Research Paper: The Feasibility of Using Playdough and Household Materials as an Educational Tool for Self-learning of Neurosurgical Anatomy During COVID-19 Lockdown

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ABSTRACT

Introduction: Neurosurgical anatomy of the brain and spine was mastered by years of hard work practicing on cadavers, fresh frozen specimens, live animal models, and 3D models. But these methods are costly and raise legal issues. During the lockdown period, many of us were free having enough time, especially when operating rooms were very quiet. So we thought of learning neurosurgical anatomy using a cost-effective model made from homemade playdough and household items.

Methods: The playdough used for the study was made at home using maida flour and fabric colors with an anatomy atlas as guidance to mold anatomical structures on a template. Higher neurovascular training in vascular anastomosis was done and practiced on a beef blood vessel which is dissected out from cattle meat brought at home. The model was shown to residents and other faculties in the Department, and their opinions were analyzed by a feedback survey regarding the feasibility of the model as a self-learning tool.

Results: Pilot feedback surveys done on neurosurgeons and residents revealed a general satisfaction with the model, with 70% saying that it was a good technique for learning neurosurgical anatomy. About 83.3.% of them opined that this self-learning method would improve their 3D orientation of complex neurosurgical approaches compared to bookish learning alone. The model was perceived as very useful for teaching (94%) preoperative planning (95%) and provided realistic surgical anatomy (81%).

Conclusion: The present pilot study based on a questionnaire survey proposes a novel, cost-effective method to create a physiologically, anatomically, and tactile model for learning neurosurgical anatomy. This model also increased the haptic ability and surgical skills as hand modeling were also practiced. This study will be unique because the feasibility of the model was also assessed in the same research by a feedback survey making it a valid study. This method will surely help upgrade the knowledge of neuroanatomy, especially when the real opportunity for surgical training was restricted due to COVID-19 lockdown.

Keywords:
Play-dough, Neurosurgery, Anatomy, Self-learnng, COVID-19, Survey

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1. Introduction

Junior neurosurgeons and resident trainees mastered the neurosurgical anatomy of the brain and spine after years of hard work practicing on cadavers and learning under the supervision of senior surgeons in actual operating rooms. But these methods of teaching raise a lot of ethical and medicolegal issues. Fresh frozen specimens and live animal models require a lot of infrastructures, money, and human resources. Three-dimensional models made from materials like wax, ivory, and bronze have been used for many centuries. Computerized 3D models have also been used for teaching neuroanatomy, neuropathology, and in different fields of neurosurgical training. But these models are all very costly.

During the lockdown period, many of us were free having enough time, especially when operating rooms were very quiet. The hands-on training was minimum, and teaching was mainly through online modes. So we thought of learning neurosurgical anatomy using a model made from playdough and household items. Playdough is a toy material that our children use for playing and learning. It can be used as an educational tool because of its simplicity, pliability, and relative inexpensiveness. Its role in increasing the haptic ability in autistic children has been proven beyond doubt. The present study proposes a novel method to create a physiologically, anatomically, and tactile model for learning neurosurgical anatomy. This cost-effective model increases the haptic ability and is unique as it increases the surgical skills as hand modeling was also practiced. To assess the feasibility of using this model for self-learning, we conducted a single-center feedback survey among junior neurosurgeons and residents in the Department. This study will be unique because its feasibility was assessed in the same research making it a valid method for learning neurosurgical anatomy. Higher neurovascular training can also be done at home using household materials.

2. Materials and Methods

Model making process

For Basic Neurosurgical Anatomy these materials are used:

- Plastic wire
- Skull and spine skeleton template
- Flag marks
- Blue cloth piece
- Playdough made from maida
- Glue
- Scissors
- Sculpturing tools

The playdough was made at home using maida flour and fabric colors (red for blood vessels, yellow for nervous tissue, brown for muscle, and blue for veins). Half a kilo of maida was mixed with fabric colors and little coconut oil and then placed in the refrigerator at 2-8°C. It was taken out the following day, and playdough was seen deformable for modeling.

An anatomy atlas can be used for guidance. Vessels were molded using red playdough. Nerves were rolled into corresponding sizes using yellow playdough. The untwined plastic wires can also be used for simulating nerves. Veins were made with blue-colored playdough. The anatomical structures were pasted on the skull and spine template for demonstration and self-learning. The sculpturing tools were also used if any difficulty arose during hand modeling. Anatomical structures are further flag-marked for teaching and learning. Materials used for studying basic neurosurgical anatomy are shown in Figure 1.

