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ScienceDirect

Procedia Engineering 159 (2016) 104 – 107

Procedia Engineering

www.elsevier.com/locate/procedia

Humanitarian Technology: Science, Systems and Global Impact 2016, HumTech2016, 7-9 June 2016, Massachusetts, USA

Silicone-based composites as surgical breast models for oncoplasty training

Deniz Kilic[a], Burcin Ustbas[b], Ece Polen Budak[c], Hande Eyisoylu[b], Cem Yilmaz[d], Barkin Eldem[a] and Ozge Akbulut[b]*

[a]*Surgitate Medikal Arge Sanayi ve Ticaret A.Ş., GOSB, Kocaeli, Turkey*
[b]*Faculty of Engineering and Natural Sciences, Sabancı University, Istanbul, Turkey*
[c]*Faculty of Arts and Social Sciences, Sabancı University, Istanbul, Turkey*
[d]*Istanbul Oncology Hospital, Istanbul, Turkey*

Abstract

Surgeons-in-training necessitate practice to improve their skill sets and the shift towards simulation-based trainings enables trainees to learn at their own pace and experience custom-based cases rather than responding to the immediate needs of the patients. Oncoplasty for breast cancer encompasses tumor removal and subsequent breast reconstruction; and there are several oncoplastic techniques to master for proper treatment of the patients. For training purposes, closest media to reality, fresh cadavers, are hard to obtain due to their price and/or unavailability. There is a need for a sustainable, reliable, and affordable platform to diffuse simulation-based trainings to medical curricula and provide trainings even in resource-limited settings. Silicone-based composite models can be designed and manufactured to fulfil the necessities of breast surgery such as precise incision, epidermal undermining, suturing, and resisting suture tension after excision of a considerable mass. We have shown the performance of such a stand-alone breast model for two oncoplastic techniques, "Batwing Mammoplasty" and "Modified Inferior Flap Rezai". This model can be used in settings where it is difficult and/or expensive to find fresh cadavers. This cost-effective and practical solution also eliminates the need for chemical/cold storage and risk of infections/molding, thus making it a preferable tool for teaching hospitals and also for individual practice. In addition, the model is suitable to be used in self-diagnosis trainings, as well as a communication platform between surgeons and patients.

Peer-review under responsibility of the Organizing Committee of HumTech2016

Keywords: Surgical simulation; surgical model; breast model; oncoplasty

1. Introduction

Breast cancer is the most common type of cancer and foremost cause of death from cancer among women [1, 2]. Medically and aesthetically successful oncoplastic surgeries assure the health of women and their return to their pre-cancer lives [3-5]. More and more women are diagnosed with breast cancer at younger ages and it became critical to preserve the physical appearance to facilitate the well-being of the patient [6, 7]. Therefore, the conflict of removing the carcinoma whilst preserving the breast tissue became a challenge for the specialists over the past few decades [8]. In recent years, the breast-conservation surgery along with the radiotherapy treatment is more favored over mastectomy, which results in the loss of higher mass breast tissues. In addition, where possible, it is preferred follow mastectomy and breast-conserving therapy by the reconstruction of the breast through plastic surgery [9]. Oncoplastic surgery, an emerging branch in breast surgeries, combines oncological and aesthetic procedure such that it allows patients to circumvent a secondary reconstruction. Through oncoplastic surgery, the patients can avoid breast deformities caused by the post-plastic surgeries and encounter reduced treatment costs [10]. Immediate reconstruction facilitates the creation of more symmetric and well-positioned creation of the breast shape with fewer scars [11, 12]. Compared to breast

* Corresponding author. Tel.: +90 – 216 – 4839968.
E-mail address: ozgeakbulut@sabanciuniv.edu

1877-7058
Peer-review under responsibility of the Organizing Committee of HumTech2016
doi:10.1016/j.proeng.2016.08.131

conservation and mastectomy techniques, oncoplastic surgery was reported to have higher patient satisfaction, higher survival rates, reduced reoperation rates; and, hence ease of patient recovery after the treatment [13].

