Evaluation of Surgical Freedom for Microscopic and Endoscopic Transsphenoidal Approaches to the Sella

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Received, April 22, 2014.
Accepted, October 9, 2014.

BACKGROUND: Microscopic and endoscopic transsphenoidal approaches to the sellar are well established. Surgical freedom is an important skull base principle that can be measured objectively and used to compare approaches.

OBJECTIVE: To compare the surgical freedom of 4 transsphenoidal approaches to the sella turcica to aid in surgical approach selection.

METHODS: Four transsphenoidal approaches to the sella were performed on 8 silicon-injected cadaveric heads. Surgical freedom was determined with stereotactic image guidance using previously established techniques. The results are presented as the area of surgical freedom and angular surgical freedom (angle of attack) in the axial and sagittal planes.

RESULTS: Mean total exposed area surgical freedom for the microscopic sublabial, endoscopic binostril, endoscopic uninostril, and microscopic endonasal approaches were 102 ± 13, 89 ± 6, 81 ± 4, and 69 ± 10 cm^2, respectively. The endoscopic binostril approach had the greatest surgical freedom at the pituitary gland and ipsilateral and contralateral internal carotid arteries (25.7 ± 5.4, 28.0 ± 4.0, and 23.0 ± 3.0 cm^2) compared with the microscopic sublabial (21.8 ± 3.5, 21.3 ± 2.4, and 19.5 ± 6.3 cm^2), microscopic endonasal (14.2 ± 2.7, 14.1 ± 3.2, and 16.3 ± 4.0 cm^2), and endoscopic uninostril (19.7 ± 4.8, 22.4 ± 2.3, and 19.5 ± 2.9 cm^2) approaches. Axial angle of attack was greatest for the microscopic sublabial approach to the same targets (14.7 ± 1.3°, 11.0 ± 1.5°, and 11.8 ± 1.1°). For the sagittal angle of attack, the endoscopic binostril approach was superior for all 3 targets (16.6 ± 1.7°, 17.2 ± 0.70°, and 15.5 ± 1.2°).

CONCLUSION: Microscopic sublabial and endoscopic binostril approaches provided superior surgical freedom compared with the endonasal microscopic and uninostril endoscopic approaches. This work provides objective baseline values for the quantification and evaluation of future refinements in surgical technique or instrumentation.

KEY WORDS: Endoscopy, Microscope, Pituitary adenoma, Surgical freedom, Transsphenoidal surgery

Operative Neurosurgery 11:69–79, 2015 DOI: 10.1227/NEU.0000000000000601

Surgical approaches to sellar region pathology have challenged neurosurgeons since the inception of the field. Microscope-based transsphenoidal approaches using either a sublabial or a transnasal passageway are the mainstays of the neurosurgical armamentarium for sellar lesions with excellent results.[1-3] In the last 2 decades, progressive technological advances in the field of neurosurgical endoscopy have ushered in the endoscopic, endonasal, transsphenoidal approach as a viable alternative to microscope-based approaches. Excellent clinical results for a wide variety of sellar pathology using purely endoscopic surgical techniques have been published.[1,4-8] A significant volume of literature has been published on the clinical outcomes and complications of microscope- and endoscope-based approaches to the sella. However, there remains a paucity of head-to-head comparisons of the strategies from a technical standpoint. Spencer and colleagues[9] performed a variety of microsurgical and endoscopic transsphenoidal approaches on cadavers and found a significantly improved volume of exposure with endoscopy-based approaches, especially in visualization superiorly (above the dorsum sella) but also in lateral and anterior bony

ABBREVIATIONS: cICA, cavernous internal carotid artery; **pICA,** petrous internal carotid artery exposure. Catapano and colleagues[10] also demonstrated greater bony exposure using an endoscopic approach compared with a microsurgical approach to the sella. However, no anatomic study has examined the surgeon's ability to manipulate instruments at the sella with these approaches or determined whether one approach provides a superior working corridor. Our laboratory and others have previously established a method of assessing the surgical freedom and angles of attack provided by various microsurgical and endoscopic exposures using stereotaxy.[11-14] This provides a quantitative analysis of the surgeon's ability to move instruments in space through the operative corridor during surgery and permits a more rigorous and objective comparison of skull base approaches. Here, we apply the same anatomic analyses to the microscopic and endoscopic transsphenoidal approaches to the sella.

METHODS

We dissected 8 silicon-injected, formalin-fixed cadaveric heads using 4 transsphenoidal approaches. Two endoscopic approaches were used: a uninostril endonasal transsphenoidal approach and a binostril endonasal transsphenoidal approach. Two microscopic transsphenoidal approaches were also used: a microscopic endonasal transsphenoidal approach and a microscopic sublabial transsphenoidal approach. Details of each approach are described below.

Endoscopic approaches were performed with a 0° endoscope and standard endoscopic techniques, burrs, dissector blades, and standard endoscopic instruments (Karl Storz, Tuttlingen, Germany) with heads placed in rigid fixation in a supine position. Microscopic approaches were performed with a standard surgical microscope (Pentero, Zeiss, Germany) and standard microsurgical instruments, with the heads placed in rigid fixation in a supine position. High-resolution computed tomography scans were performed on each specimen to document the bony facial and cranial anatomy, and the images were uploaded to an image guidance platform (StealthStation Treon Plus with FrameLink Software, Medtronic, Louisville, Colorado). Image guidance was used to obtain anatomic measurements and to confirm anatomic structures. For endoscopic measurements, the endoscope was parked in the superior aspect of the right naris with an endoscope holder. Statistical analysis was performed by comparing the data collected from the different approaches using 2-tailed t tests, and significance was determined at $P < .05$.

Uninostril Endoscopic Endonasal Transsphenoidal Approach

This approach has been described previously.[15] In brief, we used the right nostril to approach the nasal cavity, and the middle turbinate was out-fractured. The sphenoid ostia were identified bilaterally and opened widely with a mushroom punch or Kerrison rongeurs. The posterior third of the bony septum was resected, along with a piece of the vomer. The sphenoid rostrum was then opened wide with a drill or punch, and bilateral posterior ethmoidectomies were performed. The posterior wall

