Impact of Dynamic Endoscopy and Bimanual-Binarial Dissection in Endoscopic Endonasal Surgery Training: A Laboratory Investigation

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J Neurol Surg B 2015;76:365–371.

Abstract

Objective The lack of a standard technique may be a relevant issue in teaching endoscopic endonasal surgery (EES) to novice surgeons. The objective of this article is to compare different endoscope positioning and microsurgical dissection techniques in EES training.

Methods A comparative trial was designed to evaluate three techniques: group A, one surgeon performing binarial two-hands dissection using an endoscope holder (rigid endoscopy); group B, two surgeons performing a combined binarial two- and three-handed dissection with one surgeon guiding the endoscope (dynamic endoscopy); and group C, two surgeons performing a binarial two-hands dissection with one surgeon dedicated to endoscope positioning and the other dedicated to a two-handed dissection. Trainees were randomly assigned to these groups and oriented to complete surgical tasks in a validated training model for EES. A global rating scale, and a specific-task checklist for EES were used to assess surgical skills.

Results The mean scores of the global rating scale and the specific-task checklist were higher ($p = 0.001$ and 0.002 , respectively) for group C, reflecting the positive impact of dynamic endoscopy and bimanual dissection on training performance.

Conclusions We found that dynamic endoscopic and bimanual-binarial microdissection techniques had a significant positive impact on EES training.

Keywords

- ▶ endoscopic endonasal surgery
- ▶ surgical technique
- ▶ surgical training
- ▶ performance assessment

Introduction

Endoscopic endonasal surgery (EES) of the pituitary and cranial base is associated with a long learning curve.^{1–4} A structured program based on the difficulty of the surgical approach,⁴ combined with a modular anatomical approach, has been used for surgical training and to minimize surgical morbidity.^{5–7} By following this program, trainees must incrementally acquire surgical skills to master simple procedures before proceeding to the next level of difficulty.

These procedures are usually performed in close collaboration between neurosurgeons and otolaryngologists. Nonetheless, peer-reviewed literature and national and international presentations reveal there is no standard technique used for this type of surgery. Three different techniques have been commonly and successfully applied: one single surgeon performing bimanual-binarial dissection using a mechanical holder for endoscope positioning; two surgeons performing a combined two-to three-handed dissection, where one surgeon

received

October 22, 2014

accepted after revision

November 25, 2014

published online

May 13, 2015

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Stuttgart · New York

DOI <http://dx.doi.org/10.1055/s-0034-1544124>.
ISSN 2193-6331.

Fig. 1 Schematic drawing showing the different surgical techniques. Group A shows rigid endoscopy by using an endoscope holder (H) on the right nostril and one single surgeon (D1) performing bimanual-binarial dissection. Group B shows dynamic endoscopy (E1). Note that the surgeon who guides the endoscope also performs one-hand dissection (D1). The second surgeon performs uni- or bimanual uninarial dissection (D2). Group C shows the division of labor between the two surgeons. While one surgeon is dedicated to endoscope positioning (E1), the second surgeon performs bimanual-binarial dissection (D2).

guides the endoscope and simultaneously performs a one-hand dissection while the second surgeon performs uni- or bimanual-uninarial dissection; and two surgeons, one fully dedicated to endoscope positioning and another one fully dedicated to bimanual-binarial dissection.^{3,8}

Teaching safe and efficient technique is one of the most important steps of any surgical training program. The lack of a standard technique for (EES) may limit progression along this long learning curve. We consider standardization an important tool to establish instructional methods that may be more universally applied. Therefore, the main objective of this article is to compare different endoscope positioning and microsurgical dissection techniques in EES training.

Material and Methods

This study was conducted at the Surgical Neuroanatomy Laboratory of the University of Pittsburgh. A randomized comparative trial was designed to evaluate objectively the

three previously mentioned surgical techniques used for EES as follows (►Fig. 1):

Group A: One single surgeon performing binarial two-hands dissection using an endoscope holder (rigid endoscopy). If desired, the surgeon could change the position of the endoscope at any time during the exercise.

Group B: Two surgeons performing a combined binarial two- and three-handed dissection with one surgeon guiding the endoscope (dynamic endoscopy).

Group C: Two surgeons performing a binarial two-hands dissection with one surgeon fully dedicated to endoscope positioning and the other one fully dedicated to a two-handed dissection.

