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Pilot study about the use of alternative materials to teach surgical skills to medical students: a cross-sectional observational study

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Abstract

Introduction: Suturing is an important surgical procedure in which tissue margins are joined after incision or laceration, it is a fundamental medical skill and requires extensive practice to improvement, especially during the medical educational process. In the Basic Surgical Skills Course training suture is one of the foundations to learn hospital procedure techniques, that are essential during the routine of a medical professional. Objective: This study aims to evaluate the capability that EVA, eggplant, elastic tape, and chicken thigh must mimic basic surgical scenarios and replace expensive materials during the medical education of undergraduates and the development of the skills needed as future health professionals. Methods: This is a cross-sectional descriptive observational study, which evaluated students during the surgical skills class to perform suture practice on materials such as EVA, eggplant, elastic tape, and chicken thigh. Results: The materials were evaluated as useful components for training suturing practice. However, eggplant, and elastic tape were considered superior materials. Furthermore, practicality of use correlated with greater instrumental knowledge. Conclusions: The use of alternative materials for training surgical sutures is more accessible because of the low cost, however the results represent a prototype of an analysis that requires an expansion in the number of samples to better determine the cause-effect conditions.

Keywords: Suture. Surgical skills. Surgical scenarios. Medical education.

Introduction

Suturing is an important surgical procedure in which tissue margins are joined after incision or laceration, it is a fundamental medical skill and requires extensive practice to improvement, especially during the medical educational process. In the Basic Surgical Skills Course training suture is one of the foundations to learn hospital procedure techniques, that are essential during the routine of a medical professional [1,2], and a requirement issued in the National Curricular Guidelines for the degree in Medicine in Brazil and the Code of Medical Ethics [3,4].

Initially, the development of these skills in the academic setting was carried out in anatomy laboratories using biological materials and the dissection of chemically preserved cadavers to teach about human anatomy and practical training, and, onward, directed towards observational learning in the field or acquiring abilities by assisting the surgeon during the procedure [1].

The importance of using cadavers for medical teaching is unquestionable, but there are several factors that led scientists to research and develop alternative materials for their replacement, including bioethics, which establishes principles regarding the possession and management of a human remains, to guarantee academic-scientific development preserving the physical integrity and dignity of the corpse donated to science [5-7]. The use of non-human biological tissues is also a subject of debate in the scientific community, and to guarantee that the boundaries and ethics of their use are honored there is a committee mostly focused on this objective [8].

Due the value of the improvement of these surgical techniques to achieve good medical professionalism, synthetic models that simulate human skin were created. However, the high cost of the apparatus on the market makes purchasing this material unfeasible for many individuals and their economic realities [9].

In order to ensure motor competence for the safe, precise and delicate execution of sutures, it is necessary to have access to materials analogous to human skin, capable of incorporating basic characteristics that favor their use, such as accessibility to students and educational institutions, easy storage, low cost and equivalence to real situations [9-11].

Therefore, this work aims to evaluate the use of Ethylene Vinyl Acetate (EVA), eggplant, elastic tape and chicken thigh for training and improving the ability to perform sutures, in order to establish the material with the best ability to mimic real scenarios the future physician will face.

Methods

Study Design

This is a cross-sectional descriptive observational study, according to STROBE (Available at: https://www.strobe-statement.org/checklists/.

Accessed at 02/10/2024). Forty (40) medical students from Ceres Medical School (FACERES) were evaluated during their undergraduate basic surgical skills class. This study aims to evaluate the use of Ethylene Vinyl Acetate (EVA), eggplant, elastic tape, and chicken thigh to train surgical skills in order to simulate situations that doctors will face during their professional lives.

Ethical Aspects

This study was analyzed and approved by the Research Ethics Committee according to a substantiated opinion number 4.924.686. After explaining the Free and Informed Consent Form and signing it, the students were asked to perform sutures in different materials during the practice exercise of the class, such as EVA, eggplant, elastic tape, and chicken thigh.

Questionnaire Application

After this activity, the questionnaire "Objective Structures Assessment of Technical Skill" was applied to each student, which is valid for Brazil through the article "Validation of the Objective Structured Assessment of Technical Skill in Brazil" [12], composed of seven items, and the "Adapted Likert-style questionnaire" [13], consisting of six questions and adapted by the authors, demonstrating the effectiveness and quality in teaching suturing with such materials.

