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Efficacy of Reusable Rubber Moulage on Mannequin Versus Conventional Method for Burn Size Estimation

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Background: Burn size estimation is crucial to burn fluid resuscitation. Therefore, training and practice to improve the accuracy of burn size estimation is important. Using reusable rubber moulage (RRM), the newly developed equipment to cooperating with simulation might help improve the accuracy of burn size estimation compared to conventional picture illustration.

Objective: To compare the accuracy of burn size estimation in simulation between picture illustration and RRM application, and to validate the face and content validity of RRM.

Methods: Medical students, ER residents, EP staff, and paramedics were recruited and randomized into 2 groups. Each group completed 2 different burn pattern stations consisting of one RRM-decorated mannequin station and one picture illustration station. The estimation of total body surface area (TBSA) percentage was statistically analyzed to determine the difference between the 2 methods. Face and content validation were analyzed by a Likert scale.

Results: A total of 70 participants were recruited. The means of total %TBSA of pattern 1 from RRM and picture illustration were 42.29% and 41.24% (P = .61), respectively. The means of pattern 2%TBSA estimation were 41.24% and 42.65% (P = .34), respectively. Participants rated RRM quality by Likert scale with means score more than 4 out of 5 in all questions. Written comments showed a preference toward RRM.

Conclusions: There were no significant %TBSA differences between RRM decorated mannequin and picture illustration in terms of %TBSA. However, participants were satisfied with RRM quality and preferred RRM decorated mannequin.

Keywords: Moulage, Burn estimation, Emergency medicine

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Introduction

According to the World Health Organization (WHO), approximately 11 million people worldwide were burned and required medical attention in one year with a mortality rate of roughly 180 000.[1] In Thailand, there were a total of 900 burn patients within a range of 5 years (2014 - 2018) with a mortality rate as high as 25% (230 deaths).[2] Proper management of burn patients depends mainly on adequate initial fluid resuscitation as soon as possible. Delayed initial fluid resuscitation more than 2 hours after the burn injury occurred could increase mortality.[3] This requires an accurate evaluation of the percentage of burn areas. Currently, there are various methods for estimation of burn areas such as the rule of nines, Lund-Browder chart, and rule of palm.[4] Effective use of these methods to estimate the percentage of body surface burn areas accurately and precisely requires practice and experience with estimation of actual burn cases.

Training in the treatment of burn patients for general practitioners as required per the Medical Council of Thailand is to be able to diagnose, provide proper and timely management, and appropriate consultation with burn specialists.[5] While in medical school, students receive several hours of lectures on burn care and on how to estimate, manage, and care for burn wounds along with one entire week of training within a hospital's burn unit. There is no intensive burn course training equivalent to Advanced Burn Life Support (ABLS) in Thailand.

Medical school teaches conventional methods of burn estimation by using picture illustrations of burn patients together with human patient simulation. A study on burn estimation in adults using picture illustration was found to have variation among physicians by as much as 16.5%[6] indicating initial fluid resuscitation could vary by as much as 5280 milliliters. It was suspect that this extreme variation in the estimation of total body surface area (TBSA) burn may be attributed to differences in the experience of evaluators and that repeated practice of estimating various percentages of burn areas could narrow this gap difference. One learning method that can be repeatedly used in medical training and increase the experience of physicians with estimating TBSA is the use of mannequin simulation. Burn areas on mannequins can be mimicked using burn reusable rubber moulage (RRM). According to the Merriam-Webster dictionary, moulage is the art of taking an impression of evidence from an actual scene. In medical education and emergency training, moulage can be used as a tool to mimic injury and enhance training in trauma care.[7] Practicing burn estimation with RRM can help to improve the ability of physicians to be able to accurately estimate burn size in real cases compared to conventional picture illustration allowing for better management with initial fluid resuscitation.

This study aimed to compare the accuracy of burn size estimation in simulation between picture illustration and RRM application and to validate the face and content validity of RRM.

Methods

Participants

Inclusion criteria were medical students (5th - 6th year), emergency medicine residents, paramedics, and emergency physicians recruited from the Faculty of Medicine at Ramathibodi Hospital, Mahidol University, Thailand, who agreed to participate in this study with the sign-on consent form. Exclusion criteria were faculty personnel that were involved in moulage production or who refused or withdrew at any time during the study. This study included 70 participants (35 participants in each group).

