Competency-Based Education in Plastic Surgery Training

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December 2013

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Masters of Science

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Abstract

In Plastic Surgery, learning objectives have been outlined by the Royal College of Physicians and Surgeons of Canada, however, a defined curriculum to meet these objectives is absent. Several factors are reducing the practicality of the current time-based model and as a result, a competency-based training model has been proposed to replace the traditional model. Implementation of a competency-based curriculum requires several steps including the identification of both specialty specific procedures and procedural steps. The present project aims to develop a methodology for identifying procedural steps for individual Plastic Surgery procedures.

Previous studies have highlighted the lack of resident exposure to several areas of Plastic Surgery, particularly aesthetic surgery. Avenues for increasing resident exposure and training opportunities must be explored. An additional aim of this project is to achieve this through the development of a pilot simulator mannequin for aesthetic surgery training. The identification of Plastic Surgery procedural steps together with simulator training is a novel step forward towards implementation of competency-based education in Plastic Surgery training.

Résumé

En chirurgie plastique, le Collège royal des médecins et chirurgiens du Canada propose des objectifs d'études bien définis, cependant il n'y a pas de curriculum défini afin d'atteindre ces objectifs. Plusieurs facteurs réduisent l'aspect pratique du modèle en fonction du temps existant, et comme résultat, le modèle d'enseignement basé sur la compétence fut proposé pour remplacer le modèle traditionnel. La réalisation d'un curriculum basé sur la compétence demande autant l'identification des procédures spécifique de cette spécialité que des étapes procédurales. Ce projet tend à développer une méthodologie pour l'identification des étapes procédurales pour chacune des procédures de la chirurgie plastique.

Les études précédentes ont démontrées que les résidents manquent d'exposition aux connaissances de plusieurs domaines de la chirurgie plastique, particulièrement vrai pour la chirurgie esthétique. Il est donc important, pour les résidents, d'explorer tous les avenues pour augmenter cette exposition et leurs opportunités de formation. La cible additionnelle de ce projet est d'atteindre ces objectifs par le développement d'un mannequin-simulateur pilote pour l'entraînement en chirurgie esthétique. L'identification des étapes procédurales en chirurgie plastique, en concert avec l'entraînement par simulateur, engendre une nouvelle étape vers la réalisation d'une éducation basée sur la compétence en chirurgie plastique.

Acknowledgements

I would like to acknowledge my supervisory committee consisting of Mirko Gilardino, Melina Vassiliou, Jake Barralet and Sabrina Cugno. I would like to thank my supervisor Mirko Gilardino and Co-Supervisor Melina Vassiliou for editing each of the manuscipts for publication. I would like to acknowledge Mirko Gilardino for his help with the survey components and design. I would also like to thank our survey panel which consisted of all Plastic Surgery Program Directors and Division Chiefs as well as the Canadian Plastic Surgery Supervisory Committee. The survey results analysis was verified and approved by Pepa Kaneva.

I would also like to thank Thomas Hemmerling and Shantale Cyr for their guidance on writing the simulator manuscript as well as their participation in simulator design and figure creation. Lastly I would like to thank the team at FallenFX and Roy Kazan for their construction of the simulator mannequin and Allergan for their financial support.

Preface and Contribution of Authors

As first author of each manuscript, I conducted the majority of the writing and executed the necessary literature reviews and research methods. My supervisor, Mirko Gilardino, and co-supervisor, Melina Vassiliou each participated in the editing process and provided guidance regarding the execution of the methods. Pepa Kaneva verified that the statistics were valid. Thomas Hemmerling and Shantale Cyr communicated with the team at FallenFx and coordinated the design of the simulator mannequin along with Roy Kazan. They also contributed to the writing of the second manuscript for publication.

1. Introduction

Worldwide, governing bodies of residency education have agreed that the traditional time-based residency training model is insufficient for today's patient population. Such a model allows residents to graduate from their respective programs following the completion of specific time-based requirements, subjective evaluations and a knowledge-based examination. The Royal College of Physicians and Surgeons of Canada (RCPSC) as well as the Accreditation Council for Graduate Medical Education (ACGME) in the United States have increasingly emphasized the importance and necessity of training competent surgeons with a specific emphasis on assessing surgical skills.[1-3] This is due to several reasons including the mandate on reduced resident work hours,[3-6] the need for increased accountability[7] as well as the noted lack in objective assessment tools for surgical skills.[5]

Competency-based medical education (CBME) has been proposed as the solution to the current challenges in residency training. Such a curriculum would deviate from the current time-based model, and focus instead on residency program outcomes. Currently, there are a select few programs which have implemented, or taken the initial steps towards implementation of a CBME model. Plastic Surgery is in the early stages of implementation. The ACGME has contributed training objectives and milestones towards a new curriculum; however, several other steps must be taken before implementation can take place successfully.

An essential step towards CBME implementation in a given residency program, particularly a surgical program, requires the identification of specialty specific procedures and procedural steps that a resident must be able to perform upon graduation. This is no simple feat, as there are numerous procedures in each specialty, especially in Plastic Surgery which consists of a large number and variety of surgical procedures. Once these procedures are identified, the essential steps for these procedures must be outlined in order to track resident skills acquisition using customized, objective assessment tools. To facilitate this process, an efficient consensus methodology is required to identify these procedural steps as it requires input from a number of experts in the field and must be streamlined and straightforward for use across all essential procedures. The aim of this project was to pilot test whether the Delphi methodology would be an efficient consensus process for outlining the procedural steps for two Plastic Surgery procedures, for future use across all procedures in Plastic Surgery and other specialties.

The specialty of Plastic Surgery has the unique challenge of training residents in aesthetic surgery, where the patients are paying for the private practice care provided by their consulting surgeon. This custom reduces the exposure and the training opportunities for residents who are required to learn aesthetic procedures. This weaker area of training has been noted in previous studies which have highlighted both the reduced exposure and lower confidence levels of residents in aesthetic surgery.

A number of larger training programs in North America have implemented possible solutions to address the lack of exposure in aesthetic surgery. These solutions have had positive feedback; however, they would not be feasible in smaller programs as they rely on a large population of aesthetic patients. It is clear that there is a need to uncover other avenues for increasing resident exposure to aesthetic training opportunities, which would also contribute to the standardization of training across programs. An additional aim of this project was to explore the possibility of creating a simulation tool for Plastic Surgery residents in order to increase training opportunities in aesthetic surgery. The focus of this simulator tool is a breast augmentation procedure using prosthetic implants. Currently, there are a number of simulation tools in various specialties that have proven beneficial for resident training, and this includes low-fidelity training tools in Plastic Surgery. According to existing literature, aesthetic surgery lacks a high-fidelity simulator for training residents in procedural skills. Once validated, this tool can be included in the competency-based curriculum for training and objectively assessing Plastic Surgery residents in aesthetic procedural skills.

2. Competency-Based Education

2.1 Background and rationale for competency-based education in surgical training

The idea behind competency-based medical education (CBME) arose over 60 years ago when education leaders proposed that the focus of medical curricula should shift towards program goals and objectives.[8] Instead, however, instructional process became the focus rather than the outcomes. In an attempt at another redirection, outcomes-based education was born where the curriculum was designed around program outcomes rather than process.[9] This is the basis of CBME, and while it has been proposed for many years, it only recently became the focus of medical education.

The International CBME Collaborators Group (ICBME Collaborators) was formed in 2009 by the Royal College of Physicians and Surgeons of Canada.[10] The group worked together to reach a consensus about the definitions of key terms that are used in CBME development in order to standardize the concept internationally. They defined competency-based medical education as "an outcomes-based approach to the design, implementation, assessment, and evaluation of medical education programs, using an organizing framework of competencies."[10] Because competencies have already become the central focus for medical education in several frameworks such as CanMEDS[11] and the Outcome Project of the ACGME,[12] and they are the basis of CMBE, it is critical that the definition of competencies is clear. The ICBME Collaborators defined a competency as "an observable ability of a health professional, integrating multiple components such as knowledge, skills, values, and attitudes."[10] It is important to note that because competencies are observable, they can therefore be assessed for acquisition by trainees, and multiple competencies can be assembled to measure progression.