The anterior, middle, and lateral skull base anatomy models are shown in Figure 2 (parts A, B, C, D1, D2, D3). The orbital anatomy model is shown in Figure 2-B. The model anatomy of incisura, tentorial, and contents of quadrigeminal cisterns are shown in Figure 2-c. The spine models, including anatomy of spinal nerves (Figure 2), model of craniovertebral junction (Figure 2), model of the lateral spine (Figure 2), and costotranversectomy model (Figure 2), are shown in (Figure 2) and its subdivisions.

For microvascular learning

- Cattle meat vessel preparation
- Karl Zeiss Loupe
- Microsurgical instruments
- Bulldog clamps

Higher neurovascular training in vascular anastomosis was done and practiced on a beef vessel (both artery and veins) which is dissected out from cattle meat brought at

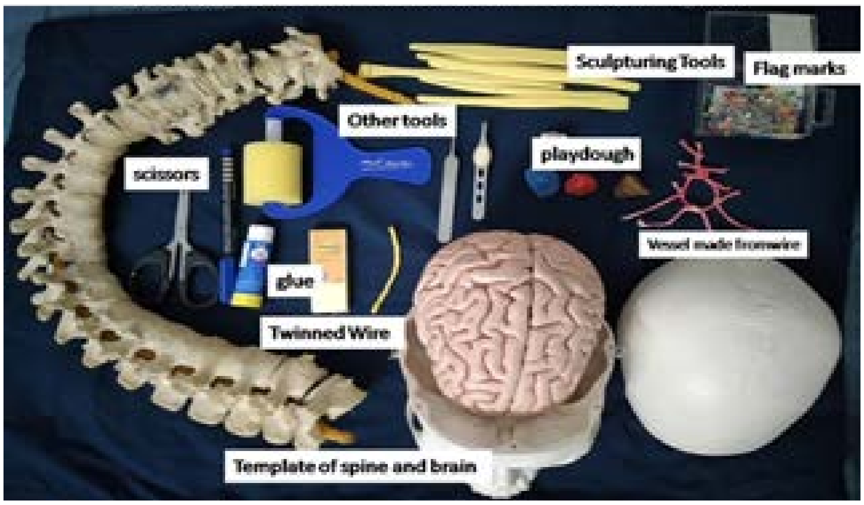


Figure 1. Materials used for studying basic neurosurgical anatomy

home. True microsurgical instruments (Figure 3) are preferred for improving handling skills. For magnification, a Karl Zeiss microsurgical loupe (Figure 3) can be used. The anastomosis was learned with the help of microsurgical instruments assisted by my wife, a plastic surgeon routinely doing microvascular anastomosis. The children at home can also be involved in the process, which can be a tension reliever for them during the COVID-19 pandemic. The model was then shown and demonstrated to residents and other faculties in the Department through online mode, and their opinion regarding the feasibility of the model (in terms of basic anatomy and higher training in the form of microvascular anastomosis) as a self-learning tool was obtained by a pilot questionnaire survey. The microvascular anastomosis model is shown in Figure 3 and its subdivisions.

Survey and feedback

A questionnaire was uploaded on Goggle spreadsheets. For checking its validity, survey questions were initially sent to four senior neurosurgeons working in various parts

A: Skull base anatomy
B: Orbital anatomy and skull base
C: Orbital anatomy and skull base
D: Spinal nerves antomy
D1: Model CV junction
D2: Model lateral spine
D3: Model costotransversectomy

Figure 2. Models of skull base approaches

Figure 3. Microvascular anastomosis model

of the state. Upon scrutiny by an expert panel, the proper corrections were made as per suggestions which we felt improved the readability and validity of the questionnaire. The final form was sent to neurosurgeons and residents by Email. The majority of questions could be answered by selecting from the multiple choices given in the Email or the web interface, and few required the participant to write a short sentence. The questionnaire used in the survey is shown in Figure 4, and the investigator was blindfolded. Data recorded in a Google spreadsheet were entered in SPSS v. 16 (SPSS Inc., Chicago, IL, USA).

3. Results

Feedback surveys from neurosurgeons and residents (n=12) in the Department of Neurosurgery, where the study was conducted, revealed a general satisfaction with the model and a broad area of potential use. Seventy percent said that it helps improve surgical skills. All participants believed that this tool would help self-learning dissection, and all will use the model for the same purpose. About 83.3.% of them opined that this self-learning method would improve their 3D orientation of complex neurosurgical approaches compared to bookish learning. The model was perceived as useful for teaching (94%) and preoperative planning (95%). It also provided realistic surgical anatomy (81%). The percentages of satisfaction of the respondents regarding the model are shown in Figure 5.