Ethics

This research was approved by the Human Research Ethics Committee of the Faculty of Medicine Ramathibodi Hospital, Mahidol University, Thailand (No. MURA2021/337 on April 24, 2021).

RRM Development

Mannequin Measurement

The body surface area of the mannequin was calculated by the height of the average ACLS mannequin (180 cm), and the ideal body weight of an adult with the same height (75 kg) which resulted in 1.94 m^2 (the Mosteller formula). The TBSA was used as the basis for RRM models.

Production of RRM

RRM made of rubber was provided by the Rubber Authority of Thailand with textures and colors which represent different depths of burn wound (2nd and 3rd degree as Supplementary Figure S1). Various sizes and shapes of RRM were developed (0.25%, 0.5%, 1%, 2%, and 5%) (Supplementary Table S1).

Burn Size Estimation Instruction Sheet

The instruction sheets were given to each participant to provide information regarding their different background knowledge. Participants were allowed to read and take notes on the instructions during an experiment. The instruction sheets were taken back after the experiment.

Questionnaire

The questionnaire was paper-based and was collected after experiments (Supplementary Figure S2). Participant information included age, sex, education levels, and experience in emergency burn care.

1) Burn size estimation of each station included %TBSA of 2nd degree burn, 3rd degree burn, and total %TBSA.

2) 6-Likert scale questions regarding feedback from participants with a written comment section.

Experiment Stations: Randomized With a Crossover Design

1) 4 stations were provided for an experiment, using 2 different burn lesion patterns with similar complex levels containing solitary and scattered lesions (Supplementary Figure S3).

Station 1A: RRM applied on mannequin with pattern 1 – 2nd degree burn 15%TBSA + 3rd degree burn 12%TBSA (total 27%TBSA).

Station 2A: 7 pictures taken from RRM decorated mannequin, including front, sides, and close up burn lesions with pattern 2 – 2nd degree burn 20%TBSA + 3rd degree burn 7%TBSA (total 27%TBSA).

Station 1B: 7 pictures taken from RRM decorated mannequin, including front, sides, and close-up burn lesions with pattern 1 – 2nd degree burn 15%TBSA + 3rd degree burn 12%TBSA (total 27%TBSA).

Station 2B: RRM applied on a mannequin with pattern 2 – 2nd degree burn 20%TBSA + 3rd degree burn 7%TBSA (total 27%TBSA).

2) Randomization and logistics of experiments: participants were simply randomized into 2 groups; and each group completed 2 stations. A calculator was allowed.

Group A: complete stations 1A and 2A within 5 minutes for each station.

Group B: complete stations 1B and 2B within 5 minutes for each station.

3) The information and answers were completed on paper-based questionnaires and collected after participants finished their 2 stations.

Duration of Data Collection

Data were collected from April 28, 2021, to September 30, 2022.

Statistical Analysis

Statistical analysis of this study consisted of 3 parts: 2 group comparisons, a Likert scale, and written comments.

The 2 group comparisons of %TBSA were managed and analyzed by Prism version 9.4.1 (GraphPad Software, Inc) and Microsoft Excel 2019 (Microsoft Corp), using the Mann-Whitney *U* test to compare continuous data. The agreement of results was visualized by the Bland-Altman plot. Associations between a variation of %TBSA (participants estimated %TBSA – %TBSA from pattern) and education-based and experience level were determined by one-way ANOVA test.

The Likert scale regarding feedback of RRM from participants was represented by the mean of each question. Written comments were grouped as positive and improvement feedback for RRM.

Results

A total of 70 participants were recruited from the Faculty of Medicine Ramathibodi Hospital, Mahidol University, Thailand, with a signed consent form. No participants withdrew from the study and there was no missing data.

Baseline characteristics of participants were presented as descriptive data. There were different education levels and experiences of the 2 groups. Group A had a higher ratio of medical students (42.9%) and group B had a higher ratio of ER resident participants (45.7%). Therefore, 45.7% of group A participants had no experience in emergency burn care while group B participants were 28.6% inexperienced in emergency burn care. However, most participants in both groups had experienced 5 or fewer emergency burn care cases (71.4% and 80%, respectively) (Table 1).