Participant Trainees and Training Session

Twelve trainees without any or very limited experience (< 10 surgeries) with EES volunteered to participate in this study. They were randomly assigned to three groups and oriented to complete surgical tasks in a validated training model for EES:

Fig. 2 Chicken wing training model (CWTM): surgical tasks. Endoscopic view. (A) Egg drilling as a simulation of bony dissection; CWTM showing different aspects of dissection. (B) Skin opening. (C) Initial exposure of the perivascularonervous sheath. (D) Final exposure of the perivascularonervous sheath. (E) Opening of the perivascularonervous sheath. (F) Neurovascular dissection.

the chicken wing training model (CWTM).⁹ Thereafter, the training sessions were randomly performed five times for each trainee (three times dissecting and two times dynamically guiding the endoscope) to minimize intervention biases (e.g., proficiency bias). A total of 36 procedures were recorded and evaluated.

The CWTM and the four tasks previously described were used for soft tissue dissection.⁹ To simulate a bony dissection, the trainees were asked to drill the shell of a chicken egg without compromising its inner membrane (►Fig. 2).

Assessment Tools

All procedures were time monitored, video recorded, and randomly submitted for a blind evaluation done by an expert in EES with the intention of minimizing expectation and experimenter bias as well as to evaluate the reliability of the model and its measurement tools. Two scoring methods were used for objective assessment of the surgical skills: a recognized global rating scale¹⁰ slightly simplified for the aim of this study (►Fig. 3) and a newly developed specific-task checklist for EES (►Fig. 4). Higher scores indicate improved performance.

PROCEDURE-SPECIFIC CHECKLIST			
Length of procedure:			
Activity	correct	satisfactory	incorrect
ENDOSCOPE POSITIONING			
Appropriate distance from target	2	1	0
Optimal field of view	2	1	0
Interference with instrumentations	2	1	0
SURGICAL EXPOSURE			
Drilling eggshell preserving inner memb.	2	1	0
Opening skin joint-to-joint	2	1	0
Exposure of perivascularonervous sheath	2	1	0
MICROSURGICAL DISSECTION			
Opening the perivascularonervous sheath	2	1	0
Neurovascular dissection	2	1	0
FINAL SCORE			

Fig. 3 Scoring of specific-task checklist for endoscopic endonasal surgery.

The scores for each specific activity were grouped in three different categories (endoscope positioning, surgical exposure, and microsurgical dissection) and graded to provide meaningful benchmarks and minimize systematic errors of evaluation. The expert determined, subjectively, how a

Respect for tissue	1	2	3	4	5
Frequently used unnecessary force on tissue or caused damage by inappropriate use of instruments			Careful handling of tissue but occasionally caused inadvertent damage		Consistently handled tissues appropriately with minimal damage
Time and motion	1	2	3	4	5
Many unnecessary moves			Efficient but some unnecessary moves		Economy of movement and maximum efficiency
Instrument handling	1	2	3	4	5
Repeatedly makes tentative or awkward moves with instruments by inappropriate use of instruments			Competent use of instruments but occasionally appeared stiff or awkward		Fluid movement with instruments and no awkwardness
Flow of operation	1	2	3	4	5
Frequently stopped operating and seemed unsure of the next move			Demonstrated forward planning with reasonable progression of procedure		Obviously planned course of operation with effortless flow from one move to the next
Use of endoscope	1	2	3	4	5
Placed poorly or failed to use effectively			Appropriate use most of the time		Strategically used to the best advantage at all times
Overall performance	1	2	3	4	5
Very poor			Competent		Clearly superior
Quality of final dissection	1	2	3	4	5
Very poor			Competent		Clearly superior
TOTAL SCORE					

Fig. 4 Simplified global rating scale of operative performance.

These exercises are valid instruments for surgical training				
1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree
These exercises help acquire surgical skills				
1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree
After these exercises, I can recognize the differences between the three techniques				
1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree
Working with an active partner increased my confidence				
1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree
Working with an active partner improved my performance				
1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree
I felt more comfortable and confident using the two-hand dissection technique				
1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree

Fig. 5 Self-assessment questionnaire.

specific activity was executed. The levels determined were “correct” when the task could be accomplished efficiently with no or very few errors; “satisfactory” when some errors occurred but the task could be accomplished without any major errors; and “incorrect” when several mistakes could be observed or the task was incompletely performed.

Lastly, a self-assessment questionnaire using a Likert scale was provided to all trainees to provide further validation of the training session (► **Fig. 5**). The Kruskal-Wallis test was used for statistical analysis. A p value < 0.05 was considered significant.

Results

Detailed results are depicted in ► **Table 1** and ► **Fig. 6**. The mean scores of the global rating scale and the specific-task checklist for EES were 24.83 and 12.58 for group A, 22.83 and 12.08 for group B, and 31.42 and 14.58 for group C ($p = 0.001$ and 0.002 , respectively) reflecting the positive impact of dynamic endoscopy and bimanual dissection on training performance. The mean time to complete the training session was 58.2 minutes for group A, 72 minutes for group B, and 45 minutes for group C ($p = 0.092$). The mean score of the self-assessment questionnaire was 27.7 (range: 24–30). All trainees subjectively agreed that the CWTM was a useful tool for surgical training, and they emphasized that working with a partner significantly increased their confidence and performance.

