ORIGINAL ARTICLE

Design and Validation of an Open-Source, Partial Task Trainer for Endonasal Neuro-Endoscopic Skills Development: Indian Experience

Ramandeep Singh[1], Britty Baby[2], Natesan Damodaran[2], Vinkle Srivastav[2], Ashish Suri[2], Subhashis Banerjee[3], Subodh Kumar[3], Prem Kalra[3], Sanjiva Prasad[3], Kolin Paul[3], Sneh Anand[1], Sanjeev Kumar[4], Varun Dhiman[4], David Ben-Israel[2], Kulwant Singh Kapoor[5]

■ BACKGROUND: **Box trainers are ideal simulators, given they are inexpensive, accessible, and use appropriate fidelity.**

■ OBJECTIVE: **The development and validation of an open-source, partial task simulator that teaches the fundamental skills necessary for endonasal skull-base neuro-endoscopic surgery.**

■ METHODS: **We defined the Neuro-Endo-Trainer (NET) SkullBase-Task-GraspPickPlace with an activity area by analyzing the computed tomography scans of 15 adult patients with sellar suprasellar parasellar tumors. Four groups of participants (Group E, n = 4: expert neuroendoscopists; Group N, n =19: novice neurosurgeons; Group R, n = 11: neurosurgery residents with multiple iterations; and Group T, n = 27: neurosurgery residents with single iteration) performed grasp, pick, and place tasks using NET and were graded on task completion time and skills assessment scale score.**

■ RESULTS: **Group E had lower task completion times and greater skills assessment scale scores than both Group N and R ($P \leq 0.03$, 0.001). The performance of Groups N and R was found to be equivalent; in self-assessing neuroendoscopic skill, the participants in these groups were found to have equally low pretraining scores (4/10) with significant improvement shown after NET simulation (6, 7 respectively). Angled scopes resulted in decreased scores with tilted plates compared with straight plates (30° $P \leq 0.04$, 45° $P \leq 0.001$). With tilted plates, decreased scores were observed when we compared the 0° with 45° endoscope (right, $P \leq 0.008$; left, $P \leq 0.002$).**

■ CONCLUSIONS: **The NET, a face and construct valid open-source partial task neuroendoscopic trainer, was designed. Presimulation novice neurosurgeons and neurosurgical residents were described as having insufficient skills and preparation to practice neuro-endoscopy. Plate tilt and endoscope angle were shown to be important factors in participant performance. The NET was found to be a useful partial-task trainer for skill building in neuroendoscopy.**

INTRODUCTION

Since its introduction to neurosurgery in 1910, endoscopy has revolutionized the approach to skull base and intraventricular surgery, providing patients with safer, minimally invasive alternatives to previously morbid procedures and considerably faster recovery.[1] The neuro-endoscopic technique, however, demands a unique skill-set whose mastery presents a steep learning curve.[2] Historically, learners have struggled with manipulating long instruments, complicated by fulcrum effect, as well as navigating within a distorted, panoramic, nonstereoscopic, and physically constrained operative field.[3,4]

Key words
- Endonasal
- Neuro-endoscopy
- Open source
- Partial task trainer
- Physical simulator
- Simulation
- Skills training
- Skull base

Abbreviations and Acronyms
NET: Neuro-endo-trainer

From the [1]Centre for Biomedical Engineering, Indian Institute of Technology Delhi, New Delhi; [2]Department of Neurosurgery, All India Institute of Medical Sciences, New Delhi; [3]Department of Computer Science and Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi; [4]Central Scientific Instruments Organization (CSIR-CSIO) Sector 30-C, Chandigarh; and [5]Department of Biostatistics, All India Institute of Medical Sciences, New Delhi, India

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

Ramandeep Singh and Britty Baby are co-first authors.

Supplementary digital content available online.

Citation: World Neurosurg. (2016) 86:259-269.
http://dx.doi.org/10.1016/j.wneu.2015.09.045

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

Despite these competency challenges, no literature exists on an evidence-based curriculum for endoscopic training within neurosurgical residency.[5]

The use of simulation in endoscopic surgical skills training was pioneered by work in laparoscopy, which began only in the last 25 years.[6] A breadth of research now exists showing that laparoscopic simulation develops fundamental skills, such as hand-eye coordination, improves performance in the operating room, is cost effective, and leads to rapid acquisition of competence in advanced surgical training.[7–13] In neurosurgical education specifically, simulation has overcome several constraints imposed by the traditional apprenticeship model, including the availability of residents and educators, case exposure, and uncompromised ethical patient care.[14–20] Yet the adoption of simulation in neurosurgical training has been slow. Early work has focused on cadaveric and virtual simulation, which prove to be resource intensive, difficult to distribute widely, and require advanced technology, which has yet to be realized.[21–28] Synthetic physical models, however, have the potential to impart to the learner a fundamental skill-set at low cost, which learners can refine before and alongside exposure to surgical cases.[23,29,30] These fundamentals, including psychomotor skills, acquaintance with non-stereoscopic visual feedback, and proficiency within limited operative space, are prerequisites for realistic success during clinical cases.[31] Synthetic physical models also are advantageous in that they are inexpensive, accessible at all times of day, and use the appropriate level of fidelity to present an applied task, helping the learner to focus on developing the surgically relevant skills needed for neuro-endoscopy. No synthetic physical model, objectively validated as an effective neuro-endoscopic simulator, currently exists.[3,32,33]

