Original Article

Low-cost synthetic model for training and simulation of nipple-areola complex (NAC) reconstruction

Modelo sintético e de baixo custo para o treinamento e simulação de reconstrução de complexo areolopapilar (CAP)

PEDRO LUCENA DE AQUINO[1]*
ARTHUR ANTUNES COIMBRA PINHEIRO PACÍFICO[1]
LETÍCIA FONTENELLE FERNANDES[1]
GISELLE FERREIRA DE SOUZA[1]
SARAH GURGEL PONTE FONTENELLE[1]
ANA HELOÍSA FEITOSA DE MACÊDO PEREIRA[1]
PÂMELLA CHRISTINE DE SOUZA MUNHOZ[1]
LETÍCIA CASTELO BRANCO DE OLIVEIRA[1]

■ **ABSTRACT**

Introduction: Reconstruction of the nipple-areola complex (NAC) is indicated when this member is amputated in mastectomies to ensure a more natural appearance to the reconstructed breast. It was first reported by Berson in 1946, but there are currently more than 60 different techniques, all described in the last 8 decades. **Method:** To construct the models, a female bust mannequin, foam sheet, mesh, scissors, Styrofoam glue, and sewing material were required. Once completed, the flap could be marked with a fine-needle brush, and the various techniques described in the literature could be practiced. The model was presented to the plastic surgeon supervising the Plastic Surgery League of the University of Fortaleza and was approved and recommended for low-cost simulation. **Results:** The interest of students in a theoretical class on NAC reconstruction techniques sparked interest in producing a synthetic training model, and due to its ease of practical handling and complete simulation, it was decided to use synthetic material, which allows training in the CV Flap technique. **Conclusion:** The synthetic model for the reconstruction of the nipple-areola complex can accurately simulate the steps of the real surgical procedure, in addition to providing benefits such as good accessibility and low production cost.

Keywords: Education, medical; Professional training; Nipples; Surgical flaps; Models, anatomic.

■ **RESUMO**

Introdução: A reconstrução do complexo areolopapilar (CAP) é indicada quando há amputação deste membro nas mastectomias, para garantir mais naturalidade à mama reconstruída. Seu primeiro relato foi feito por Berson, em 1946, mas, atualmente, existem mais de 60 técnicas diferentes, todas descritas nas últimas 8 décadas. **Método:** Para a construção dos modelos, foi necessário 1 manequim de busto feminino, lâmina de espuma, malha, tesoura, cola de isopor e material para costura e, ao ser finalizado, pôde ser realizada a marcação do retalho com pincel de agulha fina e treino das diversas técnicas descritas na literatura. O modelo foi apresentado ao cirurgião plástico orientador da Liga de Cirurgia Plástica da Universidade de Fortaleza, sendo aprovado e recomendado para simulação de baixo custo. **Resultados:** O interesse dos acadêmicos em aula teórica sobre as técnicas de reconstrução de CAP despertou o interesse na produção de um modelo sintético de treinamento e, devido à facilidade e manejo prático e completa simulação, optou-se pelo uso de material sintético, que possibilita o treinamento da técnica de *C-V Flap*. **Conclusão:** O modelo sintético de reconstrução do complexo areolopapilar consegue proporcionar a simulação das etapas do procedimento cirúrgico real com precisão, além de proporcionar ganhos como a boa acessibilidade e o baixo custo de produção.

Descritores: Educação médica; Capacitação profissional; Mamilos; Retalhos cirúrgicos; Modelos anatômicos.

Institution: Universidade de Fortaleza, Fortaleza, CE, Brazil.

Article received: February 8, 2023.
Article accepted: July 26, 2024.

Conflicts of interest: none.

DOI: 10.5935/2177-1235.2024RBCP0931-EN

[1] Universidade de Fortaleza, Medicina, Fortaleza, CE, Brazil.

INTRODUCTION

Reconstruction of the nipple-areola complex (NAC) is an essential step during breast reconstruction. It usually occurs three to four months after the procedure that restores the volume and contour of the breast.[1] This surgery is indicated in cases where this complex is amputated during mastectomies in order to ensure a more natural appearance to the reconstructed breast.

The first report was made in 1946 by Berson, and three triangular skin flaps were used to perform this procedure. Soon after, there was the publication by Adams in 1949, which also addressed new techniques for NAC reconstruction. In 2005, an update on NAC reconstruction was published by Farhadi et al., who pointed out four basic principles for achieving success in this surgery, namely:

1 - The time for breast reconstruction would be approximately 3 to 4 months after breast reconstruction[2];

2 - In a unilateral reconstruction, the collateral nipple should serve as a model, adapting only the position and asymmetries of the residual breast;

3 - In a bilateral reconstruction, the location is based on the relative and preferred anatomical landmarks of each patient;

4 - The loss of nipple projection due to contraction of the structure during the healing period must be anticipated, and there may be a correction that exceeds the desired result with local flaps by 25 to 50%.

