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A Short Trapezoidal Speculum for Suprasellar and Infrasellar Exposure in Endonasal Transsphenoidal Surgery

OBJECTIVE: A key limitation of the transsphenoidal approach for suprasellar and infrasellar lesions is restricted exposure. Microscope and endoscope-assisted procedures have traditionally used an oval-shaped speculum, the distal end of which restricts superior and inferior visualization. To improve visualization and use of the endoscope, shorter specula, with a trapezoidal distal end, were designed.

METHODS: The new specula have a working length of 60 mm. The proximal 20-mm segment is oval-shaped to conform to the nostril; the middle 20-mm segment has vertically oriented blades; and the distal 20-mm segment transitions to a trapezoidal orientation, with the distal blades angled 15 degrees upward and outward on the suprasellar speculum, or 15 degrees downward and outward on the infrasellar speculum. Both specula have a 5-degree distal outward flare. The upward-angled trapezoidal 60-mm speculum was compared with 70- and 80-mm oval specula in a transsphenoidal clay model. A pen light was projected from the nasal speculum end to a target 100 mm away using a blade opening width of 16 mm. Line drawings were made to quantify the impact of speculum length on the horizontal angle of exposure. The clinical utility of the trapezoidal specula was also assessed.

RESULTS: In the model, the 60-mm upward-angled trapezoidal speculum yielded a surface area illumination of 759 mm^2, as compared with 579 and 432 mm^2 with the 70- and 80-mm oval specula, an increase in exposure of 31 and 76%, respectively. In the line drawings, the 60-mm speculum provided a horizontal angle of exposure of 30 degrees, as compared with 26 and 23 degrees for the 70- and 80-mm specula, an increase of 17 and 33%, respectively. In patients, provided sufficient mucosa and bone are removed from the posterior nasal cavity, the trapezoidal specula provide an expanded working volume that facilitates endoscopy.

CONCLUSION: Short upward- or downward-angled trapezoidal endonasal specula increase parasellar surface area exposure and the horizontal angle of exposure. Initial clinical experience suggests that reducing the speculum length and eliminating the distal curved blades result in greater instrument maneuverability and enhanced visibility for removing parasellar tumors.

KEY WORDS: Craniopharyngioma, Endonasal, Endoscopy, Extended approach, Meningioma, Pituitary, Speculum, Transclival approach, Transsphenoidal surgery

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With the resurgence of the transsphenoidal approach in the 1960s and the introduction of the operating microscope in the 1970s, the safety and efficacy of transsphenoidal tumor removal improved dramatically. Since then, the transsphenoidal speculum has undergone numerous modifications to improve visualization of the parasellar area and to accommodate an endonasal approach (3, 13, 15, 20–24, 26). With the extended transsphenoidal approach to the suprasellar, parasellar, and cavernous sinus areas, the need for enhanced exposure and instrument maneuverability is even greater (11). However, for both microscope- and endoscope-assisted procedures, the traditional bivalve, oval-shaped transsphenoidal speculum allows only limited superior and inferior visualization. Also, it is frequently difficult to angle the endonasal speculum to the ideal trajectory, particularly for a suprasellar lesion, given the acute angulation of the nasal cavity, which tends to push the speculum blades inferiorly away from the planum. The long, tubular construction of the speculum, which is typically 70 to 90 mm in length (26), further restricts parasellar visualization, which becomes more problematic as the speculum length increases. When an endoscope is introduced into the speculum to provide more panoramic visualization of the parasellar area with simultaneous use of other instruments, the restrictions posed by the rigid speculum are readily apparent (6, 7, 17).