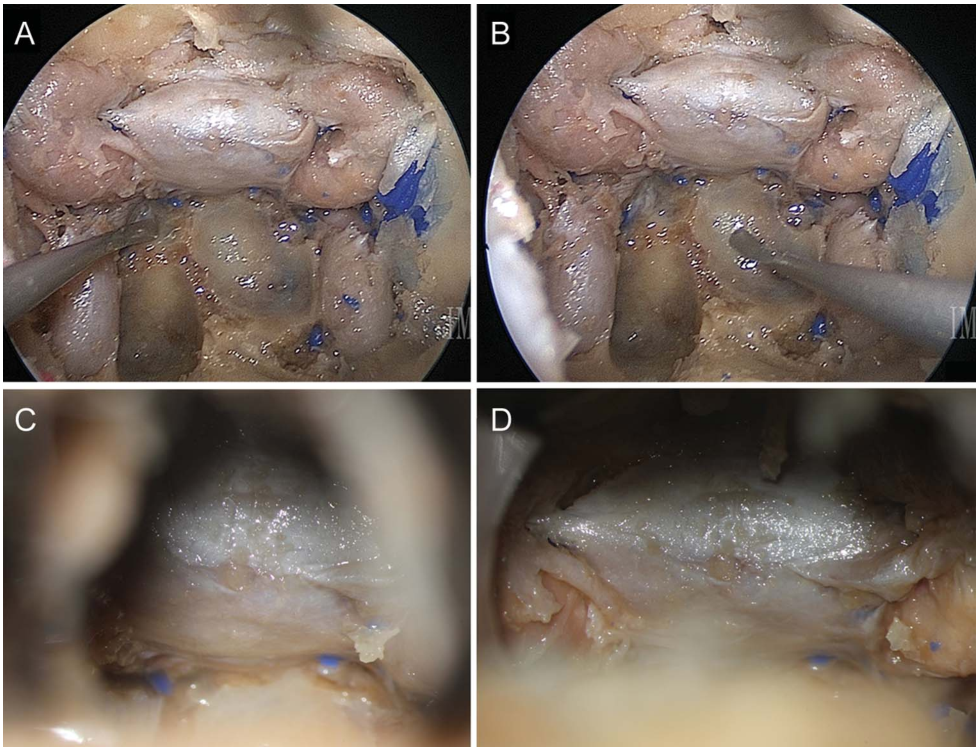

FIGURE 1. *Still images showing the exposed area for the endoscopic uninostril (**A**), endoscopic binostril (**B**), microscopic endonasal (**C**), and microscopic sublabial (**D**) approaches demonstrating the differences in visualization between techniques. Used with permission from Barrow Neurological Institute.*

of the sphenoid sinus was then removed to expose the anterior pituitary, the cavernous internal carotid artery (cICA) and a part of the petrous internal carotid artery (pICA). In a unilateral approach, the contralateral nasal mucosa was preserved. For all measurements, the endoscope and the endoscopic dissector instrument were both inserted through the right naris.

Binostril Endoscopic Endonasal Transsphenoidal Approach

In this approach, dissections were performed in a manner similar to the previous approach, but the contralateral posterior septal mucosa was removed, and the left middle turbinate was out-fractured[16,17] so that the endoscope could be inserted through the right naris and the dissector could be inserted through the left naris. To remain consistent with the other approaches, the terms ipsilateral and contralateral in reference to the carotid arteries, etc, for this approach are named by the side of endoscope insertion. For surgical freedom measurements, the dissector was placed in the left naris. An advantage to the binostril approach that we did not attempt to quantify in this study is that the dissector can be placed through whichever naris provides the best working angle for the surgeon.

Microscopic Endonasal Transsphenoidal Approach

The classic approach was well described by Griffith and Veerapen[18] in 1987, and several modifications have been reported. The technique reported in this study was performed as follows. A vertical incision was made at the mucodermal junction of the nasal septum, and the incision was extended to the nasal floor. The mucosa was then dissected from the septal cartilage and elevated from the nasal floor, and then the dissection was extended to the anterior wall of the sphenoid sinus. The posterior part of the septal cartilage was disarticulated from the plate of the ethmoid and

