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Silicone Models for Dermatological Education: Assessment of a New Teaching Tool by Dermatologists

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ABSTRACT

Introduction: The coronavirus pandemic forced universities to transfer academic curricula into the digital realm and calls for the introduction of new teaching methods to adequately compensate for the limited in-patient training. Especially in the field of dermatology, the use of 3D models presents an interesting opportunity to maintain the teaching of diagnostically essential sensory and haptic characteristics of primary lesions.

Objectives: We developed a prototype silicone model and presented it to the medical service of the Department of Dermatology of the Ludwig-Maximilians University for evaluation.

Methods: Silicone models demonstrating primary skin lesions were produced by using negative 3D-printed molds and different types of silicone. An online survey obtained evaluations from a group of dermatologists regarding the quality of previously supplied silicone 3D models and their potential use in medical education. Data from 58 dermatologists were collected and analyzed.

Results: The majority of the participants rated the models overall as positive and innovative, providing constructive feedback for additional modifications, and recommended further implementation into the regular curriculum as an additional tool after the end of the pandemic.

Conclusions: Our study underlined the possible advantages of using 3D models as a supplement in educational training even after the end of the SARS-CoV-2 pandemic.

Introduction

At the beginning of 2020, the pandemic outbreak of the coronavirus SARS-CoV-2 necessitated a quick shutdown of most public life in Germany to contain dissemination. Accordingly, universities were confronted with new challenges to continue providing high-quality education.

For most faculties, this entailed a drastic transition into the digital realm. However, a couple of specialist fields depending on physical practices could not properly substitute essential courses. Medical education in particular is heavily reliant on face-to-face contact with patients both to learn clinical pictures as well as to improve important communication skills. Different approaches already aimed to expand learning and teaching strategies beyond traditional methods even before the pandemic urged educators to revise their formerly established curriculum. Case discussions and inverted classroom courses incentivize a more active engagement of students, whereas websites and a range of mobile learning applications, e.g. for dermatological education, encourage auto-didactic learning[1-3]. Furthermore, patient-orientated-communication courses use actors to simulate true-to-life clinical situations. However, these approaches are still not able to substitute the in-patient examination of haptic manifestations of symptoms, the lack of which constitutes a major disadvantage of currently used teaching methods[4, 5]. Therefore, other medical fields have already implemented the use of 3D models in training and education, for example in anatomy, dentistry and surgical preparations[6, 7].

Expanding on this idea, we created colored 3D silicone models with texturized surface areas to emulate common primary skin lesions. Since visual and haptic examination of the skin plays a major role in dermatological differential diagnosis[8], this model should be especially useful in times of restricted patient access and possibly as a general learning tool as well.

In this study, an early version of our 3D-printed model of primary skin lesions was shown to a group of dermatologists to evaluate the quality of the model and state their opinion on incorporating 3D models into dermatological education in general.

Methods

Silicone Models

Our study object was a silicone model demonstrating primary skin lesions. The silicone models were produced using negative molds made from polylactide (PLA) using Martz PLA Matt Filament (IGO3D GmbH, Hannover, Germany) on the 3D printer Anycubic i3 Mega S printer (ShenZhen ANYCUBIC Technology Co., Ltd, Shenzhen, Guangdong, China). The layer height was adjusted to 0.1 mm without any support structures or attachment layers. The platform temperature was set at 60° C with an extrusion temperature of 200°C. Subsequently, a cotton swab soaked in tetrahydrofuran (Sigma Aldrich, Steinheim, Germany) was repeatedly used to smooth the molds. TinkerCAD online software (Autodesk, Inc, San Rafael, California, USA) was applied for designing the molds. The slicing software used was Ultimaker Cura (version 4.8, Ultimaker BV, Utrecht, Netherlands).

