In Reply to the Letter to the Editor Regarding "A Review of Physical Simulators for Neuroendoscopy Skills Training"

LETTER:

We sincerely thank Salmas et al. for their keen interest in our study. We find their comments pertinent to the issue addressed. However, our review was more tailored to the evaluation of skills training and the validation studies of physical simulators in neuroendoscopy. Hence the keywords chosen were based on direct relevance to the objective.[1] "3D printing" or "3D printed" technique is a subset of the fabrication methods used to develop physical simulators. Even in our study, we included synthetic simulators developed by 3D printing techniques that reported surgical skills evaluation in neuroendoscopy. As mentioned in our article, we included the majority of the studies, and there were 8 articles that used 3D printing for fabrication of simulator. The articles in the letter cited by Salmas et al. are majorly catering toward the method of development of 3D printed models. The main objective in these articles was regarding the manufacturing methods of the simulators, supported by some validation studies. As our review was not limited to the development of a particular kind of simulator, the cited articles only form an extension to the already included experimental studies and the conclusions derived from the review remains uninfluenced.

Our review primarily focused on the neuroendoscopy techniques, such as endoscopic third ventriculostomy and endoscopic endonasal transsphenoidal surgery. In our review, nonneurosurgical studies that appeared in the search and could accommodate to the skills training in neurosurgery were included. Furthermore, our focus was not on all the endonasal simulators developed for rhinologists and otolaryngologists, and hence some of the studies cited by Salmas et al. did not explicitly appear in our search. Our study was also specific to physical simulators that provide hands-on skills training for development of fundamental technical psychomotor skills and not on anatomic orientation or endoscopy-assisted surgeries. The precise descriptions about the cited articles, target trainees, skills training, and validation methods are included in **Table 1**.[2-11]

We agree that inclusion of the keywords "3D printing" or "3D printed" would have yielded more articles on this topic. However, we would like to reiterate the fact that the obtained conclusions on the state of physical simulators and need for extensive validation studies for their inclusion into neurosurgery curriculum remains the same. We take this comment as a positive criticism and are encouraged to enrich the published literature with the commentary on the same.

***Britty Baby*[1,2], *Ramandeep Singh*[1], *Rajdeep Singh*[1], *Ashish Suri*[1,2]**

From the [1]Department of Neurosurgery, All India Institute of Medical Sciences, New Delhi; and [2]Amar Nath and Shashi Khosla School of Information Technology, Indian Institute of Technology Delhi, New Delhi, India

To whom correspondence should be addressed: Ashish Suri, M.B.B.S., M.Ch., D.N.B. (NS) [E-mail: surineuro@gmail.com]

Conflict of interest statement: This manuscript is the result of research projects funded by extramural grants: 1. Department of Health Research (DHR) Ministry of Health and Family Welfare, Govt. of India. Project Number: GIA/03/2014-DHR; V25011/260-HRD/2016-HR; 2. Department of Science and Technology (DST), Ministry of Science and Technology, Govt. of India. Project Number: SR/FST/LSII-029/2012; and 3. Department of Biotechnology (DBT), Ministry of Science and Technology, Govt. of India. Project Number: i) BT/PR13455/CoE/34/24/2015, (ii) BT/HRD/35/01/01/2015, (iii) BT/HRD/NBA/37/01/2014.

https://doi.org/10.1016/j.wneu.2020.06.127.

REFERENCES

1. Baby B, Singh R, Singh R, et al. A review of physical simulators for neuroendoscopy skills training. *World Neurosurg*. 2020;137:398-407.

2. Ding CY, Yi XH, Jiang CZ, et al. Development and validation of a multi-color model using 3-dimensional printing technology for endoscopic endonasal surgical training. *Am J Transl Res*. 2019;11:1040-1048.

3. Zhuo C, Lei L, Yulin Z, et al. Creation and validation of three-dimensional printed models for basic nasal endoscopic training. *Int Forum Allergy Rhinol*. 2019;9:695-701.

4. Barber SR, Wong K, Kanumuri V, et al. Augmented reality, surgical navigation, and 3D printing for transcanal endoscopic approach to the petrous apex. *OTO Open*. 2018;2:2473974X18804492.

5. Yoshiyasu Y, Chang DR, Bunegin L, et al. Construct validity of a low-cost medium-fidelity endoscopic sinus surgery simulation model. *Laryngoscope*. 2019;129:1505-1509.

6. Zheng JP, Li CZ, Chen GQ, Song GD, Zhang YZ. Three-dimensional printed skull base simulation for transnasal endoscopic surgical training. *World Neurosurg*. 2018;111:e773-e782.