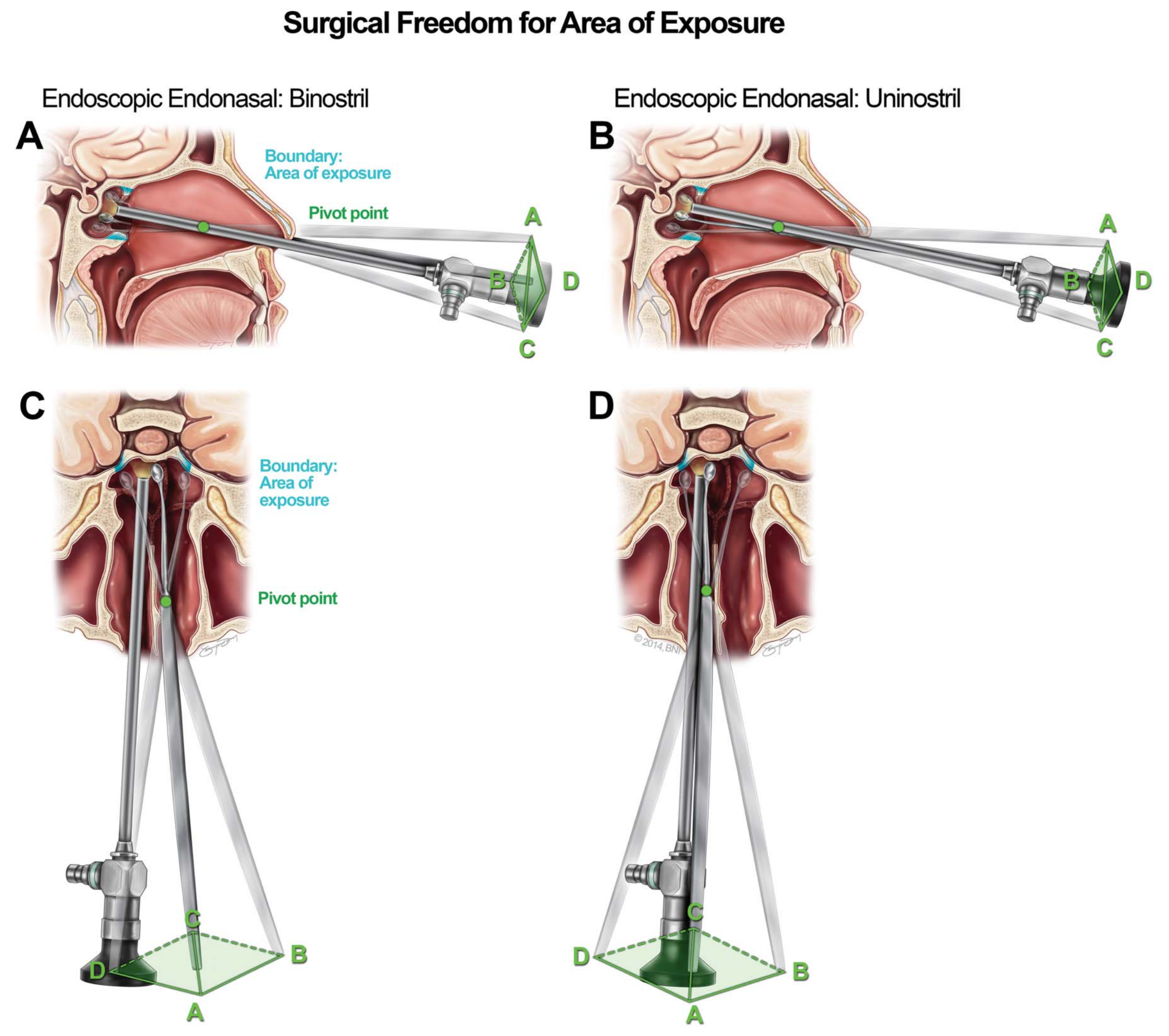

FIGURE 2. *An illustration showing the exposed area surgical freedom for the 2 endoscopic approaches: endoscopic endonasal binostril approach, (***A***) sagittal and (***C***) axial, and the endoscopic endonasal uninostril approach, (***B***) sagittal and (***D***) axial. Used with permission from Barrow Neurological Institute.*

vomer, and the 80-mm nasal speculum was inserted to retract the mucosa and to expose the anterior wall of the sphenoid sinus. The anterior wall of the sphenoid was removed, and bilateral ethmoidectomies were performed to expose the clivus and sellar floor. The pituitary gland, cICA, and pICA were exposed by bony removal of the posterior sphenoid wall and the carotid prominence. The right naris was used for all measurements.

Sublabial Microscopic Transsphenoidal Approach

Similar to the classic technique described by Hardy,[19] a horizontal incision was made under the upper lip at the junction of the gum. This incision was made deep enough to incise the periosteum and then elevated with a Cushing periosteal elevator to expose the nasal cavum, which was enlarged with rongeurs. The mucosal elevator was introduced along the nasal septum to detach the mucosa from the cartilage to the deepest part of the septum to the vomer. A Fukushima nasal speculum was used to hold the mucosa out of the field, and the nasal cartilage was removed, creating a new submucosal cavity. The vomer was detached, and further resection of the sphenoid wall was performed to expose the whole sphenoid sinus cavity. The sphenoid mucosa was removed, exposing the sellar floor, along with the carotid prominence on both sides.

Exposed Area

To enable a valid comparison between the previously mentioned approaches, posterior septectomy was standardized and limited to the posterior third of the bony septum, at the level of the superior turbinate. Ethmoidectomy was performed to the degree that complete sphenoidectomy could be performed. The sellar floor was opened from the cavernous sinus to the cavernous sinus in all approaches (Figure 1).

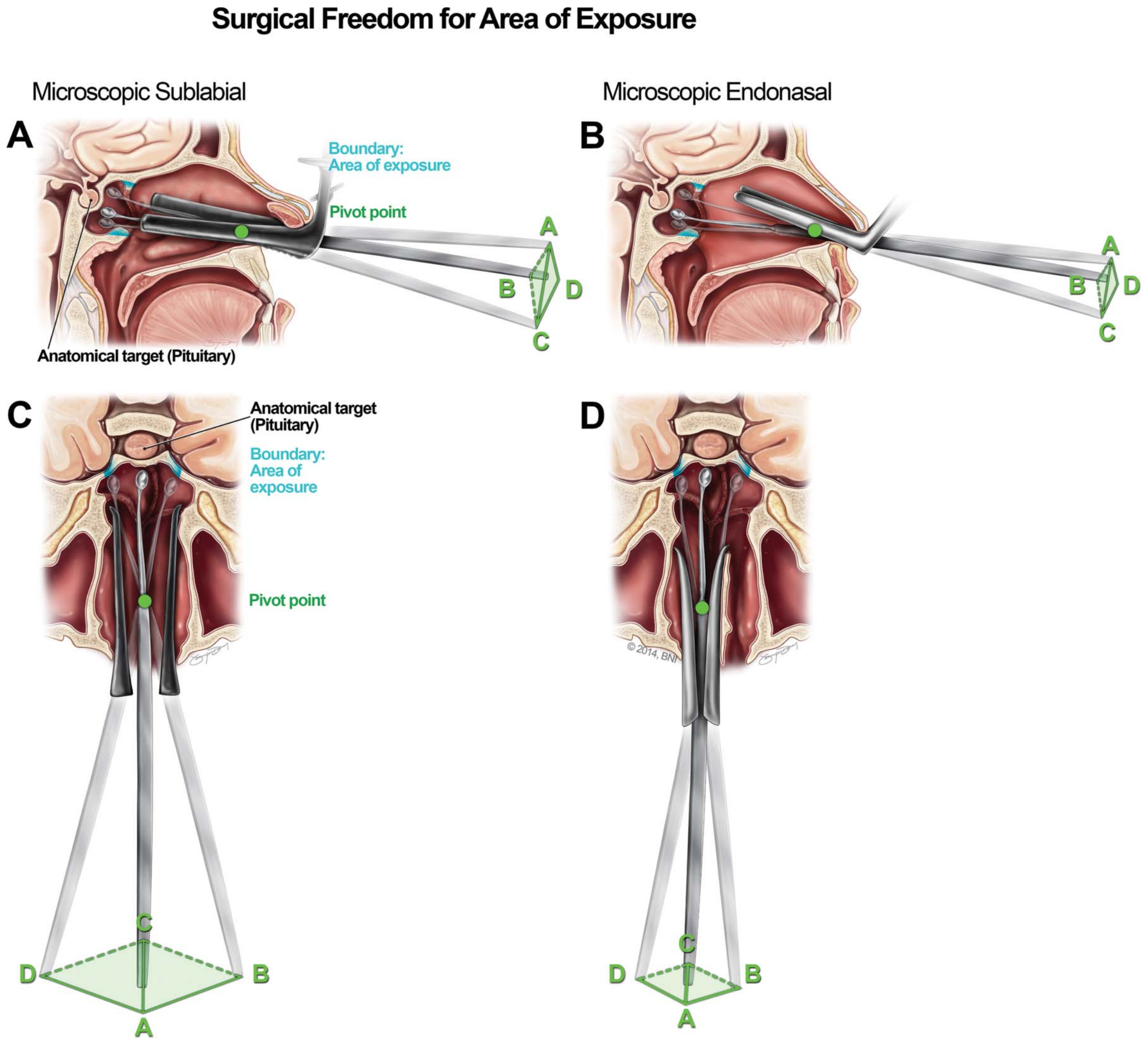

FIGURE 3. *An illustration showing the exposed area surgical freedom for the 2 microscopic approaches: microscopic sublabial approach (using a Fukushima retractor), (**A**) sagittal and (**C**) axial, and the microscopic endonasal approach, (**B**) sagittal and (**D**) axial. Used with permission from Barrow Neurological Institute.*

All 4 approaches were performed on each specimen to validate our comparison, and to avoid any false increase in surgical freedom as a result of tissue removal, the approaches were performed in a sequence from the approach with the least tissue removal approach to the most extensive one. The endoscopic uninostril approach was performed first, exposing the sella and the 2 cavernous internal carotid arteries (ICAs). After measurements were collected for the endoscopic uninostril approach, the microscopic endonasal approach, the endoscopic binostril approach, and finally the microscopic sublabial approach, which required the most extensive tissue removal, were performed in succession.