Next, after degassing for 1 minute using a vacuum pump (diaphragm vacuum pump, Vacuubrand GmbH+Co., Wertheim, Germany), we poured silicone rubber (equal amounts of part A and B) according to the lesion properties (**Suppl. File 1**), polymerized overnight at room temperature and applied normal skin as the last layer on the second day (all materials: KauPo Plankenhorn e.K., Spaichingen, Germany). After another overnight polymerization period, the silicone model was stripped off and stuck onto a postcard sized (approximately 10.5 cm × 14.8 cm) overhead transparency (**Figure 1A**). Finally, to obtain a matt surface finish our models were powdered with household starch.

Survey

In February 2021, we performed a longitudinal study using an online survey addressed to dermatologists of the Ludwig-Maximilian-University (LMU) in Munich/Germany to use their knowledge and dermatological expertise in the assessment of silicone models in medical teaching. Questions were answered using a grading from strongly agree, agree, neutral, disagree to strongly disagree. The survey was in German language and carried out completely anonymously (translated version **Suppl. File 1**).

Participants were asked about their work experience, acquired knowledge about moulages and their opinion about the study object, possible benefits for students and suggestions for improvement.

Statistics

Statistical calculations were done using SPSS statistics 26.0 (IBM Corp., released 2019, Armonk, NY/USA), visualizations were performed using GraphPad Prism version 9.0.0 (GraphPad Software, La Jolla, CA). Metric variables were indicated as mean values ± standard deviation (SD). P value was calculated by using the Mann-Whitney Test. Significance level was set at $P<.05$. The data were evaluated descriptively. Ethical approval was obtained from the committee of the LMU (project KB 20/031).

Results

Study Population

Fifty-eight dermatologists participated in the survey. Thirty-eight participants were female (65.5%), and twenty