With these various components comprising one single competency, multiple specific sub-competencies may be combined into a more general core-competency.[13] Used in context, an essential professional activity of a given specialty may consist of several general core-competencies. The integration of these competencies into an activity, known as an Entrustable Professional Activity (EPA), allows educators to measure the acquisition of the skills required to perform this activity through competencies that are organized into progressive milestones. An example of an EPA in Plastic Surgery may be a breast reconstruction procedure. A core-competency of that procedure would be the pre-operative planning. A sub-competency within that core-competency may be the patient consent process and the milestones would be increasing levels of expectations for these competencies that a resident must be able to demonstrate. Once all the milestones have been reached, the EPA is said to be successfully demonstrated and the trainee is qualified to perform this activity unsupervised upon graduation.[14]

The shift of residency education to a CBME model remains a controversial topic. There are several groups who argue for its use and others who are concerned about the implementation challenges of a new curriculum model. The highlighted challenges of the model include thoughts that the milestones are abstract and require a link to clinical practice to be considered meaningful.[15] There are also concerns about a lack assessment tools for these milestones.[16] In addition to this, other logistical issues have been raised which include the potential scheduling difficulties associated with a deviation from a time-based model, as well the need for greater resources and instructor training.[10,17] While these concerns are warranted and certainly cannot be ignored, the advantages of CBME are thought to be far more significant. Such advantages include higher accountability and scrutiny by patients[7,18] and a greater-learner-centeredness such that trainees can take responsibility for their progress through the milestones. A shift from the time-based model also allows for the necessary flexibility to accommodate variable learning rates. Rather than basing resident training on the time spent in each area, the focus will shift to the abilities acquired and the outcomes achieved.[10] The current time-based model focuses primarily on experience and measuring knowledge with no assurance that program graduates are competent in all the essential areas of their specialty. The new CBME model differs in that it emphasizes the needs and standards of the patient population, and ensures that graduating trainees can meet those standards with expertise.[18]

2.2 Literature review on competency-based education

2.2.1 Competency-based education in resident training to-date.

To date, a small number of residency programs have adopted a full competency-based curriculum for resident training. In Canada, the Royal College of Physicians and Surgeons of Canada established the CanMEDS Framework in 1996 and listed 7 domains of patient care (Medical Expert, Collaborator, Communicator, Professional, Health Advocate, Scholar and Manager).[19] In the United States, a similar project was implemented in 1999 by the American Council for Graduate Medical Education and listed 6 domains (Patient Care, Medical Knowledge, Practice Based Learning and Improvement, Systems Based Practice, Professionalism and Interpersonal Skills and Communication).[12] It was mandated that all programs phase in the teaching and assessment of these core competencies.[20] As an early pilot project, the ACGME and the American Board of Pediatrics made an effort to shift to the CBME model through the Pediatric Redesign Project.[21] Their goal was for residents to reach a specified level of independence and to standardize program outcomes through a flexible curriculum. This has also been extended to areas such as Anesthesiology[22] and Family Medicine[23].

Importantly, the Royal College of Physicians and Surgeons of Canada implemented a pilot project to assess the feasibility of introducing a competency-based curriculum into a residency training program.[24] They attempted this through the Orthopedic Surgery training program at the University of Toronto in Toronto, Ontario, Canada in July 2009.[25] This pilot project required 4 years of planning before implementation was possible and once it was implemented, it became clear that the new curriculum model required more time and energy from the staff and a large amount of resources to fund the appropriate assessment tools and organization of teaching and assessment plans for each of the defined core competencies.[26] The project, however, functioned successfully and was felt to be a significant improvement from the traditional training model.

While the goal of these programs was to deviate away from the traditional time-based model, it became evident that the new CBME model would create heavy logistical challenges. To address this concern, several programs have opted to create a hybrid model[27] whereby the curriculum continues to be competency-based, however, individual rotation blocks will continue to be scheduled in a time-based manner. The difference lies in the flexibility of the program. If a resident requires more time to reach competence in a given block, this must be accommodated.

2.2.2 Is there a need for competency-based education in Plastic Surgery?

Competency-based medical education has recently been the central focus of education leaders, particularly for surgical specialties. Due to concerns of patient safety and physician proficiency, documentation of skills training and acquisition has become critical.[28-30] Traditionally, trainees are taught in the operating room in real surgical environments and assessment has occurred through subjective evaluations or based on the number of procedures with no measure of the level of involvement or performance in those procedures.[31] Competency requires appropriate decision making, surgical technique and technical proficiency[32] and would be best demonstrated during patient encounters[33] or during procedures that residents have greater opportunities to perform. Importantly, this level of operating room presence may no longer be a consistent training option with medical-legal and ethical barriers[34] such as the insurance concerns surrounding unsupervised residents, in addition to the reform of resident education, reduced training hours, complex new surgical technologies and limited case volumes.[32,35,36] Experience, however, is necessary to obtain consistent results with minimal complications therefore there must be a curriculum in place to ensure residents make the most of their clinical encounters in order to graduate as ethical physicians who are expertly skilled.[33] For these reasons, just as any of the surgical specialties, Plastic Surgery would certainly benefit from a competency-based curriculum, especially given the expectations for excellence in this specific patient population.

2.2.3 What is needed to implement competency-based education into a Plastic Surgery residency curriculum?

The International CBME Collaborators group has developed a procedural outline for educational leaders to follow in the development of a CBME curriculum.[10] An essential step in designing a CBME curriculum for a given specialty is the identification of the "gaps" in training and assessment strategies.[31] It is imperative that a multi-institutional approach is taken to determine the critical issues that are common to all programs in order to design a framework to address them. The first step is to define the abilities needed by graduates in a given specialty, based on needs assessments of their patient population and practice setting as well as task analysis.[16,37] The next step involves defining the required competencies of that specialty and their specific components, and organizing them in a building-block framework.[38,39] This is followed by defining milestones for the progressive development of competence. Instructional methods and assessment tools are subsequently identified to facilitate skills acquisition[40] and measure the progression of competence along these milestones and finally an evaluation tool for program outcomes is designed.

In line with this method of curriculum development, milestones for Plastic Surgery training were outlined by the ACGME in the United States,[41] however, they are difficult to teach and assess due to their abstract nature and broad descriptions. In order to address this issue and in following the development plan outlined by the International CMBE Collaborators group, specific abilities, or skills, required of a Plastic Surgeon needed to be identified in order to use the milestones in the context of a clinical setting. The aim of this project was to determine the specific skills required for two Plastic Surgery procedures through a survey and consensus process. Educational leaders in Plastic Surgery were sent a checklist of procedural steps and were asked to decide whether each was an essential or non-essential step in the procedure. These two procedures would serve as a pilot for selecting the most efficient consensus methodology for identifying the required abilities of Plastic Surgery residents.

Used in practice, the procedural checklist identified in the consensus process can be a teaching and assessment tool. Providing this checklist in the residency objectives would impart consistency and clarity for the instructors and allow the residents to perform the procedures knowing the correct sequence of steps. The residents would know that the steps on the checklist are the skills that they must successfully demonstrate in order to perform the procedure independently**.** Each criterion must be observable indicators of performance.[10] Some are decision-making steps, others generic intraoperative skills that can be applied to other procedures, and finally, the more task-specific elements for the given procedure, taking into consideration endpoints that account for variations in surgical approach. Thus the entire procedure is represented, in addition to some skills that are common to other procedures.

