The efficacy of artificial skin as a simulation-based training model for intradermal injection

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ABSTRACT:

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Background: Simulation-based training is a safe and efficient tool to help residents and medical students gain more experience and skills before operating on real patients. Intradermal injection is frequently performed in dermatology, pediatrics and other departments. Commercial intradermal injection simulator is expensive, therefore we invented an intradermal injection simulator made from affordable local materials. This study assesses the efficiency of this intradermal injection training simulator.

Objective: To assess the efficacy of this artificial skin as a simulation-based training model for intradermal injection

Materials and Methods: Self-evaluation and satisfaction questionnaires were distributed to participants before and after the intradermal injection simulator workshop. In the questionnaires we addressed statements and asked the participants to check in the box of 0,1,2,3,4,5,6,7,8,9 to 10 referring to completely disagree, strongly disagree, disagree, mildly disagree, minimally disagree, neither agree nor disagree, minimally agree, mildly agree, agree, strongly agree to completely agree, respectively. After the workshop, residents and medical students did an intradermal injection on real patients to assess their skills by a blinded dermatologist. An immediate wheal indicates the correct injection.

Results: After the workshop, participants were significantly more prepared and confident administering intradermal drug injection as well as they were more confident that their hands did not shiver while giving injection ($p<0.001$). Residents and medical students were completely satisfied with the intradermal injection simulator and would recommend intradermal injection simulator to other learners. They completely agreed that the simulator model is a good method to learn drug injection, easy to use and can be applied to patients. All patients (100%) had small wheals after injections which were assessed by a blinded dermatologist.

Conclusion: This new simulator model in local intradermal injection training seems to be a simple, effective and affordable tool to aid medical education and help students gain more skills before performing the procedure on real patients. Nevertheless, further studies should be conducted focusing on the clinical usefulness of the simulator with respect to training and patient outcomes.

Key words: Simulation-based training, Intradermal injection, Experience and skills

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โครงการวิจัยประสิทธิผลของหนังเทียมซึ่งเป็นอุปกรณ์ช่วยฝึกฝนทักษะการฉีดยาเข้าชั้นผิวหนังแท้
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อุปกรณ์ฝึกทักษะหัตถการเป็นเครื่องมือการเรียนรู้ที่ปลอดภัยและมีประสิทธิภาพ ช่วยส่งเสริมทักษะแก่นักศึกษาแพทย์และแพทย์ประจำบ้านก่อนการทำหัตถการในผู้ป่วยจริง การฉีดยาเข้าชั้นผิวหนังเป็นหัตถการที่พบบ่อยในสาขาตจวิทยา กุมารเวชศาสตร์ และสาขาอื่นๆ เนื่องด้วยอุปกรณ์ฝึกการฉีดยาเข้าชั้นผิวหนังที่ขายตามท้องตลาดมีราคาสูง ทางทีมผู้วิจัยจึงประดิษฐ์คิดค้นอุปกรณ์ฝึกการฉีดยาเข้าชั้นผิวหนังเพื่อใช้ทดแทนอุปกรณ์ดังกล่าว

วัตถุประสงค์: เพื่อประเมินประสิทธิภาพของอุปกรณ์ฝึกการฉีดยาเข้าชั้นผิวหนังจากยางพารา

วิธีการศึกษา: ผู้เข้าร่วมวิจัยแต่ละคนจะได้รับแบบสอบถามประเมินตนเองและแบบประเมินความพึงพอใจก่อนและหลังการฝึกทักษะด้วยอุปกรณ์ฝึกการฉีดยาเข้าชั้นผิวหนัง โดยในแบบสอบถามได้ชี้แจงและให้ผู้เข้าร่วมวิจัยเลือกคำตอบเป็นตัวเลขบ่งปริมาณ 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 ถึง 10 โดยหมายถึง ไม่เห็นด้วยอย่างยิ่ง ไม่เห็นด้วยมาก ไม่เห็นด้วย ค่อนข้างไม่เห็นด้วย ไม่เห็นด้วยบ้าง เฉยๆ เห็นด้วยบ้าง ค่อนข้างเห็นด้วย เห็นด้วย เห็นด้วยมาก และเห็นด้วยอย่างยิ่ง ตามลำดับ หลังจากผ่านการเรียนแล้ว ผู้เข้าร่วมวิจัยจะได้ฝึกฉีดยาเข้าชั้นผิวหนังผู้ป่วยจริงภายใต้การดูแลและประเมินโดยตจแพทย์