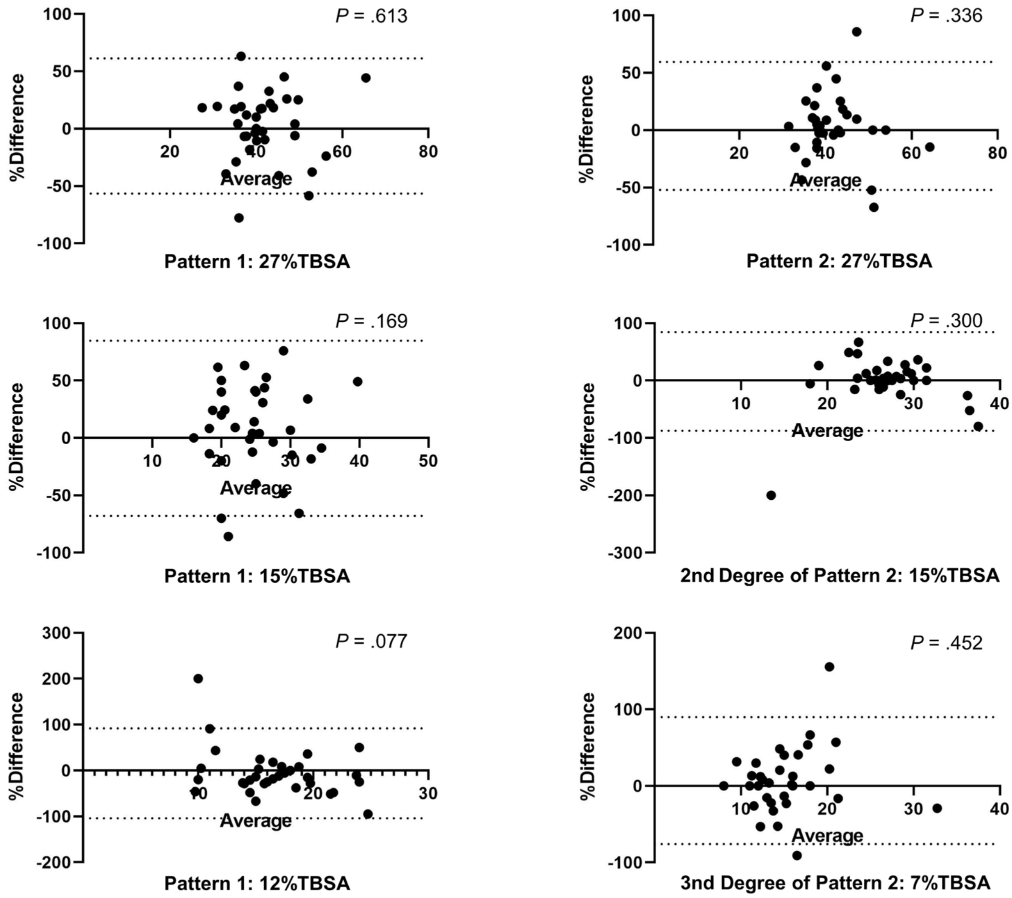
The primary outcome regarding the accuracy of %TBSA burn showed overestimations of both RRM decorated mannequins and picture illustrations by both groups. The means of pattern 1 %TBSA estimation were 42.29% and 41.24% by RRM and picture illustration (P = .61), respectively. The means of pattern 2 %TBSA estimation were 41.24% and 42.65% (P = .34), respectively. The 2nd degree and 3rd degree lesions %TBSA were presented as not statistically significant (P > .05) different in estimations. Bland-Altman plots showed an agreement of both RRM and picture illustration of %TBSA estimation in both patterns (Figure 1).

Mean and standard deviation (SD) of %TBSA variation (estimated %TBSA – actual %TBSA) from each subgroup based on education and experience were determined. An ANOVA test resulted in neither significant association between variation of %TBSA estimation and education level (P = .86) nor experience level (P = .36). However, experience-based %TBSA variation demonstrated that the highest mean was among the more than 10 cases experience group (pattern 1: 19.2% and pattern 2: 19.88%) (Figure 2).