Exposed Area Surgical Freedom

This variable is calculated using 4 points in space and represents the available area of maneuverability that can be offered for the proximal (surgeon's) end of an endoscopic instrument (2-mm dissector, 23 cm in length) while moving the distal end of this instrument along the borders of the exposed area (holding the endoscope within the nasal vestibule in the endoscopic approaches). The 4 points were determined using the neuronavigation system. Each point corresponded to the position (outside the patient) of the proximal end of the dissector while placing the distal end of the dissector at an anatomic target. The 4 anatomic targets for the distal dissector were as follows: first point, contralateral cICA with the proximal dissector as inferior and lateral as possible; second point, ipsilateral pICA with the proximal dissector as superior and medial as possible; third point, ipsilateral cICA with the proximal dissector as inferior and medial as possible; and fourth point, contralateral pICA with the proximal dissector superior and lateral as possible (Figure 2). In case of microscopic approaches, surgical freedom was measured after placing the nasal speculum and measuring the freedom of the dissector in a similar fashion (Figure 3). With these 4 points measured, 3 vectors were calculated that represent 2 juxtaposed triangles, and the surgical freedom is the sum of the area of these 2 triangles.[11-14]

Anatomic Target Surgical Freedom

This variable represents the maneuverability of the proximal end of the dissector while fixing the distal end of the dissector on a specific anatomic target and placing the endoscope within the vestibule (in cases of endoscopic approaches) or after placement of the nasal speculum (in cases of the microscopic approaches).

Four points were again determined with the neuronavigation system that represent the 4 positions of the proximal end of the dissector outside the patient while fixing the distal end on an anatomic target and placing the proximal end as inferiorly, superiorly, medially, and laterally as possible. As described above, after these 4 points are calculated, 3 vectors

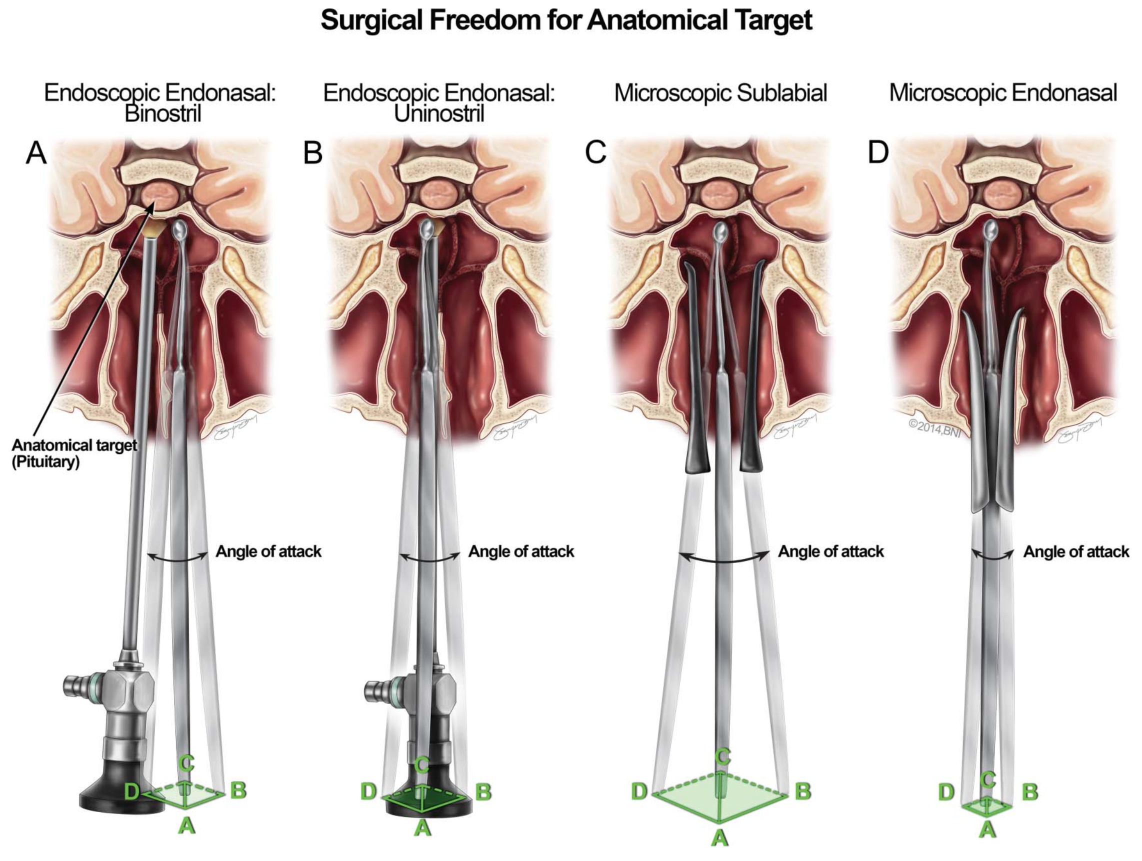

FIGURE 4. *Illustration showing the anatomic target surgical freedom and angle of attack for the pituitary gland in the axial plane for the endoscopic endonasal binostril approach (***A***), endoscopic endonasal uninostril approach (***B***), microscopic sublabial approach (***C***), microscopic endonasal approach (***D***). Used with permission from Barrow Neurological Institute.*