ผลการศึกษา: หลังผู้เข้าร่วมวิจัยเข้ารับการเรียนการฉีดยาเข้าชั้นผิวหนังกับอุปกรณ์ช่วยฝึกฝนทักษะการฉีดยาเข้าชั้นผิวหนังแท้ พบว่ามีความมั่นใจมากขึ้นและทักษะดีขึ้นอย่างมีนัยสำคัญทางสถิติ ($p<0.001$) ผู้เข้าร่วมวิจัยมีความพึงพอใจอย่างมากต่ออุปกรณ์ช่วยฝึกฝนทักษะการฉีดยาเข้าชั้นผิวหนัง และเห็นสมควรว่าควรแนะนำให้ผู้ที่ต้องการเรียนรู้ฝึกฝนการฉีดยาเข้าชั้นผิวหนังแท้ด้วยอุปกรณ์ช่วยฝึกฝนทักษะนี้ ผู้เข้าร่วมวิจัยต่างเห็นว่าอุปกรณ์ช่วยฝึกฝนทักษะการฉีดยาเข้าชั้นผิวหนังแท้เป็นอุปกรณ์ที่ช่วยที่ดีสำหรับการเรียนรู้และพัฒนาทักษะการฉีดยา ใช้ง่าย และมีประโยชน์ในการประยุกต์กับผู้ป่วยได้จริง ผู้เข้าร่วมวิจัยสามารถฉีดในผู้ป่วยจริงได้อย่างถูกต้อง โดยพบตุ่มนูนขนาดเล็กที่ประเมินโดยตจแพทย์ว่าเป็นตำแหน่งและระดับความลึกที่เหมาะสม

สรุปผล: อุปกรณ์ฝึกทักษะหัตถการเป็นอุปกรณ์ที่เรียนรู้ง่าย ราคาไม่แพง แต่มีประสิทธิภาพสูง ช่วยส่งเสริมทักษะได้ผู้ที่ยังไม่มีความชำนาญเพียงพอได้เป็นอย่างดี อย่างไรก็ดี คุณภาพของหนังเทียมที่ใช้ในการทำอุปกรณ์ฝึกทักษะหัตถการควรจะได้รับการศึกษาและพัฒนาเพื่อปรับปรุงประสิทธิภาพให้เหมาะสมกับหัตถการทางผิวหนังอื่นๆอีกต่อไป

คำสำคัญ: อุปกรณ์ช่วยฝึกฝนทักษะ, การฉีดยาเข้าชั้นผิวหนังแท้, ประสบการณ์และทักษะ

Introduction

Nowadays there has been a dramatic increase in dermatologic procedures. In 2001 - 2007 cosmetic procedures have increased 120.2%, most of which are filler and botulinum toxin injections (405% and 324.4% respectively).[1,2] Although dermatology residency program offers training in a variety of dermatologic procedures such as skin biopsy, suture, comedone extraction, sclerotherapy, laser surgery, chemical peels, scar revision, botulinum toxin and filler injections, a survey has found that dermatology residents feel uncomfortable with cosmetic procedures.[3-6] However the most common cosmetic procedures performed during residency are botulinum toxin injections, filler injections and sclerotherapy.[7]

Simulation-based training is a safe and efficient tool to help residents and medical students gain more experience and skills before operating on real patients. It has been used in medical education for hundreds of years.[8] There are many types of simulators based on fidelity, animate and procedurals.[9] Fidelity or Realism of a stimulator is characterized by visual and tactile perceptions, ability to feedback and interact with the apprentice.[10]

Intradermal injection is frequently performed in dermatology including steroid injection to treat keloid, botulinum toxin injection in lifting procedure. Other departments such as Pediatrics also require skills in intradermal injection such as BCG vaccine injection and tuberculin skin test. Normally, immediately after intradermal injection, a wheal will appear at the skin which indicates that the injector has injected correctly.[11] There has been commercial intradermal injection simulator but the prize is very expensive. In the past, intradermal injection was taught by lecture and practice on skin of dead chickens but an important limitation is the lack of feedback capabilities.

An artificial skin was developed for medical training. Therefore, the purpose of this study was to assess the efficiency of this intradermal injection training simulator.

Materials and Methods

The Department of Dermatology, Siriraj Hospital in collaboration with Medical Education Technology Center, Mahidol University have developed a simulator that resembles the skin in terms of visuality, tactile perception and feedback by using affordable local materials. The simulator is made of rubber which gives an elasticity similar with the skin. When injected with normal saline the volume beneath the rubber increases resulting in a circular elevation of the rubber reflecting wheal in real patients. (Figure 1)

