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Image-Guided Endoscopic Transsphenoidal Removal of Pituitary Tumours

Amin R. Javer, BSc, Osama Marglani, MD FRCSC, Andrew Lee, MD FRCSC, Mark Matishak, MD FRCSC, and Krista A. Genoway, BSc

ABSTRACT

Background: **With continuing advancements in minimally invasive endoscopic nasal and sinus surgical techniques, image-guided endoscopic transsphenoidal approaches to the pituitary gland and anterior skull base have progressively become more popular.**

Methods: **Clinical records were reviewed retrospectively from 2001 to 2006. Twenty-nine consecutive patients with pituitary tumours underwent transnasal endoscopic surgery.**

Results: **We outlined our endoscopic surgical technique with the use of image guidance. The duration of surgery, complications, and hospital stay were also reviewed.**

Conclusions: **Image guidance can be applied during transnasal transsphenoidal endoscopic surgery and requires a minimal amount of time. It can reduce morbidity and allow for a more complete and safer operation with minimal postoperative discomfort. It can significantly reduce postoperative hospital stay, resulting in a reduced cost to the medical system.**

SOMMAIRE

Introduction: **Avec l'avancement continuel des techniques d'endoscopie chirurgicales nasales et sinusiennes, les approches endoscopiques transphénoidales peu effractives guidées par ordinateur vers l'hypophyse et la base du crâne antérieur ont gagné en popularité.**

Méthode: **Nous avons revu les dossiers cliniques entre 2001 et 2006. Nous avons opéré par endoscopie trans-nasale 29 patients avec une tumeur hypophysaire.**

Résultats: **Nous présentons les grandes lignes de notre technique endoscopique utilisant la guidance par ordinateur. La durée de la chirurgie, les complications et la durée de séjour ont aussi été évaluées.**

Conclusions: **La guidance par ordinateur s'applique facilement à la chirurgie endoscopique transnasale, transphénoidale et ne demande que peu de temps. Elle peut réduire la morbidité et permettre une opération plus complète et plus sécuritaire avec un incomfort postopératoire minimal. Elle peut réduire de façon significative la durée de séjour hospitalière ce qui diminue les coûts imposés au système de santé.**

Key words: *endoscopic, pituitary surgery, transsphenoidal*

The past 10 years have seen a fascinating development and refinement of minimally invasive surgery. A prime example of this surgical evolution is the use of the endoscope to access the sphenoid sinus for surgery of pituitary and skull base tumours. Horsley removed the first pituitary adenoma through a bifrontal craniotomy approach in 1889.[1] The first transnasal approach was developed by Schloffer in 1907.[2] Soon after, Halstead introduced the gingivobuccal incision to provide a sublabial transseptal approach to the sella. It was not until 1910 that Oskar Hirsch and Harvey Cushing described and popularized the transnasal and sublabial approaches to the pituitary gland via the transphenoidal route.[3] Cushing, in 1914, combined the sublabial incision with a submucous septal approach, thereby preserving nasal function and avoiding a facial scar.[4] He then abandoned this procedure a decade later because of poor visualization and complications. The next advancement came with the use of the operating microscope and intraoperative fluoroscopy by Guiot in the 1960s. This dropped the mortality rates for transnasal hypophysectomies to approximately 1.9%.[5] The reaffirmation of the transsphenoidal procedure in North

Amin R. Javer, Osama Marglani, *and* Krista A. Genoway: *St. Paul's Sinus Centre, St. Paul's Hospital, Vancouver, British Columbia; and* Andrew Lee *and* Mark Matishak: *Department of Neurosurgery, Royal Columbian Hospital, New Westminster, British Columbia.*

Address reprint requests to: Amin R. Javer, *St. Paul's Sinus Centre, St. Paul's Hospital, 1081 Burrard Street, Vancouver, BC V6Z 1Y6; e-mail: sinussurgeon@drjaver.com.*

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America was related to the work and vision of Jules Hardy at Notre-Dame Hospital in Montreal. He introduced the surgical microscope that proved to be an invaluable tool, critical to the eventual widespread acceptance of the transsphenoidal approach.[3] The transseptal approach using the microscope was used extensively and remains a preferred method at many centres today.

The development of modern optics, coupled with endoscopic instrumentation, paralleled the popularity of endoscopic sinus surgery in the 1970s. Endoscopes provide unparalleled visualization and access to the sphenoid sinus with minimal trauma, improved patient comfort, and decreased morbidity postsurgery. Successful endoscopic transnasal transsphenoidal pituitary surgery was first described in three cases by Jankowski and colleagues in 1992.[6] Multiple centres adopted this approach as a complement to the traditional use of the operating microscope, with the endoscope being used for access and final inspection after the procedure. Jho and colleagues described what is now known as minimally invasive transsphenoidal surgery in 1996, when the endoscope was used for the entire procedure in three cases.[7] New technologies are now emerging, including computer-assisted navigation and endoscopy-based specific instrumentation; these advances continue to increase the efficacy of the procedure while decreasing morbidity and mortality.

