2020

Evaluating a low-fidelity inguinal canal model

Jake Hindmarch

Khalil Bazzi

The University of Notre Dame Australia, khalil.bazzi@nd.edu.au

John Lahoud

Ali Malik

The University of Notre Dame Australia, ali.malik@nd.edu.au

Sankar Sinha

The University of Notre Dame Australia, sankar.sinha@nd.edu.au

Follow this and additional works at: https://researchonline.nd.edu.au/med_article

Part of the [Medicine and Health Sciences Commons](#)

This article was originally published as:

Hindmarch, J., Bazzi, K., Lahoud, J., Malik, A., & Sinha, S. (2020). Evaluating a low-fidelity inguinal canal model. *Surgical and Radiologic Anatomy*, Early View Online First.

Original article available here:

<https://doi.org/10.1007/s00276-020-02553-0>

This article is posted on ResearchOnline@ND at
https://researchonline.nd.edu.au/med_article/1192. For more
information, please contact researchonline@nd.edu.au.

This is a post-peer-review, pre-copyedit version of an article published in *Surgical and Radiologic Anatomy*.

The final authenticated version is available online at: [https://doi.org/ 10.1007/s00276-020-02553-0](https://doi.org/10.1007/s00276-020-02553-0)

Hindmarch, J., Bazzi, K., Lahoud, J., Malik, A., and Sinha, S. (2020) Evaluating a low-fidelity inguinal canal model. *Surgical and Radiologic Anatomy, Early View Online First*.
<https://doi.org/10.1007/s00276-020-02553-0>

Title: Evaluating a Low-fidelity Inguinal Canal Model

Authors: Jake Hindmarch¹, Khalil Bazzi¹, John Lahoud¹, Sankar Sinha^{1,2}

¹ The University of Notre Dame Australia, Department of Anatomy, Sydney, New South Wales, Australia

² University of Tasmania, Department of Surgery, Hobart, Tasmania, Australia

Corresponding Author:

Name: Jake Hindmarch

Postal Address: 160 Oxford Street, Darlinghurst, NSW, 2010, Australia

Phone: 0477434656

ORCID iD: <https://orcid.org/0000-0002-5706-6903>

E-mail: jakehindmarch19@gmail.com

Title Evaluating a Low-Fidelity Inguinal Canal Model

Abstract

Purpose The inguinal canal anatomy is of paramount clinical significance due to the common occurrence of direct and indirect inguinal hernias. However, the inguinal canal is often an area of great difficulty for medical students to understand. The aim of this study was to evaluate the use of a low-cost, low-fidelity inguinal canal model as a teaching and learning aid.

Methods A low-fidelity inguinal canal model was introduced as a learning aid in an anatomy tutorial on the inguinal region. Students were randomised into intervention (n=66) and control (n=40) groups. Following the tutorial, all students completed a multiple-choice question quiz on the inguinal canal. The intervention group also completed a questionnaire evaluating the positive and negative aspects of the model.

Results Students taught with the inguinal canal model achieved higher scores (mean: 88.31% vs 81.7%, $p = 0.087$). Positive aspects of the model as described by the students included its simplicity and ability to improve their three-dimensional understanding of the inguinal canal. Students requested more hands-on time with the model during the tutorial.

Conclusion The present study supports current literature in that low-fidelity anatomy models are a useful adjunct to aid students' learning of complex anatomical concepts. Students may benefit from creating their own inguinal canal model to retain as a personal study tool.

Key words

Inguinal canal, anatomy model, low-fidelity model, anatomy teaching

Declarations

Funding

Not applicable

Conflicts of interest

The authors disclose no conflicts of interest

Ethics approval

Ethics approval was obtained from the University of Notre Dame Australia Human Research Ethics

Committee (HREC - 018044S)

Consent to participate

Informed consent was obtained from all individual participants included in the study

Consent for publication

Participants signed informed consent regarding publishing their data

Availability of data and material

Available upon request

Code availability

Available upon request

Introduction

The inguinal canal is of paramount clinical significance due to the common occurrence of direct and indirect inguinal hernias, with a lifetime risk of 27% in males and 3% in females [5]. A sound understanding of the anatomy of the inguinal canal is vital when assisting and performing inguinal hernia repairs. However, due to its three-dimensional nature, the inguinal canal is often a source of great difficulty for medical students to understand [6]. The use of high quality cadaveric specimens could be considered the ideal means to teach a difficult three-dimensional concept, however, adequately prepared prosections may neither be readily available nor accessible for medical students.

