Data Article

3D simulation of aneurysm clipping: Data analysis

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ABSTRACT

Aneurysm clipping requires the proficiency of several skills, yet the traditional way of practicing them has been recently challenged. The use of simulators could be an alternative educational tool. The aim of this data analysis is to provide further evaluation of a reusable low-cost 3D printed training model we developed for aneurysm clipping [1]. The simulator was designed to replicate the bone structure, arteries and targeted aneurysms. Thirty-two neurosurgery residents performed a craniotomy and aneurysm clipping using the model and then filled out a survey. The survey was designed in two parts: a 5-point Likert scale questionnaire and three questions requiring written responses [1]. Two dimensions of the model were evaluated by the questionnaire: the face validity, assessed by 5 questions about the realism of the model, and the content validity, assessed by 6 questions regarding the usefulness of the model during the different steps of

the training procedure. The three questions requiring written responses referred to the strengths and weaknesses of the simulator and a global yes/no question as to whether or not they would repeat the experience. Demographic data, experience level and survey responses of the residents were grouped in a dataset [2].

A descriptive analysis was performed for each dimension. Then, the groups were compared according to their level of expertise (Junior and Senior groups) with an independent sample *t*-test. A Confirmatory Factor Analysis (CFA) was estimated, using a Weighted Least Squares Mean Variance adjusted (WLSMV) which works best for the ordinal data [3]. Fitness was calculated using chi-square (χ^2) test, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). A non-significant χ^2, CFI and TLI greater than 0.90 and RMSEA < 0.08 were considered an acceptable fit [4]. All data analysis was performed using IBM SPSS 23.0 statistical software. Data are reported as mean + standard deviation (SD). A probability $p < 0.05$ was considered significant.

Exploratory Factor Analysis was done to explore the factorial structure of the 11-items scale in the sample, first we performed a principal components analysis. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO = 0.784; Bartlett's Test of Sphericity χ^2 (55) = 243.44, $p < .001$), indicating correlation is adequate for factor analysis. Considering Eigen values greater than 1, a two-factor solution explained 73.1% of the variance but left one item in factor 2 (Q 11). The results of this factor analysis are presented in Table 1. Confirmatory Factor Analysis, considering only the 10 items in the first factor (removing question 11 of our model), was performed. This model reached the following fit: χ^2 (35) = 38.821, $p > .05$; CFI = 0.997; TLI = 0.996; RMSEA 0.058, without any error terms to exhibit covariance. Regarding the reliability of the questionnaire, the internal consistency was explored in the 10 items selected in the confirmatory factor analysis with an alpha coefficient ($\alpha = 0.941$).

Specifications Table

Subject	Surgery
Specific subject area	Teaching in Neurosurgery, 3D Simulation Model for Aneurysm Clipping, Evaluation Data Analysis.
Type of data	Table
	Exploratory analysis
	Confirmatory analysis
	Reliability analysis
	Questionnaire
How data were acquired	Survey (Table 1 from research article [1]) and provided as a supplementary file ("*supplementary file questionnaire*")
Data format	Analysed

Parameters for data collection	Results of the 5-point Likert scale survey and written responses were collected. Demographic data and experience level of the residents were also considered.
Description of data collection	The training with the simulator was implemented during a recent course for neurosurgical residents. After the residents performed a craniotomy and clipped an aneurysm, they were asked to fill a survey to validate the efficacy of this simulation.
	Two dimensions of the model were evaluated by the questionnaire: the face validity, assessed by 5 questions about the realism of the model, and the content validity, assessed by 6 questions regarding the usefulness of the model. Additionally, there were three questions referring to the strengths and weaknesses of the simulator and a global yes/no question as to whether or not they would repeat this experience.
	The questionnaire is provided as a supplementary file.
Data source location	Institution: Pontificia Universidad Católica de Chile
	City/Town/Region: Santiago
	Country: Chile
	Latitude and longitude for collected samples/data: 33,5°S, 70,7°W
Data accessibility	Repository name: Mendeley Data
	Data identification number: https://doi.org/10.17632/5yx8xc9w9v.1
	Direct URL to data: https://data.mendeley.com/datasets/5yx8xc9w9v/1
Related research article	F. Mery, F. Aranda, C. Méndez-Orellana, I. Caro, J. Pesenti, J. Torres, R. Rojas, P. Villanueva, I. Germano. A Reusable Low-cost 3D Training Model for Aneurysm Clipping, *World Neurosurgery*. 2021;147:29–36.
	https://doi.org/10.1016/j.wneu.2020.11.136