Over the past 3 years, we have used a short adult speculum 70 mm in length or a pediatric speculum 65 mm in length for all extended approaches to help maximize instrument maneuverability. Still, the oval-shaped blades of these traditional specula hinder superior and inferior visualization and restrict instrument movement. To address these hindrances, an ultrashort endonasal speculum of only 60 mm in length was designed, in which the distal 20-mm segment transitions to an upward trapezoidal shape for suprasellar exposure or to a downward trapezoidal shape for infrasellar exposure. Herein, we present an assessment of this speculum in a transsphenoidal model and with line drawings to document the advantages gained in exposure to the parasellar area. We also present initial clinical impressions from using these specula in patients with suprasellar and infrasellar lesions.

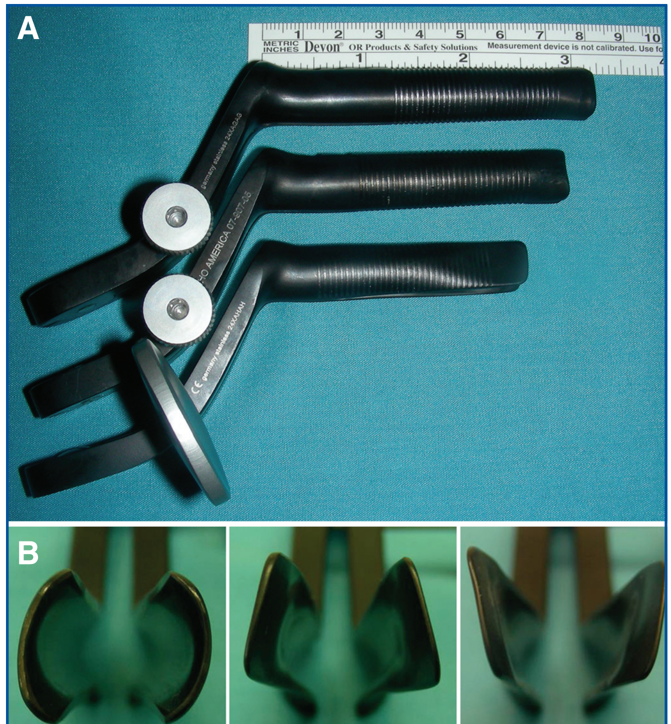

FIGURE 1. **A**, *photograph comparing the 60-mm upward-angled trapezoidal speculum with the 70- and 80-mm oval-shaped specula.* **B**, *photographs comparing the distal ends of an oval-shaped speculum with the downward- and upward-angled trapezoidal specula.*

MATERIALS AND METHODS

Speculum Design

Two new trapezoidal specula with a short length (60 mm) were designed, one with a trapezoidal upward-angled distal end or a trapezoidal downward-angled distal end (Mizuho-America, Inc., Beverly, MA) (*Fig. 1*). In contrast to the longer (70–90-mm), oval-shaped endonasal specula, the new speculum blades have three segments. The first 20-mm segment is an oval shape similar to the traditional endonasal specula, to conform to the nostril and minimize mucosal trauma; the middle 20-mm segment is vertically oriented and the distal 20-mm segment transitions to a trapezoidal shape with either a 15-degree upward and outward orientation or a 15-degree downward and outward orientation for suprasellar and infrasellar access, respectively. Both the suprasellar and the infrasellar trapezoidal specula have a 5-degree outward flare at the distal end.

Intraoperative Measurements and Model Development

To develop a realistic model, intraoperative measurements were obtained using the three different specula (60-mm trapezoidal upward-angled, 70-mm oval, and 80-mm oval) in five patients undergoing surgery for pituitary tumor removal. As described previously (14, 28), after the initial approach was performed, a 70-mm endonasal speculum was inserted and a wide sphenoidotomy performed. The speculum was opened to the maximum width allowed by stretching of the nostril and restriction from the nasal cavity structures, including the nasal septum and middle turbinate. After the initial opening, the following measurements were made for the 60-, 70-, and 80-mm specula with the proximal speculum end flush with the nostril (i.e., with no excess speculum exposed): 1) the distance from the nostril to the sellar floor, and 2) the internal diameter (width) of the speculum opening at the proximal (nasal) end and at the distal speculum end. For the 70- and 80-mm oval-shaped specula, widths were measured at the widest part of the bivalve speculum (at the equator). For the trapezoidal upward-angled speculum, the distal-end width measurement was taken at the upper (widest) aspect of the blades. These measurements yielded the following results, which were relatively consistent across the three lengths of specula. The diameter of the opening at the proximal and distal ends were 16 ± 1 and 16 ± 2 mm, respectively, for the 60-mm speculum; 15 ± 1 and 16 ± 2 mm, respectively, for the 70-mm speculum; and 15 ± 1 and 15 ± 2 mm, respectively, for the 80-mm speculum. The average distance from nostril to sellar floor was 98 ± 8 mm.