Low-fidelity anatomy models have been widely used to aid students' learning of complex anatomical concepts [7]. Several advantages of these models have been described, including their ability to serve as memory aids, reduce the cognitive load of learning a new concept, and increasing student enthusiasm and participation [3]. Such models are promising due to their educational effectiveness, accessibility and low cost [7].

To address this issue, the authors designed and created an inexpensive three-dimensional model to supplement students' learning of the inguinal canal at the University of Notre Dame Australia, School of Medicine Sydney (UNDA SoMS). The model was designed to be a simplistic and tangible representation of the male inguinal canal and aimed to illustrate the boundaries, structure, orientation and contents of the inguinal canal.

The aim of this study was to evaluate a low-fidelity model of the inguinal canal as a learning aid amongst first year medical students and to determine if it would assist students in achieving a deeper understanding of this anatomical region.

Materials and Methods

A three-dimensional representation of the right male inguinal canal was designed by the UNDA SoMS anatomy department and created using readily available materials in under one hour at minimal financial cost. These materials included a toothpaste box representing the four walls of the inguinal canal (Figure 1 & 2). Thin coloured card was rolled into a tube to represent the spermatic cord, coloured marker was used to draw the inferior epigastric vessels, white string was used to represent the ilioinguinal nerve and a label maker was used to label the model.

The inguinal canal model was introduced as a teaching aid during a scheduled tutorial on the inguinal canal and anterior abdominal wall. The student cohort of 120 first year medical students was split into ten tutorial groups. Five tutors led the tutorials over two sessions. Three tutors were randomly assigned to lead the intervention groups, with the remaining two tutors leading the control groups. Students were randomly assigned to intervention and control groups.

All students had received a lecture on the inguinal canal one week prior to the tutorial. The tutorial was designed to reinforce key anatomical concepts such as the borders and contents of the inguinal canal as well as important relations. All tutors were instructed to allocate thirty minutes of the tutorial towards teaching these concepts. The intervention group was taught with the addition of the model. Tutors were instructed to allow each student a similar amount of time with the model.

After the inguinal canal anatomy had been taught for thirty minutes, both intervention and control groups were given a quiz with seven multiple-choice questions which aimed to assess student learning outcomes regarding the inguinal canal. The multiple-choice quiz was created in conjunction with the learning objectives set out by the UNDA SoMS and was reviewed and adjusted in an iterative manner until there was overall agreement regarding the questions' reliability and validity (See Appendix A). Each multiple-choice question had three options, as research indicates similar reliability compared to multiple-choice

questions with four options, whilst being simpler to formulate [6]. In addition, participants in the intervention group were asked to complete a questionnaire evaluating the model, utilising 5-point Likert scale items as well as a free comments section aimed at determining students' perceptions of utility value of the model. Ethics approval was obtained from the University of Notre Dame Australia Human Research Ethics Committee (HREC - 018044S).

Data analysis was completed using SPSS v. 24 (Statistical Package for Social Sciences, version 24, SPSS Inc., Chicago, IL, USA). As the data were normally distributed, a two-sample T test was performed. Data are reported as mean and standard deviation of the mean. Statistical significance was considered at $P < 0.05$.

Results

A total of 106 students consented to participate in the study, with 66 assigned to the intervention group and 40 assigned as control. Students in the intervention group achieved an overall higher quiz score than those in the control group (mean: 88.31% vs 81.7%, $p = 0.087$) (Figure 3). Questions 2 and 6 showed a significant difference in favour of the intervention group (Figure 3). Question 7 was the only question where students in the control group achieved a higher quiz score than those in the intervention group, however the difference was not significant (Figure 3).