Understanding that it would be logistically challenging for staff surgeons to assess each resident for each procedure using a lengthy checklist, it would be recommended that the checklist be used once as formative feedback part-way through the training block and again as summative feedback towards the end. While these checklists are specifically geared towards intra-operative skills, an additional assessment tool must be designed to evaluate the resident in the pre-operative and post-operative management with careful observation.[42,43]

In conjunction with the checklist of essential procedural steps, an evaluation scale must be incorporated to provide an objective assessment of the execution of skills. An ideal evaluation scale would be similar to the Ottawa Surgical Competency Operating Room Evaluation, or O-Score [44] whereby residents are evaluated using descriptive anchors that assess whether they are competent to perform independently rather than comparing their performance to that of their peers. The descriptive anchors should include the level of involvement that was necessary from the staff surgeon, such as ‘did not need to be in the room’ or ‘required staff help for >50% of the procedure’. These clear descriptions avoid central scoring and bias from the evaluating staff and would limit preconceptions that the evaluator might have of the trainee.

The next step in the assessment tool design would be to determine the content validity, or the extent to which the essential steps address trainee competency and skill.[2] Future studies may examine patient satisfaction with resident performance however these two outcomes are beyond the scope of this project. Importantly, a single tool should not be used to determine competency. These tools should be used for formative feedback, summative evaluation and to assess any need for remediation, however, a holistic approach should be taken to ensure relevant issues have not been overlooked and all CanMEDS roles have been assessed.[1-3] Residents' scores on the assessment tool should not be the single determinant of their future.

2.3 Manuscript

The Development of Assessment Tools for Plastic Surgery Competencies

2.3.1 Abstract

Background: Objective tools to assess procedural skills in Plastic Surgery residency training are currently lacking. The purpose of this pilot study was to establish a methodology for determining the essential procedural steps for two Plastic Surgery procedures to assist resident training and assessment.

Methods: Following a literature review and needs assessment of resident training, the authors purposefully selected two procedures lacking robust assessment metrics (breast augmentation and facelift) and used a consensus process to complete a list of procedural steps for each. Using an online survey, Plastic Surgery Program Directors, Division Chiefs and the Royal College Specialty Training Committee members in Canada were asked to indicate whether each step was considered 'essential' or 'non-essential' when assessing competence among graduating Plastic Surgery trainees. The Delphi methodology was used to obtain consensus among the panel. Panelist reliability was measured using Cronbach's alpha.

Results: A total of 17 steps for breast augmentation and 24 steps for facelift were deemed essential by consensus (Cronbach's alpha 0.87 and 0.85, respectively).

Conclusion: Using the aforementioned technique, the essential procedural steps for two Plastic Surgery procedures were determined. Further work is required to develop assessment instruments based on these steps and to gather validity evidence in support of their use in surgical education.

2.3.2 Introduction

Currently in North America, Plastic Surgery residency education is largely based on a traditional time-based training model. As with most other surgical specialties, graduation is achieved following successful completion of a formal training period gauged via subjective performance evaluations and the completion of a knowledge-based examination. There is no formal or objective assessment of technical skills among plastic surgery trainees.[1,5,45]

While this model has served surgical residency training adequately for many years, there is growing pressure to update the teaching paradigm to reflect important changes in residency education that threaten to reduce the practicality of time-based training. These factors include resident work hour restrictions[3-6] and pressure from governing bodies such as the Accreditation Council for Graduate Medical Education (ACGME) in the United States and the Royal College of Physicians and Surgeons of Canada (RCPSC)[24] to objectively assess surgical skills and competence. This is necessary in order to meet training standards, ensure accountability and to safely meet the needs of today's patient population.[1,2,7,46]

The result has been the emergence of competency-based medical education (CBME) in residency training which relies on the objective assessment of observable behaviors ("competencies") encompassing knowledge, skills and attitudes.[10] Along these lines, the ACGME has recently released a set of learning objectives and milestones for Plastic Surgery education[41] outlining specific benchmarks of ability designed to track resident's progression during advancement through training. While this is a major step forward in Plastic Surgery resident training, as discussed by Knox, et al.,[47] a necessary companion to these milestones will be objective tools to track the acquisition of technical skills at critical stages of development.[7] In practice, the assessment of individual milestones and competencies is proving difficult due to their broad descriptions and relative lack of context. One way to assist with assessment of competencies is through identification and assessment of Entrustable Professional Activities (EPAs). EPAs are defined as "tasks or responsibilities to be entrusted to the unsupervised execution by a trainee once he or she has attained sufficient specific competence."[14] EPAs are not an alternative for competencies and milestones, but instead represent a complimentary method designed to translate competencies into clinical practice. Whereas competencies are specific descriptors of desirable attributes of physicians, EPAs are descriptors of work that require demonstration of multiple competencies in an integrative and holistic manner.[14] EPAs are well suited for surgical training, adding clarity and significance to competencies by putting them in the context of familiar procedures and providing an assessment system that easily integrates with the existing process of gradually providing increasing autonomy and decreasing supervision of trainees.

With respect to procedural skills, assessment ideally would occur during the actual delivery of care, however, this may not always be feasible.[48] Furthermore, due to the sheer number of procedures performed by Plastic Surgeons, assessment of every procedural skill would not be realistic. To facilitate the assessment process it is therefore critical that high quality instruments be developed for key procedures that best demonstrate an understanding of a broad range of Plastic Surgery principles that are deemed to be essential to the specialty. Once identified, these key procedures encompassing their numerous respective competencies and milestones can be assessed as EPAs.[15] The successful demonstration of EPAs using objective assessment tools would establish recognition that a trainee is competent to perform a procedure at specific level of supervision ranging from observation to readiness for independent practice.

In addition to identifying which procedures should represent EPAs for our discipline, it will be crucial to develop robust assessment instruments capable of documenting resident performance of these procedures. Within the field of Plastic Surgery, preliminary attempts have been made to objectively assess specific skill sets such as suturing skin and tendon repair.[5] Previously, defined procedural steps for procedures such as a flexor tendon repair have been developed using a labor-intensive cognitive task analysis,[49] however, this involved repeated, individual interviews followed by group discussions in order to reach a consensus. Due to the geographical dispersion of content experts and the large number of procedures in Plastic Surgery, a more efficient consensus process is required. The goal of the present study was to pilot test a methodology that could be universally applied to the development of assessment tools for Plastic Surgery programs as well as any other residency programs worldwide, using a consensus of content experts. These standardized tools could assist with assessment of EPAs in a new CBME curriculum.

For the purposes of the present study, two Plastic Surgery procedures were selected to pilot this methodology. The authors selected procedures within an area of pedagogical weakness in Plastic Surgery – aesthetic surgery. This weakness is multifactorial, but largely due to limited exposure in the academic hospital teaching setting, and the lack of consistent resident participation in such cases. The two procedures chosen for this study (breast augmentation and facelift) were selected based on a review of existing literature on resident surgical exposure[33,42,43,50,51] and on data extracted from a national resident case log database (T-Res©, Resilience Software Inc, Vancouver, BC) which revealed a relative lack of exposure to these procedures. In addition, they were selected for their potential to serve as EPAs that would cover a wide range of surgical principles and technical skills within the domain of aesthetic surgery teaching. While the procedures are aesthetic in nature, the goal of this project would be to determine a sound methodology that could be applied to other procedures requiring assessment in Plastic Surgery.