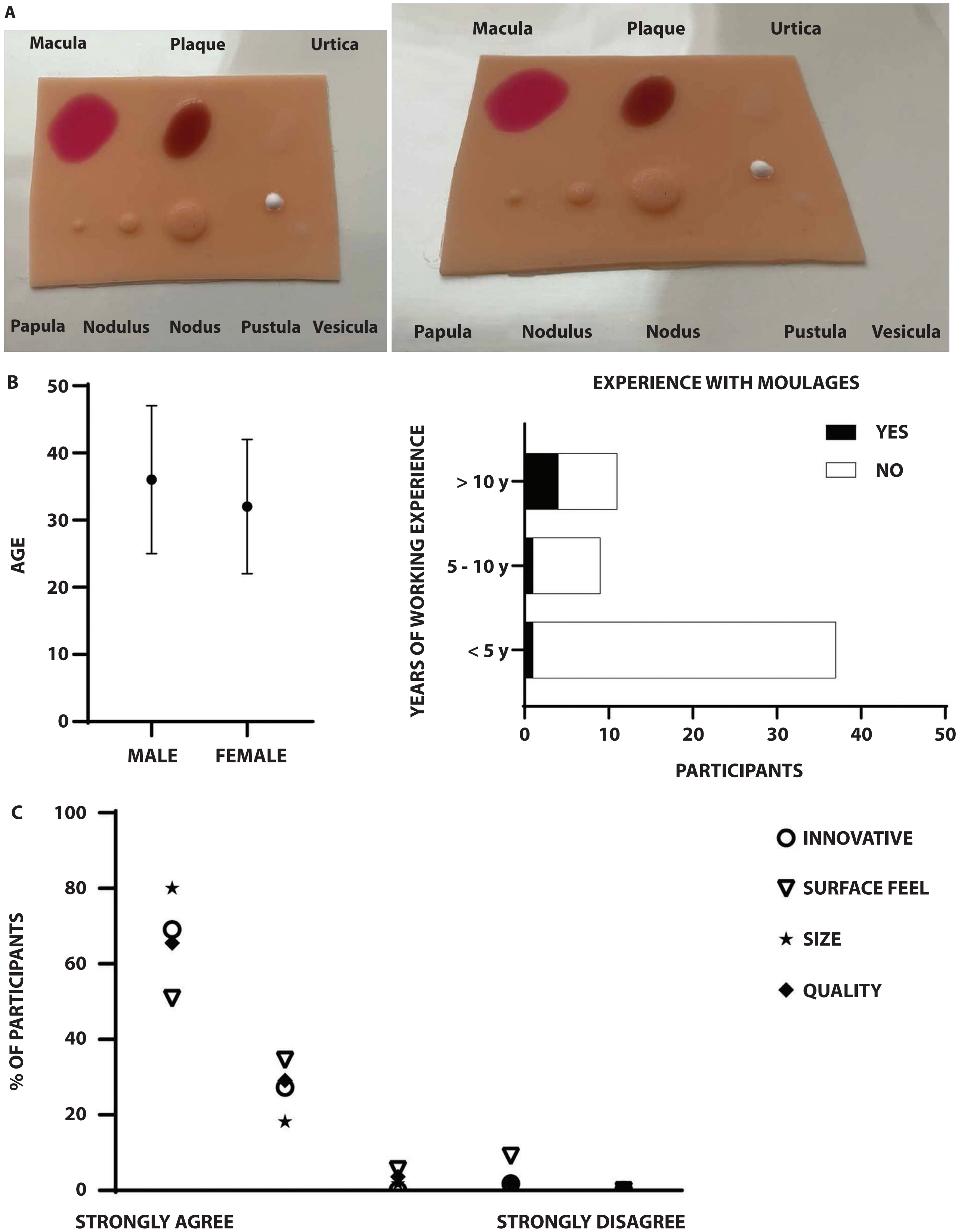

Figure 1. A: Study object (silicone model): Upper row illustrating patch (Macula), plaque (Plaque) and wheal (Urtica), lower row depicting papule (Papula), nodulus (Nodulus), nudule (Nodus), pustule (Pustula) and vesicle (Vesicula) (left to right, respectively; Latinized German terms in brackets). B: Age and gender distribution of all participants (left panel). Experience with moulages depending on working experience (right panel). C: Exemplary represented assessment (from "strongly agree" to "strongly disagree") for different evaluation criteria.

participants were male (34.5%). The current mean age was 34.6 years (range 25 – 64 years). Among all participants, thirty-eight (65.5%) were dermatological residents with less than five years of working experience. Nine doctors were attending physicians (15.5%) and worked between five and ten years in the field of dermatology and eleven (mainly advanced attending physicians) (19.0%) worked for more than ten years as dermatologists. Overall, fifty-one doctors (89.5%) stated that they have not worked or taught students by using moulages while six participants (10.5%) have already gained experience by using them. Doctors who already used moulages provided a significantly higher working experience (P=.003) (Figure 1B).

Survey

To review the true-to-life properties of the silicone models, the participants were asked if they would assess the moulage as realistic in terms of sensory and haptic perception. Almost two-thirds (62.5%, 35/56) answered "strongly agree", a quarter (25%, 14/56) answered "agree" and 12.5% (7/56) answered "neutral or strongly disagree".

Subsequently, when asked whether the model was representative of the clinical picture regarding haptic properties, 50.9% (28/55) answered "strongly agree" 34.5% (19/55) answered "agree" and 14.6% (8/55) answered "neutral or disagree". Furthermore, 65.5% (36/55) answered "strongly agree" when asked if the models are of good quality regarding their elaboration, 29.1% (16/55) answered "agree" and 5.4% (3/55) answered "neutral or disagree".

More than three-quarters (76,4%, 42/55) of the participants strongly agreed that the model was sufficient in size, while 18.2% (10/55) agreed and the rest (5.4%, 3/55) answered "neutral or disagree". Additionally, when asked if the model was of a handy size, 80% (44/55) answered "strongly agree", 18.2% (10/55) answered "agree" and only one participant (1.8%, 1/55) answered "neutral". Subsequent questions regarded the use of models as learning/teaching tools. Therefore, participants were asked if they considered the training with models as innovative regarding the current situation. Over two-thirds (69.1%, 38/55) answered "strongly agree", 27.3% (15/55) answered "agree" and 3.6% (2/55) answered "disagree or strongly disagree" (Figure 1C).