The analysis of each subcategory of the specific-task checklist for EES showed a mean score of 4.42, 4.25, and 5.67 for “endoscope guidance” ($p = 0.0001$); 5.25, 5.17, and 5.17 for “surgical exposure” ($p = 0.930$); and 2.92, 2.67, and 3.75 for “microsurgical dissection” ($p = 0.002$) with groups A, B, and C, respectively (► **Fig. 7**).

Discussion

The goal of surgical training is the acquisition of knowledge, attitudes, and skills to decrease morbidity, improve outcomes, and promote efficiency. Attempts at improving surgical education began in Paris about AD 1210 at the Collège de Saint-Côme and were followed by a remarkable evolution in surgical education over the ensuing centuries. Most recently, many factors such as increased concerns for patient safety, limited resident working hours, financial pressure, development of new technologies, and early specialization have forced a paradigm shift in surgical training programs. Many different models have been proposed to optimize the effectiveness of training programs by promoting a faster and safer acquisition of surgical skills. However, the effectiveness depends on a variety of factors including characteristics of the learner, learning objectives, and features of the training system, for example, the peculiarities of the surgical technique being trained.^{11–16}

Over the past 20 years, endoscopic endonasal approaches have been increasingly adopted as part of the armamentarium of the skull base surgeon with many different surgical techniques currently applied. The lack of a standard technique, however, may limit the development of educational programs to ensure its safety and efficacy.³ A comparison of different surgical techniques performed by different surgeons at different sites does not provide a truly valid and reliable assessment of surgical safety and efficacy.¹⁶ Therefore, to overcome these difficulties, we conducted this laboratory investigation with inexperienced surgeons to assess the impact of dynamic endoscopy and bimanual-binarial dissection on EES training.

Table 1 Evaluation of training performance

Video no.	Specific performance (maximum score: 16)	General performance (maximum score: 35)	Time	Technique
V1	11	19	111 min, 53 s	A
V2	14	30	26 min, 27 s	A
V3	13	22	52 min, 04 s	A
V4	12	26	60 min, 24 s	C
V5	15	29	49 min, 43 s	B
V6	10	21	36 min, 40 s	B
V7	16	35	59 min, 48 s	C
V8	13	29	29 min, 44 s	B
V9	15	34	28 min, 20 s	C
V10	14	23	68 min, 51 s	C
V11	13	27	46 min, 40 s	B
V12	13	25	44 min, 47 s	C
V13	13	19	183 min, 14 s	B
V14	16	35	43 min, 10 s	A
V15	13	27	52 min, 04 s	A
V16	11	19	100 min, 41 s	B
V17	12	23	49 min, 55 s	A
V18	11	21	92 min, 30 s	B
V19	10	21	57 min, 01 s	B
V20	14	27	61 min, 01 s	A
V21	14	32	55 min, 07 s	C
V22	16	34	33 min, 27 s	C
V23	14	27	70 min, 29 s	B
V24	15	34	32 min, 14 s	C
V25	11	21	59 min, 47 s	A
V26	11	23	55 min, 02s	A
V27	12	20	45 min, 23 s	B
V28	16	35	45 min, 59 s	C
V29	13	26	61 min, 10 s	A
V30	12	22	92 min, 12 s	B
V31	13	31	42 min, 26 s	C
V32	12	25	37 min, 12	A
V33	15	33	29 min, 13 s	C
V34	11	19	62 min, 40 s	B
V35	16	35	38 min, 49 s	C
V36	11	20	87 min, 42 s	A

Assessment of Surgical Techniques

Performance assessments may establish cut-off points and ensure standards to be used in surgical practice. However, the measurement of surgical performance is an extraordinarily complex task. Assessment tools need to be valid, reliable, and properly aligned to a suitable surgical training model. The combination of rating scales and self-assessment question-

naires has proven to be a useful tool in evaluating surgical skills and the feasibility of training models.^{11–16} Using this approach, along with the CWTM, we were able to simulate an adequate training environment for EES.

Global rating scales are useful in measuring the overall quality of a surgical procedure, but they are unable to specify a skill deficiency. In contrast, procedure-specific scales are

Fig. 6 Graphical analysis of main data. Box and whisker plots illustrating scores of the global rating scale (left) and specific-task checklist for endoscopic endonasal surgery (center) for each group. The training performance was significantly better on group C compared with groups A and B; Right: box and whisker plot illustrating operative time, in hours, for each group. This difference was not statistically significant.