In the literature, between the months of February and August 2020, approximately 92 articles were described that described new NAC[3] techniques. There are more than 60 different technique counts that have been described in the last 8 decades.

Since then, numerous techniques have emerged with the aim of improving contralateral symmetry in position, size, shape, texture, and pigmentation. Today, NAC reconstruction is a greatly enhanced procedure with techniques such as star flap, skate flap, arrow flap, S-flap, CV flap, cylindrical flap, and double opposing flap, among others[3].

Furthermore, it is necessary to mention the contraindications and complications of this procedure, such as performing NAC before the completion of breast reconstruction, especially when the final shape and volume have yet to be defined. The main complication is the loss of nipple projection through local flaps since it is close to or in previous scars, and the blood supply may be damaged, with 45% to 75% of the projection being predicted, making it an unpredictable complication. In addition, appearance and asymmetry are existing risks that should always be discussed preoperatively[4].

Therefore, it was necessary to create synthetic models to improve the technique, such as the "training model in zone IV of the TRAM flap", published in the *Revista Brasileira de Cirurgia Plástica*, which was tested with residents between 2006 and 2009 and showed that the skills acquired during training with the model were transferred to the operating rooms[4].

With this same purpose, the low-cost synthetic model for NAC training and simulation was created to reduce the learning curves of the techniques, making it simpler for professionals in operating room situations. This model covers techniques such as CV Flap, Star Flap, and Skate Flap, among others, and is easily reused, which generates an exponential growth curve since training in this model becomes unlimited[4,5].

OBJECTIVE

This article aims to present a synthetic, novel and practical model for training in reconstruction techniques of the nipple-areola complex, developed to be easy to perform and low cost.

METHOD

To build the model, we needed a female bust mannequin, 1 and 2 cm thick foam sheet, mesh fabric (96% polyester, 4% elastane), scissors, hot glue, Styrofoam glue, and sewing material.

Initially, the assembly consisted of lining the mannequin using foams of different thicknesses and hot glue and then covering it with the mesh fabric to finish it off (Figures 1A and 1B), leaving 2 circular openings in the breast region for later positioning of the model's refill parts (Figures 1C and 1D).

The refill pieces were made by gluing a circular piece of mesh to the 2 cm thick foam sheet with the aid of Styrofoam glue (Figure 2A) so as to allow the simulation of the skin and subcutaneous tissue.

After completion, the flap is marked in the nipple-areola region with a fine-tipped brush (Figure 2B), making it possible to practice the various techniques described in the literature.

The model creation process was carried out by the plastic surgery academic league of the University of Fortaleza (UNIFOR) at the beginning of the 2023 academic semester, with an average cost of R$175.50, with a recharge cost of approximately R$83.07 per training session. The process between the development of the idea and the completion of the model took around 30 days.

The model was presented to the plastic surgeon who teaches and advises the UNIFOR Plastic Surgery Academic League and was approved and recommended

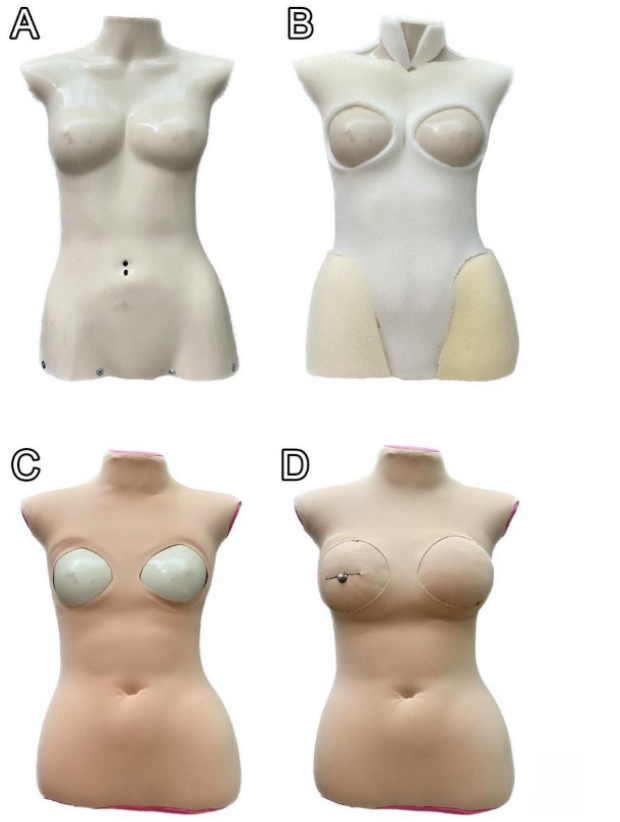

Figure 1. Model construction stages. A. Complete mannequin; B. Covering the mannequin with mesh fabric; C. Space marked for practicing the synthetic model; D. Complete positioning of the breasts for practicing and recharging the model.

