

Investigating the Efficacy of Anatomical Silicone Models Developed from a 3D Printed Mold for Perineal Repair Suturing Simulation

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Categories: Medical Education, Medical Simulation, Obstetrics/Gynecology

Keywords: medical simulation, 3d printing, obstetrics, gynaecology, postpartum, surgery, perineal repair, oasis

How to cite this poster

Goudie C, Shanahan J, Gill A, et al. (2017) Investigating the Efficacy of Anatomical Silicone Models Developed from a 3D Printed Mold for Perineal Repair Suturing Simulation. Cureus 9(8): e.

Abstract

There is a scarcity of affordable, validated, standardized and anatomically correct silicone perineum models for the rehearsal of postpartum laceration repair. The purpose of this technical report is to describe and validate evidence for a silicone, perineal repair model created from a 3D printed mold for medical resident training and clinical skills maintenance.

A pre-existing model from an open-source royalty-free website was purchased and converted using Fusion360™ into a stereolithography (.stl) file and altered to produce a negative mold. Using a spatula, a fine silicone layer was first applied inside the mold, followed by a small piece of flesh-coloured mesh netting material within the perineal surface area, fitting the width of the mold. The mesh was pressed into the thin layer of silicone, which was meant to provide anatomical structure to prevent the sutures from tearing through the silicone. The remainder of the silicone mix was then poured into the mold, which required three hours to fully set before being removed from the mold. Twelve silicone models were produced and used during a one-hour workshop at the Rural and Remote Conference by 16 Obstetrics and Gynecology residents and practicing rural physicians, and four facilitators. At the end of the workshop, the participants were provided with a qualitative survey and asked to rate the perceived realism and educational effectiveness of the silicone perineum model as compared to pre-existing simulation models that they have used previously. The overall workshop participant feedback was positive, noting that the models provided more realistic visualization for the suturing simulation of 1st and 2nd degree perineal injuries.

The silicone models were considered to be useful in simulation training when attempting 1st and 2nd degree perineum suturing techniques within a confined space. The overall feedback was positive, noting that they provided more realistic visualization experience compared to pre-existing simulation models, such as beef tongues and synthetic sponges. The feedback from the participants and facilitators included thoughts about how to add additional mesh to the silicone model so the subcutaneous and vaginal plane sutures would hold, as well as increasing the size of the vaginal canal size to more accurately represent a postpartum repair. There were also suggestions to alter the colour of the model to be flesh-toned as opposed to pink, to more accurately simulate human tissue.

Open Access

Published 08/31/2017

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Silicone perineum models, created from a 3D printed mold, are an economical training tool as compared to commercially available, cost prohibitive models. They also provide anatomically accurate simulation training opportunities for residents to learn and maintain clinical skills in perineal repair, as compared to beef tongues and synthetic sponges, which have previously been used in Obstetrics and Gynecology simulation-based medical education.



“The silicone perineal repair model provided better visualization of the 3D nature of tears.”

...

“The model provided an opportunity to get clinical feedback during hands-on practice.”

INTRODUCTION

Simulation-based medical education (SBME) is rapidly advancing with tools such as three-dimensional printers to assist with the development of anatomically correct silicone models for the rehearsal of high acuity, low occurrence procedural skills [1]. Such models can be created from 3D printed molds, designed to provide more advanced haptic simulation for medical students and clinicians. Specialized fields such as obstetrics and gynecology benefit from such medical simulation opportunities to rehearse procedural skills in a safe learning environment, specifically to practice complex suturing patterns as applied in postpartum perineal repair [2]. Despite the emphasis on such procedural accuracy, a recent study revealed that a majority of obstetrics and gynecology students are not adequately prepared to independently perform such complex surgical skills at the end of their medical residency due to a lack of hands-on experience [3]. For simulation training purposes, trainees have commonly used synthetic sponges and raw beef tongues to represent female anatomy for the purpose of practicing perineal laceration suturing techniques [4]. However, such artificial objects and animal anatomy fail to accurately replicate the anatomical structure of female genitalia, thus does not provide ideal simulation training for such specialized procedures. Furthermore, the variability of animal anatomy does not allow for standardization of practice or consistent assessments [5].

CONTEXT

The Rural and Remote Conference held in St. John's on April 14, 2018, was held at the Delta Hotel in St. John's, Newfoundland (Figure 1). The conference attracted rural health care practitioners, specifically, medical students, residents and family doctors from across Canada. Throughout the conference, various medical workshops were offered as a means to advance and maintain specialized skills required by rural family doctors and medical students. The perineal repair workshop had 16 participants (residents and practicing rural physicians) and was located within a breakout group lecture room, which contained six horizontal lecture tables, acting as the platform for which the participants performed the suturing upon.