4. Discussion

Neurosurgery residents familiarize themselves with the 3D structure of the brain and spine experientially through work on cadavers or in actual operating rooms. But these methods raise a lot of ethical and medicolegal issues nowadays. Also, cadavers are not freely available. Fresh frozen specimens and live animal models, which provide near to reality hands-on training, require a lot of infrastructures, money, and human resources. These methods also raise several ethical issues.

Three-dimensional models made from wax, bronze, and ivory have been used for many centuries. The first 3D

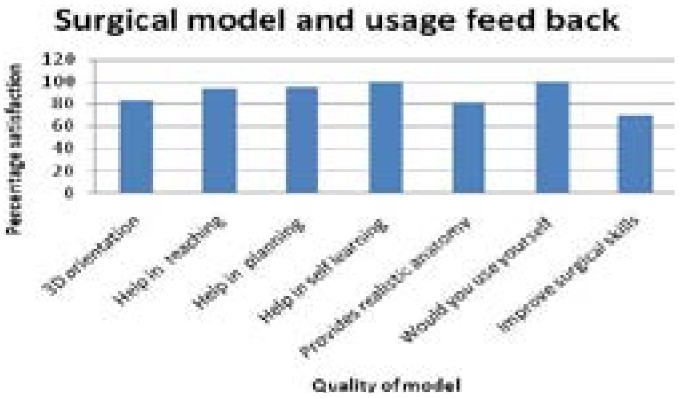
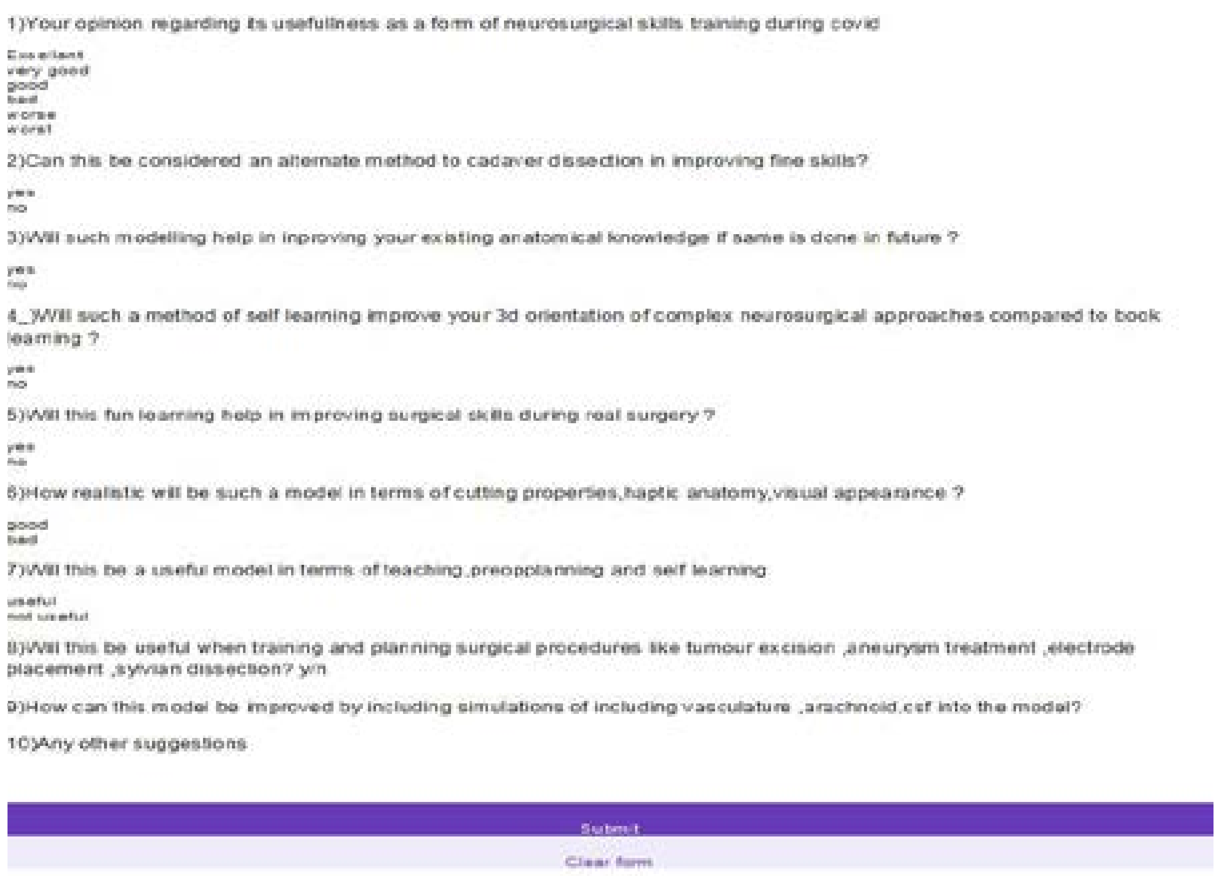