The main objective of this study was to develop and validate an open-source synthetic physical partial task simulator, which successfully trains the fundamental skills useful in neuro-endoscopic surgery, with an emphasis on endonasal approaches. An attempt also was made to establish baseline competency of neurosurgeons and neurosurgery residents at various stages of training.

MATERIALS AND METHODS

Development of the Neuro-Endo-Trainer (NET) SkullBase-Task-Grasp PickPlace

We began the development of the synthetic physical model by replicating the dimensions of the surgical field in endonasal endoscopic skull base surgery. A total of 15 consecutive patients between the ages of 18 and 60 years who underwent sellar-suprasellar-parasellar endoscopic endonasal surgery between May and June of 2013 were analyzed. All measurements, either taken directly through physical examination or from preoperative computed tomography imaging studies, were averaged over all 15 patients. Preoperatively, the largest cross-sectional dimension between the nares was measured. On computed tomography in the sagittal plane, distances were defined between the (a) nasal vestibule, (b) anterior aspect of the cribriform plate, (c) tuberculum sellae, and (d) inferior border of the clivus (Figure 1A). In the coronal plane, the (e–f) intercarotid and (g–h) interlateral opticocarotid recess distances were measured (Figure 1B).

Using these data, we constructed a rectangular 110 × 80-mm activity plate with orthogonally oriented pegs situated in a light-proof box with an entry port for endoscopic instrumentation (Table 1; Figure 2). Then, 1.5-mm thick, 12-mm diameter rings were fashioned and placed on the pegs to be used during endoscopic training. The plate was positioned 90 mm from the entry port on a motorized base at a fixed angle of 45° from the horizontal and was rotatable about the vertical axis by 50° both in the clockwise and counterclockwise directions. Two versions of the activity plate were designed, one flat and one with a trough to replicate increased depth after access into the sphenoid sinus.

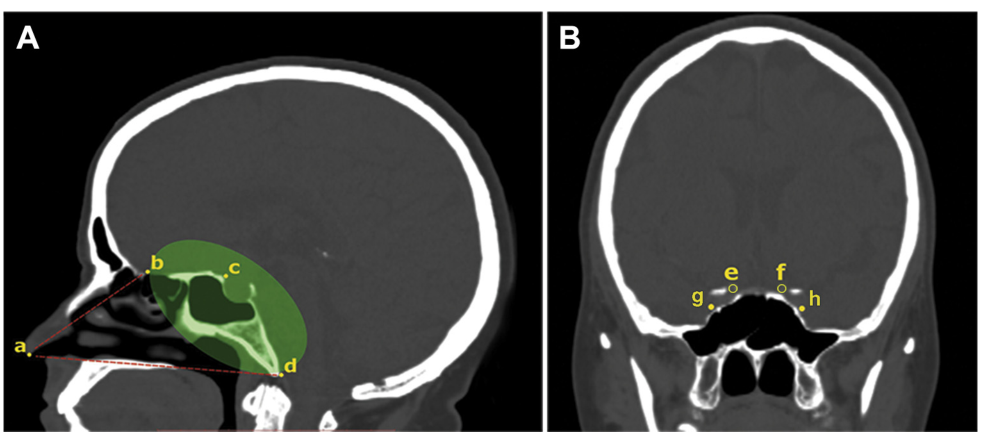

Figure 1. Endoscopic endo-nasal skull base approach operating area: a, nasal vestibule; b, cribriform plate; c, tuberculum sellae; c′, floor of sella; d, inferior margin of clivus; e, right internal carotid artery; f, left internal carotid artery; g, right lateral opticocarotid recess; h, left lateral opticocarotid recess. (**A**) Sagittal view. Line "ab" corresponds to the anterior most trajectory of the endoscope; line "ad" to posterior inferior trajectory of the endoscope; line "bcd" denotes the operative field in the midline. The green eclipse denotes the operative reach of Endoscopic Endo-nasal Skull Base approach. (**B**) Line "ef" denotes intercarotid distance; line "gh" denotes distance between lateral opticocarotid recesses.