Table 1. Baseline Characteristics of Group A and Group B Participants

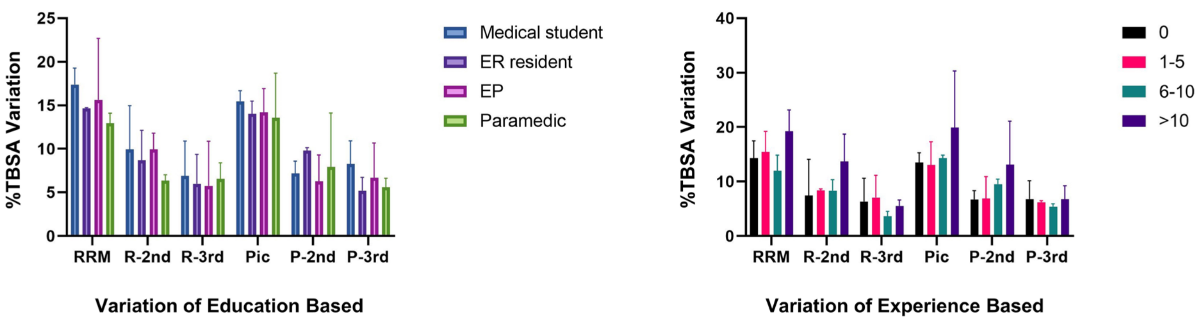
Characteristic	No. (%) Group A (n = 35)	Group B (n = 35)
Sex		
Male	13 (37.1)	17 (48.6)
Female	22 (62.9)	18 (51.4)
Age, mean, y	26.9	27.4
Education		
Medical students	15 (42.9)	11 (31.4)
ER residents	8 (22.9)	16 (45.7)
EP staff	6 (17.1)	4 (11.4)
Paramedics	6 (17.1)	4 (11.4)
Experience of emergency burn care, case		
0	16 (45.7)	10 (28.6)
1 - 5	9 (25.7)	18 (51.4)
6 - 10	8 (22.9)	2 (5.7)
> 10	2 (5.7)	5 (14.3)

Figure 1. Bland-Altman Plot of %Difference vs Average of %TBSA



Abbreviation: TBSA, total body surface area.

Figure 2. Mean and SD of %TBSA Variation Based on Education and Experience



Abbreviations: Pic, picture illustration; P-2nd, picture illustration of 2nd degree burn; P-3rd, picture illustration of 3rd degree burn; RRM, reusable rubber moulage; R-2nd, reusable rubber moulage of 2nd degree burn; R-3rd, reusable rubber moulage of 3rd degree burn; TBSA, total body surface area.

Face and content validation of RRM were obtained by 6-Likert scale questions. All categories received a mean of more than 4 out of 5. In the context of the content validity, participants gave a mean of 4.668 points regarding RRM's potential to improve burn size estimation training. The lowest score was 4.014 reflecting RRM representation of burn depth (Table 2).

Written comments suggested that the realism of RRM was acceptable, but the smooth cut edge was too noticeable. The opinions on 2nd and 3rd RRM texture were controversial, while some comments thought the difference between 2 textures were cleared enough, while others suggested the texture should be improved to reflect each degree more accurately, such as burnt eschars. The smoother connection and attachment of RRM were also mentioned as improvement points. However, most comments preferred the RRM decorated mannequin over the picture because of more accessible details and 3-dimensional perspective. RRM might be more suitable for the rule of palm estimation and teaching.

Table 2. Mean of 6-Likert Scale Questions Regarding Face and Content Validity of RRM

Question	Mean
RRM looks realistic.	4.114
The pattern of the lesion is realistic.	4.100
RRM could improve burn depth differentiation training.	4.014
RRM could improve %TBSA estimation training.	4.686
RRM is suitable for teaching material.	4.443
RRM is suitable for examination.	4.229

Abbreviations: RRM, reusable rubber moulage; TBSA, total body surface area.

Discussion

The primary outcome regarding the accuracy of burn size estimation was not statistically significant between the RRM decorated mannequin and picture illustration. The 2nd degree and 3rd degree burn size estimation by both methods were also not significant. However, the results of the study showed an overestimation of burn size by most participants regardless of education level or experience. This finding is similar to previous studies[8-10] that found the tendency of overestimation of burn size by providers, including estimation via a picture of patients[6, 11] with various ranges of error. Increased realism of burn simulation by RRM decorated mannequin might cause an overestimation of lesions like the overestimation observed in real burn patients.

The relationships of education and experience of participants to burn size estimation accuracy were not significant. A previous study had shown different conclusions in which higher experience should provide more accurate burn size estimation.[8] An unexpected result was the higher experience group (> 10 cases) tended to have a higher variation of %TBSA. This might be caused by the process of introducing an unfamiliar tool (RRM) which increased the difficulty of simulation for those participants and could negatively affect some performances like a previous study result of introducing new moulage to a paramedic simulation.[12]

The secondary outcome of face and content of RRM validated by the Likert scale demonstrated satisfaction toward RRM in all questions, with mean scores more than 4 out of 5. Written comments also preferred RRM more than picture illustration. This finding agreed with Pywell et al[13] that participants or students likely preferred more realistic simulation. These results suggested the possibility of RRM as a teaching resource to improve engagement of simulation. However, burn depth texture, attachment pattern and other details of RRM could be improved to reflect real burn lesions and increase participants' satisfaction.