7. Eastwood KW, Bodani VP, Haji FA, Looi T, Naguib HE, Drake JM. Development of synthetic simulators for endoscope-assisted repair of metopic and sagittal craniosynostosis. *J Neurosurg Pediatr*. 2018;22:128-136.

8. Alrasheed AS, Nguyen LHP, Mongeau L, Funnell WRJ, Tewfik MA. Development and validation of a 3D-printed model of the ostiomeatal complex and frontal sinus for endoscopic sinus surgery training. *Int Forum Allergy Rhinol*. 2017;7:837-841.

9. Chang DR, Lin RP, Bowe S, et al. Fabrication and validation of a low-cost, medium-fidelity silicone injection molded endoscopic sinus surgery simulation model. *Laryngoscope*. 2017;127:781-786.

10. Shah KJ, Peterson JC, Beahm DD, Camarata PJ, Chamoun RB. Three-dimensional printed model used to teach skull base anatomy through a transsphenoidal approach for neurosurgery residents. *Oper Neurosurg (Hagerstown)*. 2016;12:326-329.

11. Wen G, Cong Z, Liu K, et al. A practical 3D printed simulator for endoscopic endonasal transsphenoidal surgery to improve basic operational skills. *Childs Nerv Syst*. 2016;32:1109-1116.

Table 1. Description of 3D Printed Models for Surgical Simulation, Target Trainees, and Skills Validation Methods

S. No	Title	Journal, Publication, Date	Neuroendoscopy	Target Trainees	Skills Training and Validation
1	Ding et al. "Development and validation of a multi-color model using 3-dimensional printing technology for endoscopic endonasal surgical training."[2]	*American Journal of Translational Research* 2019;11:1040-1048.	Yes	Otolaryngologists and neurosurgeons	Subjective questionnaire and time taken for drilling, curetting, and biting, and aspiration and manual verification of the status of the shell membrane.
2	Zhuo et al. "Creation and validation of three-dimensional printed models for basic nasal endoscopic training."[3]	*International Forum of Allergy & Rhinology* 2019;9:695-701.	Yes	Rhinology	Face validation, content validation using 5-point Likert scale.
3	Barber et al. "Augmented reality, surgical navigation, and 3D printing for transcanal endoscopic approach to the petrous apex."[4]	*OTO Open* 2018;2:2473974X18804492.	Yes	Otolaryngologists	Physical simulation + augmented reality no validation.
4	Yoshiyasu et al. "Construct validity of a low-cost medium-fidelity endoscopic sinus surgery simulation model."[5]	*The Laryngoscope* 2019;129:1505-1509.	Yes	Rhinology otolaryngology	Task-specific checklist.
5	Zheng et al. "Three-dimensional printed skull base simulation for transnasal endoscopic surgical training."[6]	*World Neurosurgery* 2018;111:e773-e782.	Yes	Neurosurgeons	No specific tasks for hands-on skills, 3D models used for anatomy orientation. Likert questionnaire.
6	Eastwood et al. "Development of synthetic simulators for endoscope-assisted repair of metopic and sagittal craniosynostosis."[7]	*Journal of Neurosurgery: Pediatrics* 2018;22:128-136.	Endoscope-assisted craniosynostosis	Neurosurgeons	All participants completed a 13-item questionnaire (using 5-point Likert scales).
7	Alrasheed et al. "Development and validation of a 3D-printed model of the ostiomeatal complex and frontal sinus for endoscopic sinus surgery training."[8]	*International Forum of Allergy & Rhinology* 2017;7:837-841.	Yes	Rhinologists and otolaryngologists	Subjective questionnaire, 5-point Likert scale, time taken, 19- point survey, content, and construct validity.
8	Chang et al. "Fabrication and validation of a low-cost, medium-fidelity silicone injection molded endoscopic sinus surgery simulation model."[9]	*The Laryngoscope* 2017;127:781-786.	Yes	Rhinologists and otolaryngologists	Seven tasks, subjective 22- point questionnaire, face and content validity.
9	Shah et al. "Three-dimensional printed model used to teach skull base anatomy through a transsphenoidal approach for neurosurgery residents."[10]	*Operative Neurosurgery* 2016;12:326-329.	Yes	Neurosurgeons	No specific tasks for hands-on skills, 3D models used for anatomy orientation.
10	Wen et al. "A practical 3D printed simulator for endoscopic endonasal transsphenoidal surgery to improve basic operational skills."[11]	*Child's Nervous System* 2016;32:1109-1116.	Yes	Neurosurgeons	Objective scoring for drilling, curetting, and aspirating.