Fig. 7 Graphical analysis of specific-task checklist for endoscopic endonasal surgery. Box and whisker plots illustrating scores of endoscope positioning (left), surgical exposure (center), and microsurgical dissection (right) for each group. Endoscope positioning and microsurgical dissection performances were significantly better for group C compared with groups A and B.

designed to cover in detail all relevant aspects of an operation to identify at which part a deficiency may be present. Combining both types of rating scales helps identify the factors that may be responsible for an overall poor performance.¹⁶ As supported by our data, the use of dynamic endoscopy and bimanual-binarial dissection in an EES training model had a positive impact on trainee's performance.

Broadbent proposed the concept that an individual has a finite capacity for attention.¹⁷ Based on it, Gallagher et al described a conceptual framework on learning modules where a master surgeon has significantly more attentional resources than a novice surgeon.¹⁴ Furthermore, Hsu et al demonstrated that distraction may significantly impair the surgical abilities of novice surgeons.¹⁸ They suggest that experienced surgeons had achieved a higher level of automatization to the point where a cognitive distractor (e.g., multiple tasks) was not able to affect their performance. Complex manual skills are actually acquired in three sequential steps: a cognitive stage, an associative stage, and an autonomous stage.

The same concepts may be applied to our study to understand the results. Trainees (novice surgeons) have less attentional resources and may be more easily distracted during a surgical procedure. During an endoscopic endonasal procedure, multitasking is constantly demanded. The surgeon must be able to guide the endoscope to provide an optimal view of the operative field and avoid interference with other surgical instruments as well as to perform dissection under endoscopic visualization (bidimensional image with loss of depth perception) through a relative narrow surgical corridor. Work in conjunction with an active partner may be an additional challenge because surgical maneuvers should be perfectly coordinated. In our study, when trainees were focused on

only one activity, especially endoscope positioning or microsurgical dissection, their performance was significantly better. In fact, dynamic endoscopy, combined with bimanual dissection, is able to provide visual and haptic feedback to surgeons to increase their efficiency. The trainees were also able to complete all training tasks in a shorter period of time when using the same technique ($p = 0.092$). Therefore, our results suggest that adopting an educational program where basic techniques are emphasized, to decrease the complexity of the learned tasks, may shorten the long learning curve for EES by fostering a faster transition from the cognitive to the autonomous stage.

Study Limitations

To our knowledge, this study is the first to evaluate objectively the impact of different surgical techniques in EES training. Importantly, the trainees enrolled in this study were internally recruited, and, despite their lack of experience with EES, they might be more familiar with the surgical technique used at our institution (dynamic endoscopy and bimanual-binarial dissection), which may have contributed to a selection bias. The technique used in our institution may also have contributed to an evaluation bias, despite our efforts to perform a blind evaluation of the videos (group A could be potentially identified by the evaluator). In addition, the CWTM, despite its utility, is not able to recreate all the aspects of a real EES, and the development of more precise training models may be desirable. In our study, we used only human assessment methods for measuring procedure performance. The use of other objective parameters, such as dexterity metrics, may provide additional data and increase our knowledge of how to teach endoscopic endonasal techniques to novice surgeons.

This study does not apply to active experienced surgeons who may be facile with whatever technique they may have applied for an extensive period of time. The conclusions can only be applied to untrained surgeons and their learning curve.

Future Perspectives

Surgical education is an exciting and rapidly evolving field of medicine. The development of new surgical techniques, supported by tremendous technological innovation, has expanded the skills needed for surgery. Developing these skills in the setting of increased operational, financial, and technical restraints is a real challenge. Therefore, we should understand the theoretical framework behind the acquisition of surgical skills and identify the best training methods to maximize learning and skill transfer to the operative room.

We believe that a combination of apprenticeship-based training, proficiency-based curricula, valid assessment tools, training models, and new technologies (e.g., surgical simulators) is of foremost importance to improve training in EES. Training interventions should be rigorously investigated and validated by assessing their impact on surgical outcomes.

Conclusions

Endoscopic endonasal pituitary and cranial base surgery have been successfully performed using a variety of different surgical techniques. The lack of a standard technique, however, may be a relevant issue in teaching endoscopic endonasal techniques to novice surgeons. By using a laboratory-training model (CWTM), we conducted a blind evaluation of a comparative trial where three commonly used techniques were assessed by an expert in EES. We found that dynamic endoscopic and bimanual-binarial microdissection techniques had a significant positive impact on performance during EES training.

Conflict of Interest

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this article.

Note

Portions of this work were presented at the 24th Annual North American Skull Base Society Meeting in San Diego, California, on February 15, 2014.

Acknowledgments

The authors wish to thank Wendy Fellows-Mayle, PhD, for her invaluable assistance during the dissections, and all trainees who were willing to perform the dissections.

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