Based on these measurements, a model of the sinonasal structures was created. The 60-mm trapezoidal upward-angled, 70-mm oval, and 80-mm oval specula were compared in terms of surface area exposure at 100 mm from the proximal speculum end with a 16-mm distal internal diameter opening. The specula were wrapped in modeling clay with the clay extending to the distal speculum end. Clay was removed superiorly and inferiorly at the distal end of each speculum to simulate the wide sphenoidotomy and removal of obstructing soft tissue and bone required for adequate parasellar exposure. A penlight was placed at the proximal speculum entrance and shined at the surface, 100 mm away from the proximal opening, onto grid paper with 5-mm grid lines. As shown in *Figure 2,* the light cast at this distance was hand-traced onto the grid paper and the surface area exposure was calculated. Measurements of surface area illumination were made using the GNU Image Manipulation Program (version 2.2.5, www.gimp.org).

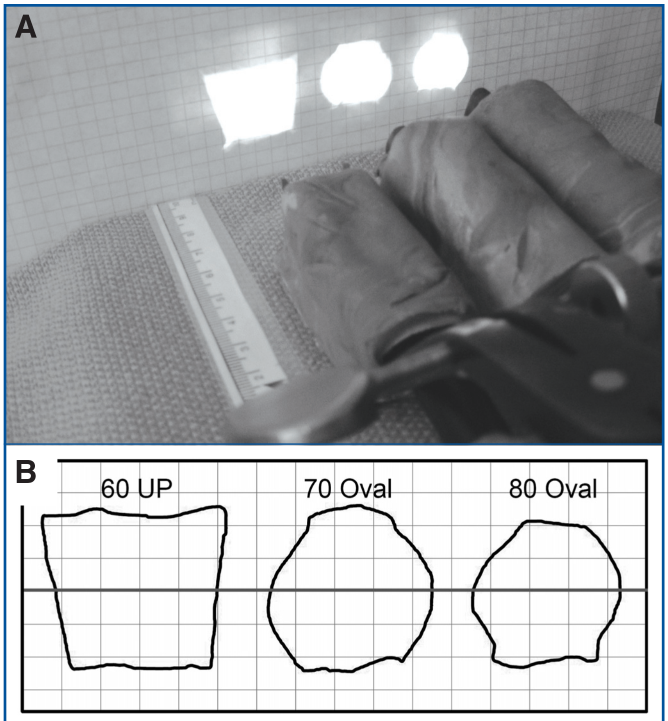

FIGURE 2. **A**, *photograph of the clay model used to simulate the endonasal approach to the parasellar area. The three specula (60-mm upward-angled trapezoidal, 70-mm oval, and 80-mm oval) were positioned with the proximal end of each speculum 100 mm from the target surface and a distal end internal diameter opening of 16 mm. A pen light was placed at the entry of each speculum, and the area of illumination at the target was traced by hand.* **B**, *with the 60-mm upward-angled trapezoidal speculum (*60 UP*), the overall area of illumination compared with the 70- and 80-mm oval specula, increased by 31 and 76%, respectively, and the superior half of the illuminated field increased by 41 and 81%, respectively.*

Measurements were made of both the overall surface area illumination and the superior half of the illuminated field.