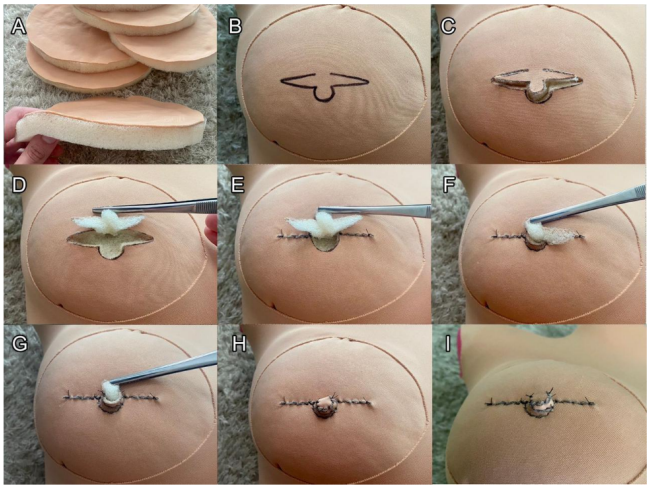

Figure 2. Demonstration of the practice of reconstruction of the nipple-areola complex (NAC) using the proposed model via the CV Flap technique. A. Simulation of the skin and subcutaneous tissue; B. Demarcation of the NAC flap to perform the CV Flap technique; C. Incision at the previously marked site; D. Detachment of the skin and subcutaneous tissue while maintaining the pedicle; E. Suturing of the NAC edges; F. First approximation of the lateral "wings" of the flap; G. Second approximation of the lateral "wings" of the flap; H. Central closure with creation of the papilla protrusion; I. Suturing of the flap and secondary defect.

for low-cost simulation of the procedure. Furthermore, it is worth noting that the study did not involve humans or animals, so, in accordance with the Helsinki principles, there was no need for permission from the Research Ethics Committee to build the model, which was obtained using synthetic and disposable materials.

RESULTS

Academics demonstrated interest in carrying out the procedure after an extracurricular theoretical class on techniques for reconstructing the nipple-areola complex.

The experiment developed a model for simulating a specific technique for reconstructing the nipple-areola complex without restrictions on the use of the synthetic model and material.

Regarding the shape of the areola and the materials used to resemble the structure of the local cutaneous and subcutaneous tissue, it was observed that the synthetic model was easy to handle in practice and, consequently, it was completely simulated due to the structure used, enabling training in the CV Flap technique, which requires incision, detachment, maintaining the pedicle and suturing of the flaps.

DISCUSSION

Surgical knowledge in undergraduate medical courses is a relevant issue, especially in relation to its practical application, due to the lack of economically accessible methods that can simulate the process in question, in addition to the limited time spent on learning such procedures. In this context, simulation in the practical setting offers several benefits for learning at different levels of knowledge, providing better performance in the surgical environment due to the skills covered by the training models.

It is known that a surgical curriculum presupposes repetitive training of such techniques, with the aim of developing the necessary fine manual skills, especially in students whose contact with the surgical center is restricted, such as the skills exemplified in stages B to I in Figure 2. Thus, in a complementary way to the traditional learning model based on long internships and dependent on the master-apprentice relationship, the alternative method presented in the present study proposes the construction of an anatomical breast simulator that makes it possible to mirror the real surgical scenario, allowing the repeated execution of the reconstruction of the nipple-areola complex, with an acceptable level of fidelity[6].

According to Santos et al.[7], the benefits of simulation experience for residents or undergraduate students are varied. The low cost of production and

maintenance of the model democratizes access to this type of training beyond the high-cost synthetic models, exposing the student to situations similar to the real context, thus reducing iatrogenic and aesthetic complications for patients, in addition to ethical issues[7].

Among the brief limitations of the proposed prototype, the inconvenience that may restrict its widespread use is the need for a certain amount of sewing expertise for its construction, although reusing a mannequin saves a great deal of time spent on manufacturing, as can be seen in finishing stages B and C in Figure 1.

In comparison to training models that use fresh cadavers and animal parts, the creation of a synthetic model replaces the ethical impasse in the effort to search for inputs that have maximum similarity to human tissue, such as the simulator by Jefferson et al.[8], which equates the use of synthetic skin to pig skin as handling objects for training.