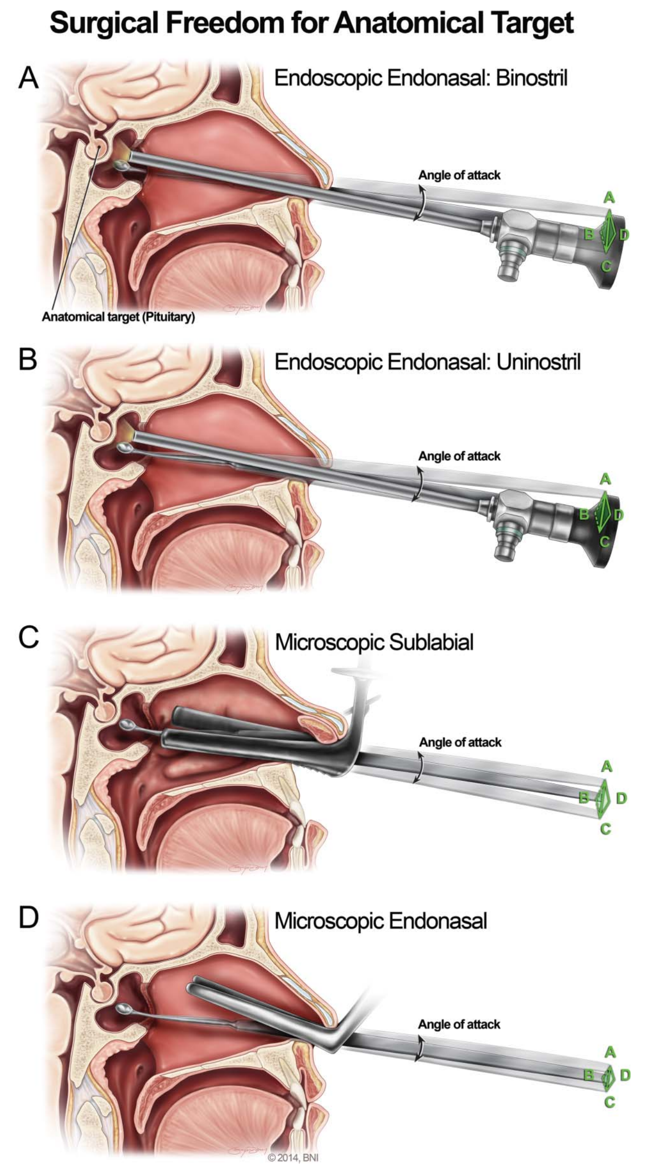

FIGURE 5. *Illustration showing the anatomic target surgical freedom and angle of attack for the pituitary gland in the sagittal plane for the endoscopic endonasal binostril approach (***A***), endoscopic endonasal uninostril approach (***B***), microscopic sublabial approach (***C***), microscopic endonasal approach (***D***). Used with permission from Barrow Neurological Institute.*

can be measured that represent 2 juxtaposed triangles, and the surgical freedom is the sum of the area of these 2 triangles (Figures 4 and 5). We measured anatomic target surgical freedom for the center of the pituitary gland and the 2 cavernous ICAs.

The exposed area surgical freedom and anatomic target surgical freedom evaluate surgical approaches somewhat differently. Surgical area freedom represents the total degree of maneuverability attained by the surgeon within the entire surgical area; certain areas may be more or less accessible to microdissection within this area. In contrast, target site freedom represents the degree of maneuverability around a certain smaller target only and does not consider the accessibility of the rest of the surgical field.

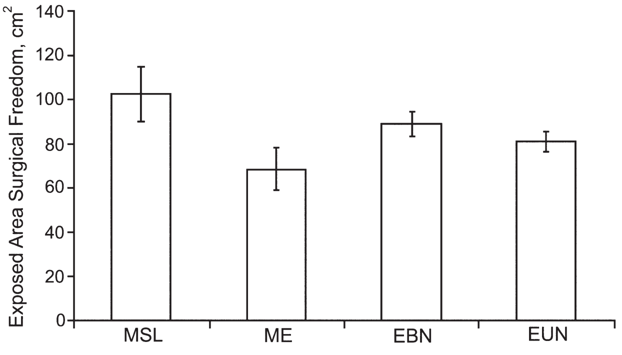

FIGURE 6. *Total exposed area surgical freedom by approach. Every measurement reported is statistically significant compared with all other values by 2-tailed t test. EBN, endoscopic binostril; EUN, endoscopic uninostril; ME, microscopic endonasal; MSL, microscopic sublabial. Used with permission from Barrow Neurological Institute.*

Angle of Attack

The angular surgical freedom (angles of attack) in 2 planes was determined for 3 targets: the pituitary gland and both cICAs. This was measured, as we have described previously, by fixing the distal end of the dissector on the anatomic target and moving the proximal end of the dissector as far left and right as possible to determine the maximum angle of attack within the axial plane (Figure 4).[14] The angle of attack in the sagittal plane was calculated by measuring the maximum angle of movement when fixing the distal end of the dissector on the anatomic target and moving the proximal end as superior and inferior as possible (Figure 5). These measurements were taken while positioning the endoscope against the nasal vestibule and providing a full view of the exposed area for the endoscopic techniques and after placing the microscopic nasal speculum in case of the microscopic approaches.

RESULTS

Exposed Area Surgical Freedom

The microscopic sublabial approach provided the greatest exposed area surgical freedom (102.3 ± 12.6 cm^2; Figure 6), followed by the endoscopic binostril approach (88.9 ± 5.5 cm^2; 2-tailed t test compared with microscopic sublabial, $P = .02$), the endoscopic uninostril approach (80.9 ± 4.5 cm^2; 2-tailed t test compared with microscopic sublabial, $P = .004$), and the microscopic endonasal approach (68.7 ± 9.6 cm^2; 2-tailed t test compared with microscopic sublabial, $P < .001$). The statistical significance of each approach compared with every other approach is summarized in the Table.

Anatomic Target Surgical Freedom

The largest anatomic target surgical freedom for the pituitary gland was provided by the endoscopic binostril approach (27.7 ± 5.4 cm^2), followed by the microscopic sublabial approach (21.8 ± 3.5 cm^2; 2-

TABLE. Two-Tailed *t* Test *P* Values for Each Approach Compared With a Microscopic Sublabial Approach, an Endoscopic Binostril Approach, a Microscopic Endonasal Approach, and an Endoscopic Uninostril Approach[a]