Line Drawings

To determine the difference in the angle of exposure in the horizontal plane using the three speculum lengths, line drawings were made to scale for the 60-, 70-, and 80-mm specula, depicted as parallel tubular structures with a 16-mm internal diameter. Diagonal lines were drawn from the proximal speculum end and projected past the distal speculum end to a target 100 mm distal. The angle of exposure and the width of exposure at the 100-mm distal target were calculated for each speculum length using conventional trigonometry (*Fig. 3*).

RESULTS

Model Assessment

Using the model with a 16-mm distal internal diameter opening, as described above, the 60-mm upward-angled trapezoidal, 70-mm oval, and 80-mm oval specula were compared. The area of illumination at the target surface 100 mm away was 759, 579, and 432 mm^2 for the 60-, 70-, and 80-mm specula, respectively. Compared with the 70- and 80-mm oval specula, the 60-mm upward-angled trapezoidal speculum provides an increase in overall surface area illumination of 31 and 76%, respectively, and an increase in illumination of the superior half of the exposure of 41 and 81%, respectively.

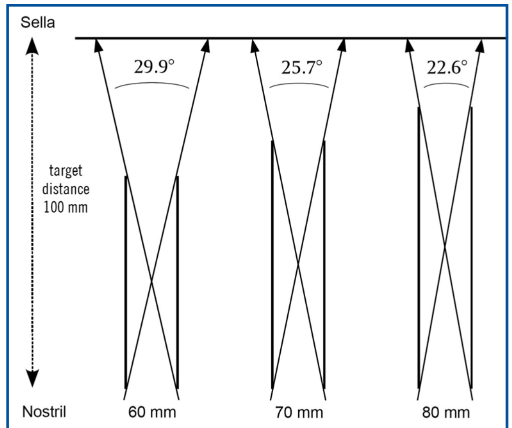

FIGURE 3. *Line drawings comparing the 60-, 70-, and 80-mm specula depicted as parallel lines, with 16-mm proximal and distal openings and a distance of 100 mm from the nostril to the sellar target. Note the increase in the angle of exposure for the 60-mm speculum. The width of exposure at the 100-mm target is 37 mm with the 60-mm speculum, as compared with 30 mm with the 70-mm speculum and 24 mm with the 80-mm speculum.*

Exposure Angles and Widths

The angles of exposure of the 60-, 70-, and 80-mm specula are 29.9, 25.7 and 22.6 degrees, respectively (*Fig. 3*). At the target located 100 mm from the proximal speculum end, these angles yield horizontal widths of exposure of 37 mm, 30 mm, and 24 mm for the 60-, 70-, and 80-mm specula, respectively.

Clinical Assessment

The upward- and downward-angled trapezoidal specula have been used to treat pituitary adenomas, nonadenomatous suprasellar lesions, and infrasellar lesions in patients. After an oval-shaped speculum (typically 70-mm) is used for the initial sphenoidotomy, the trapezoidal-shaped speculum is easily inserted and opened. To maximize the benefit of the new design, additional bone and soft tissue removal is required in the posterior nasal cavity, including an additional 10 mm of the posterior nasal septum and lateral soft tissue which may include a portion of the superior turbinate. Once this is done, the exposure within the sphenoid sinus is noticeably greater, which facilitates use of the endoscope with simultaneous use of other instruments.

DISCUSSION

Compared with the standard 70- and 80-mm endonasal oval-shaped specula in a transsphenoidal model, the 60-mm upward-angled trapezoidal speculum provided increased surface area exposure at the parasellar target and a wider angle of exposure, particularly in the superior parasellar area. The line drawings further reinforce the concept that shorter specula yield wider angles of exposure in the horizontal plane.