The first questionnaire analyzed the integrity of the material (frequent use of force not necessary on the tissue or causing damage, care when handling the tissue but occasionally causes damage and appropriate handling with minimal damage to the tissue), time and motility (many movements not necessary, efficient time/motility but with unnecessary movements, economy of movement and maximum efficiency), instrumentation (repeatedly makes strange attempts or movements with instruments, competent use of instruments but with occasional use of strange handling of instruments and appropriate movements with instruments), knowledge of instruments (often orders the wrong instrument and uses it incorrectly, knows the names of most instruments and uses them appropriately, is familiar with instruments and knows their names), use of auxiliary instruments (failure to use or misuse of auxiliary instruments, correct use of most auxiliary instruments, strategic and correct use of auxiliary instruments), planning and flow of the operation (often stops during the procedure or needs to discuss the next movement, demonstrates adequate ability to perform the procedure, demonstrates optimal ability to perform the procedure), knowledge of the procedure (little knowledge and requires instruction in most steps, knows all important aspects of the procedure, demonstrates familiarity with all aspects of the procedure). Furthermore, the variables are scaled from one to five sequentially (Appendix 1).

The second questionnaire presented variables such as comfort in suturing the materials (1 = lesscomfortable, 5 = very comfortable), how useful learning with the materials was (1 = not very useful, 5 = veryuseful), how good the material is compared to that generally used for learning (1 = worse, 3 = equal, 4 =better), how much the use of the material improved your suturing skill (1 = no improvement, 5 = 100%improvement), and how important it was to practice in the material (1 = not important, 5 = very important)(Appendix 2).

In this way, participants from seven and eight semesters, regularly enrolled in the FACERES medical course, over 18 years of age and those approved in the FACERES Surgical Skills I discipline were included. Those who did not sign the Informed Consent Form, completed the questionnaire inappropriately, did not carry out the activities proposed by the study, were under 18 years of



age and who were in I, II, III, IV and V semesters were excluded from this study.

Statistical Analysis

After all these eligibility and project practice processes, the data from the questionnaires were recorded in the Microsoft Excel Operating System in binary numbers to carry out statistical analysis of the results for publication. To calculate the sample size, the applicability of the research was considered as a pilot study, therefore, the sample size were 40 participants. In this way, the separation of these participants into four groups was taken into account, with ten participants in each, randomly.

Exploratory data analysis included descriptive statistics, mean, median, standard deviation, minimum value and maximum value for numerical variables and number and proportion for categorical variables. To analyze the behavior of continuous variables, descriptive statistics, histogram and boxplot graphs, and the specific test for the theoretical assumption of Shapiro-Wilk normality were considered. Comparison of numerical variables between 2 groups was made using the Student's t-test or Mann-Whitney test and categorical variables using Pearson's chi-square test or Fischer's exact test, when appropriate. Spearman correlation analysis was performed to verify the correlation between two numerical or ordinal variables. Statistical analysis was performed using IBM-SPSS Statistics version 27 software (IBM Corporation, NY, USA).

Results

The research participants were composed of medical students from the seventh and eighth semesters, who had already completed at least one term of surgery studies throughout their medical course. The study is carried out as pilot and therefore only ten samples of each component were collected in order to constitute a simple evaluation basis for future analyzes with mass studies. Thus, Pearson's Chi-square test was used to compare the variables and indicate significant qualitative differences.

In general, the materials were evaluated by students as useful components. However, eggplant and elastic tape were considered superior materials, that is, the use of these components was thought to be more effective for replacing traditional materials such as pork skin, beef ribs, and synthetic skin (Figure 1).

Figure 1. Interaction between materials and usefulness of suture learning with p = 0.00182.



Source: Own Authorship.

Furthermore, practicality of use was correlated with a greater degree of instrumental knowledge. The understanding of the existence of interference from the difficulty in handling the chicken thigh and the EVA harm the correct application of the practical content learned and developed during surgery classes (Figure 2).

Figure 2. Interaction between materials and knowledge at the time of performing the suture with p = 0.01015.



Source: Own Authorship.