2.3.3 Methods

Study Design

The study was approved by the McGill University Health Centre Research Ethics Committee. In order to identify the essential procedural steps for our chosen procedures, the researchers employed the Delphi methodology to obtain a consensus among a panel of expert plastic surgery educators. The Delphi methodology consists of repeating rounds of survey administration until the experts' responses are deemed to reach "consensus".[52-54] Upon analysis of the first round of responses, the result averages are sent back to study participants with the subsequent survey round. During subsequent rounds participants have an opportunity to alter their responses knowing how the majority of panellists responded during the previous round, but are often blinded to their own previous responses. This method was chosen due to the anonymity of the survey process, the ability to achieve consensus within a group over a large geographic area, and the reduction of the impact of particularly influential experts. It has been previously used for diagnostics and technical skills curricula[53,54] and similarly, for identifying competencies.[55]

Our survey was developed and delivered using SurveyMonkey (Palo Alto, CA). Each of the two questions was initiated by an introduction that described the purpose of the study followed by a list of individual peri- and intra-operative procedural steps for each surgery. The lists were generated in consultation with Richard Warren, an internationally renowned expert in aesthetic surgery techniques, and using a review of the literature pertaining to these procedures.

Breast augmentation consisted of 25 procedural steps and facelift had 35 steps (Tables 1a & 1b). Each step was listed alongside binary response options[56] and the participants were asked to anonymously rate whether each step should be considered an "essential" or "non-essential" step for determining resident competency with this procedure. The survey design required a response for each step and additional comments or suggestions were invited using a comment box.

The survey was sent to a panel representing education experts in the specialty, which included all Plastic Surgery Program Directors, Division Chiefs and Specialty Training Committee members across Canada, for a total of 28 members. The first round of the survey was open for 8 weeks with reminder notices sent to all recipients after 4 weeks. The group averages for each survey item were calculated and included with the corresponding survey items for the subsequent survey round. The second round was open for 6 weeks with reminders sent after 4 weeks. Prior to data analysis, the researchers established a minimum agreement rate of 90% to be considered "consensus" for a particular procedural step based on previously published methods.[2,52]

Data Analysis

The degree of consensus within the group was determined by calculating the internal consistency of the survey responses.[53,57] The latter was achieved using the Cronbach's alpha calculation as previously described for the Delphi method[53,58-60] involving survey items with binary responses.[61] The closer the Cronbach's alpha is to 1.0, the greater the reliability of the panel and consistency of their responses and in turn, the significance of the consensus. Values between 0.7-0.8 are considered satisfactory when applied to surveys, while a value of 0.8-0.9 is accepted for applications such as certification procedures.[62] Based on these criteria the target Cronbach's alpha for the present study was set as greater than 0.8 and the survey rounds were repeated until this value was reached.

2.3.4 Results

After two rounds, the survey process was successful in achieving consensus among the panel of experts regarding the essential steps for two plastic surgery procedures. In the first round a 90% agreement was reached for 16 steps for both breast augmentation and facelift (Table 2). Cronbach's alpha was 0.60 and 0.57 for breast augmentation and facelift respectively, which indicated the need for an additional survey round. The overall response rates were 61% (first round) and 54% (second round). One participant indicated that he/she listed several steps as non-essential because residents who may be exposed to facelifts may not necessarily have a chance to perform all of the procedural steps. The responses by this participant were excluded as they deviated from the purpose of the study. This exclusion increased the Cronbach's alpha to 0.60 for the facelift survey.

All comments and suggestions from the first round were considered. Two comments were made about including patient selection issues and choice of technique as survey items, however, the researchers felt these issues although critical, were not specific to technical skills and were outside the scope of this project. One additional step was added to the facelift survey for the second round based on a participant's suggestion from the first round. Study participants were notified of this change in the second round survey invitation.

In the second round, procedural steps with over 90% agreement increased to 17 for breast augmentation and 24 for a facelift (Table 2). Additionally, Cronbach's alpha increased to 0.87 and 0.85, respectively indicating that no additional rounds were required. The response rate remained steady at 54% for both procedures. Comments left for both procedures provided insight as to the decision making process, however, these comments did not impact the consensus results.

2.3.5 Discussion

The authors set out to develop a tool to assess technical competency in keeping with the current move to develop a competency-based curriculum for Plastic Surgery education. It was felt that in order to develop a measure of procedural competence, consensus about the essential steps for that procedure would be needed. The latter would then be an integral component of an objective assessment tool for the acquisition of surgical skills. Due to the great number of Plastic Surgery procedures and the implausibility of "assessing" each one individually, a set number of procedures could be pre-determined to be good measures of skill development within a particular subdomain (for example, ability to perform a prosthetic breast reconstruction as a gauge of non-autologous breast reconstruction competence). These EPAs could then form the backbone of a procedural skills curriculum that measures skill acquisition or procedural competence with Plastic Surgery training.

With that in mind, the authors selected two such "index" cases (breast augmentation and facelift) representing key operations within the domain of aesthetic surgery. The procedures were intentionally selected based on a perceived educational need, however, it is important to note that other procedures could also be selected based on additional criteria (e.g. procedures that are rare yet emergent, most commonly performed in independent practice, or those most representative of the core principles of Plastic Surgery). While Plastic Surgery is a broad field, the teaching of aesthetic surgery is particularly challenging due to its performance primarily in the private-practice setting. Previous studies have shown that polled graduate residents have varying levels of comfort performing breast surgery compared to face and neck surgery,[51] however, the study was limited in that the numbers of reconstructive and aesthetic procedures were combined. Additional information was extrapolated from surgical data logs from Canadian Plastic Surgery residents (T-Res©) that were pooled over 10 years. Although this data will be discussed in more detail in a future publication, the results demonstrated that the number of training opportunities in aesthetic versus reconstructive procedures were far from equal as the latter[63] were more prevalent likely due to their practice in an academic setting.[33] While the procedures themselves were selected deliberately due to a defined area of pedagogical weakness, their nature relative to Plastic Surgery education as a whole was not the main focus. Instead the focus of the present study was the utility of the proposed methodology to determine consensus on the essential components of each procedure.

The results demonstrate that the Delphi technique was able to achieve consensus on essential steps for both procedures after two survey rounds. While the response rates may seem low, this includes participants who were approached but did not agree to participate. Due to the anonymity of the survey, individual recipient participation was not confirmed. Had the number of agreeable participants been recorded, the denominator would have been lower, and the response rate higher. Nevertheless, the number of expert panel members who participated suggests we obtained a good representation of Canadian Program Directors and Division Chiefs.[64,65] Based on the Cronbach's alpha cutoff of 0.8 and the consensus requirement of over 90%, high levels of panel reliability were obtained (Table 2). This provides validity evidence to support the use of the essential task list for each procedure as a foundation for the development of assessment metrics.[52-54,66] A future goal is to obtain additional validity evidence through performance comparisons between groups of varying expertise.

While this pilot study was advantageous in that it enabled the cumulative input of Plastic Surgery education leaders and experts across a large geographical area, it did reveal the challenge of narrowing the number of steps required for assessment in these complex procedures. Despite setting "consensus" at 90% agreement, the process resulted in 17 essential steps for breast augmentation and 24 for a facelift. From a practical standpoint, if all of these steps were evaluated each time, assessment of technical competence would be an onerous process. Ideally, assessment tools should be easy and efficient to use and require minimal evaluator teaching to ensure proper use of such tools in the busy clinical setting. It may be more feasible to use this tool for more formal entrustment decisions such as acknowledging a trainee successfully passing a threshold allowing for decreased supervision (e.g. summative feedback during at the middle or end of a rotation).

Although in independent practice some of these steps may be delegated to support staff, to assess competence during training it is critical that each essential step is included in the assessment tool, regardless of complexity. Omitting steps, such as those that are more commonly delegated, would create difficulties in identifying specific trainee weaknesses when providing formative feedback. Furthermore, checklists for EPAs extend beyond technical ability and in order to be deemed ready for unsupervised practice, each step must be performed independently without delegating to others.[14] Unfortunately, due to limitations of context specificity, it cannot be assumed that these skills are transferred over from other procedures. Thus it is equally important to include both general and specific procedural tasks in the assessment tool as it represents an overview of the procedure and such tasks occur in the real environment. Specific steps allow the assessment of skills that may not be seen in other procedures, while general steps allow raters to use their expertise to efficiently capture complex skills while allowing for variations in technique and differences between training centres.

