, and 2 missed 2 half-day sessions due to clinical obligations. Missed material was reviewed separately with these residents.

FIGURE 1. Practical workshops: (A) completed auricular framework completed by an Ecuadorian otolaryngology resident; (B) residents working on synthetic rib cartilage carving for microtia auricular framework; (C) nasal model simulator with mucoperichondrium being elevated; (D) residents participating in the rhinoplasty workshop. All residents gave written consent for publication of their photos.

The microtia and nasoseptal deformity workshops were successfully completed as planned. The facial nerve workshop, which took place on the third day, was modified to include a suturing workshop on pigs' feet to address soft-tissue-handling deficiencies noted among the residents during live surgeries. As a result, the originally planned eFACE practice workshop did not receive focused attention but was available to the residents.

All participating residents (n = 18, 100%) completed both pre- and postmodule testing. There was a highly significant increase in testing performance across nearly all testing modalities in each subject (Table, Figs. 2 and 3). There was a significant difference between the first- and second-year resident scores on their premodule written microtia test (36.61% vs 72.14%, $p < 0.001$), but no difference between the 2 groups in any of the other pre- or postmodule scores.

The resident feedback was exceedingly positive with average scores for each component of the teaching module ranging from 8.9 to 9.8 on a Likert scale from 0 (very poor) to 10 (excellent), with highest scores being given to the practical simulation workshops. A majority of the residents reported that they enjoyed the workshops the best. One resident commented "I loved the nasal and ear models, this way of teaching is really great" and another wrote "I liked that we could first review the academic part with lectures, then do workshops and later participate in the surgery." Opportunities for improvement in the course reported by the residents included more didactic and practical time for each subject, providing more books and articles for the residents to read, allowing more time for hands on surgical cases, and simplification of some of the lecture material. All residents reported that the module was valuable and they desired further teaching programs with coverage of additional subject areas.

TABLE. Pre- and Postmodule Testing Scores

	Pre-module Average [SD] (%)	Postmodule Average [SD] (%)	p value
Microtia			
Written	58.3 [22.8]	72.5 [20.2]	0.081
Oral	49.5 [19.8]	79.4 [13.0]	<0.001
Practical	29.4 [19.8]	74.4 [19.2]	<0.001
Rhinoplasty			
Written	60.7 [22.0]	87.4 [15.9]	<0.001
Oral	61.1 [20.7]	90.5 [10.7]	<0.001
Practical	43.9 [16.5]	92.8 [9.6]	<0.001
Facial nerve			
Written	61.1 [18.7]	87.7 [11.7]	<0.001
Oral	41.0 [14.6]	85.9 [13.0]	<0.001
Practical	38.1 [12.5]	38.9 [24.4]	0.908

Written, oral, and practical pre- and post-module scores in each subject area are demonstrated.
SD, standard deviation.

DISCUSSION

An intensive facial plastic surgery teaching model was piloted in Quito, Ecuador with great success. The partnering residency program was in its second year of existence, and in need of facial plastic and reconstructive surgery training and capacity building. There are a few senior otolaryngologists in Ecuador who were trained outside the country; however, there are no surgeons in Ecuador who perform facial reanimation surgery. Microtia surgery is generally performed by plastic surgeons in Ecuador, though a need for increased access to this surgery remains. Rhinoplasty, on the other hand, is performed by both plastic surgeons and otolaryngologists. The topics of this module were chosen based on a combination of surgical need and resident interest.

Pre- and postmodule testing allowed for a quantitative assessment of the teaching module's efficacy in transferring both knowledge and skills in the areas of microtia, nasoseptal abnormalities, and facial paralysis through a combined approach using lectures, hands on simulation workshops, and participation in live surgery in the operating room.

Second-year residents were expected to perform better than the first-year residents on all premodule testing; however, the 2 groups performed equivalently in all but the written microtia examination. This suggests a general lack of exposure to the subject material during residency training, thereby removing the expected performance improvement. Quito has a high incidence of microtia, attracting many visiting surgical teams.[11] Exposure to these teams may explain the higher premodule written microtia test scores among the second-year residents. There was no significant difference between these 2 groups at postmodule testing.