The undergraduates who carried out the activities mentioned that the biggest difficulty in using chicken thighs is the consistency of the skin, which was deemed unstable, as well as the elastic tape in the absence of adequate support. EVA was considered very different when compared to skin. On the other hand, eggplant was described as an effective utensil due to its firm consistency but difficult due to its dark tone compared to the use of Nylon threads.

As the study is a pilot, the sample is small and therefore statistical tests, such as Pearson's Chi-square, did not present the number of responses necessary for them to be made viable and validated. Therefore, some variables did not demonstrate mathematical and statistical significance. Thereby, the comfort of the materials was similar and did not influence the technique applied. And there was no material capable of being considered better or one being considered the worst.



Furthermore, the cost of the materials did not present any variation that would influence their usual use and the same applies to the care taken when developing the suture. Time and handling were also similar for all materials tested, as well as the flow of movement and the appropriate handling of the auxiliary instruments. Finally, knowledge of the procedure did not vary depending on the material used. The results represent a prototype of an analysis that requires an expansion in the number of samples to better determine cause and effect conditions.

Discussion

Suturing is an essential surgical technique, used to approximate and mend the edges of tissues that have suffered injuries or incisions, allowing the healing process to be appropriate, with less harm to the patient and providing adequate cure [14-16]. However, its practice requires qualified training, so that future professionals in the medical and, especially, surgical fields can master and execute its techniques safely and precisely [16,17]. Furthermore, Scally et al. [18] infer that training provided in the medical curriculum is not sufficient to provide the necessary skills for medical practice, meaning that extracurricular training in medical procedures, such as suturing, is necessary.

Primarily, training for the practice of sutures involved the use of tissues of human origin, in disagreement with the current reality of academic medical education [19]. Since legal access to corpses is limited and involves several ethical, moral, and legal issues, and also due to the ease of damage and the difficulty of reusing them for the same purposes, this leads to disturbing their access and consequently the improvement of this skill by students and its ability to practice outside the academic environment, also evidenced by this research [19]. Materials of animal origin can be used for the student to have a sense of depth and the division of layers of the human body, such as skin in a way that allows suture training as well as dissection and biopsy [20].

Furthermore, some barriers learning are highlighted by the students themselves, such as the visual repulsion and odor of formaldehyde used on corpses, the emotional maturity necessary for its manipulation and even restrictions related to individual beliefs [6]. Moreover, the use of non-human anatomical pieces is also a stage for discussion in the scientific community, and to guarantee the limits and ethics of their use there is a committee focused on this objective. Therefore, with technological growth and the advent of questions involving biological ethical principles, various materials were developed for learning how to suture in a dignified and moral way.

In this context, the search for alternative materials with the capacity to mimic the human biological constitution becomes a necessity, offering advantages, such as the possibility of being reused several times and enabling students to practice performing sutures more frequently [21]. Since safe and effective clinical practice are pillars of the profession, repetition training is crucial [16,21], a fact reported by many of the individuals who participated in this research [20].

Therefore, this project was built to evaluate the usefulness of materials such as EVA (E) (Figure 3a), eggplant (B) (Figure 3b), elastic tape (F) (Figure 3c) and chicken thigh (C) (Figure 3d), which are affordable, easy to find, have different textures and, in some (such as eggplant and chicken thigh), with different layers (depth levels). In this way, it is possible to train suturing techniques repeatedly and constantly, and thus improve their performance.

Figure 3. Illustration of the materials used during this work.



Source: Own Authorship. Caption: Figure 1a: participant performing single stitch sutures in black EVA with 4-0 nylon thread, needle holder and rat-tooth forceps. Figure 1b: single stitch suture performed on eggplant with 4-0 nylon thread. Figure 1c: participant performing a single stitch suture on elastic tape with 4-0 nylon thread with the aid of a needle holder. Figure 1d: participant performing a simple stitch suture on a chicken thigh with 4-0 nylon thread with the aid of a needle holder.

EVA is a plastic material widely used in various segments, such as crafts, footwear, toys, packaging, among others. It is highly known for its lightness, flexibility, water resistance and durability. It can be found in different colors, including white and black. Both have a soft and velvety texture to the touch, being easy to cut and mold into different shapes and sizes, so the student can simulate different training situations. Eggplant is a vegetable originate from India and widely consumed around the world. It is a vegetable with an oval and elongated shape, dark purple or black in color, with a firm and shiny texture. Due to the layers with different textures, it allows the assessment of the notion of depth when performing sutures in subcutaneous tissue.