	Angle of Attack						Surgical Freedom			
	Axial			Sagittal			Anatomic Target			
Surgical Approach	Pit	I-cICA	C-cICA	Pit	I-cICA	C-cICA	Pit	I-cICA	C-cICA	Exposed Area
Microscopic sublabial approach										
ME	0.0002[b]	0.2	0.001[b]	0.008[b]	0.005[b]	0.06	0.005[b]	0.001[b]	0.08[b]	0.0008[b]
EBN	0.02[b]	0.02[b]	0.04[b]	0.03[b]	0.005[c]	0.2	0.01[c]	0.003[c]	0.3	0.02[b]
EUN	0.001[b]	0.007[b]	0.02[b]	0.8	0.5	0.9	0.1	0.4	>0.99	0.004[b]
Endoscopic binostril approach										
MSL	0.02[b]	0.02[c]	0.04[c]	0.03[b]	0.005[b]	0.2	0.01[b]	0.003[b]	0.3	0.02[c]
ME	0.002[b]	0.6	0.6	0.002[b]	0.00007[b]	0.01[b]	0.001[b]	0.00004[b]	0.01[b]	0.0009[b]
EUN	0.003[b]	0.09	0.3	0.0003[b]	0.0000003[b]	0.002[b]	0.0003[b]	0.002[b]	0.02[b]	0.0002[b]
Microscopic endonasal approach										
MSL	0.0002[c]	0.2	0.001[c]	0.008[c]	0.005[c]	0.06	0.005[c]	0.001[c]	0.08[c]	0.0008[c]
EBN	0.002[c]	0.6	0.6	0.002[c]	0.00007[b]	0.01[b]	0.001[c]	0.00004[c]	0.01[c]	0.0009[c]
EUN	0.7	0.08	0.2	0.02[c]	0.004[c]	0.08[c]	0.03[c]	0.001[c]	0.03[c]	0.009[c]
Endoscopic uninostril approach										
MSL	0.001[c]	0.007[c]	0.02[c]	0.8	0.5	0.9	0.1	0.4	>0.99	0.004[c]
ME	0.7	0.08	0.2	0.02[b]	0.004[b]	0.08	0.03[c]	0.001[b]	0.03[b]	0.009[b]
EBN	0.003[c]	0.09	0.3	0.0003[b]	0.0000003[c]	0.002[c]	0.0003[c]	0.002[c]	0.02[c]	0.0002[c]

[a] C-cICA, contralateral cavernous internal carotid artery; EBN, endoscopic binostril; EUN, endoscopic uninostril; I-cICA, ipsilateral cavernous internal carotid artery; ME, microscopic endonasal; MSL, microscopic sublabial; Pit, pituitary gland.

[b] Represents a statistically significant superiority.

[c] Represents a statistically significant inferiority.

tailed *t* test compared with endoscopic binostril, *P* = .01), endoscopic uninostril approach (19.7 ± 4.8 cm^2; 2-tailed *t* test compared with endoscopic binostril, *P* < .001), and microscopic endonasal approach (14.1 ± 2.7 cm^2; 2-tailed *t* test compared with endoscopic binostril, *P* = .001; Figure 7). The surgical freedom for the ipsilateral cICA (right cICA) was greatest with the endoscopic binostril approach (27.0 ± 4.0 cm^2), followed by the endoscopic uninostril approach (22.4 ± 2.32 cm^2; 2-tailed *t* test compared with endoscopic binostril, *P* = .002), the microscopic sublabial approach (21.3 ± 2.4 cm^2; 2-tailed *t* test compared with endoscopic binostril, *P* = .01), and the microscopic endonasal approach (14.1 ± 3.17 cm^2; 2-tailed *t* test compared with endoscopic binostril, *P* < .001). For the contralateral cICA (left cICA), the endoscopic binostril approach had the greatest anatomic target surgical freedom (23.0 ± 3 cm^2), followed by the endoscopic uninostril approach (19.5 ± 2.9 cm^2; 2-tailed *t* test compared with endoscopic binostril, *P* = .01), the microscopic sublabial approach (19.5 ± 6.2 cm^2; 2-tailed *t* test compared with endoscopic binostril, *P* > .05, nonsignificant), and the microscopic endonasal approach (16.3 ± 4.0 cm^2; 2-tailed *t* test compared with endoscopic binostril, *P* = .02). The statistical significance of each approach compared with every other approach is summarized in the Table.

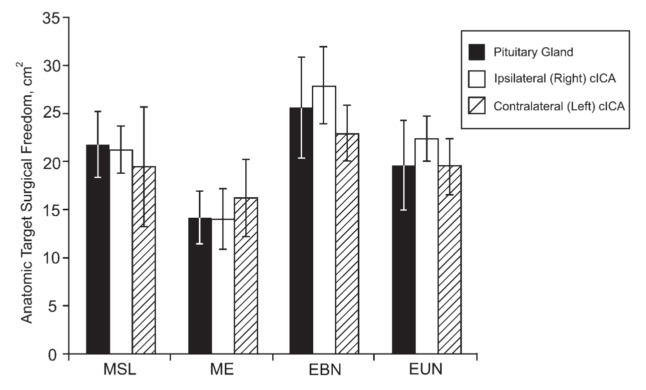

FIGURE 7. *Anatomic target surgical freedom by approach. Statistical comparisons are reported separately in the Table. cICA, cavernous internal carotid artery; EBN, endoscopic binostril; EUN, endoscopic uninostril; ME, microscopic endonasal; MSL, microscopic sublabial. Used with permission from Barrow Neurological Institute.*

Angle of Attack

The axial plane angle of attack for the pituitary gland was greatest for the microscopic sublabial approach (14.7 ± 1.3°; Figure 8), followed by the endoscopic binostril approach (12.8 ± 1.7°; 2-tailed *t* test compared with microscopic sublabial, *P* = .02), the microscopic endonasal approach (9.5 ± 1°; 2-tailed *t* test compared with microscopic sublabial, *P* < .001), and the endonasal uninostril approach (9.2 ± 2°; 2-tailed *t* test compared with microscopic sublabial, *P* = .001). The angle of attack for the pituitary gland in

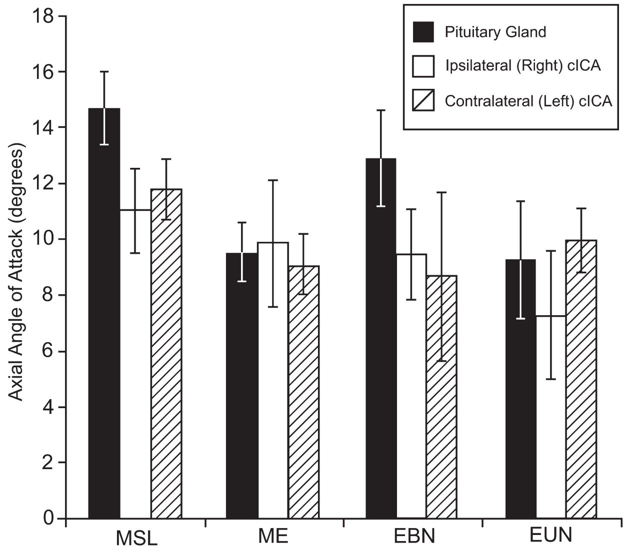

FIGURE 8. *Axial angle of attack by approach. Statistical comparisons are reported separately in the Table. cICA, cavernous internal carotid artery; EBN, endoscopic binostril; EUN, endoscopic uninostril; ME, microscopic endonasal; MSL, microscopic sublabial. Used with permission from Barrow Neurological Institute.*

the sagittal plane was greatest for the endoscopic binostril approach (16.5 ± 1.7°; Figure 9), followed by the microscopic sublabial approach (14.9 ± 1.9°; 2-tailed t test compared with endoscopic binostril, $P = .03$), the endoscopic uninostril approach (14.7 ± 1.3°; 2-tailed t test compared with endoscopic binostril, $P < .001$), and the microscopic endonasal approach (12.4 ± 2°; 2-tailed t test compared with endoscopic binostril, $P = .002$). The axial and sagittal plane angles of attack for the ipsilateral (right) and contralateral (left) cICAs by approach are summarized in Figures 7 and 8; in short, the microscopic sublabial approach had the greatest axial angle of attack for both cICAs, whereas the endoscopic binostril approach had the greatest sagittal angle of attack for both cICAs. The statistical significance of each approach compared with every other approach is summarized in the Table.

