Acta Neurochir (2014) 156:1403–1407
DOI 10.1007/s00701-014-2035-7

EXPERIMENTAL RESEARCH - NEUROSURGERY TRAINING

The chicken egg and skull model of endoscopic endonasal transsphenoidal surgery improves trainee drilling skills

Takeshi Okuda · Juli Yamashita · Mitsugu Fujita · Hiromasa Yoshioka · Takayuki Tasaki · Amami Kato

Received: 14 December 2013 / Accepted: 10 February 2014 / Published online: 8 March 2014

Abstract
Background We verified the effectiveness of training in endoscopic endonasal transsphenoidal surgery (eETSS) techniques using chicken eggs and a skull model.
Methods We verified the area of eggshell removed by drilling when five residents and four experts used the chicken eggs and a skull model.
Results When residents performed drilling on 10 eggs, a mean (± standard deviation [SD]) area of 31.2 ± 17.5 mm2 was removed from the first egg, and 104.8 ± 3.3 mm2 from the tenth and final egg, representing an increase in area and a decrease in SD. The experts performed the same drilling operation on a single egg, and removed a mean area of 257± 31.7 mm2. These results demonstrated that skills improved as a result of this training, and suggested that this method was also capable of overcoming the initial individual differences in the amount of force applied and ability. An obvious difference between residents and experts was seen in the area removed ($p = 0.00011$); however, this was attributed to differences in endoscopic manipulation, rather than drilling skill.
Conclusion Our findings suggest that this training method could be adequate for acquiring eETSS techniques. Although experts showed superior endoscopic manipulation, residents may also be able to acquire adequate endoscopic skills through further training, and our training method appears to offer an effective means of improving eETSS techniques.

Keywords Endoscopic endonasal transsphenoidal surgery · Training · Chicken egg

Introduction

The use of endoscopic endonasal transsphenoidal surgery (eETSS) has been rapidly adopted since it was first reported for the treatment of pituitary tumors in the early 1990s [4, 5]. A variety of skull base closure methods have recently been developed and are now being used for parasellar lesions; they are also being used more widely in the skull base region [6, 7]. However, eETSS is a highly specialized procedure that requires training to master [1, 13]. Cadaver dissection and hands-on seminars are both used, but these chiefly focus on understanding the surgical anatomy [10], and training in surgical techniques is not yet as advanced as that available for microscopic surgery [2, 3]. The expanding use of eETSS in recent years to cover a wider range of conditions means that training in eETSS techniques similar to that for microscopic surgery will become more important in the future. We have previously reported a specialized training method for eETSS techniques that utilizes chicken eggs and a skull model [11]. This method has low running costs and can be used for repeated practice, meaning that it has the potential to contribute to improving eETSS techniques. The present study investigated the value of this method in training residents in eETSS techniques.

Methods

Subjects comprised five residents, with two in post-graduate year (PGY)-2, one in PGY-3, and two in PGY-4. No subjects had any experience in neuroendoscopic surgery. An Okuda

T. Okuda (✉) · H. Yoshioka · T. Tasaki · A. Kato
Department of Neurosurgery, Kinki University Faculty of Medicine, 377-2 Ohno-Higashi, Osaka-Sayama, Osaka 589-8511, Japan
e-mail: okuda@med.kindai.ac.jp

J. Yamashita
Human Technology Research Institute, National Institute of Advanced Industrial Science and Technology, Ibaraki, Japan