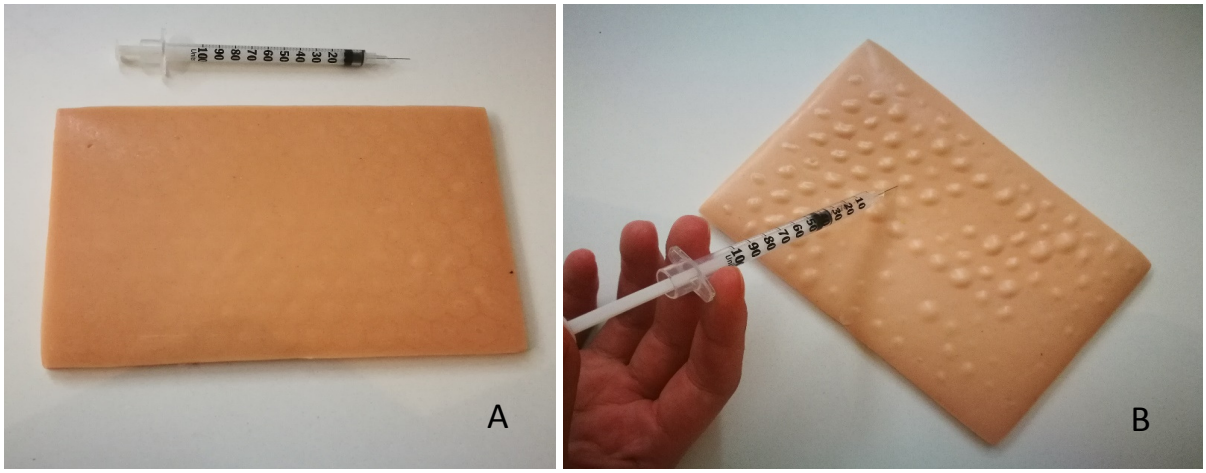

Figure 1 Artificial Skin; A. Before injection, B. After injection with normal saline

During May and October 2017, medical students and residents rotating in dermatology and attended in the artificial skin workshop using the simulator were included. Participants were asked to complete a self-evaluation and satisfaction questionnaire before and after the workshop. (Table 1,2). In the questionnaires we addressed statements and asked the participants to check in the box of 0,1,2,3,4,5,6,7,8,9 to 10 referring to completely disagree, strongly disagree, disagree, mildly disagree, minimally disagree, neither agree nor disagree, minimally agree, mildly agree, agree, strongly agree to completely agree, respectively.

Table 1 Demographic data

Characteristic	Value
Age; median (min-max) year	**29.5 (28-36)**
Sex	
- Male; n (%)	7 (35)
- Famale; n (%)	13 (65)

After the simulator training, those medical students and residents each performed a 2-unit intradermal injection of botulinum toxin at the crow's feet area of a randomized volunteered real patient**.** Immediately after injection, a blinded dermatologist assessed for the wheal formation at the site of injection and checked for any complication. Patients were also asked to

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complete a 10-level satisfaction questionnaire of how they feel about their doctor, the research and the injection. Patients were followed up at 2 weeks after the procedure and were asked to self-evaluate the results and adverse effects of the botulinum toxin injections.

Analysis was performed using Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). Median, range and Wilcoxon signed ranks test was used to compare differences of continuous variables due to non-normal distributed data. Percentage was used to analyze categorical variables. A p-value of < 0.05 was considered statistically significant.

Table 2 Participant self-assessment

Statements	Agreement scale* Median (Min-Max)		*p***
	Before simulation training	After simulation training	
I was prepared administering intradermal drug injection for the first time.	7.0 (3.0-10.0)	8.5 (5.0-10.0)	0.001
I was nervous administering intradermal drug injection for the first time.	6.0 (1.0-9.0)	3.0 (0.0-8.0)	0.005
I was confident in administering intradermal drug injection for the first time.	5.0 (1.0-9.0)	9.0 (3.0-10.0)	<0.001
I was confident in identifying the correct insertion point of my needle.	5.0 (2.0-8.0)	9.0 (6.0-10.0)	<0.001
I was confident that my hand didn't shiver while giving injection.	6.0 (2.0-8.0)	9.0 (5.0-10.0)	<0.001

**Agreement Scale: 0-strongly disagree, 10-completely agree*

*** p less than 0.05 is significant*

Results

Twenty participants with a median age of 29.5 years were included. (Table 1) Before workshop, each participant was asked to complete a questionnaire. Residents and medical students have mildly agreed that they were prepared (7.0) administering intradermal drug injection for the first time. However, they minimally agreed that they were nervous (6.0) and that their hands did not shiver (6.0) while

administering intradermal drug injection for the first time. In terms of confidence in administering intradermal drug injection for the first time and identifying the correct insertion point, residents and medical students neither agree nor disagree (5.0). (Table 2)

After the workshop, another questionnaire was distributed to every participant. Residents and medical students have strongly agreed that their hands did not shiver (9.0). They were strongly confident in identifying the correct insertion point (9.0) and administering intradermal drug injection to real patients (9.0) Moreover, they agreed that they were prepared (8.5) however participants mildly disagreed that they were nervous (3.0) administering intradermal drug injection.