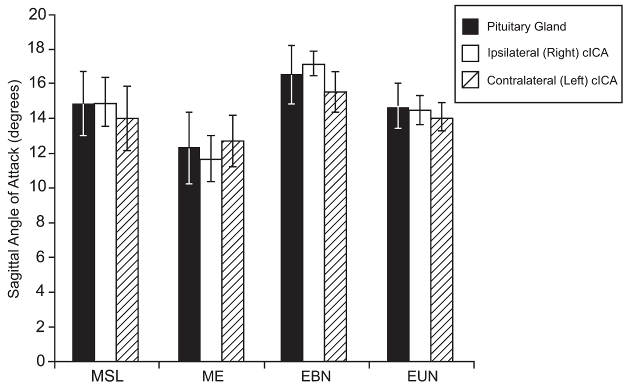

FIGURE 9. *Sagittal angle of attack by approach. Statistical comparisons are reported separately in the Table. cICA, cavernous internal carotid artery; EBN, endoscopic binostril; EUN, endoscopic uninostril; ME, microscopic endonasal; MSL, microscopic sublabial. Used with permission from Barrow Neurological Institute.*

DISCUSSION

Microscopic transsphenoidal surgery represents the gold standard for addressing lesions of the sella turcica.[1-3] The 2 most commonly used microsurgical approaches are the uninostril endonasal approach and the sublabial transsphenoidal approach, but recent endoscopic technological advances and the development of effective closure techniques have led to the adoption of purely endoscopic, endonasal approaches to the sella.[4-8,20] The 2 most commonly used endoscopic approaches are the uninostril and binostril transsphenoidal techniques. Although much recent literature has focused on the technical nuances of individual approaches and preliminary patient outcomes, few objective technical comparisons of the approaches exist. Surgical freedom is an important skull base principle that describes the extent to which a surgeon can moves his or her hands in the operative field. Increased surgical freedom and angle of attack limit sword fighting and instrument collisions, reduce surgeon frustration, improve delicate microdissection, and improve target visualization. Numerous impediments to surgical freedom in the crowded nasal corridor exist, such as the nasal septum, turbinates, nares, sphenoid sinus bone, endoscope, and retractors. In this study, we present the first objective comparison of surgical freedom of the 4 most commonly performed transsphenoidal approaches to remove a pituitary tumor. We estimated surgical freedom using 4 measurements (exposed area surgical freedom, target surgical freedom, axial angular freedom, and sagittal angular freedom). These complementary measurements allow us to determine not only the total area of freedom, but also in which plane one approach may be superior to another.

We demonstrated that the sublabial microscopic and binostril endoscopic approaches were superior to the uninostril microscopic and uninostril endoscopic approaches in the examined variables. The sublabial approach provided the greatest surgical freedom in the exposed area and axial angular freedom, whereas the endoscopic binostril approach provided the greatest target surgical freedom and sagittal angular freedom.

The microscopic endonasal approach provided the least surgical freedom in 3 of the 4 measurements in our model. The surgical freedom results can be explained by the anatomic structures that limit movement in each approach. For example, in the sublabial approach, the retractor is placed in a horizontal plane, providing a wide but short orifice at the distal end of the exposure. In contrast, in the endoscopic approaches, the axial angular freedom is limited by the nares, nasal septum, middle turbinate, and maxillary sinus wall. However, sagittal angular freedom is excellent because one can elevate the soft tissue of the nares to generate more freedom. The uninostril microscopic approach provided the least amount of surgical freedom because axial plane freedom was limited by the nasal speculum, and the sagittal freedom was reduced by the skin and cartilage of the nares made tight by the expanded retractor. This could explain why the microscopic sublabial approach had greater surgical freedom in the axial plane compared with the endoscopic binostril approach; the sublabial approach is less restricted by these factors. The other interesting observation was the noted superiority of the binostril endoscopic approach compared with the uninostril approach. This confirms our clinical impression. The uninostril approach surgical freedom was more affected by the presence of the endoscope and the conflicts between the endoscope and dissecting instruments. In a standard binostril approach, the endoscope is parked in the right nostril, and the dissectors are placed in the left nostril, thus limiting collisions. Finally, the endoscopic approach compared with the microscopic approach allows a panoramic view without hindrance by the nasal speculum, as illustrated in Figure 1. The benefit of removing this obstacle is reflected in the superior anatomic target surgical freedom of the endoscopic binostril approach.

These results provide practical information for surgeons choosing a surgical approach and help quantify clinical impressions. In the microscopic approaches, for example, the senior author (A.S.L.) chooses a sublabial microscopic approach over a microscopic uninostril approach for complex sellar tumors such as craniopharyngiomas because of the greater surgical freedom and shorter operative distance compared with the direct endonasal approach. Regarding the endoscopic approaches, we now use an exclusively binostril approach instead of a uninostril approach for all sellar lesions because of the added surgical freedom of the binostril approach. This improves the ease of tumor dissection, limits endoscope-instrument conflict, and significantly eases the hassle of sellar reconstruction. One could consider addressing simpler lesions such as Rathke cleft cyst fenestration with a uninostril approach because these lesions can easily be treated with limited surgical freedom. However, surgical freedom is only one of several factors that a surgeon considers when choosing an approach. Other factors include approach-related morbidity[21] and surgeon experience/preference.