Value of the Data

- These Data are useful because they validate the efficacy of a new training model for aneurysm clipping and also prove the usefulness of the evaluation instrument (questionnaire).
- Residents, Faculty and Residency Program Directors can benefit from these data, allowing them to make decisions regarding their own training/teaching and curriculum of the current residency programs.
- These data could be used in the future in two ways: incorporating this same simulation model and evaluating its efficacy in your residency program/practical course, or using the validated questionnaire and subsequent analysis to assess a different teaching technique.

1. Data Description

The data contained in the linked repository [2] were collected from 32 residents who filled out a survey after performing a craniotomy and clipping an aneurysm, in a recent simulation experience. The survey, which was used to validate the efficacy of the simulation, is presented as a supplementary file, described below. Twenty three (72%) were male and the mean age was 30.2 years (± 3.6). The participants were divided between junior and senior groups according to their level of experience. Responses to each question are included in the dataset, suggesting that the model was representative of surgical anatomy and useful in performing the surgical steps.

An exploratory and confirmatory factor analysis of the items included in the survey, and the reliability of the questionnaire were assessed. The analysis is detailed in the supplementary data described below. The exploratory factor analysis grouped 10 questions together and left question 11 out (Table 1). In the confirmatory analysis of the 10 selected questions, the model reached an acceptable fit. Additionally, exploring the internal consistency of the survey, it was considered as highly reliable ($\alpha = 0.941$).

Table 1. **Exploratory factor analysis of the items.** This assessment was performed to explore the factorial structure of the 11-items scale in the sample. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO = 0.784; Bartlett's Test of Sphericity χ^2

Table 1
Exploratory Factor Analysis of the items.

	Factor loading		Communality
	1	2	
Question 1	**.748**	−0.283	.640
Question 2	**.646**	−0.402	.580
Question 3	**.824**	−0.416	.852
Question 4	**.814**	.401	.824
Question 5	**.890**		.793
Question 6	**.795**		.635
Question 7	**.852**		.727
Question 8	**.808**		.662
Question 9	**.801**		.645
Question 10	**.894**		.803
Question 11	.612	**.710**	.878
Eigen value	6.940	1.099	
% of variance	63.091	9.992	

(55) = 243.44, $p < .001$), indicating correlation is adequate for factor analysis. Considering Eigen values greater than 1, a two-factor solution explained 73.1% of the variance but left one item in factor 2 (Q 11).

Supplementary file. Simulation Experience Questionnaire. The survey was designed in two parts: a 5-point Likert scale questionnaire and three questions requiring written responses. Two dimensions of the model were evaluated by the questionnaire: the face validity, assessed by 5 questions about the realism of the model, and the content validity, assessed by 6 questions regarding the usefulness of the model during the different steps of the training procedure. The three questions requiring written responses referred to the strengths and weaknesses of the simulator and a global yes/no question as to whether or not they would repeat the experience.

Supplementary Data. Exploratory/confirmatory factor analysis and reliability of the questionnaire. Description of the exploratory and confirmatory factor analysis of the questions included in the survey and the reliability analysis of the questionnaire.

2. Experimental Design, Materials and Methods

2.1. Simulator development

The simulator was designed from Computed Tomography Angiography (CTA) DICOM files of two patients harboring an anterior communicating artery (ACoA) and a basilar apex aneurysm. These CTA exams included slices every 0.3 mm and were fused together and transformed in a digital stereolithography (STL) model using Mimics software (materialize, Belgium). Bone structures and arterial blood vessels were identified and isolated including the targeted aneurysms. The STL model was transformed in an efficient simulator model with 3-Matic software (materialize, Belgium). Using a Connex 2 Eden 260 3D printer (Stratasys) in Verowhite material, a model of the image with multiple parts was developed and printed in a 0.1 mm high resolution. Then, using red colonial silicone density 10 material, a cast was made to create a mold, in order to obtain multiple copies of the intracranial vasculature and aneurysms. This particular silicone was chosen because of its elasticity and resistance to multiple clip applications.