A future modification of the methodology could involve vetting across a broader sampling of opinions including Program Directors, Plastic Surgery educators as well as experts in subspecialties (e.g., hand surgery) across the country and using the Delphi survey methodology outlined in the present study. Requesting participant practice patterns may also contribute to the significance of survey responses. While this study was anonymous, Canadian experts in aesthetic surgery confirmed their participation. Lastly, some would argue that the substitution for a Likert scale may permit greater flexibility of responses, however, using a binary method efficiently identified those steps that were unanimously felt to be essential while still allowing concerns to be addressed using the comment boxes.

2.3.6 Conclusion

In summary, the present study demonstrated a technique that may be a useful strategy in the development of essential objective assessment tools for the implementation of CBME into Plastic Surgery education. The Delphi methodology was successfully used to identify the essential procedural steps for two pilot Plastic Surgery procedures. The goal is to extrapolate the experience gained with this pilot study to develop similar itemized skills for other procedures deemed to be essential to the discipline. With the presented groundwork and proposed modifications, this methodology can be used to develop robust instruments that will assist with assessment of procedural EPAs as part of a competency-based curriculum in Plastic Surgery training. This framework will provide objective goals for trainees and assessment tools for educators faced with the challenge of ensuring the continued training of competent surgeons.

3. Training difficulties associated with aesthetic surgery

Plastic Surgery residents have poor and variable exposure to aesthetic surgical procedures which presents a unique challenge for the Plastic Surgery specialty. This reduced exposure is due in part to the private nature of aesthetic Surgery. Aesthetic patients have high expectations of the post-operative results and often request personalized attention from one individual surgeon.[67] For this and other institutional reasons such as operating room time and costs, the university setting is less than ideal for the performance of aesthetic procedures. Residents require more hands-on experience in aesthetic surgery, including operative execution of procedures, patient selection and complication management.[33]

There are numerous benefits for residents who are exposed to the private practice setting such as the individualized teaching and the opportunity to learn patient selection and management[42,68] in addition to learning about human resources and other manager roles. However there are very few opportunities for residents to practice patient selection or technical skills in aesthetic surgery. Patient volume is often insufficient and there may be a limited number of private offices available to accept residents for training. If this exposure is especially low in some sites, it may be necessary for residents to spend elective time visiting other programs. Proper aesthetic instruction is critical in order to compete favorably with specialties outside of Plastic Surgery who have begun to offer aesthetic procedures without careful evaluation of the patients' psychological and anatomical needs.[33,50]

Aesthetic surgery is highly represented on the Plastic Surgery Royal College of Physicians and Surgeons board examinations. In order to successfully graduate residents, programs must address the difficulties of training in an aesthetic environment. Their curriculum design should involve the objective evaluation of residents during their brief and limited encounters. Additional aims of the curriculum should be the advancement of surgical skills education and to enhance access to aesthetic training opportunities within and among institutions.

4. Filling in the gaps: Competency-based training and assessment of aesthetic surgery

4.1 Literature review on resident training opportunities in aesthetic surgery

Numerous studies have shown that Plastic Surgery programs worldwide have concerns over the level of exposure their residents have to aesthetic surgery.[69-71] It is unanimously felt that residents require increased exposure in order to achieve sufficient expertise. A poll of private practice aesthetic patients was conducted and showed that while most patients were comfortable having residents present for the consultation, only 1/3 of patients were comfortable having the residents perform the surgery.[72] This is a common finding at several sites and the outcome has been the initiation of resident-run aesthetic clinics[33,67,73-75] where the residents conduct the cases for each patient, from the pre-operative consult, through the surgery and into post-operative follow-up, all at a reduced fee.

A recent 2008 survey of American Plastic Surgery training programs[76] found that 98% of programs had a specific cosmetic surgery rotation and 72% had a resident cosmetic clinic. Despite these high numbers, the survey also found that residents lacked confidence in a number of aesthetic procedures and that 49% of polled residents were not satisfied with their cosmetic surgery training. Residents did agree that cosmetic clinics were the most beneficial form of teaching. A comparison was made between aesthetic programs in the United States and Brazil, and found that resident confidence levels were much higher in Brazil where the cosmetic demand is high and patients are more eager to pay the reduced fees.[70] The ACGME has established a minimum case requirement for each cosmetic procedure[77] which would seem to regulate levels of exposure, however, the requirements do not specify the role that the resident must play in the operating suite. As a result, the resident may simply be an assistant for every case and will not reach an appropriate level of skill or confidence for the number of cases logged.

While this study was looking at American programs specifically, a similar study was conducted for Canadian Plastic Surgery programs in 2010.[51] This study also found lower self-reported confidence scores in aesthetic surgery procedures, however, several of the more common procedures, such as facelift and breast augmentation were grouped together with reconstructive procedures. As a result, those confidence scores cannot be used in an analysis of Canadian resident confidence levels specific to aesthetic procedures.

4.2 Is there a role for simulation in Plastic Surgery?

Acknowledging the reduced resident exposure to aesthetic surgery in Plastic Surgery training programs, an alternative strategy must be conceived in order to address this training weakness. While some programs have addressed this concern by developing 'resident-run' clinics, this option would not be feasible in areas where the aesthetic patient population is minimal and the Plastic Surgery programs are small. Additionally, each of these clinics operate under their own guidelines thus there lacks standardization across programs. Consequently, a standardized training strategy that enhances resident training opportunities in aesthetic surgery is needed.

Surgical training programs in other specialities have had similar concerns regarding resident training opportunities. This led to the implementation of mandatory simulation programs in General Surgery training.[78-80] This requirement was linked with the demonstration that simulation tools in residency programs were found to increase patient safety[31,81] and that the skills acquired were transferable to the operating suite.[29,30,78,81-83] Therefore, as in General

Surgery, it can be conceived that a simulation program in Plastic Surgery would produce similar outcomes.

Currently there are no open, high-fidelity surgical simulation tools for use in aesthetic surgery training. Basic low-fidelity models do exist in the field of Plastic Surgery, such as the flexor tendon repair training tool[84], a pig skin portable model for z-plasties[85] and the 3-dimensional computer-based skills training simulator for hand surgery[86] developed by Mimic Technologies (Burlington, Mass). There exists also computer simulation programs for planning a cleft lip repair[86], craniofacial surgery[87] and outcomes of breast augmentation for patient consultations[88].

The design of a simulation tool is a long and complicated. It must be demonstrated that the tool is affordable, accessible to all programs, practical in terms of space requirement and servicing needs, it must be useful for educational purposes and most importantly, the tools must be validated. Validation studies are critical if the simulator is being used as an assessment tool.[30] This is especially true if the tool is used for demonstrating skills acquisition leading to operating room privileges.

The essential validation studies for a simulator tool that would be used for assessments include face validity, content validity and construct validity.[30] Face validity asks whether the tool is a good measure of the skill in question and whether it will actually improve that skill. Content validity questions whether the tool represents the appropriate content with respect to the skills in question. This is determined by asking field experts to assess the sensitivity and specificity of the model representation of the skills in question.[89] Lastly, construct validity asks whether the test scores from the tool accurately reflect the level of skill the tool is attempting to measure. This is measured by comparing the performance between groups of various known skill levels. With successful validation studies, a simulator tool is one step closer to implementation in residency programs.