Following the intensive training modules, there was a highly significant improvement in overall testing scores in each of the subject areas (Fig. 2). In addition, there was a highly significant improvement in nearly all testing modalities in each subject area (Table and Fig. 3), with the exception of the practical facial nerve exam and the written microtia exam, demonstrating the successful transfer of both knowledge and skills through this training module. The value of practical workshops in addition to didactic lectures was demonstrated by the lack of improvement in the facial nerve practical examination. While a detailed lecture on the eFACE scale was provided, the facial nerve workshop, where residents were

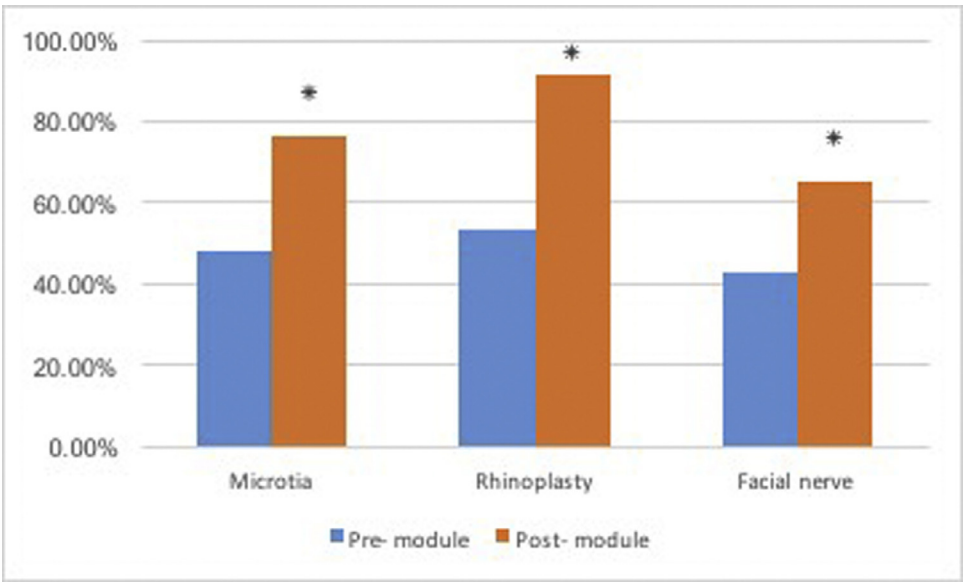

FIGURE 2. Overall Pre- and postmodule testing scores. Combined scores were obtained by adding the written, oral, and practical examination scores for each subject area. Asterisks indicate $p < 0.001$.

scheduled to practice using the eFACE, was eliminated to accommodate a suturing workshop due to a deficiency in soft-tissue handling noted among the residents during participation in surgical cases. Because the residents did not receive the planned practice using the eFACE facial nerve grading scale, it is not surprising that their performance on the facial nerve practical exam was unchanged at postmodule testing, and further highlights that lectures alone are inadequate to completely transfer surgical knowledge. The change in microtia written scores did not reach significance ($p = 0.081$). This is likely explained by the significantly higher premodule testing performance seen among the second-year residents, limiting the amount of improvement gained in postmodule testing.

The residents rated all aspects of the teaching module extremely high (8.9-9.8 out of 10), with highest scores given to the simulation workshops. Each practical workshop involved procedural simulation-carving auricular cartilage from synthetic rib, performing a septoplasty and carving and placing various grafts in a nasal model, and practicing suturing techniques on pig's feet. In a