Results of the evaluation questionnaire indicated a high degree of student satisfaction with the model, with 47% of students agreeing and 37.9% of students strongly agreeing that the model improved their ability to visualise the inguinal canal in a three-dimensional manner (Figure 4). Of the students surveyed, 78.8% either agreed or strongly agreed that they would be interested in creating a similar model to retain as a personal study tool.

Following thematic analysis of students' free comments, various positive and negative themes emerged (Table 1). Students appreciated the simplicity of the model and noted an improvement in their three-dimensional understanding of the inguinal canal. Students were at times frustrated by the absence of labels on the contents of the inguinal canal, for example the spermatic cord and ilioinguinal nerve. In addition, students requested more hands-on time with the model.

Discussion

The objective of the present study was to evaluate the use of a low-fidelity model of the inguinal canal as a learning aid amongst first year medical students. Previously reported advantages of low-fidelity models for teaching anatomy include their ability to serve as a memory aid by simplifying complex anatomical regions, reducing cognitive overload and to facilitate problem solving [2]. Another major advantage these models have over cadaveric specimens or digital models is that they are readily available, easy and inexpensive to produce and since damaging models is of no consequence, students are less afraid to manipulate the models in order to learn from them [3].

The results of the present study suggest our low-fidelity model of the inguinal canal serves as an effective learning aid for medical students. Results from the student quiz indicate that the inguinal canal model may be particularly useful in demonstrating the boundaries which form the inguinal canal as well as the spatial relations of the deep inguinal ring (Figure 3). Analysis of student feedback demonstrated that the model was generally well perceived by the students (Figure 4). Positive aspects of the model, include the model's ability to improve student three-dimensional visualisation of the inguinal canal and the model's simplicity, findings which support existing literature on the utility of low-fidelity models [2-4].

However, based on the findings of this study, the model could be improved in several ways. These include labelling the right and left side of the model to allow for easier orientation. In addition, clear labelling of the spermatic cord and ilioinguinal nerve may assist students in accurately identifying these structures as they course through the inguinal canal. The students expressed a desire for more hands-on time with the model (Table 1). Future use of the model could involve students building their own to retain as a personal study aid, with 78.8% of students indicating a willingness to do so (Figure 4).

The limitations of the study include the small sample size being conducted in one institution, potential variability in pre-existing knowledge of the inguinal canal as well as potential variability between tutors' teaching styles. Additional limitations include the limited number of multiple-choice questions in the quiz and the limited amount of time each student had access to the inguinal canal model.

Conclusion

A low-fidelity model of the inguinal canal was developed to promote a deeper understanding of an anatomical region often found to be challenging for medical students. Our model has been shown to be effective in addressing the objective at minimal cost. The present study supports current literature in that low-fidelity anatomy models are a useful adjunct to aid students' learning of complex anatomical concepts and validation of this study by other medical schools would be useful.

Authors' Contributions

K Bazzi: Ethics approval, protocol development, data collection, manuscript writing

J Hindmarch: Ethics approval, protocol development, data collection, data analysis, manuscript writing

J Lahoud: Ethics approval, protocol development, manuscript writing

S Sinha: Ethics approval, protocol development, manuscript writing

Acknowledgements

Nil

References

1. Baghaei P, Amrahi N (2011) The effects of the number of options on the psychometric characteristics of multiple choice items. *Psychological Test and Assessment Modeling*, 53(2):192
2. Chan LK, Cheng MM (2011) An analysis of the educational value of low-fidelity anatomy models as external representations. *Anatomical sciences education*, 4(5):256-263
3. Chan LK (2015) The use of low-tech models to enhance the learning of anatomy. In *Teaching Anatomy*, Springer, Cham, 259-266
4. Fagan SP, Awad SS (2004) Abdominal wall anatomy: the key to a successful inguinal hernia repair. *The American journal of surgery*, 188(6):3-8
5. Kingsnorth A, LeBlanc K (2003) Hernias: inguinal and incisional. *The Lancet*, 362(9395):1561-1571
6. Perrott CA (2004) Inguinal hernias: room for a better understanding. *The American journal of emergency medicine*, 22(1):48-50
7. Yammine K, Violato C (2016) The effectiveness of physical models in teaching anatomy: a meta-analysis of comparative studies. *Advances in Health Sciences Education*, 21(4):883-895