Elastic tape, also known as elastic band or elastic bandage, is a strip of elastic fabric commonly used in physical activities, physiotherapy, rehabilitation and in this



case, adapted for suture training. The elastic tape is produced from synthetic materials, such as nylon and elastane, which provide elasticity. This can be an interesting factor for training sutures in areas with greater tension. Chicken thigh is one of the most consumed parts of chicken meat. The chicken thigh is made up of two parts: the drumstick, which is the upper and meatier part, and the down drumstick, which is the lower and smaller part. Both parts have skin and bone, which can contribute to the creation of some types of sutures, such as the one that uses stainless steel to fix bones.

Another important advantage of using alternative materials is being more environmentally friendly and ethical. Its use reduces the need to use tissues of animal origin and can reduce the risk of transmitting infectious diseases. Despite this, for medical learning, animal tissue is the closest material, in terms of characteristics, to the human body for improving suturing techniques, a fact exposed by our study participants [22].

Furthermore, alternative resources offer a wide variety of clinical scenarios for students to practice, especially because they enable the student to develop a three-dimensional understanding of the procedures, respecting the layers of the skin during training [20,23-25]. The materials can be used to simulate different types of tissues and wounds, allowing preparation for different circumstances in professional life, being essential for a complete and adequate medical training [25]. Rojo A et al. [26] demonstrated that by correlating learning and emotion, it makes the individual feel motivated and stimulated to study and prepare by promoting motor coordination and repetition of movements, leading to effective knowledge retention. In such manner, when comparing its conclusion with the research carried out in the present project, it can be argued in a playful and alternative way that performing suture training through repetition stimulates learning and the development of refined and precise movements [16,21].

The choice of the best material for suture training depends on the individual preferences and needs of the practitioner, demonstrated through the relationship between materials and utility (p<0.05). For those looking for a more economical option, alternative materials are a good choice. And, for those looking for a more realistic simulation and who are willing to invest a little more, synthetic materials and some organic materials such as chicken thighs are a viable option. Unlike the findings in this study, Meyer-Pflug AR et al [27] inferred that synthetic models can be considered the best model for teaching medical students to perform medical procedures, especially because they proved that student satisfaction between a synthetic and biological model was similar.

It is important to remember that developing suturing skills through practice and repetition is fundamental to

perfecting the basic skills that every doctor must be able to perform, regardless of the material used for improvement, resulting in reduced risk of several complications for both the future doctor and the patient [27,28]. This can be demonstrated by the fact that participants in the study by Meyer-Pflug et al. [27] showed decreased confidence in carrying out such a procedure after a few months without training.

Denadai R. et al. [20] demonstrated that students can acquire surgical skills regardless of the fidelity of the material used for suture training, exemplified by fruits, vegetables, EVA, and rubber plates, bringing focus to learning derived from repetition outside the room class, since these materials are "simple, portable, reproducible, well versed, easy to access and handle", contradicting the conviction of the superiority of the more realistic apparatus.

In the literary review by Emmanuel et al. [29], the correlation between the retention of suturing skills and the frequency of practicing the procedure in question was highlighted. The longer the student practice and exercise the technique, the more improved the final result becomes. Concomitantly, if the practice is postponed, there is a deterioration in the practitioner's long-term performance. Because of this fact, studies have shown an enhance in practical skills with artificial and domestic materials, such as the use of EVA and vegetables, achieving equally effective and promising results in comparison to biological materials, both in the training of students in preclinical stages as well as in clinical stages with prior knowledge of the procedure in question, as demonstrated here in this study. It is worth mentioning that the accessibility of domestic materials, giving students the possibility of practicing outside the academic environment, proved to be a factor with extreme impact on the final undergraduate performance.

In this way, a quality article not only facilitates students' improvement, but encourages them to seek theoretical and practical enrichment, making their development more enjoyable and often more pleasurable [27]. However, training beginners in practical medical skills does not require high-fidelity materials, because this is not the objective, but rather to improve their practice for improvement in an individual and repetitive manner [20,28]. Furthermore, medicine professors must be well prepared to teach students and provide homogeneous training using alternative materials that heighten their teachings to students [20,27].