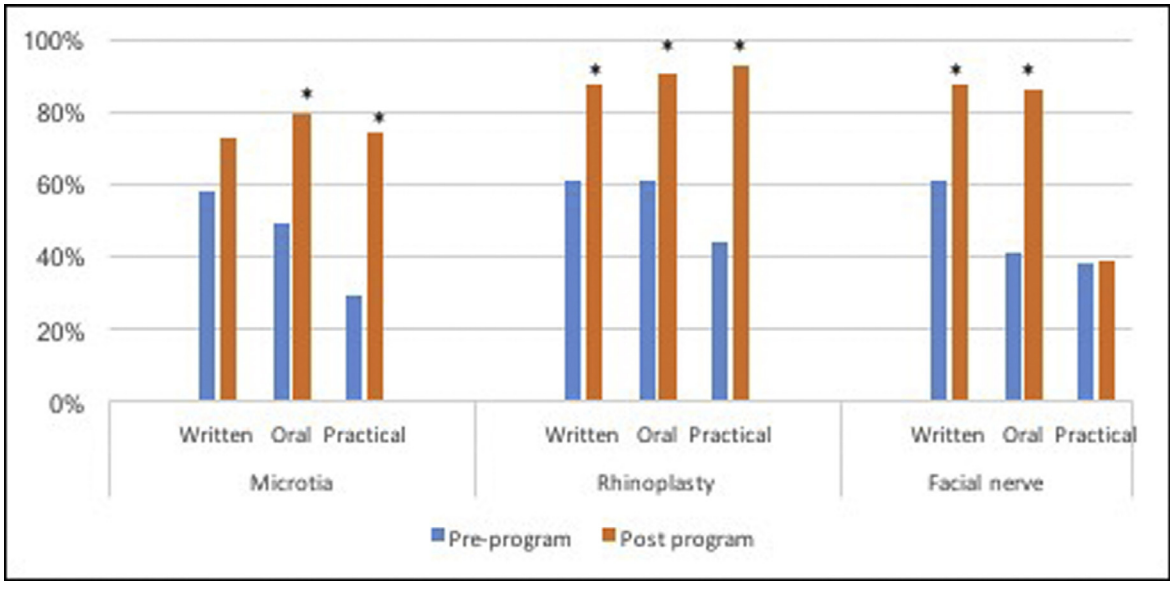

FIGURE 3. Pre- and postmodule testing scores by testing modality. Pre- and postmodule scores in each subject by exam type. Asterisk indicates $p < 0.05$.

resource-limited setting without access to cadavers, these simulations allowed novice surgeons to quickly gain practice and understanding of the surgical techniques taught in the lectures prior to proceeding to the operating room. In addition, it allows a greater number of residents to be trained at once per instructor.

Surgical simulation has gained increasing popularity in the United States medical curriculum and has been found to lead to improved surgical performance, medical knowledge, procedural comfort, and skill retention.[12-14] The Association of Medical Education in Europe, a worldwide organization for medical education, reported that simulation-based healthcare education can be used to help novice trainees to become proficient in specific tasks and that simulation-based healthcare education with deliberate practice leads to improved and lasting results compared with traditional clinical education.[13] The use of simulation in our study led to improved performance on practical exams and likely higher retention of the material presented in the lectures.

The simulation models used in our study were inexpensive and allowed 18 residents to simultaneously and efficiently practice surgical procedures without the use of cadavers or live patients under the observation and instruction of visiting surgeons. Surgical simulation offers a promising adjunct to lectures and more traditional models of teaching in LMICs for surgical capacity building. The skills learned in these workshops were subsequently actualized in the operating room, further cementing the concepts taught.

This educational program was successfully implemented in an LMIC with need for capacity building and knowledge transfer, and demonstrates feasibility of this type of program. The success of the program was not only demonstrated by significant multimodal test-score improvements, but perhaps more importantly, by the fact that all residents were interested in participating in future teaching models and many residents requested these modules being given multiple times per year. Students in LMIC crave exposure to knowledge, skills, and competencies, thus supplying the educators with a high level of attention to learn. This program provides a structured model through which much needed surgical capacity building in LMIC could be generated and provides a quantitative evaluation of both knowledge and skill acquisition. The subject modules used in this encounter can be transferred to other low-resource cities and countries. The model could be expanded to multiple needed subject areas across otolaryngology and beyond.

Assessment of long-term retention of the subject material was not assessed in this feasibility study. Further studies assessing the long-term retention of the material and the impact on surgical practice are warranted. Validation of the testing delivered is also needed. The duration of the course was short as it was designed to be an adjunct to a weeklong surgical trip. Video recording the lectures, practical exercises, and surgeries and leaving simulation models for future review or use may prove beneficial to clinicians who wish to incorporate these modules into their practice. Another limitation of this sort of module is an unfamiliarity with the baseline surgical skills of the learners, as was demonstrated by the inexperience with soft-tissue handling and suturing skills discovered during live surgery. While additional precourse assessment of skill may help, some flexibility in the curriculum is needed for program modifications to address identified deficiencies. Additionally, because the residency program had only been in existence for 2 years, there were only first- and second-year residents available to complete the course. Going forward, this program may be better suited for more senior residents and/or junior faculty who have already developed these basic skills and who demonstrate a particular interest in the taught topics. Revisiting the same sites at future dates will lead to a better understanding of current and retained skill sets. While the long-term benefit of this type of program is yet to be determined, this model of training may prove to be a useful tool in addressing surgical capacity via surgical simulation and module-based education.

CONCLUSION

We demonstrate feasibility of implementing an intensive surgical training module that combines didactics, practical workshops using simulation, and performance of live surgery in an LMIC for local surgical capacity building. Surgical simulation proved to be an important and valued component of the module that allowed for teaching of surgical skills to multiple learners at once in an efficient manner. Performance on multimodality testing in the taught subject areas improved significantly following the course, demonstrating the successful transfer of both skills and knowledge. While further long-term studies are warranted, this study demonstrates the successful implementation of this model, a perceived benefit by the local surgeons, and a mechanism of addressing the need for surgical capacity building in the developing world.

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