Evolution of the Transsphenoidal Speculum

With the introduction of rhinoscopy in the mid 19th century, a variety of specula were designed for transnasal surgery (25). Frankel's speculum combined fenestrated blades with a self-retaining screw and was used for the first transseptal modification of the transnasal pituitary operation (22). In 1914, Cushing (10) described his own speculum for better visualization of the sellar floor through the sublabial approach. In the microscopic transsphenoidal era, Hardy et al. (15) added toothed edges to the inferior blade surface to minimize speculum slippage. In 1975, Landolt and Novoselac (22) described a modification of the Cushing speculum in which the distal blades curved outward to retain tissue lateral to the surgical corridor. In 1980, Kern and Laws (20) developed a modification of the Hubbard sublabial speculum with a self-retaining retractor and distally flanged concave blades to further enhance lateral exposure (22). More recently, additional modifications have been introduced for both sublabial and endonasal approaches to expand visualization laterally. These changes have included thinning the proximal speculum blades (23), shortening one blade for better contralateral exposure (3), and adding another hinge for more panoramic visualization (21). Of the commonly used endonasal specula, most are thinner and have a variety of lengths, ranging from 70 to 90 mm (3, 21, 23, 24, 26).

The currently available endonasal specula typically have curved blades from the proximal to the distal end that result in an oval-shaped surgical corridor. Although this construction provides adequate exposure for sellar targets situated directly in line with the speculum, in many instances, the target extends beyond this trajectory, either superiorly in the suprasellar space or inferiorly in the clival region. This problem of inadequate exposure is often encountered if one is trying to access suprasellar tumors such as craniopharyngiomas, tuberculum sella meningiomas, or adenomas with large suprasellar extensions. Similarly, access to infrasellar lesions such as clival chordomas and prepontine epidermoid tumors is limited by the curved blade construction.

Clinical Utility of the Short Trapezoidal Speculum Design

The trapezoidal design minimizes the problem of curved blade obstruction encountered with traditional oval specula. The combination of the distal trapezoidal construction and shorter length expands the working volume within the speculum, widens the degree of horizontal exposure in the parasellar space, and improves instrument maneuverability. Because of the open-book–style trapezoidal construction, the working volume within the speculum expands superiorly for the upward-angled speculum and inferiorly for the downward-angled speculum. As shown in the model, the 60-mm upward-angled speculum increases exposure in the superior field by approximately 40 and 80% compared to the 70- and 80-mm specula, respectively. Shortening the speculum working length to 60 mm widens the horizontal angle of exposure, as seen in the line drawings, and this improved functionality is confirmed clinically. Instrument manipulations are improved with the shorter length and the absence of the restrictive curved blades. This enhanced maneuverability is particularly evident with the rigid endoscope, which becomes less obtrusive alongside other instruments because there is a greater working volume within the speculum itself. Multiple clinical and anatomic studies show that the endoscope provides more panoramic visualization of the parasellar region as compared with the microscope alone, particularly with 30- and 45-degree angled lenses (1, 5, 8, 9, 16, 19, 27). Thus, the short trapezoidal construction improves the functionality of the endoscope for access to the suprasellar, infrasellar, and medial cavernous sinus areas.

We now use the trapezoidal specula for all extended suprasellar and transclival approaches. The upward-angled trapezoidal speculum is also used for many cases of pituitary adenomas, given the enhanced suprasellar exposure. This speculum is particularly useful when a patient's nasal anatomy precludes placing the traditional oval specula at the ideal trajectory to the sella. In this situation, even if the trapezoidal speculum cannot be aimed directly at the sella, adequate suprasellar exposure and instrument maneuverability can be achieved by removing obstructing soft tissue above the upper plane of the speculum blades. More bone and soft tissue removal is required in the posterior nasal cavity to maximize the benefit of these short specula. Resection of the ipsilateral middle turbinate will yield additional exposure of the ipsilateral cavernous sinus area, although this is typically not needed (1, 2, 17, 18). Anecdotally, we have not seen an increase in postoperative sinonasal complaints from patients as a result of more extensive soft tissue and bone removal in the posterior nasal cavity. However, the impact of these short specula on patient recovery has not been studied systematically as we have done in the past for the standard and extended endonasal approaches (12).