4.3 Manuscript

The Development of a Part-Task Trainer for Aesthetic Breast Surgery

4.3.1 Summary

The acquisition of technical skills in the domain of aesthetic Plastic Surgery can be challenging for trainees due to the limited access to clinical practice for such procedures. To that end, the authors have developed a part-task trainer (PTT) to provide a simulated environment for breast augmentation, a common aesthetic procedure. The PTT was designed to simulate the appearance and feel of the breast and thorax. Following basic initial testing, the PTT was found to adequately simulate the anatomy, allowing execution of the main steps of a breast augmentation procedure including incision, pocket dissection, implant insertion and layered tissue closure. Although further development is required, the present PTT may eventually be a useful tool for trainees to attain the basic technical skills for breast augmentation.

4.3.2 Introduction

In recent years, the importance of teaching and assessing resident surgical skills has received significant attention.[30] Surgical expertise with consistently good results requires repeated practice, however, reduced resident work hours and case volumes have limited potential opportunities to such learning experiences.[29,89-91] In addition, medico-legal and ethical concerns[79,92,93] are preventing trainees from learning all tasks in the operative setting.[34,35] In the interest of patient safety[93] and physician competency, the development of surgical simulation is on the rise. This is of particular importance to Plastic Surgery educators who must provide trainees with adequate exposure to aesthetic surgery, where opportunities to attain technical skills can be limited.

Simulation programs have recently become mandatory for General Surgery residency programs[78-80] in an effort to supplement clinical exposure and standardize training across programs. Importantly, it has been demonstrated that patient safety is improved through simulation-based training[31,81] and that technical skills are transferrable from virtual to real environments.[29,30,78,81-83] Simulation programs commonly use human cadavers, live animals and bench models,[30,79,80,94-96] however, cadavers and animal models are subject to ethical concerns and availability issues. Additionally, simulators often lack all the elements needed to teach the essential competencies of a given procedure.[32] Part-task trainers (PTT) are particularly useful because they can be tailored to a specific procedure and provide interactive feedback for certain tasks.[89] Moreover, structured practice sessions with a simulator that is customized to address competency milestones, such as those recently introduced by the Accreditation Council for Graduate Medical Education (ACGME) for Plastic Surgery[41], could assist with the teaching and objective assessment of specific technical skills[78] in the progression towards procedural competence.[31] With further development, the preliminary PTT presented here could allow Plastic Surgery trainees to practice a breast augmentation procedure and acquire the basic skill set before they apply the manoeuvres in the clinical setting.

4.3.3 Concept and Preliminary Results

Design

The PTT was designed using anatomic references from a literature review[97] (Figure 1). The anatomic layers included the ribs and intercostal muscles as the deepest layer, progressing superficially to the pectoralis major muscle, breast tissue, subcutaneous fat and layers of the skin (Figure 2).

Fabrication

Eight different molds were developed to represent the different layers of the breast and torso. Each layer was composed of silicone or foam, modified in elasticity and density to provide the most realistic appearance, touch and tissue dissection resistance. Each layer was dyed to mimic the colors of a realistic dissection.

Surgery Simulation

An experienced Board Certified Plastic Surgeon and surgical educator tested the PTT's ability to simulate a breast augmentation procedure. An incision in the infra-mammary area was created with a scalpel down to simulated breast parenchyma, where dissection was continued bluntly (digitally) into the subglandular plane to develop an appropriate pocket. The subpectoral plane was also developed in a separate trial. A 90cc textured silicone breast prosthesis (Allergan Inc. Irvine, CA) was inserted manually with the surgeon's digits. The position of the implant was verified to ensure appropriate placement. The incision was then closed in layers, beginning with the breast parenchyma using 3-0 Vicryl© sutures (Ethicon, Inc Cincinnati, OH) followed by a running 4-0 monofilament subcuticular suture for the skin (Figure 3). Initially, the yellow foam used to simulate breast parenchyma was found to shear upon suture approximation and thus the model was modified by adding a superficial layer of firmer foam (Reston, 3M, St. Paul, MN) that permitted appropriate suture closure.

4.3.4 Discussion

There is a recognized need for simulation in resident training with adequate representation of the essential competencies of a surgical procedure. The medico-legal and ethical issues that arise with regards to residents performing aesthetic surgery are significant and impact their training. Many patients express their concerns about paying private fees for aesthetic procedures and potentially undergoing surgery by a trainee.[98] These limitations have been documented in studies that have clearly demonstrated reduced resident exposure to aesthetic procedures compared to that of non-private procedures.[51]

To the best of our knowledge, the model presented here is the first part-task trainer that is designed to simulate breast augmentation for the learner. Although the model is in its preliminary stages, our study demonstrated that it would allow the trainee to simulate dissection of the breast, either subpectorally or subglandularly, followed by implant insertion and tissue closure. Future modifications could include improved virtual and/or visual feedback for bleeding and danger zones to mimic a more realistic clinical environment. The authors foresee that such a simulator could be used by junior-level residents until basic technical competence is demonstrated (based on predetermined skills or steps that have been identified to require assessment) allowing subsequent participation in the clinical setting. In addition to its use for residents in training, such a part-task trainer could also be used by experienced surgeons to explore new technologies or instruments such as a Keller Funnel™ (Keller Medical, Inc, Stuart, FL) prior to employing them on their own patients in the clinical setting.

While this model represents an important initial step in the development of essential surgical simulators for Plastic Surgery trainees, a number of aspects still require further investigation. Although such simulators have been demonstrated to improve initial clinical performance in other specialties,[29,30,78,81-83] validation that this PTT assists trainees in acquiring the skills required for breast augmentation would be useful. In addition, the costs of employing such teaching strategies must be assessed. With cost in mind, the present model was designed to be reusable with a permanent base (thorax) and a more superficial layer that can be replaced as needed. In the era of 3D printing, the production of such layers can be done rather cost-effectively.[99] Lastly, the role of such a simulator within the move to a competency-based Plastic Surgery curriculum must be better defined, with specific attention to what skills should be acquired on such simulated platforms before progressing to training in the clinical environment.

5. Summary and final conclusion

Competency-based medical education has resulted in a paradigm shift in residency education. Despite the challenges associated with implementation, it has become an important goal for regulatory bodies worldwide. This change in the residency curriculum aims to train more competent and proficient physicians with a higher degree of accountability and patient safety.

The aim of this project was to determine whether competency-based medical education is suitable for Plastic Surgery resident training programs. A literature review revealed the importance of this curriculum model and what is needed for implementation. Once those requirements were uncovered, an attempt was made to identify a methodology for determining the required procedural steps for essential Plastic Surgery procedures. This was done through a survey process with a goal of establishing a consensus among education leaders. The success of this methodology permits residency education governing bodies to employ the methodology for determining all essential procedures and procedural steps, thus facilitating the implementation of Plastic Surgery milestones in familiar clinical contexts.

An additional aim of the project was to highlight aesthetic surgery as an area of weakness in Plastic Surgery training and to develop a solution. A literature review of studies conducted worldwide revealed lower confidence levels among residents in aesthetic surgery rotations despite training in resident aesthetic clinics. Importantly, no new strategies have been employed to enhance training opportunities among these residents. One solution for programs across various specialities has been training through simulation tools. This led us to the development of a simulator model for training and assessing residents in aesthetic surgery.

The aforementioned methodology and simulation assessment tool is novel in the field of Plastic and Reconstructive Surgery. This project represents an innovative step forward in the implementation of competency-based medical education in Plastic Surgery training.