M. Fujita
Department of Microbiology, Kinki University Faculty of Medicine, Osaka, Japan

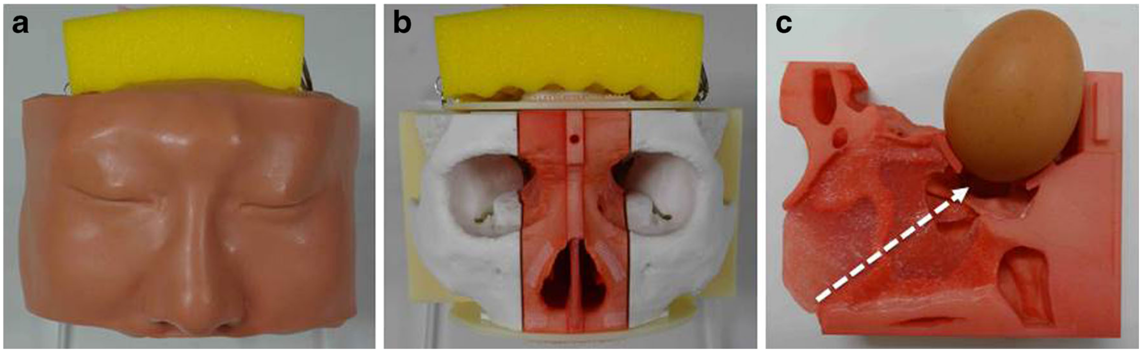

Fig. 1 External appearance of the Okuda training model. **a** Frontal view of the facial simulation model. The egg is secured by pressure from the sponge above it. **b** Frontal view with the facial simulation model removed. The nasal cavity and nasal sinuses are constructed from three Plates. **c** Side view of the model. The anterior wall of the sphenoid has been removed in advance. The posterior part of the nasal septum can easily be cut in the desired location (it has already been cut in this photograph). The white arrow is operative view

training model (SurgTrainer, Ibaragi, Japan) was used as the training model (Fig. 1). This model is made using 3-dimensional (3D) printing technology to reproduce the nasal cavity and nasal sinuses from patient computed tomography scans as 3D plates, recreating a more realistic operative field (Fig. 2). This depicts the nasal ala of the facial model with greater reality, reproducing both its flexibility and the degree of displacement caused by surgical instruments (Fig. 3). As training with this model starts from the sellar floor, the anterior wall of the sphenoid is removed in advance. The sellar floor area is also open, but a chicken egg is inserted in this area to create a simulated tumor. The eggshell is extremely thin, with an inner shell membrane composed of extremely fragile tissue. Rough drilling not only fractures the shell but also easily ruptures the shell membrane, resulting in leakage of the contents. In this study, we measured the area of eggshell that could be removed by drilling without fracturing the shell membrane. This area was measured by attaching Inkjet Printable Temporary Tattoo Paper (squared paper, 2 mm× 2 mm) to the eggs used for measurement, with each subject