As experience with the shorter specula has increased, the 80-mm speculum is rarely used, and the 90-mm speculum has been removed from the endonasal set. In fact, in most adults, the 90-mm speculum will extend into the sphenoid sinus, which can lead to a cranial base fracture if the blades are opened too forcefully (4). To minimize the amount of soft tissue and bone removal needed in the posterior nasal cavity, the trapezoidal speculum is also made in a 70-mm length, which provides adequate exposure for many parasellar lesions.

Model Limitations

There is wide variability across patients in terms of the dimensions of the nostrils and turbinates, the alignment of the nasal septum, and the depth of the sphenoid sinus (26). The rationale for using the clay model was to allow a comparison of the three specula in a consistent anatomic setting. The model design was based on actual patient measurements, and the dimensions used, including the distance from the nostril to the sella and the width of the speculum openings, are, thus, clinically relevant. Notably, for all three speculum lengths, the width between the two speculum blades was relatively constant, both proximally and distally, for each speculum and for all three speculum lengths. Although the distal speculum opening can go beyond 16 mm in some patients, in most individuals, opening the speculum wider risks tearing the nostril in the alar crease. As noted above, if the ipsilateral middle turbinate is removed, the distal speculum can be opened more widely without traumatizing the nostril.

The line drawings were drawn to scale and based on the same anatomic assumptions as the clay model. The measurements show that with a 60-mm speculum opened to 16 mm proximally and distally, a horizontal width of exposure of 37 mm is achieved at a target distance of 100 mm from the nostril. Anatomic studies by Garcia and Rhoton (13) indicate, however, that the distance between the optic nerves at the anterior wall of the sphenoid sinus ranges from 27 to 31 mm. At a distance of 10 mm inside the sphenoid sinus (which is close to the 100-mm depth of the target used in our model), the distance between the optic nerves decreases further, ranging from 14 to 17 mm (13). So, although the optic canals as well as the cavernous carotid arteries limit the extent of lateral maneuverability within the posterior sphenoid sinus, these line drawings emphasize the concept that a shorter speculum yields a wider horizontal exposure. This widened exposure can be used for better visualization of these areas as well as of the parasellar areas situated superiorly and inferiorly to the optic canals.

CONCLUSION

Short (60-mm) trapezoidal endonasal specula with a 15-degree upward or downward orientation and a 5-degree outward distal flare increase parasellar exposure and working volume within and beyond the speculum. Our initial clinical experience with these specula suggests that they provide expanded visualization, improve access to the parasellar region, and facilitate endoscope-assisted tumor removal.

Disclosure

Daniel F. Kelly, M.D., has a consulting and royalties arrangement with Mizuho-America, Inc., but has not received any financial support in conjunction with the generation of this manuscript. A patent is pending for this instrumentation.

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COMMENTS

This is an interesting design of a speculum for transsphenoidal surgery, whether via a microscopic or endoscopic technique. The restriction of view secondary to the speculum is clearly more problematic for the microscopic surgical approach. With the endoscopic approach, the visual exposure is far wider than that offered with any speculum. An important point noted is that the widest visual exposure is obtained with the shortest speculum possible: the longer the speculum, the more limited and narrow the field. The variation with curved up or down as well as the narrowed tips should be very helpful when those views are required.

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This article makes two important points about specula used for endonasal transsphenoidal surgery: first, that a longer speculum is not necessary for retraction and actually restricts the angle of view; and, second, that the configuration of the speculum blades at the distal end can be modified to further enhance the field of view. In my practice, I also use the 60-mm speculum. Rather than modifying the blade configuration, however, I simply rotate the oval speculum so that the blades are oriented at various angles between vertical and horizontal. By adjusting the microscope and working between the blade opening, the exposure is significantly expanded beyond the usual core (*Fig. 13* in the article). The magnetic resonance-computable speculum that I use has a smaller flange (*Fig. C1*) at the top, which facilitates rotation, and adjustment of the speculum and microscope usually takes only a few seconds. With this technique it is possible to visualize the entire posterior sphenoid sinus, equivalent to the range of view for the 0º-angled endoscope. I prefer the stereoscopic view and high-intensity illumination of the microscope compared with the endoscope.