6. Tables, figures and illustrations

Tables (1a,b-2)

Table 1a: Survey Items Breast Augmentation
Determining and marking incision placement including adjustment of IMF position based on the anticipated implant for the procedure
Appropriate choice of implant type, shape, surface texture and size
Adequate marking of pocket size based on anticipated implant size/type
Appropriate patient positioning on the operating table
Active participation in the surgical time-out before making an incision
Appropriate use and ordering of peri-operative antibiotics (before incision made)
Appropriate surgical site sterilization (preparation and draping)
Safe selection, dosing and infiltration of local anaesthetic
Adequate selection and performance of incisions in the axillary, the peri-areolar or the inframammary fold locations
Adequate incision and dissection technique to desired plane with attention paid to position (adjustment) of IMF
Appropriate dissection of planned implant pocket (adequate size, proper plane, attention to medial and lateral desired pocket location)
If a prepectoral pocket is planned, appropriate dissection in either the retromammary or the retrofascial plane
If subpectoral pocket is planned, appropriate identification and release of pectoralis major muscle
Appropriate intraoperative size adjustment
Adequate hemostasis
Use of antibiotic solution irrigation
Acceptable technique of insertion silicone/saline implant with minimized skin contact
Proper implant positioning (right side up)
Symmetric implant positioning bilaterally
Ability to plicate pocket/IMF in the event of pocket over-dissection
Adequate closure of deep layers (safe technique protecting implant from damage)
Appropriate layered skin closure
Placement of adequate dressing
Adequate and complete postoperative orders (pain medications, antibiotics, etc)
Acceptable follow-up appointment prescribed
Other (please specify)

Table 1b: Survey Items Facelift
Appropriate placement of incision markings
Ability to mark anatomic landmarks (nasolabial folds, SCM location, mandibular border, external jugular vein, etc).
Ability to diagnose and mark active platysmal bands
Ability to determine and mark vectors for skin and/or SMAS redraping
Ability to note significant facial asymmetries
Ability to identify any areas for contouring (debulking) or volume addition (if any required)
Appropriate patient positioning
Appropriate selection of anti-embolic precautions
Adequate surgical site sterilization (preparation and draping)
Adequate use of eye protection
Active participation in time-out procedure prior to making an incision
Appropriate use and selection of antibiotics prior to incision
Appropriate use of antihypertensive medications (if required)
Safe selection, dosing and infiltration of local anaesthetic
Appropriate incision technique including attention to direction of hair follicles in hair-bearing skin and accurate pre-auricular/tragal incision execution
Proper identification of subcutaneous plane
Delicate handling of soft-tissues and skin edges
Adequate/even dissection of subcutaneous plane to limits of markings
Appropriate identification of SMAS in face
Appropriate identification of platysma in neck (laterally)
Appropriate dissection of submental approach (if planned) and identification of medial platysmal borders and submental fat
Adequate suture plication of medial platysmal bands or wedge resection/myotomy (if planned)
Adequate hemostasis
Appropriate vector selected for SMAS plication, SMASectomy or SMAS flap advancement
Safe execution of the SMASectomy procedure
Safe execution of a Sub SMAS dissection
Safe execution of SMAS suture technique (with respect to facial nerve protection and avoidance of danger areas)
Appropriate vector of skin redraping
Adequate excess skin resection with appropriate tension on future skin closure
Proper placement of subcutaneous drain (if selected)
Proper orientation and insetting of ear lobule
Adequate layered closure with appropriate attention to skin redraping (and dog ear management, if any)
Appropriate selection and placement of soft-dressing
Adequate and complete post-operative orders
Appropriate timing of follow-up visit
Other (please specify)

Table 2: Survey results

	Breast Augmentation		Facelift	
	Round 1	Round 2	Round 1	Round 2
Number of procedural steps	25	25	35	36[ϕ]
Number of survey participants	17	15	14[‡]	15
Steps with ≥ 90% agreement	16	17	16	24
Cronbach's alpha[†]	0.60	0.87	0.60[‡]	0.85

†Calculated as the ratio of variances of participants' responses with a desired value ≥0.80

‡Values following the omission of an ineligible participant

ϕFollowing the addition of a suggested procedural step

Figures (1-3) – Legends for figures

Figure 1: External appearance of the breast mannequin, with its different layers viewed through the infra-mammary incision

Figure 2: Breast mannequin side view: thoracic cage bones with different tissue layers

Figure 3: (A) Breast mannequin showing the silicone breast implant midway in the process of insertion; (B) final outcome after implant insertion and completion of suturing