Comparing the mean score of the agreement scale, participants were significantly more prepared (p=0.001) and confident in identifying the correct insertion point and administering intradermal drug injection as well as they were more confident that their hands did not shiver while giving injection (p<0.001). In addition, residents and medical students felt significantly less nervous administering intradermal drug injection after the workshop (p=0.005).

Table 3 Intradermal injection simulator assessment

Statement	Agreement scale* Median (Min-Max)
Using the intradermal injection simulator model made me confident in administering intradermal drug injection for the first time.	9.0 (7.0-10.0)
Using the intradermal injection simulator model made me knowledgeable in administering drug injection.	10.0 (7.0-10.0)
Intradermal injection simulator model is a good method to learn drug injection.	10.0 (5.0-10.0)
Intradermal injection simulator model was easy to use.	10.0 (7.0-10.0)
Intradermal injection simulator lessons can be applied to patients.	10.0 (7.0-10.0)
I would recommend intradermal injection simulator to other learners	10.0 (8.0-10.0)
Satisfaction of using intradermal injection simulator.	10.0 (8.0-10.0)

**Agreement Scale: 0-strongly disagree, 10-completely agree*

In terms of simulator assessment, residents and medical students were completely satisfied with the intradermal injection simulator (10.0) and completely agreed that the simulator model was a good method to learn drug injection (10.0), easy to use (10.0) and made them more knowledgeable in administering drug injection (10.0). They also completely agreed that intradermal injection simulator training can be applied to patients (10.0) and would recommend intradermal injection simulator to other learners (10.0). Furthermore, participants strongly agreed that using the intradermal injection simulator model made them feel confident (9.0). (Table 3)

Lastly, residents and medical students did a two-unit intradermal injection of botulinum toxin at the crow feet area of a randomized volunteered real patient. All patients (100%) have small wheals after injections which were assessed by a blinded dermatologist. All volunteered patients completely agreed that they felt wrinkle reduction in their crow feet area (10.0) and did not notice any bruises on their faces at two-weeks follow-up (10.0), hence would like to be part of this exercise further (10.0). Patients strongly felt comfortable with their doctors (8.5) and stated that their doctors appeared confident (8.0). Patients had neither agreed nor disagreed that they felt needle insertion was painful (5.0). (Table 4) Only two injections out of twenty injections resulted in a contusion which was about 0.5 centimeters in diameter and had already disappeared at the time of follow up. No other adverse effect was demonstrated.

Table 4 Patient assessment

Statement	Agreement scale* Median (Min-Max)
My dermatologist appeared confident.	8.0 (7.0-10.0)
I felt comfortable with my dermatologist.	8.5 (8.0-10.0)
I felt needle insertion was painful.	5.0 (0.0-10.0)
I want to be part of this exercise further.	10.0 (10.0-10.0)
I wouldn't have noticed the bruises on my face.	10.0 (5.0-10.0)
I felt wrinkle reduction.	10.0 (6.0-10.0)

**Agreement Scale: 0-strongly disagree, 10-completely agree*

Discussion

Evolution of medical education and health care has expanded the amount of medical knowledge that students are required to learn and yet patient safety concerns have raised.[12-15] Therefore simulator-base training benefits learning environment and improves cognition by decreasing stress and anxiety from the clinical settings.[16] It allows a safe environment where students can assess, fail and practice skills before encountering a real patient.[14,17] A study has found that skills gained from simulator-base training help stimulate clinical practice and education.[18]

High-fidelity simulators are characterized by visual and tactile perceptions, ability to feedback and interact with the apprentice.[10] However, the cost of a high-fidelity commercial simulator is expensive and insufficiently affordable in many medical schools. We hereby introduced an intradermal injection simulator made from affordable local rubber materials that is simple to use and reproducible. Furthermore, the intradermal injection simulator can interact and feedback learners by resulting in an elevation of the artificial skin which resembles a wheal after injection. This feedback is an important key for apprentice in learning.[19] From our study, participants felt more prepared and confident after the simulator workshop. They felt that simulator was a good method to learn drug injection and was easy to use as well.

In this study, there are several limitations. Firstly, the sample size was small with only 20 participants whom were residents and medical students therefore there might be some bias while completing the questionnaires. Secondly, we have not compared the simulation-base training with conventional lecture and did not have a control group to compare outcomes in real patients. Although a systematic review including studies before 2005 concluded that simulation-base training was superior to no training but not to standard training[10], further studies in the future should focus on the efficiency of simulation-base training comparing with conventional training and relative clinical performance improvements.

Conclusions

After assessing a new simulator model in local intradermal injection training, it seems that this simulation based-training can be a simple, effective and affordable tool to aid medical education and help students gain more skills and confident before performing the procedure on real patients. Nevertheless, further studies should be conducted focusing on the clinical usefulness of the simulator with respect to training and patient outcomes.

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