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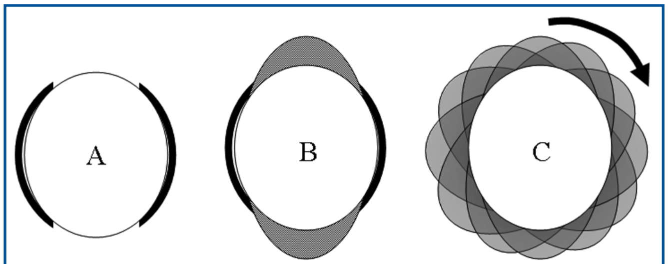

FIGURE C1. *Field of view through nasal speculum.* **A**, *normal field of view.* **B**, *expansion of field by angling microscope line of sight through open blades of speculum.* **C**, *expanded field of view achieved by speculum rotation and microscope orientation.*

The transsphenoidal approach is the most commonly used approach for sellar pathological lesions. The speculum represents the key instrument of the procedure, which is in continuous evolution. At present, the transsphenoidal approach may be performed using a microsurgical technique, an endoscopic-assisted technique, and a purely endoscopic technique. The latter technique avoids the use of the speculum because it may be the source of a series of surgical complications and represents a limit to the flexibility of surgical trajectories and to the maneuverability of the instruments. However, numerous neurosurgeons continue to perform the microsurgical transsphenoidal approach, using the endoscope to improve visualization of the surgical field (endoscopic-assisted technique). They use the speculum, which has been perfected, and now requires modification to be adapted to the new targets of the transsphenoidal approach, which are the suprasellar, parasellar, and cavernous sinus areas.

The speculum of Fatemi et al. was created to enhance exposure and increase instrument maneuverability. The authors designed an ultrashort endonasal speculum of only 60 mm in length in which the distal 20 mm changes to an upward trapezoidal shape for suprasellar exposure or a downward trapezoidal shape for infrasellar exposure. To maximize the benefit of the new design, additional bone and soft tissue removal is required in the posterior nasal cavity, including an additional 10 mm of the posterior nasal septum.

I agree with the authors that this adjunctive tissue removal is without clinical consequences and should not be overemphasized. Fatemi et al.'s article deals with the modification of a key instrument of one of the most important neurosurgical procedures. I sincerely hope that this new instrument will make it easier to reach "Paradise," which is to avoid instrument morbidity and to obtain good exposure and optimal instrument maneuverability, allowing the surgeon to continue to benefit from a tridimensional microsurgical view.

Giorgio Frank
Bologna, Italy

Dan Kelly returns to the "scene of the crime" and delivers another good job! No doubt he should be mentioned as one of the more updated and modern ambassadors of the neurosurgical transsphenoidal technique. His studies concerning surgical techniques and take-home messages from daily experiences have permitted improvements in the extraordinary transsphenoidal approach, which nowadays can be used, as foreseen by Hardy in 1971 (1), not only in the sella, but also in regions around it with the extended transsphenoidal procedures.

Exposure and management of the increased surgical target area permitted by this new device provide renewed strength and further possibilities of approaches through the sphenoid. Credit must be given to endoscopic operators for proposing these recent strategies, i.e., the extended transsphenoidal approaches, thereby pushing microsurgery to follow suit.

We favor the use of the endoscope alone to visualize the surgical field without any speculum to gain an even wider working angle and views of the relevant anatomy, but we do appreciate the ideas and proposal of Kelly's group, which are confirmed by excellent scientific contributions and clinical results.

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