Figure 1

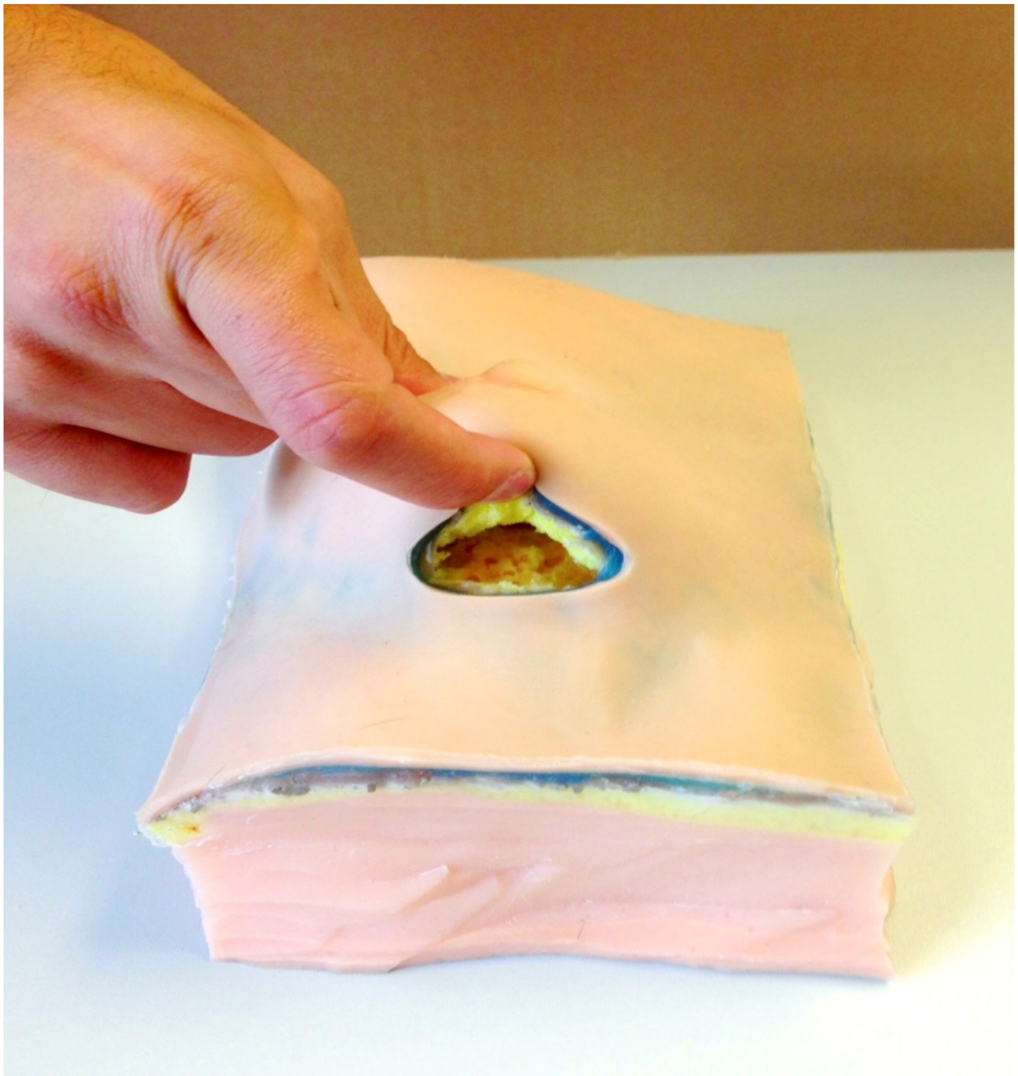


Figure 2

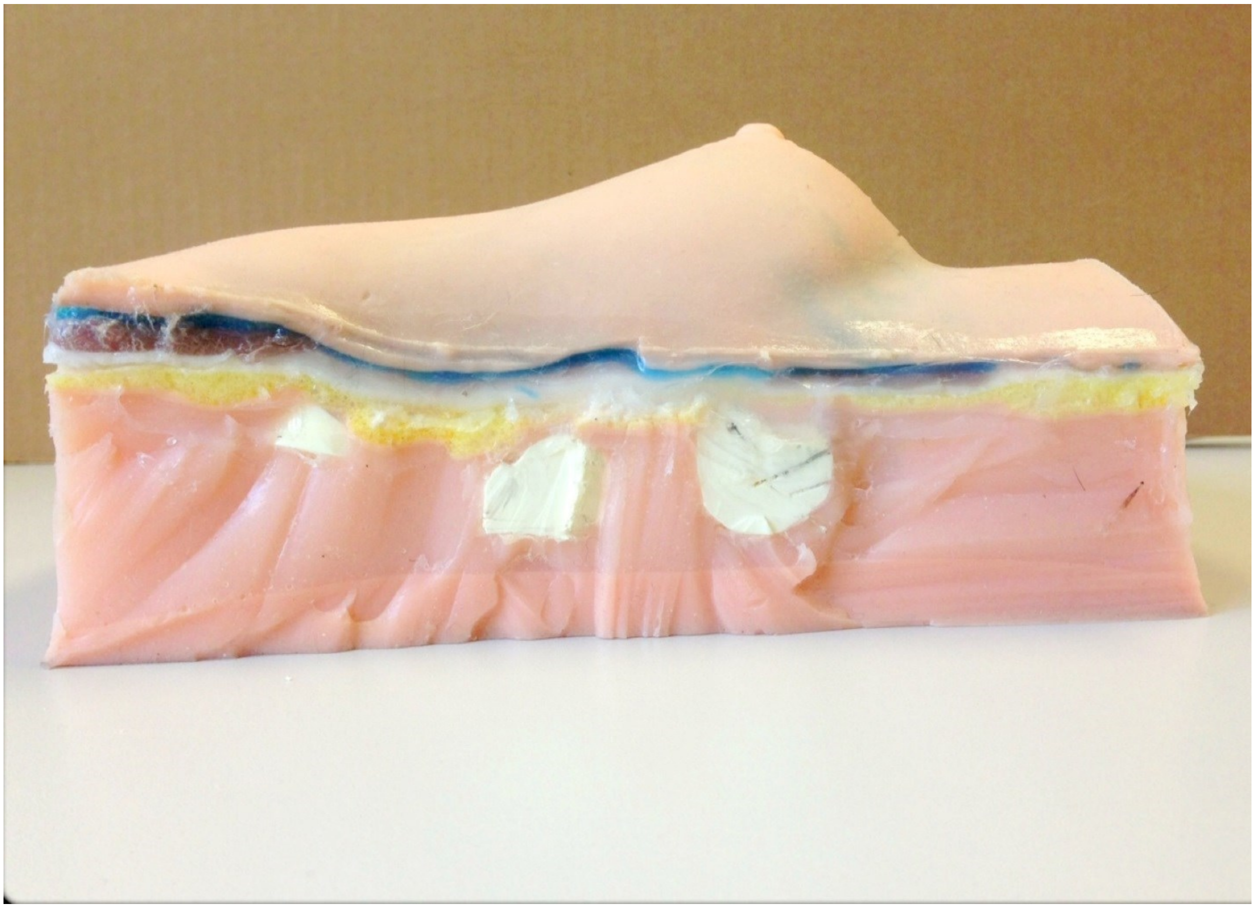
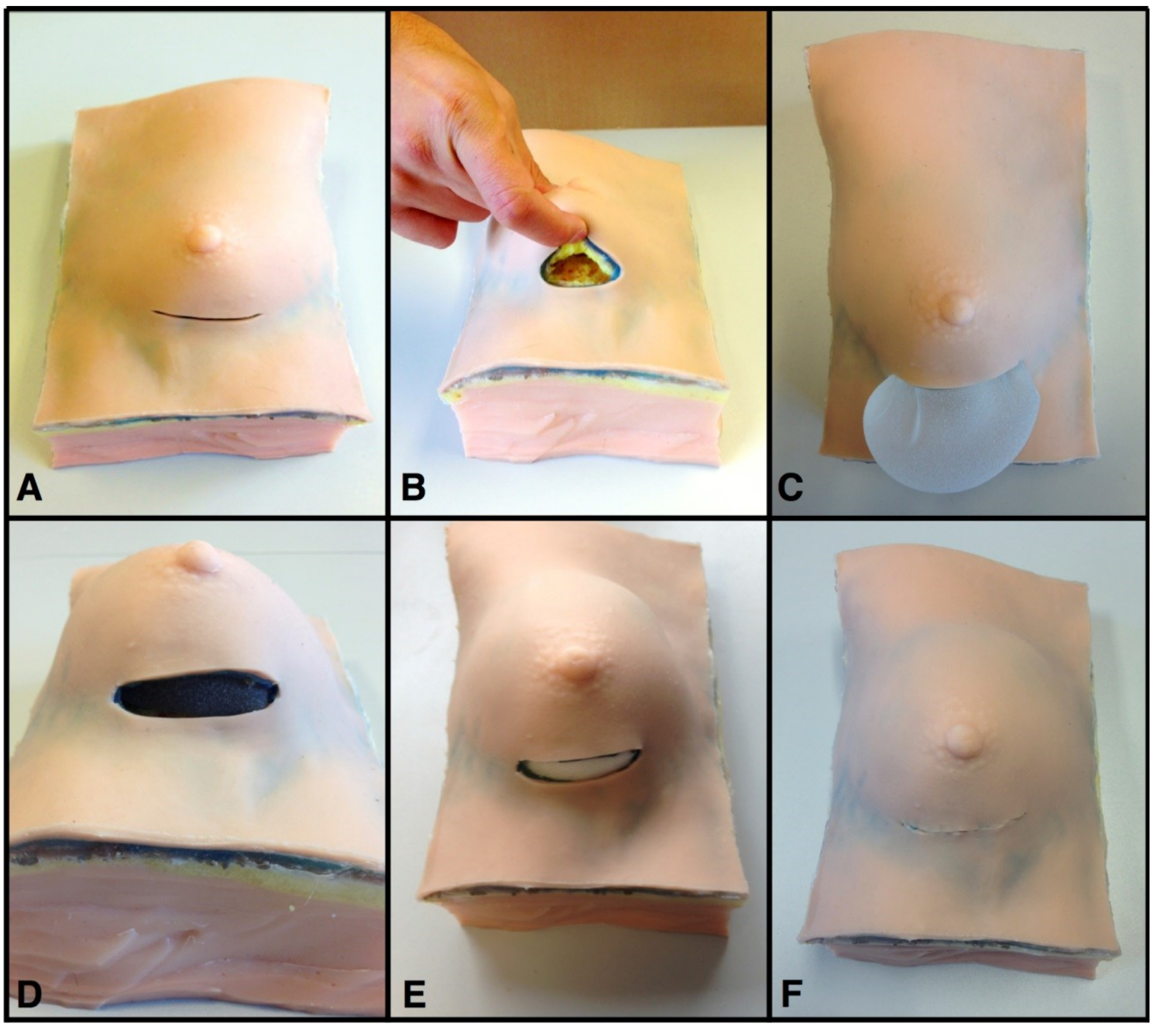


Figure 3 (A)

Figure 3(B)

Illustrations (not submitted with Manuscript #2 due to figure restrictions)

Illustration 1 Step-by-step of breast implant insertion procedure (A) breast part-task trainer after performance of infra-mammary incision (B) after blunt dissection and pouch creation (C) breast implant insertion midway through the process (D) breast implant in place (E) open-cell foam substrate in place used as a simulator for subcutaneous tissue (F) breast part-task trainer avec multi-layer suturing



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