There are several different types of oncoplastic techniques that are chosen depending on the position and the size of the tumor [9, 14]. Also, it is ideal to have a single surgeon who can integrate the resection of the breast carcinoma and restorative plastic surgery instead of the dual efforts of a general and a plastic surgeon [15]. Proficiency of surgeons on oncoplastic techniques depends on the level of experience and practice they get [16]. Surgeons are mostly trained in apprentice-based systems and “learn-by-doing”; however, feedback-based and learner-centered approaches started to gain attention. Employing simulation in surgical training i) allows the surgeons-in-training to learn at their own pace, ii) focuses on the needs of the learner rather than the immediate needs of the patient, and iii) offers a safe environment where failing is a part of learning. Fresh tissues (i.e., torso models) are ideal for oncoplastic surgeons to practice on; [17] however, the lack of cadavers, either due to lack of donations or their high cost, hinders the quality of medical education. Therefore, there is a need for a practical and durable platform for oncoplasty trainings. Here, for the first time in the world, we present a stand-alone breast model, on which such trainings can be provided. This silicone-based model allows surgeons to i) incise with scalpels and scissors, ii) suture, iii) excise small/large masses, iv) palpate malign/benign tumors, v) manipulate the position of the nipple, and vi) reduce the size of the breast. We have worked with oncoplastic surgeons throughout the design of this model and received constant feedback to improve the response of the model to surgical interventions. We have chosen two common oncoplastic techniques to demonstrate the performance of this model. We believe this tactile simulation platform will assist surgeons to improve their surgical skills and facilitate their learning process. In addition, this affordable medium is expected to be especially critical for under-served areas since in these regions, patient rights are poorly defended and usually there is a shortage of educated medical personnel and lack of funds.

2. Results and Discussion

Silicone is a widely used material for anatomical models, prosthetics, and special effects in film industry [18]. It can be colored and textured to imitate real tissue and offer a wide range of mechanical properties [19]. Silicone-based materials can be tailored to provide realistic responses to incision, dissection, and suturing; thus, enable tactile simulations in surgical skills laboratories and there are several companies that provide silicone-based models and materials for modeling purposes. (The Chamberlain Group, US, Home Page. http://www.thecgroup.com, Smooth-On Inc., US, Home Page http://www.smooth-on.com (accessed February 02, 2016) [20].

Here, for the breast models, we used tear-drop shaped aluminum molds. Silicone-based or gypsum molds did not produce models with well-defined contours and dimensional stability. We, first, cured the inner tissue, employed a textile layer, and then, applied the outer silicone layer that simulates dermis and epidermis. The Young Modulus of the inner tissue is adjusted though the addition of silicone-oil. The areola is molded and colored separately, and attached to the breast after the curing of the outer layer. The back of the models were capped with Velcro to be attached to a wooden plane that provides four different angles of inclination. Anatomical landmarks like the clavicles and jugular notch can be marked on this plane for training purposes.

Moreover, we recycle used surgical models in the fabrication of “self-diagnosis” models that are used in hands-on trainings. These models are designed to contain masses that simulate malign tumors of different sizes at different locations such that the trainees can learn how to check their breasts. The surgical models are to be used only once, however, although incised and sutured, the inner tissue of these models can still be utilized in the production of self-diagnosis models. During molding process, pieces of cured silicone from the used models are added to the uncured silicon mix, and then the entire system is cured to ensure the attachment of individual recycled pieces. These models can also be employed as anatomical models in clinical practice as decision making tools for surgeons to determine proper operation techniques for complicated cases and as a platform for communication between surgeons and patients.

We have chosen two different techniques to underline the performance of surgical breast models. In Figure 1, Batwing Mammoplasty (BWM) technique is demonstrated [21, 22]. BWM is a simple and easy-to-learn technique that is mostly targeted for periareolar cancers that are located in the upper quadrant of the breast. In this technique, there is also no need for positioning nipple-areola complex and the patients report positive cosmetic outcomes [22]. After marking and measuring the landmarks, the tumor site which is superior to the nipple is resected till deep fascia of pectoralis major muscle. Then, the operation site is repaired with the neighboring breast tissue.