Figure 4. Questionnaire used in the survey


1)Your opinion regarding its usefulness as a form of neurosurgical skills training during covid

Excellent
very good
good
bad
worse
worst

2)Can this be considered an alternate method to cadaver dissection in improving fine skills?

yes
no

3)Will such modelling help in inproving your existing anatomical knowledge if same is done in future ?

yes
no

4_)Will such a method of self learning improve your 3d orientation of complex neurosurgical approaches compared to book learning ?

yes
no

5)Will this fun learning help in improving surgical skills during real surgery ?

yes
no

6)How realistic will be such a model in terms of cutting properties,haptic anatomy,visual appearance ?

good
bad

7)Will this be a useful model in terms of teaching ,preopplanning and self learning

useful
not useful

8)Will this be useful when training and planning surgical procedures like tumour excision ,aneurysm treatment ,electrode placement ,sylvian dissection? y/n

9)How can this model be improved by including simulations of including vasculature ,arachnoid,csf into the model?

10)Any other suggestions

Submit
Clear form

Figure 5. Satisfaction of the respondents regarding the model

ANATOMICAL SCIENCES

model was created by a follower of Mondino de'Luzzi in the 14th century. The molten wax was injected into the vascular system, forming a cast that was carefully dissected out from the surrounding tissues [1, 2]. In the 17th and 18th centuries, artists such as Ercole Lelli (1702–1766) turned to colored waxes to realistically recreate dissected figures and organs [3, 4]. Computerized 3D models have been used for teaching neuroanatomy, neuropathology, and in different fields of neurosurgical training [5-8]. However, all of these procedures are very costly.

Studying neuroanatomy textbooks is an essential and first step in surgical training, but textbook images only provide 2D snapshots of the real 3D anatomy. Cadaver dissection offers valuable insight into neuroanatomy, but they are very difficult to procure nowadays and have a lot of ethical and litigation issues [9]. Live animal surgeries provide a realistic feel, but the animal anatomy might differ significantly from the human anatomy [3]. With the advance of novel manufacturing technologies [10], surgical models are recognized as powerful, cost-efficient methods that can replace cadaver or animal involvement [11]. The model in the present study can be prepared easily. It can be used for educational purposes in developing countries as a cost-effective method compared to the above measures. We believe that practicing on this model will improve the surgical skills of junior neurosurgery residents as they become more aware of neuroanatomy, thereby improving outcomes in neurosurgery. With this in mind, the present model was thoroughly examined by neurosurgeons and surgical residents in the Department. Their feedback was generally positive. Surgeons and residents unanimously rated the model as very useful and stated that they would use it for learning, teaching, patient illustration, surgical training, and preoperative planning. This method can be used as a comparable method to cadaver dissection and frozen specimens in upgrading surgical skills and knowledge of neuroanatomy, especially when an actual opportunity for surgical training was restricted due to COVID-19 lockdown. Higher neurovascular training can also be done at home using household materials.

5. Conclusion

The present pilot study based on a questionnaire survey proposes a novel, cost-effective method to create a physiologically, anatomically, and tactile model for learning neurosurgical anatomy. This model also increased the haptic ability and surgical skills as hand modeling were also practiced. This study will be unique because the feasibility of the model was also assessed in the same study by a feedback survey making it a valid one. This method will surely help upgrade the knowledge of neuroanatomy, especially when the actual opportunity for surgical training was restricted due to COVID-19 lockdown.

Study limitations

The concept of the present model and subsequent pilot survey is only a preliminary attempt. In future studies, it has to be precisely planned on a large group of young neurosurgeons and resident trainees for assessing feasibility. Further multicenter involvement with innovative ideas using cheaper, cost-effective methods must be designed and implemented as part of skill training.

Future research

Future work can focus on adding the cerebral vasculature ventricles, brainstem, and meninges [12], providing a more realistic experience [12]. Also, if gelatin is used, it will be insoluble at room temperature and thus provide a liquid environment to mimic the cerebrospinal fluid. This material would open additional opportunities as a training tool for accurate external ventricular drain placement for monitoring intracranial pressure [13-16].

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing – original draft preparation: Vinu Gopal; Writing – review & editing, visualization, supervision, project administration: Lekshmi Bhoosahn.

Conflict of interest

The authors declared no conflict of interest.

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