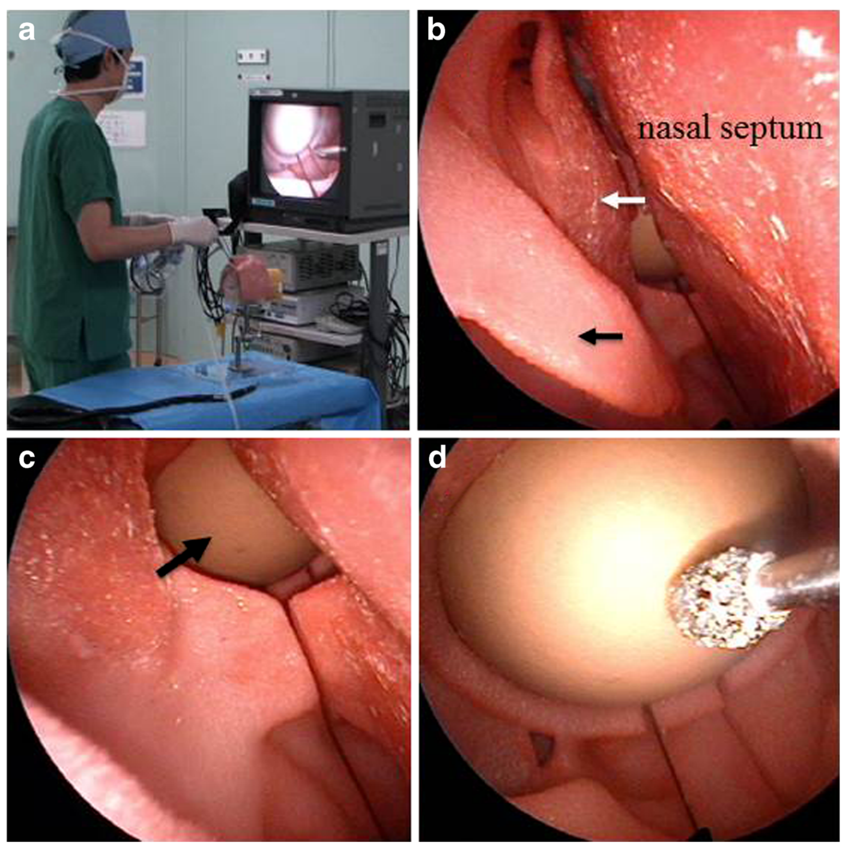

Fig. 2 Endoscope inserted into the model. **a** Actual training in progress. **b** The endoscope inserted from the right nasal cavity. The front right black arrow indicates the inferior nasal concha, and the back white arrow indicates the middle nasal concha. Part of the chicken egg is also visible at the back. **c** The endoscope is further inserted. As the anterior wall of the sphenoid has already been removed, the inside of the sphenoid sinus is visible, and the egg that forms the simulated sellar floor can be seen (*arrow*). **d** The endoscope inserted into the sphenoid sinus. The egg appears just like a sellar floor that has ballooned

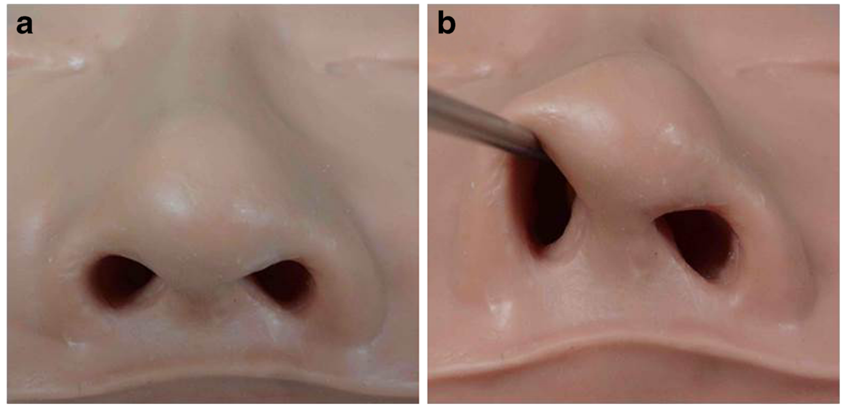

Fig. 3 Nasal ala in the model. **a** No displacement of the nasal ala. **b** With the nasal ala displaced. The nasal ala faithfully reproduces the hardness of the living body, giving the user the same experience of inserting surgical instruments by displacing the ala as that during actual clinical surgery. Two or three instruments can be inserted from one side, enabling the user to experience a more realistic unilateral approach

performing simulated eETSS using 10 eggs (Fig. 4). The data thus obtained were compared with the areas removed by experts (one-way analysis of variance, 1 % level). The experts used only a single chicken egg. The endoscope used was a 4-mm, 0° endoscope (EndoArm; Olympus, Tokyo, Japan).

Results

Data from the five residents showed that they removed a mean (±standard deviation [SD]) area of 31.2±17.5 mm^2 on the first try. For all residents, the area removed increased in proportion to the number of eggs used (Fig. 5). SD was clearly decreased for the tenth and final egg, with an area of 104.8±3.3 mm^2 removed. The mean area removed by the four experts (individual data: 236, 240, 248 and 304) was 257±31.7 mm^2, with an obvious significant difference between this and the area removed by residents (p=0.00011) (Fig. 6).

Discussion

Data from the five residents showed that the area of eggshell removed increased in proportion to the number of eggs used. This result demonstrated that drilling skills were improved using this method. Individual differences in the area that could be removed were evident on the initial try; this may be attributed to differences in individual ability and the amount of force applied. After continued training, however, SD decreased and no great differences were observed between the five residents in the area removed from the final tenth egg. This finding indicated that differences in individual ability and the amount of force applied were resolved through training. It has been reported that eETSS entails a learning curve, and the present results may be described as indicating a similar finding [8, 9, 12]. However, the results from inexperienced residents were obviously inferior to those from the experts. This may have been due to differences in the ability to manipulate the endoscope. Residents kept the position of the endoscope almost fixed while drilling, observing the procedure from practically a single direction. In contrast, experts effectively displaced the nasal ala to ensure that the operative field encompassed both sides and the anterior and posterior directions, providing a wider drillable area of shell. If residents could undergo further training in endoscopic manipulation, their skills would presumably improve further.