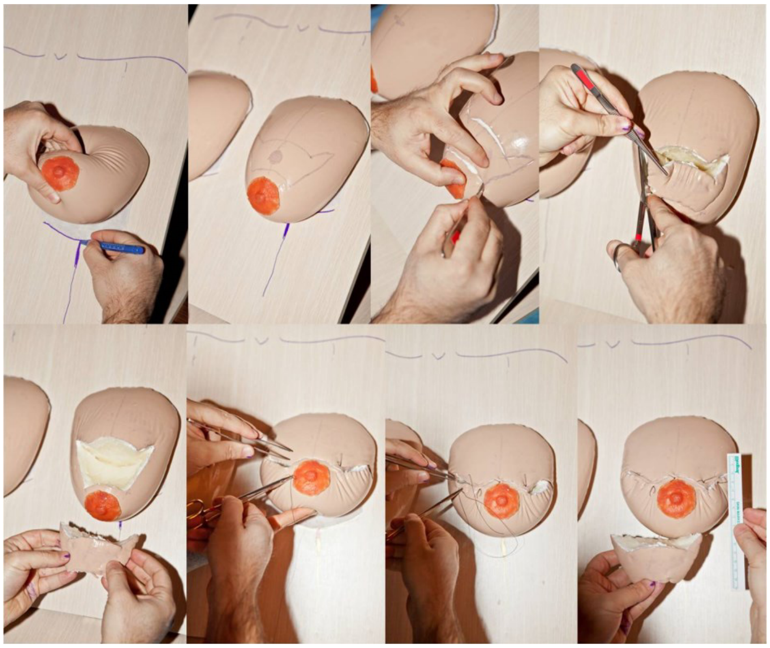

Fig. 1. Sequential photography of Batwing Mammoplasty technique

In Figure 2, Rezai technique is presented. It is one of the oncoplastic techniques that can offer high level of local control along with a high level of aesthetic outcome [23]. After planning the Wise Pattern which is modified by Dr. Mahdi Rezai [24], the surgeon can resect the tumor in any portion of the breast. After resection, the site is reconstructed with the remaining breast tissue.

Fig. 2. Sequential photography of Rezai technique

For early diagnosis, self-exam is crucial; however, surveys from resource-limited settings clearly demonstrate the lack of education for self-diagnosis in public and most strikingly even among healthcare workers. Countries that lack proper infrastructure rely especially on non-governmental organizations or healthcare workers to visit rural areas [25, 26]. Portable education-enabling tools, such as the “self-diagnosis” model that is described here, are expected to improve breast cancer awareness and detection. Cost-effective fabrication of realistic self-diagnosis models will potentially allow access to these models by a higher number of agents that provide such trainings; hence, increase the number of beneficiaries.

3. CONCLUSION

Surgical models can offer a cost-effective, easy-to-handle, and sustainable alternative to real tissues. A key milestone for global impact on medical education is to design and fabricate affordable models such that medical schools and even individual physicians can afford these models. Depending on the utility of the model, the target groups can also be expanded to medical/veterinary students and medical staff including nurses and other healthcare professionals. Considering new laws restraining cadaver use outside of anatomy laboratories and European Union regulations limiting training hours of medical interns, demand for this type models is expected to increase. In addition, affordable "self-diagnosis" models will facilitate the training of healthcare workers and public; and are expected to potentially enable earlier diagnosis of breast cancer. We believe, through effective collaboration between medical doctors and engineers, best possible training platforms can be designed for the betterment of the medical education.

Acknowledgements

O.A. acknowledges The Scientific and Technological Research Council of Turkey grants 1512 (Project No. 2140090) and 1005 (Project No. 214M121). The authors thank Istanbul Oncology Hospital for their assistance and Mr. Baris Dervent for the photography.

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