Methods

Patient Characteristics and Statistical Analysis

Between November 2001 and March 2006, 29 patients with pituitary adenomas and several other intracranial or sellar lesions underwent surgery via an endoscopic technique at the Royal Columbian Hospital. The demographics collected included age, sex, presenting symptom(s), prior surgical procedure(s), and preoperative laboratory results. Follow-up data were collected, including operative time, length of hospitalization, and the incidence of complications, including cerebrospinal fluid (CSF) fistulae, diabetes insipidus (DI), anterior pituitary insufficiency, intrasellar hematoma formation, loss of vision, central nervous system injury, meningitis, carotid artery injury, and death. Statistical analysis was performed by a biostatistician using *SAS* 9.1 (SAS Institute, Cary, NC). Statistically significant differences were assessed at a significance level of .05.

Perioperative Evaluation and Management

A complete preoperative rhinologic workup was carried out on all patients. Any previous symptoms of sinus blockage, headache, facial pressure, or anosmia, as well as a history of nasal trauma or surgery, were documented. A complete endoscopic examination of the nasal cavity was performed to identify pathology that might interfere with surgical access, that is, septal deviation, perforation, nasal polyps, or infection. All patients had magnetic resonance imaging (MRI) and three-dimensional computed tomography (CT) preoperatively. Postoperative CT scans and MRIs were obtained in every patient. Patients were also seen by a neurosurgeon, an ophthalmologist, and an endocrinologist preoperatively.

Image Guidance

The Instatrak 3500 Plus image guidance system (GE), an electromagnetic stereotactic tracking device, was used in all of the surgeries. The CT scan was loaded onto the Instatrak computer, and the headset was placed in position on the patient's head intraoperatively. Registration and calibration of the suction tip were then carried out and verified. Electromagnetic technology was used to track the position of the suction tip in all cases.[8]

Nasal Phase

The procedure is performed under general anesthesia with orotracheal intubation. Neurosurgical pledgets soaked in 0.1% xylometazoline (Otrivin) are placed in the nasal cavity for 5 minutes. Once adequate nasal congestion is achieved, careful nasal endoscopy using a 0° 4 mm endoscope is performed. The middle turbinate is gently lateralized to maximize the space between the middle turbinate and the nasal septum. This creates the surgical pathway for access to the sphenoethmoid recess. Lidocaine 1% with epinephrine 1:200 000 is then injected submucosally in the posterior third of the nasal septum and face of the sphenoid sinus. The middle turbinate is protected with pledgets soaked in xylometazoline to avoid any mucosal bleeding and swelling. The sphenoethmiod recess and the natural sphenoid ostium are then identified. A sickle knife and caudal elevators are then used to elevate a mucoperichondrial flap off the posterior septum. The posterior aspect of the bony septum leading to the sphenoid rostrum is then removed with through-cutting instrumentation and rongeurs. If a significant septal deviation is present and obstructing the transnasal access to the posterior septum, then a transseptal approach may be warranted. In such a case, a hemitransfixion incision is performed and a mucoperichondrial flap is elevated endoscopically. The cartilaginous and bony septa are disarticulated from the maxillary crest and pushed toward the contralateral side of the nose or removed in one (or several large) piece(s). This wide exposure then allows for easy visualization of the sphenoid rostrum. If a transseptal approach is not necessary, adequate access is obtained to the sphenoid sinus from both sides using both nostrils during the tumour removal phase of the procedure, a biportal technique. The middle turbinates are never removed (even partially) for access to the pituitary fossa.

Sphenoid Phase

Using a 0° endoscope, mucosa is elevated off the rostrum, exposing the sphenoid ostia bilaterally. The Instatrak tip is used to confirm midline position at the sphenoid face prior to entering the sphenoid sinus. A midline sphenoidotomy is then created with 2 mm chisels and enlarged to include both sphenoid ostia with backbiting Kerrison punches. The entire anterior wall of the sphenoid sinus is visualized and systematically removed using various Kerrison punches. Care must be taken in the inferolateral direction, where the posterior branch of the sphenopalatine artery may be injured.