Because this model is similar to eETSS and the instruments are the same, it is reasonable to assume that the skills would be transferable. In addition, the surgeons who perform eETSS

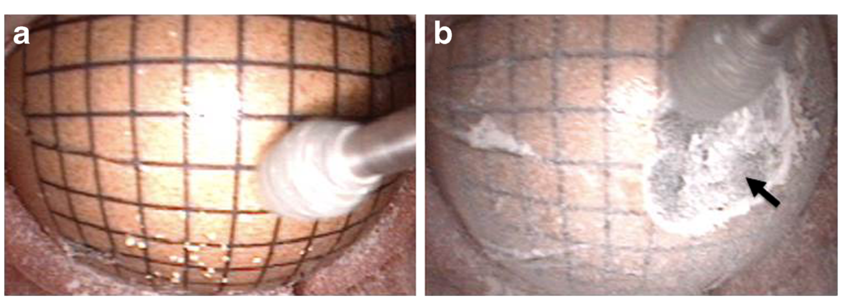

Fig. 4 Eggshell drilling test. **a** Inkjet Printable Temporary Tattoo Paper (squared paper, 2 mm×2 mm) is attached to the egg, and only the shell is drilled. **b** Example of an egg from which only the shell has been drilled. The shell membrane can be seen underlying the region of removed shell (*arrow*)

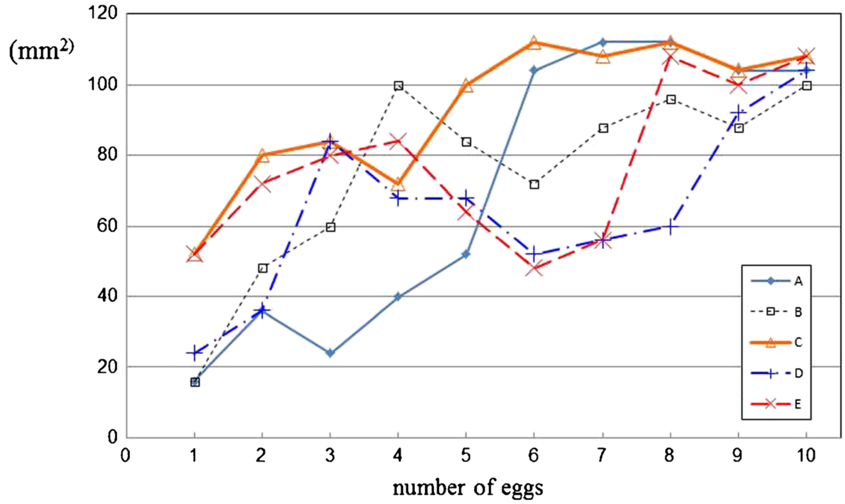

Fig. 5 Comparison of areas removed by five residents. On the first try, the five residents removed 31.2±17.5 mm^2 (mean ± SD). For all residents, the area removed increased in proportion to the number of eggs used, reaching 104.8±3.3 mm^2 for the tenth and final egg

were much better from the outset than residents, and the residents, through training, were moving toward where experienced surgeons were. Hence, our findings suggest that this training method may be used to facilitate the acquisition and improvement of eETSS techniques.