Limitations

This study was the first one to determine the effect of moulage on burn size estimation accuracy, so the calculation of sample size was challenging. Further study with a bigger sample size could provide more power to a study and more homogenous randomization. Moreover, there were only 10 EP staff and 7 participants with more than 10 cases of experience, with no surgeon or burn unit provider recruited in the study. More experts and more experienced participants might facilitate a subgroup analysis.

Conclusions

RRM effect of improving burn size estimation accuracy compared to picture illustration was not significant regardless of education level or experience. However, RRM could provide more satisfaction and engagement in burn simulation. Further improvement of RRM design with further study would be beneficial. Burn size estimation training is crucial to reduce overestimation and improve the accuracy of providers.

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Supplementary Information

Supplementary Figure S1 download from https://he02.tci-thaijo.org/index.php/ramajournal/article/view/266672/183160
Supplementary Table S1 download from https://he02.tci-thaijo.org/index.php/ramajournal/article/view/266672/183161
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Supplementary Figure S3 download from https://he02.tci-thaijo.org/index.php/ramajournal/article/view/266672/183163

References

1. World Health Organization. Fact sheets: burns. Updated October 13, 2023. Accessed December 13, 2023. https://www.who.int/news-room/fact-sheets/detail/burns
2. Social and Quality of Life Database System, Office of National Economic and Social Development Council. Thailand conflagration annually report 1989-2018. Updated June 13, 2019. Accessed December 13, 2023. http://social.nesdc.go.th/SocialStat/StatReport_Final.aspx?reportid=3673&template=2R1C&yeartype=M&subcatid=48
3. Snell JA, Loh NH, Mahambrey T, Shokrollahi K. Clinical review: the critical care management of the burn patient. *Crit Care.* 2013;17(5):241. doi:10.1186/cc12706
4. Pham TN, Bettencourt AP, Bozinko GM, et al. *Advanced Burn Life Support Course: Provider Manual 2018 Update.* American Burn Association; 2018:16. Accessed December 13, 2023. https://ameriburn.org/wp-content/uploads/2019/08/2018-abls-providermanual.pdf
5. The Medical Council of Thailand. Announcement: Medical Competency Assessment for National License 2012. Accessed December 13, 2023. https://www.tmc.or.th/service_law03.php
6. Parvizi D, Kamolz LP, Giretzlehner M, et al. The potential impact of wrong

TBSA estimations on fluid resuscitation in patients suffering from burns: things to keep in mind. *Burns.* 2014; 40(2):241-245. doi:10.1016/j.burns.2013.06.019
7. Felix HM, Simon LV. Moulage in Medical Simulation. In: *StatPearls.* StatPearls Publishing; 2022.
8. Pham C, Collier Z, Gillenwater J. Changing the way we think about burn size estimation. *J Burn Care Res.* 2019;40(1):1-11. doi:10.1093/jbcr/iry050
9. Harshman J, Roy M, Cartotto R. Emergency care of the burn patient before the burn center: a systematic review and meta-analysis. *J Burn Care Res.* 2019;40(2):166-188. doi:10.1093/jbcr/iry060
10. Harish V, Raymond AP, Issler AC, et al. Accuracy of burn size estimation in patients transferred to adult Burn Units in Sydney, Australia: an audit of 698 patients. *Burns.* 2015; 41(1):91-99. doi:10.1016/j.burns.2014.05.005
11. Smith K, Poterlowicz K, Southern S, Mahajan AL, Jivan S. The effect of a known object in a static image of a burn to improve the burn size estimation. *Burns.* 2021;47(6):1295-1299. doi:10.1016/j.burns.2020.12.023
12. Mills BW, Miles AK, Phan T, et al. Investigating the extent realistic moulage impacts on immersion and performance among undergraduate paramedicine students in a simulation-based trauma scenario: a pilot study. *Simul Healthc.* 2018;13(5):331-340. doi:10.1097/SIH.0000000000000318
13. Pywell MJ, Evgeniou E, Highway K, Pitt E, Estela CM. High fidelity, low cost moulage as a valid simulation tool to improve burns education. *Burns.* 2016;42(4):844-852. doi:10.1016/j.burns.2015.12.013