INPUT

The equipment provided to residents included: non-toothed tissue forceps, suturing scissors, needle drivers, surgical absorbent pads, medical grade catgut suture, raw beef tongue, and silicone perineum model. The participants were presented with a Powerpoint slideshow of the suturing patterns to rehearse on each simulator.

PROCESS

Following the Powerpoint presentation slideshow, the participants were asked to apply the skills-based learning segment to their simulation models. No instruction was provided as to which model the participants were to begin with, however, it was reported that most participants voluntarily started with the beef tongue model to rehearse the suturing patterns, followed by the silicone model to rehearse the application of the suturing within a smaller, confined space.

PRODUCTS

Twelve pink silicone perineum models were fabricated in total, which were altered prior to the workshop, by making incisions mediolaterally to replicate a first or second-degree perineal laceration (Figure 2,3,4). In addition to the silicone models, and upon receiving verbal consent from workshop participants, the facilitators provided a survey to determine the efficacy of the silicone model as a training tool as compared to the contrasting beef tongue models.



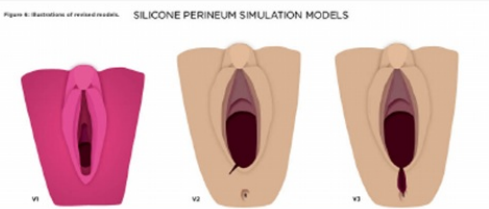
DISCUSSION

The silicone model was considered to be useful in terms of providing an anatomically correct simulation tool for the suturing training. The response overall was quite positive and provided a number of changes required to make this a more accurate and fully functional simulation tool for future workshops and potentially being integration into an SBME learning curriculum. Specifically, feedback from the workshop facilitators included thoughts that the silicone models were slightly too small and narrow to be considered an accurate postpartum vaginal canal simulation model (Figure 5). It was also suggested that the models should ideally include pre-made lacerations in the mold so the silicone tissue remains slightly ajar to more accurately represent the properties of soft tissue when torn. To provide a more accurate context for the simulation, ideally, the perineum models would also have blood and excess tissue surrounding the opening of the vaginal canal during the procedure. In addition, it was noted that the sutures only held where the mesh netting was contained within the silicone and did not hold in the absence of the internal mesh. Consequently, future iterations should include mesh netting along the vaginal plane in addition to the current mesh along the perineal plane. There were also suggestions to replicate more accurate musculature layers near the perineal plane, as well as the addition of an anus, including muscular-type structure that would simulate that of a sphincter muscle (Figure 6). Finally, a 3D printed PLA stand should be integrated into the design to change the angle of positioning of the perineal model to 45 degrees, which would better simulate the position of the anatomy during such a perineal repair procedure (Figure 7). One of the educational facilitators also suggested that another model should be created, specifically to rehearse third and fourth-degree obstetric anal sphincter injury (OASIS) repair (Figure 8).

The second iterative molds were later created to produce the revised silicone models, which included improvements such as: flesh tone colour, strategic placement of mesh netting for suturing, pre-made lacerations, integration of an anus, wider vaginal canal, and a 3D printed base to tilt the models at a 45-degree angle. In September 2018, 25 of the newly revised OASIS perineum models were brought to Dhaka, Bangladesh (with author CG) in collaboration with Team Broken Earth (brokenearth.ca) for use during their International Training Course on High Risk Labour and Delivery Management. The three-day workshop focused on women's health and provided an opportunity for local clinicians to rehearse OASIS repairs, which is an injury linked to a high maternal mortality rate in such regions [6]. Workshop outcomes were documented and a follow-up technical report is underway to report the findings that surround the efficacy of using such models for SBME in developing countries.

CONCLUSIONS

Silicone perineum models, created from 3D printed molds are a reusable and cost-effective method to more accurately teach and maintain perineal repair skills, compared to contrasting models such as beef tongues, currently used in obstetrics and gynecology SBME. The silicone models were thought to be beneficial because of the visual and physical realism. Specifically, they provide the constrained space and necessary visual cues where the learners can practice the technical suturing on an anatomically accurate model. With suggested modifications made, the model can potentially be used at future obstetrics and gynecology workshops, within international SBME, for clinical skills maintenance, and for patient education.



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