Finally, it is worth noting that the respective study is not without limitations. During data collection, the first obstacle identified was the need to fix the elastic tape on a solid base for its stability to accurately perform the suture. This was remedied by using two Kelly clamps to repair its ends. Another limitation found was the similar



intensity of colors between the eggplant and the suture thread (3-0 nylon). This made it difficult to visualize the nylon during the completion of the procedure, making it take longer than usual. It is estimated that the use of a thread that contrasts with the color of the vegetable (3-0 silk thread) or the use of an eggplant with a softer outer layer of pigmentation (such as light eggplant) would be enough to overcome this unforeseen. The respective additional observations are important for future studies and in the academic's choice to acquire material for home practice of suturing training.

Conclusion

The use of alternative materials for training surgical sutures is more accessible, with lower cost and highly availability. It is important to emphasize that this alternative should not completely replace the use of human cadavers and tissues in improving surgical skills to simulate specific clinical conditions or to improve medical training in general. However, the similarity in the quality of the techniques applied to alternative materials compared to organic materials is evident, as the main factor for this is the constant and routine practice of suturing, regardless of the material used. Furthermore, carrying out studies with more robust samples plays a fundamental role in obtaining more reliable and representative results. At the same time, investing in research with a more extensive sample is essential to strengthen scientific evidence and support more informed decisions in different fields of study.

CRediT

Author contributions: Conceptualization - Mariana Gomes de Oliveira Santos, Natalia Ferrari, Marcela Rodrigues da Cunha Alvarenga; Data curation - Mariana Gomes de Oliveira Santos, Natalia Ferrari, Marcela Rodrigues da Cunha Alvarenga, Leticia Peres Moraes; Formal Analysis - Raphael Raphe, Pedro Henrique Soubhia Sanches; Investigation - Mariana Gomes de Oliveira Santos, Natalia Ferrari, Marcela Rodrigues da Cunha Alvarenga, Leticia Peres Moraes; Methodology -Mariana Gomes de Oliveira Santos, Natalia Ferrari, Marcela Rodrigues da Cunha Alvarenga, Letícia Peres Moraes; Raphael Raphe, Pedro Henrique Soubhia Sanches; Project administration - Mariana Gomes de Oliveira Santos, Natalia Ferrari, Raphael Raphe, Pedro Henrique Soubhia Sanches; Supervision - Raphael Raphe, Pedro Henrique Soubhia Sanches; Writing - original draft -Natalia Ferrari, Mariana Gomes de Oliveira Santos, Marcela Rodrigues da Cunha Alvarenga Raphael Raphe, Pedro Henrique Soubhia Sanches; Writing-review & editing -Mariana Gomes de Oliveira Santos, Natalia Ferrari, Marcela Rodrigues da Cunha Alvarenga, Leticia Peres Moraes; Raphael Raphe, Pedro Henrique Soubhia Sanches.

Ethical Approval

This study was analyzed and approved by the Research Ethics Committee according to a substantiated opinion number 4.924.686. After explaining the Free and Informed Consent Form and signing it, the students were asked to perform sutures in different materials during the practice exercise of the class, such as EVA, eggplant, elastic tape, and chicken thigh.

Informed Consent

It was applicable.

Funding

Not applicable.

Data Sharing Statement

No additional data are available.

Conflict of Interest

Was obtained from the participants of the survey in written format.

Similarity Check

It was applied by Ithenticate[@].

Peer Review Process

It was performed.

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APPENDIX 1 - Objective Structured Assessment of Technical Skill (OSATS)