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ประสิทธิภาพการฝึกประเมินขนาดแผลไฟไหม้โดยใช้แบบแผลไฟไหม้จำลองจากยางพาราเทียบกับการประเมินขนาดแผลไฟไหม้จากรูปภาพ

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บทนำ: การประเมินขนาดแผลไฟไหม้เป็นส่วนสำคัญในการให้สารน้ำในผู้ป่วย ดังนั้น การเรียนการสอนและการฝึกฝนจึงเป็นส่วนสำคัญในการเพิ่มความแม่นยำในการประเมินขนาดแผลไฟไหม้ การใช้แบบแผลไฟไหม้จำลองจากยางพาราร่วมกับหุ่นจำลองอาจช่วยเพิ่มความแม่นยำในการประเมินแผลไฟไหม้ได้มากขึ้นเมื่อเทียบกับการประเมินจากรูปภาพ

วัตถุประสงค์: เพื่อเปรียบเทียบความแม่นยำของการประเมินขนาดแผลไฟไหม้จากการใช้แบบแผลไฟไหม้จำลองจากยางพาราและการประเมินขนาดแผลไฟไหม้จากรูปภาพ และประเมินความเที่ยงตรงเชิงปรากฏและความเที่ยงตรงเชิงเนื้อหาของแบบแผลไฟไหม้จำลองจากยางพารา

วิธีการศึกษา: : ผู้เข้าร่วมวิจัย ได้แก่ นักศึกษาแพทย์ แพทย์ประจำบ้านเวชศาสตร์ฉุกเฉิน อาจารย์แพทย์เวชศาสตร์ฉุกเฉิน และนักปฏิบัติการฉุกเฉินการแพทย์ ถูกแบ่งเป็น 2 กลุ่ม โดยการสุ่ม แต่ละกลุ่มเข้าฐานประเมินขนาดแผลไฟไหม้ 2 ฐาน ที่มีรูปแบบของแผลแตกต่างกัน ฐานหนึ่งใช้แบบแผลไฟไหม้จำลองจากยางพารา และอีกฐานใช้การประเมินจากรูปภาพ จากนั้นนำผลการประเมินขนาดแผลไฟไหม้จาก 2 วิธี มาเปรียบเทียบกัน ส่วนความเที่ยงตรงของแบบแผลไฟไหม้จำลองประเมินจากมาตรวัดแบบ Likert scale

ผลการศึกษา: ผู้เข้าร่วมวิจัยจำนวนทั้งหมด 70 คน พบว่า ค่าเฉลี่ยของขนาดแผลไฟไหม้ที่ประเมินจากแผลรูปแบบที่ 1 โดยใช้แบบแผลไฟไหม้จำลองจากยางพาราและใช้รูปภาพ คิดเป็นร้อยละ 42.29 และ 41.14 ตามลำดับ (P = .61) ส่วนค่าเฉลี่ยของขนาดแผลไฟไหม้ที่ประเมินจากแผลรูปแบบที่ 2 คิดเป็นร้อยละ 41.24 และ 42.65 ตามลำดับ (P = .34) การประเมินโดยมาตรวัดแบบ Likert scale พบว่า ผู้เข้าร่วมวิจัยให้คะแนนมากกว่า 4 จาก 5 คะแนนเต็ม ในทุกคำถาม จากความคิดเห็นเพิ่มเติมแสดงให้เห็นว่าผู้เข้าร่วมวิจัยพอใจแบบแผลไฟไหม้จำลองจากยางพารามากกว่า

สรุป: จากการวิจัยไม่พบความแตกต่างของการประเมินขนาดแผลไฟไหม้ระหว่างการใช้แบบแผลไฟไหม้จำลองจากยางพาราและการประเมินจากรูปภาพ แต่ผู้เข้าร่วมวิจัยมีความพึงพอใจคุณภาพของแบบแผลไฟไหม้จำลองจากยางพารา และชอบการใช้แบบแผลไฟไหม้จำลองจากยางพารามากกว่า

คำสำคัญ: แบบจำลองแผลไฟไหม้ การประเมินขนาดแผลไฟไหม้ เวชศาสตร์ฉุกเฉิน

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