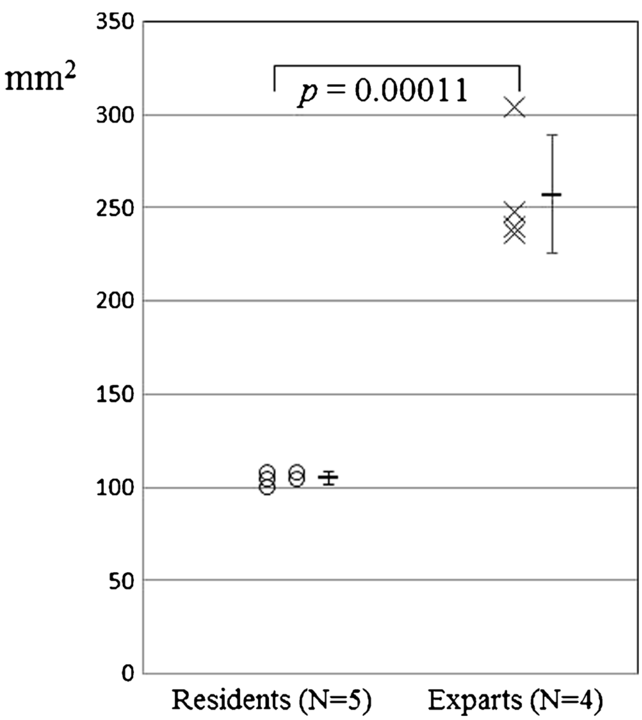

Fig. 6 Comparison of areas removed by residents and experts. We compared the results of the five residents for the tenth egg, from which the greatest area was removed, with the results from four experts. The mean area removed by the experts was 257±31.7 mm^2, with an obvious significant difference between this and the area removed by residents

Disclosure Dr. Kato has received support from GlaxoSmithkline K.K. and Otsuka Pharmaceutial Co., Ltd for non-study-related clinical or research efforts. Other authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this manuscript.

Author contributions to the study and manuscript preparation include the following. Conception and design: Okuda, Yamashita. Acquisition of data: all authors. Drafting the article: Okuda, Yamashita, Fujita. Critically revising the article: all authors. Approval of the final version of the manuscript on behalf of all authors: Okuda. Study supervision: Kato.

This study has no financial support.

References

1. Hanna GB, Shimi S, Cuschieri A (1997) Optimal port locations for endoscopic intracorporeal knotting. Surg Endosc 11:397–401
2. Hino A (2003) Training in microvascular surgery using a chicken wing artery. Neurosurgery 52:1495–1498
3. Inoue T, Tsutsumi K, Adachi S, Tanaka S, Saito K, Kunii N (2006) Effectiveness of suturing training with 10–0 nylon under fixed and maximum magnification (×20) using desk type microscope. Surg Neurol 66:183–187
4. Jankowski R, Auque J, Simon C, Marchal JC, Hepner H, Wayoff M (1992) Endoscopic pituitary tumor surgery. Laryngoscope 102:198–202
5. Jho HD, Carrau RL (1997) Endoscopic endonasal transsphenoidal surgery: experience with 50 cases. J Neurosurg 87:44–51
6. Kassam AB, Thomas A, Carrau RL, Snyderman CH, Vescan A, Prevedello D, Mintz A, Gardner P (2008) Endoscopic reconstruction of the cranial base using a pedicled nasoseptal flap. Neurosurgery 63: ONS44–ONS53
7. Kassam AB, Prevedello DM, Carrau RL, Snyderman CH, Thomas A, Gardner P, Zanation A, Duz B, Tonya Stefko S, Byers K, Horowitz MB (2011) Endoscopic endonasal skull base surgery: analysis of complications in the authors' initial 800 patients. J Neurosurg 114:1544–1568
8. Koc K, Anik I, Ozdamar D, Cabuk B, Keskin G, Ceylan S (2006) The learning curve in endoscopic pituitary surgery and our experience. Neurosurg Rev 29:298–305
9. Leach P, Abou-Zeid AH, Kearney T, Davis J, Trainer PJ, Gnanalingham KK (2010) Endoscopic transsphenoidal pituitary

surgery: evidence of an operative learning curve. Neurosurgery 67(5):1205–1212

10. Nogueira JF, Stamm AC, Lyra M, Balieiro FO, Leão FS (2008) Building a real endoscopic sinus and skull-base surgery simulator. Otolaryngol Head Neck Surg 139:727–728
11. Okuda T, Kataoka K, Kato A (2010) Training in endoscopic endonasal transsphenoidal surgery using a skull model and eggs. Acta Neurochir 152:1801–1804
12. O'Malley BW Jr, Grady MS, Gabel BC, Cohen MA, Heuer GG, Pisapia J (2008) Comparison of endoscopic and microscopic removal of pituitary adenomas: single-surgeon experience and the learning curve. Neurosurg Focus 25: E10
13. Yang I, Wang MB, Bergsneider M (2010) Making the transition from microsurgery to endoscopic transsphenoidal pituitary neurosurgery. Neurosurg Clin N Am 21:643–651