216	Fig. 1 The anterior wall of the model representing the right inguinal canal with the lateral third of
217	the external oblique aponeurosis lifted showing the underlying internal oblique muscle
218	
219	Fig. 2 The posterior wall of the right inguinal canal model showing the transversalis fascia and the
220	conjoint tendon
221	
222	Fig. 3 Intervention vs control group quiz results
223	
224	Fig. 4 Student evaluation of inguinal canal model
225	
226	Table 1 Summary of the free comments grouped into themes
227	
228	Appendix A
229	Table A-1 Student Quiz

Lateral 1/3 of aponeurosis lifted to show underlying internal oblique muscle

TRANSVERSUS ABDOMINUS &
INTERNAL OBLIQUE

INTERNAL OBLIQUE
MUSCLE

EXTERNAL OBLIQUE
APONEUROSIS

Superficial inguinal ring

Spermatic cord

Ilioinguinal nerve

Fig 1 : The anterior wall of the model representing the right inguinal canal with the lateral third of the external oblique aponeurosis lifted showing the underlying internal oblique muscle

Fig 2 : The posterior wall of the right inguinal canal model showing the transversalis fascia and the conjoint tendon

Fig 3 Intervention vs control group quiz results

Fig 4 Student evaluation of inguinal canal model

Category	Theme	Number of comments	Selected comments
Positive comments	Improved 3D visualisation	34	Made it a lot easier to visualise the 3D structure of inguinal canal. Easier to understand than lectures, textbook
			Can visualise where deep and superficial rings are in relation to each other and which muscles they are going through
			Great 3D representation which helped my understanding of what forms the boundaries
	Simplicity	12	I really liked the simplicity of the model and being able to visualise all the structures in 3D space and seeing where structures were in relation to each other.
			Simple, easy to visualise structures It was simple and clear
Negative comments	Inadequately labelled	11	Did not label left or right side
			Box did not have labels for what entered and exited the model
			Did not label the deep or superficial inguinal rings
	Limited time with model	11	Not enough time with the model
			Each person only had a very small amount of time to view the model

Table 1 Summary of the free comments grouped into themes

Table 1. Student Quiz

Question	Answers
1.The superficial inguinal ring is formed by a defect in which of the following structures	<ul style="list-style-type: none"> a. Internal oblique muscle b. Transversus abdominus c. External oblique aponeurosis
2.The deep inguinal ring is formed by an opening through which of the following structures	<ul style="list-style-type: none"> a. Transversalis fascia b. Internal oblique muscle c. Transversus abdominis muscle
3.Which of the following structures forms the anterior wall of the inguinal canal	<ul style="list-style-type: none"> a. Inguinal ligament b. External oblique aponeurosis c. Conjoint tendon
4.Which of the following structures forms the posterior wall of the inguinal canal	<ul style="list-style-type: none"> 1. Cremaster muscle 2. External oblique muscle 3. Transversalis fascia
5. The inguinal ligament forms which boundary of the inguinal canal?	<ul style="list-style-type: none"> a. Posterior wall b. Roof c. Floor
6. Which of the following statements is true?	<ul style="list-style-type: none"> a. The inferior epigastric vessels lie medial to the deep inguinal ring b. The external iliac artery lies superior to the deep inguinal ring c. The superficial ring lies lateral to the deep inguinal ring
7. Which of the followings enters the inguinal canal through the deep inguinal ring?	<ul style="list-style-type: none"> a. Ilioinguinal nerve b. Spermatic cord c. Femoral branch of the genitofemoral nerve

Table A-1 Student Quiz