Escala de Classificação Global de Instrumento de Avaliação Objetiva e Estruturada de Habilidades Técnicas Operatórias (Global Rating Scale of Objective Structured Assessment of Technical Skills)					
Cuidados com o Tecido (Respect for tissue)	1. Utilizou frequentemente de força desnecessária sobre o tecido ou causou danos ao mesmo pelo uso inapropriado dos instrumentos. (Frequently used unnecessary force on tissue or caused damage by inappropriate use of instruments.)	2	3. Manipulou cuidadosamente o tecido, mas ocasionalmente, causou danos inadvertidos. (Careful handling of tissue but occasionally caused inadvertent damage.)	4	5. Consistentemente manipulou o tecido de forma apropriada, causan- do danos mínimos. (Consistently handled tissues appro- priately with minimal damage.)
Economia de Tempo e Movimentos (Time and motion)	1. Muitos movimentos desnecessários. (Many unnecessary moves.)	2	3. Movimentos eficientes, mas alguns desnecessários. (Efficient time/motion but some unnecessary moves)	4	5. Evidente economia de movimen- tos e máxima eficiência. (Economy of movement and maxi- mum efficiency.)
Manuseio dos Instru- mentos (Instrument handling)	1. Constantemente faz movimentos hesitantes ou desajeitados com os instrumentos. (Repeatedly makes tentative or awkward moves with instruments.)	2	3. Uso competente dos instru- mentos, embora, ocasional- mente, apresenta-se travado ou desajeitado. (Competent use of instruments although occasionally appeared stiff or awkward.)	4	5. Movimentos ajustados e fluidos com os instrumentos. (Fluid moves with instruments and no awkwardness.)
Conhecimento dos Instrumentos (Knowledge of instru- ments)	1. Frequentemente usou ou solicitou instrumentos inapropriados. (Frequently asked for the wrong instru- ment or used an inappropriate instru- ment.)	2	3. Conhecia o nome da maioria dos instrumentos e os utilizou adequadamente para a tarefa. (knew the names of most instruments and use appropriate instrument for the task.)	4	5. Evidentemente familiarizado com os instrumentos requisitados e com os seus respectivos nomes. (Obviously familiar with the instru- ments required and their names.)
Fluxo operatório e antecipação no plane- jamento cirúrgico (Flow of operation and forward planning)	1. Frequentemente interrompeu o procedimento operatório ou necessitou discutir sobre o próximo passo. (Frequently stopped operating or needed to discuss next move.)	2	3. Demonstrou capacidade de antecipação no planejamento op- eratório com progressão contínua do procedimento. (Demonstrate ability for forward planning with steady progression of operative procedure.)	4	5. Evidentemente planejou o curso da operação, sem esforços para avançar no passo-a-passo da cirurgia. (Obviously planned course of oper- ation with effortless flow from one move to the next.)
Uso de Auxiliares (Use of assistants)	1. Consistentemente alocou mal os auxiliares ou falhou ao utilizá-los. (Consistently placed assistants poorly or failed to use assistants.)	2	3. Bom uso dos auxiliares na maior parte do tempo. (Good use of assistants most of the time.)	4	5. Utilizou os auxiliares estrategi- camente, com o máximo proveito durante todo o tempo. (Strategically used assistant to the best advantage at all times.)
Conhecimento do Pro- cedimento Operatório Específico (Knowledge of specific procedure)	1. Conhecimento deficiente. Necessitou de instrução específica na maioria dos passos operatórios. (Deficient knowledge. Needed specific instruction at most operative steps.)	2	3. Conhecia todos os aspectos importantes da operação. (Knew all important aspects of the operation.)	4	5. Demonstrou familiaridade em todos os aspectos da operação. (Demonstrate familiarity with all aspects of the operation.)

Source: Campos, MEC; Oliveira, MMR; Assis, LB; Reais, AB; Gonçalves, FB. Validation of the Objective Structured Assessment of Technical Skill in Brazil. Rev Assoc Med Bras. 2020; 66(3): 328-33.



APPENDIX 2 - Adapted Likert-Style Questionnaire

- 1. Qual o material usado?
 - () Acetato-Vinil de Etileno (EVA)
 - () Berinjela
 - () Fita elástica
 - () Coxa de frango
- 2. O quão confortável foi aprender a suturar com este material (assinalado no item 1)?
- () Pouco confortável
- () Muito confortável
- 3. Quão útil foi aprender a suturar com este material (assinalado no item 1)?
 - () Pouco útil
- () Muito útil
- 4. Comparado com o material biológico, o quão melhor/pior foi aprender a suturar com este material (assinalado no item 1)?
- () Pior
- () Igual
- () Melhor
- 5. O quão importante é necessário que os materiais para a sutura sejam baratos?
- () Não importante
- () Muito importante

Source: Wong, K. Bhama, PK. Mazimpaka, JD; Dusabimana, R; Lee, LN; Shaye, DA. Banana fruit_ An "appealing" alternative for practicing suture techniques in resource-limited settings. Am J Otolaryngol. 2018; 39(5): 582-4.