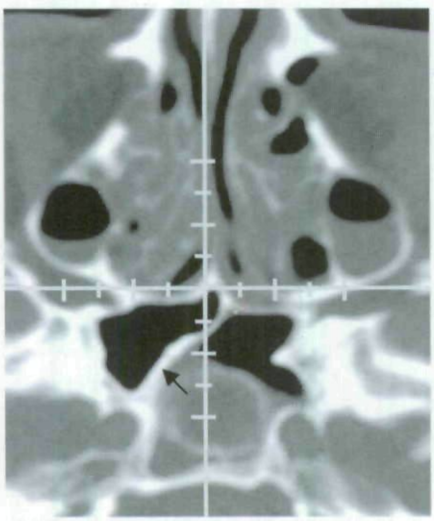
With the aid of sagittal images on the image-guided system, the superior limit of the sphenoid face is easily identified to ensure a safe distance from the skull base. If a transseptal approach is chosen, a Hardy retractor is placed through the septal incision. The endoscopes, together with the localizing suction probe, provide excellent visualization of the sphenoid sinus and related structures. Landmarks such as the intrasinus septa, optic nerves, carotid arteries, and skull base are easily localized by the navigation system.

The images of the sphenoid sinus septations revealed by the preoperative CT scan (in coronal and axial projections) are closely compared with the endoscopic views, especially when the septa are implanted on the carotid prominences. Twisting of the septations is carefully avoided if they need to be removed (Figure 1).

The mucous membrane over the posterior wall of the spheniod sinus is then carefully elevated with a straight suction curette. The mucosa is folded away laterally and preserved from the dissection site, with the aim of replacing it back in its original position at the end of the procedure (Figure 2). The thin posterior sphenoid bone is then removed by a chisel and Kerrison instrumentation.

Sellar Phase

We use an all-endoscopic technique for removal of the pituitary mass. Our neurosurgeons (M.M., A.L.) use both hands during the tumour removal process and operate off the monitor while the endoscope is held in the contralateral nostril by the sinus surgeon (A.R.J.), providing unhindered visualization. The pituitary tumour is removed in the standard manner with blunt ring curettes and pituitary forceps. At the conclusion of tumour removal, angled endoscopes are used to inspect the "hidden" regions of the sella for residual tumour and CSF leak. Thirty and 70° endoscopes may be used to visualize the most anterosuperior quadrant of the sella. Once satisfied that the tumour has been completely excised, a small piece of absorbable Gelfoam is gently



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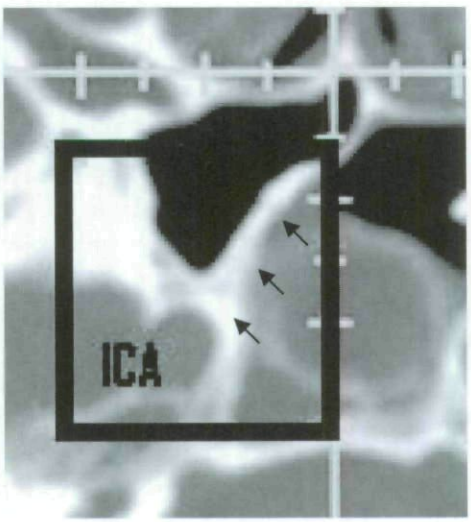

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Figure 1. *A*, Axial computed tomographic scan showing the intersinus septum (*arrows*) and its crucial relationship to the internal carotid artery (ICA). *B*, Closer view.

Figure 2. Mucosal elevation off the sellar face.

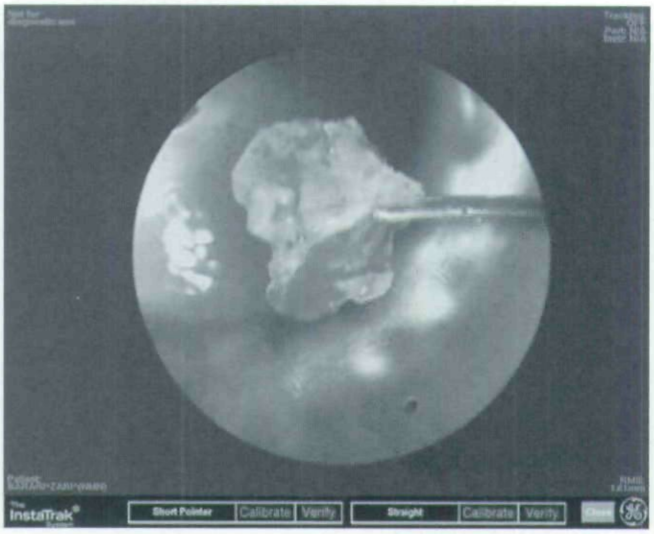

Figure 3. The sellar face bone is reused for reconstruction.

placed within the sella. The Gelfoam behaves as back support for the bone graft that is placed to reconstruct the posterior wall of the sphenoid sinus.