Limitations

Our study has multiple limitations that deserve discussion. We used cadaveric heads fixed in standard preservatives, and these preservatives decrease the elasticity of tissue. This is a drawback inherent to any anatomic study performed in cadavers. We tried to address this variable by performing the measurements in the same specimens for all 4 approaches, thereby having each specimen serve as its own internal control. Because we proceeded stepwise for each approach on each specimen, it is possible that the measurements obtained last in the microscopic sublabial approach could be falsely elevated because of additional tissue compression and removal. However, we did not attempt to remove any additional tissue in the earlier approaches that would not have also been removed from the sublabial approach. To standardize the methodology, we chose to use only straight instruments and 0° endoscopes. Different surgical freedom areas could have been obtained with angled instruments or endoscopes. Next, our study examines a standardized dissection using each approach. Individual patient anatomy and surgical pathology are highly variable, and each surgical approach in the living patient is tailored to that patient's unique anatomy. Therefore, surgical freedom and angles of attack may differ somewhat when these approaches are used in the operating room. Finally, in the endoscopic binostril approach, the surgeon may use both nares. We measured the surgical freedom for the dissector in only 1 naris while the endoscope was placed in the other (to avoid sword fighting with the endoscope) and to simplify our model. The ability to exploit both nostrils is an advantage that we did not quantify in this study.

The choice to approach a lesion from an endoscopic, microscopic, or combined approach has many deciding factors and can yield excellent clinical results. We view the present results not as an unqualified endorsement of the endoscopic binostril approach or sublabial approach, but instead as the early steps toward a rigorous and objective anatomic comparison of surgical approaches in sellar surgery. With these baselines now established for routine approaches, we can use the same principles to evaluate expanded exposures, new instrumentation, and other technical modifications. Innovations in surgical approach will, in the future, have standardized quantitative, rather than simply qualitative, data to support their adoption.

CONCLUSION

The microscopic sublabial approach to the sella provides the greatest surgical freedom in the axial plane and the greatest total surgical area freedom. The endoscopic binostril approach provides the greatest degree of sagittal surgical freedom and freedom at common anatomic targets within the sella. Microscopic endonasal and endoscopic uninostril approaches yielded significantly less surgical freedom in most examined variables. This research provides a foundation for the quantitative measurement of endoscopic skull base approaches.

Disclosures

Karl Storz Endoscopy provided the endoscopic equipment for this study. Medtronic provided for fellowship support for Dr Elhadi and material support to conduct this study. This research was funded in part by the Newsome Family Endowed Chair in Neurosurgery Research held by Dr Preul. Dr Little has an equity interest in Kogent Surgical. Dr Nakaji is a consultant for Aesculap. The other authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

With the widespread use of endoscopic surgery of the skull base, it is both appropriate and important to explore the advantages and limitations of the various approaches that are available. The authors do just this by studying the concept of surgical freedom, which is the ability to move instruments in a fixed space. They look not only at the ability to move at the target point but also at the ability to move when one is fixed on the target point with the instrument and one wants to move one's hand at the point where one is holding the instrument.

This is a clever idea, and I commend the authors for studying it. The study does have some limitations, including the fact that these fixed specimens are quite rigid but in real life the tissues are very flexible. It is impossible to know just how much difference this makes, but it could be quite a bit. It is also important to realize that the challenges of endoscopic surgery are not limited to the ability to move instruments but also relate to the ability to visualize important structures. Another significant challenge is that some endoscopic instruments are still quite primitive compared with microscopic instruments.

It is therefore hard to know exactly how much this information should or would alter an individual neurosurgeon's practice. Nonetheless, I believe the information is valuable and that studies like this will add to our knowledge about endoscopic surgery and its advantages and disadvantages.

David S. Baskin
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With the widespread use of endoscopic endonasal approaches to the sella, it is important to objectively define the advantages of these approaches compared with approaches that have previously been used to the sella such as microscopic endonasal and sublabial approaches. The authors do this in an innovative manner, by comparing the area of surgical freedom and angular surgical freedom between 4 different transsphenoidal approaches (microscopic sublabial, endoscopic binostril, endoscopic uninostril, and microscopic endonasal) in cadaveric specimens. Their findings of increased surgical freedom with endoscopic binostril approaches provide important objective support for the perception that many surgeons have had after adapting these approaches in their practice. Meanwhile, their findings of increased surgical freedom with microscopic sublabial approaches serve as a reminder that, although this approach has been used less frequently over time as a result of less frequent cosmetic concerns arising from endonasal approaches, it offered tremendous surgical freedom. With the caveats that cadaveric specimens are less flexible and accommodating than patients and that there is considerable variation in the size of endoscopes and endoscopic instruments, which could influence freedom, this study still underscores the value of cadaveric specimens in comparing surgical approaches and defining their advantages and limitations. Variations of cadaveric studies like this could also be used to test and improve the surgical freedom conferred by new instruments proposed for endoscopic use before they become adapted in the operating room.

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The authors present a practical cadaveric study investigating the degree of surgical freedom and angles of attack using either microscopic vs endoscopic endonasal transsphenoidal approaches. It is no surprise that the sublabial microscopic approach had the highest angle of attack in the axial plane. This is a function of how wide the nasal speculum can open up in the axial plane with a wide sublabial incision. It however does not have great angles of attack in the sagittal plane because microscopic visualization is limited by the vertical limits of the working aperture. In a unilateral endonasal microscopic approach, the angles of attack become even more limited because the nasal speculum cannot be opened widely using a single nostril. Thus, in the microscopic approaches, the angles of attack and surgical freedom are largely determined by the corridor width provided by the blades of the nasal speculum. This, however, can be a double-edged sword, because the speculum blades can limit the surgical freedom (the maneuverability and range of motion of instruments at the surgical target). For example, the opening of the sphenoidotomy is limited by the exposure provided by the nasal speculum. Although not determined in this study, the speculum also limits the amount of light reflected on the surgical target and limits the degree of visualization around the target area.

On the other hand, the surgical freedom and angles of attack in the endoscopic approaches, particularly the binostril approach, are largely determined by the extent of posterior septectomy and removal of additional sinonasal tissue (middle turbinate, posterior ethmoidectomy). Removal of these soft tissues allows more freedom of movement to maneuver instruments for optimal bimanual surgical dissection. Some technical pearls that also optimize surgical freedom include maximizing the sphenoidotomy, removal of the vomer and floor of the sphenoid, and drilling down any bony overhang that can obstruct surgeon's line of sight and surgical freedom.[1-3] It is clear that the binostril endoscopic technique is more superior than the uni-nostril technique in providing increased surgical freedom. Overall the endoscopic binostril approach had the highest area of exposure for the three designated targets. Figure 1 beautifully illustrates why the anatomic target surgical freedom is greatest in the endoscopic binostril approach as compared to the other approaches. This, in my opinion, is a function of the panoramic visualization and increased illumination offered by the endoscope that is unhindered by a nasal speculum.

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Figure 2. Dr Sandeep Kunwar utilizing the operating microscope at the start of an endonasal transsphenoidal approach to the removal of a growth hormone-secreting pituitary adenoma.