Additionally, when asked if they would expect the moulages to facilitate the student's learning approach, 74.5% (41/55) answered "strongly agree", 20% (11/55) answered "agree" and 5.4% (3/55) answered "neutral or disagree".

More than two-thirds (67.3%, 37/55) of the dermatologists strongly agreed that they consider the moulages a good supplement to in-patient teachings even after the end of the pandemic. Almost a quarter (23.6%, 13/55) answered "agree" and 9% (5/55) answered "neutral, disagree or strongly disagree".

However, 61.8% (34/55) of the participants strongly agreed that the models should be expanded to include secondary lesions or dermatological clinical pictures as well. Over a quarter (27.3%, 15/55) answered "agree" and 10.9% (6/55) answered "neutral, disagree or strongly disagree".

To evaluate possible benefits of the 3D-printed models, the participants were asked if they would deem the silicone moulages advantageous over the more traditional, usually wax-based models, to which almost two-thirds (65.5%, 36/55) strongly agreed, while 25.5% (14/55) answered "agree" and 9.1% (5/55) answered "neutral".

Finally, the participants were asked to rate the general idea of teaching with silicone moulages on a scale ranging from very good (1) to poor (5), to which 72.7% (40/55) answered "very good", while 20% (11/55) answered "good" and only 7.3% (4/55) answered "moderate or poor".

Additionally, the participants had the opportunity to comment on their perceived shortcomings and their general opinion of the silicone moulages in two open-ended questions. Constructive criticism involved suggestions to modify color, haptics and size to improve resemblance to actual clinical cases. However, one comment stated that the models are, although nice to have, rather irrelevant since students have always been able to correctly identify primary lesions without additional teaching methods.

Almost all of the participants gave positive feedback, complimenting the resourcefulness and good realization, as well as describing the model as a great supplement to the traditional teaching methods and long-distance teaching tool, especially in times of limited patient contact due to COVID-19 restrictions.

Discussion

In the medical field, providing the best possible education and preparation of students for clinical practice at any given time is of paramount concern. Usually, this is accomplished by connecting the knowledge obtained by lectures and textbooks with actual clinical pictures via bedside teaching. However, times of limited patient access impose the need for alternative substitutional methods.

Physical 3D models have already found their way into various medical fields to better illustrate spatial visualization of anatomical features and pathologies, rendering them a suitable candidate for a contactless teaching experience[6]. Various studies reported improvements in students' self-perceived knowledge and confidence following an auto-didactic study session[9]. Furthermore, studies have shown an objective increase in knowledge acquisition[10, 11], even proving to be superior in direct comparison with cadaveric material[12], CT scans or 3D computer simulations[13, 14]. All aforementioned studies additionally received positive feedback from students, who expressed wishes to incorporate the 3D models into the regular curriculum.

Correspondingly, medical experts also reported their satisfaction with the models and emphasized their usefulness in medical education[15]. These findings concur with our own results, as the idea of 3D models generally yielded a very positive response, and the majority of questioned dermatologists found the silicone models to be innovative and to facilitate learning of primary lesions. Although it was noted that 3D models cannot fully encapsulate the visual and sensory representation of primary lesions and are therefore not able to replace the clinical picture, the models primarily attempt to create a basic understanding in students with little to no clinical dermatological experience. This is especially crucial since dermatological problems are numerous and often occur as comorbidities in a variety of medical domains[16].

Additionally, the restricted ability to replicate the clinical picture in complete detail should not be seen as a limitation, considering the model an auxiliary teaching tool rather than a replacement for in-patient training once the pandemic subsides. For this application, our study yielded almost universal approval among participants.

Improvement suggestions stated in the open-ended questions regarded slight modifications of color, size and haptic characteristics. Since the nature of the silicone models allows for quick and easy incorporation of feedback, our prototype model can be constantly upgraded utilizing these suggestions at a fairly low price point (approximately 50 Eurocent (0.5 €) per model).

Conclusions

In conclusion, experts approved the utilization of silicone 3D-printed models as a highly promising method in dermatological education in times of restricted in-patient contact and further recommended the incorporation of the models as an additional tool into the regular curriculum.

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