The replica of the cranium was modeled in two pieces: the skull base and the orbitofrontal part [1]. Both pieces were made in a F170 printer (Stratasys) using high-performance Ultem 9085 composite with 0.1 mm resolution. The skull base was used as a final product. The orbitofrontal

replica was used as a cast to obtain a room temperature vulcanization (RTV) silicone mold, to allow multiple copies of G26 polyurethane composite with 30% particles of crystal microspheres. This compound was chosen to create pieces with similar density and resistance to the bone, and with similar behavior under drilling to avoid the overheating of 3D printed plastic models. The two pieces of the cranium were designed to assemble together with a quick-lock mechanism, enabling fast change of a replacement part after the craniotomy was performed. The brain was simulated by using medium density foam.

2.2. Simulation set-up

The training with the above simulator was implemented during a recent World Federation of Neurosurgical Societies (WFNS) boot camp course for neurosurgical residents. The model was placed in a fixed holder to simulate the clinical setting. Junior and Senior residents were instructed to perform a pterional craniotomy and clip the ACoA aneurysm or Fronto-Orbito-Zygomatic (FOZ) craniotomy and clip the ACoA and basilar apex aneurysms respectively. Every station included a Zeiss operative microscope (also an AEOS-Aesculap microscope was available); Aesculap Elan 4 drill; retractors; micro-instruments; Aesculap XS and Slim clip appliers and Yasargil clips. At each station, a group of 3–4 resident performed the simulated surgery in a 1-hour rotation. After each group finished its rotation, the orbitofrontal piece was changed promptly using the quick-lock mechanism. The digital template replicated a precise image of the bone structure, arterial blood vessels and aneurysms.

2.3. Simulator evaluation

To validate the efficacy of this simulation, the residents were asked to fill out a 5-point Likert scale questionnaire [1]. Two dimensions of the model were evaluated by the questionnaire: the **face validity**, assessed by 5 questions about the realism of the model, and the **content validity,** assessed by 6 questions regarding the usefulness of the model during the different steps of the training procedure. Additionally, there were three questions requiring written responses referring to the strengths and weaknesses of the simulator and a global yes/no question as to whether or not they would repeat this experience. The questionnaire is provided as a supplementary file.

2.4. Data analysis

A descriptive analysis was performed for each dimension. Then, the groups were compared according to their level of expertise with an independent sample *t*-test. An Exploratory Factor Analysis was performed to explore the factorial structure of the 11-items scale in the sample, first we performed a principal components analysis. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis. A Confirmatory Factor Analysis (CFA) was estimated, using a Weighted Least Squares Mean Variance adjusted (WLSMV). This estimation works best for the ordinal data [3]. Fitness was calculated using chi-square (χ^2) test, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). A non-significant χ^2, CFI and TLI greater than 0.90 and RMSEA $<$ 0.08 were considered an acceptable fit [4]. To evaluate the reliability of the items considered in the questionnaire, the internal consistency was explored in the items selected in the confirmatory factor analysis with an alpha coefficient. All data analysis was performed using IBM SPSS 23.0 statistical software. Data are reported as mean + standard deviation (SD). A probability $p<.05$ was considered significant.

Ethics Statement

This study was approved by the Ethics Committee of Health Science, Pontificia Universidad Católica de Chile (ID: 210319004). All the participant data were fully anonymized, and the study protocol was conducted according to the Declaration of Helsinki.

CRediT author statement

Francisco Mery: Conceptualization, Methodology, Writing - original draft preparation, Writing - reviewing, and editing; **Carolina Méndez-Orellana:** Formal analysis, Writing - reviewing & editing; **Javier Torres:** Formal analysis; **Francisco Aranda:** Conceptualization, Methodology, Writing - original draft preparation; **Iván Caro:** Conceptualization, Methodology, Writing; **José Pesenti:** Formal analysis; **Ricardo Rojas:** Conceptualization, Methodology, Writing; **Pablo Villanueva:** Writing - reviewing and editing; **Isabelle Germano:** Conceptualization, Methodology, Writing - original draft preparation, Writing - reviewing & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.107258.

References

[1] F. Mery, F. Aranda, C. Méndez-Orellana, I. Caro, J. Pesenti, J. Torres, R. Rojas, P. Villanueva, I. Germano, A reusable low-cost 3D training model for aneurysm clipping, World Neurosurg. 147 (2021) 29–36, doi:10.1016/j.wneu.2020.11.136.
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