The arrangement of materials in the proposed synthetic model simulates the structure of the cutaneous and subcutaneous tissue, enabling the practice of techniques effectively described in the literature and providing easy handling of the flap and the incision with a scalpel. Furthermore, the use of easily replaceable materials differs positively from the organic models proposed by scholars who use, for training plastic surgery residents, flaps from post-mortem animals, such as chicken skin, beef tongue, discarded porcine tissues, and even symbiotic yeast cultures, making the experience limited to use due to the lack of availability of the material[9].

Regarding the financial investment related to its architecture, as well as the reinstallation of synthetic breasts for new sutures, mentioned in steps C and D of Figure 1, the selected materials allow for almost unlimited reuse of the simulator by academics and supervising surgeons due to the low cost of the main inputs, such as mesh, Styrofoam glue, and sponge sheet. Comparatively, anatomical models of great contemporary relevance, such as those that use three-dimensional (3D) printing, require additional costs in technology that are inaccessible to a large portion of the academic population. The approval by renowned plastic surgeons of the new simulator created successfully, demonstrated the quality of this low-cost synthetic model, despite its simplicity[10].

CONCLUSION

The proposed synthetic model for the reconstruction of the nipple-areola complex has great potential to aid in the training and improvement of available surgical techniques for the procedure since it can accurately simulate the steps of the real surgical procedure. In addition, it has proven to be a tool that provides gains in terms of accessibility and low manufacturing costs.

COLLABORATIONS

PLA Conception and design study, Project Administration, Supervision, Visualization, Writing - Original Draft Preparation, Writing - Review & Editing.

AACPP Methodology, Realization of operations and/or trials, Supervision, Validation, Writing - Review & Editing.

LFF Conception and design study, Conceptualization, Resources, Writing - Original Draft Preparation.

GFS Methodology, Realization of operations and/or trials, Writing - Original Draft Preparation.

SGPF Realization of operations and/or trials, Visualization, Writing - Review & Editing.

AHFMP Conception and design study, Project Administration, Realization of operations and/or trials, Resources.

PCSM Conception and design study, Methodology, Realization of operations and/or trials.

LCBO Methodology, Realization of operations and/or trials, Writing - Original Draft Preparation.

REFERENCES

1. Lamartine JD, Cintra Junior R, Daher JC, Cammarota MC, Galdino J, Pedroso DB, et al. Reconstrução do complexo areolopapilar com double opposing flap. Rev Bras Cir Plást. 2013;28(2):233-40.
2. Balbinot P, Ono MCC, Groth AK, Silva ABmD. Reconstrução do complexo areolopapilar e da mama com colocação de implante no mesmo tempo cirúrgico. Rev Bras Cir Plást. 2013;28(3 Suppl.1):65.
3. Paolini G, Firmani G, Briganti F, Sorotos M, Santanelli di Pompeo F. Guiding Nipple-Areola Complex Reconstruction: Literature Review and Proposal of a New Decision-Making Algorithm. Aesthetic Plast Surg. 2021;45(3):933-45.
4. Gomes AAR, Pessoa BBGP, Pessoa SGP. Nipple-areola complex reconstruction: training bench model in zone IV TRAM flaps. Rev Bras Cir Plást. 2010;25(2):379-80.
5. Strassburger CP, Ramos RFMR. Nipple-areola complex reconstruction: What we have today? Rev Bras Mastologia. 2016;26(1):18-23.

6. Pacífico AACP, Correia AS, Borges BMC, Costa MB, Arrais MPFF, Carneiro SL, et al. Low-cost synthetic model for skin flap training. Rev Bras Cir Plást. 2020;35(3):304-8.
7. Santos NEB, Lima, EB, Sales MA, Vieira APSB, Melo RB, Sá CDL. A utilização de modelos de simulação para treinamento cirúrgico - revisão integrativa. Res Soc Dev. 2021;10(2):e21210212420.
8. Jefferson IS, Robinson SK, Surprenant D, Whittington A, Arshanapalli A, Tung-Hahn E, et al. Surgical training tools for dermatology trainees: porcine vs. synthetic skin for excision and repair. Arch Dermatol Res. 2021;313(9):793-7.
9. Dreven VA, Garner SJ, MacDermott ST, Yates MW, Costa SG, et al. Will SCOBY do? An alternative for teaching basic surgical skills of suturing and skin excision. J Surg Simul. 2018;5(99):99-104.
10. Garcia TR, Macedo RM, Vaz MHV, Borges GHI, Zendron IM, Arruda JT. Impressão 3D de peças anatômicas como ferramentas de educação e auxílio na prática clínica. Res Soc Dev. 2022;11(13):e248111335234.

***Corresponding author:** **Pedro Lucena de Aquino**
Av. Washington Soares, 1321, Edson Queiroz, Fortaleza, CE, Brazil.
Zip Code: 60911-905
E-mail: pedrolucena@edu.unifor.br