Sellar Reconstruction Phase

A small piece of septal bone is used to reconstruct the sellar face. The previously preserved mucosal flap is repositioned over the reconstructed sellar face. A small amount of Gelfoam is placed over the repair site on the sphenoid side. The sphenoid sinus is never packed.

In the event of an intraoperative CSF leak, autologous fat is harvested from the periumblical or left lower quadrant region. We prefer not to take the fat graft from the right lower quadrant to avoid mimicking an appendectomy scar that may cause unnecessary confusion in the future. The fat is placed within the sella. Autologous bone or cartilage from the nasal septum or the sphenoid face is then used to repair the sellar face (Figure 3), followed by the usual repair process as described above. Placement of material in the sella reduces the presence of dead space and prevents the descent of the optic chiasm into the sellar cavity.

Closure of the Nasal Septum

The mucoperichondrial flap and the bony and cartilaginous septum are then repositioned and secured to the maxillary crest. The anterior hemitransfixion incision is closed with 4-0 plain gut interrupted sutures. Two running mattress stitches are placed through the septum to prevent the development of a septal hematoma. Bilateral sphenoethmoid recesses are then examined to ensure that adequate sphenoidotomies are created for future examination of the sphenoid sinus. Doyle septal splints with built-in air passages are placed along the septum by a single 2-0 nylon stitch sutured through the caudal membranous nasal septum.

The patient is followed in hospital by the endocrinologist and seen in the otolaryngology outpatient clinic at 6 days for removal of the nasal splints. Figure 4 shows an endoscopic view of the surgical site 3 month postoperatively.

Results

Our patient population included 18 men and 11 women, ranging in age from 18 to 79 years (median 53 years). The histologic diagnoses included 24 pituitary adenomas, 2

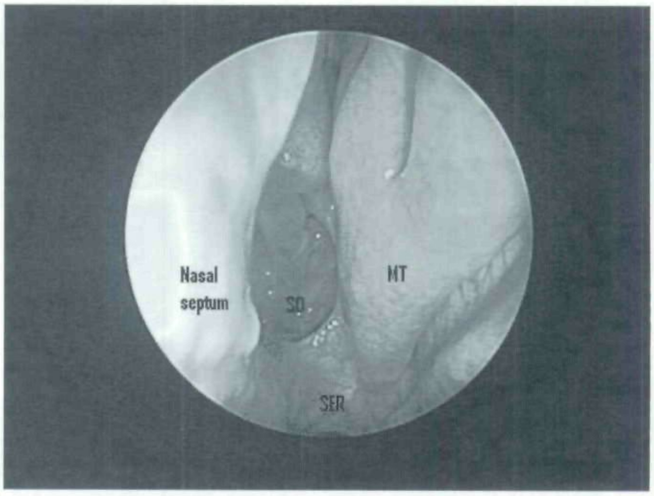

Figure 4. Three-month postoperative view. MT = middle turbinate; SER = sphenoethmoid recess; SO = sphenoid ostium.

Rathke cleft cysts, 2 epidermoid cysts, and 1 craniopharyngioma. The patient charts were retrospectively reviewed, and information from follow-up visits was collected to assess operative success rates and the incidence of complications.

Clinical presentation varied and was divided into three categories: 12 patients (41%) presented with visual disorder, 5 patients (17%) with endocrine abnormalities, 3 patients (10%) with severe intractable frontal and retro-orbital headaches, 1 patient (4%) with symptoms of pituitary apoplexy, and the remaining 8 patients (28%) with combined symptoms of the three categories.

The endoscopic transnasal transsphenoidal surgical approach was the primary surgical route used in 68% of cases. The endoscopic transseptal transsphenoidal approach was used in the other 32% of patients only if significant septal deviation obstructed the visual field.

The mean operative time was 152.2 minutes, ranging from 90 to 210 minutes. The endoscopic transseptal approach averaged 171.2 minutes and the endoscopic endonasal approach 141.2 minutes. The Wilcoxon two-sample test produced a mean score of 18.1 for the transseptal group and a mean score of 11.0 for the transsphenoidal group, with a p value of .033 (Figure 5). This indicates a significant difference of mean surgical time between the two groups.

The postoperative hospitalization period was 4.7 days. The most common surgical complications were CSF leak, which occurred in three patients (10.8%), regrowth of residual tumour in three patients (10.8%), DI in two patients (6.8%), and anesthetic complications in one patient (2.9%). Surgical complications observed in this study compared with a national survey by Ciric and colleagues[9] can be found in Table 1. The three patients who developed intraoperative CSF leaks were all repaired successfully. The temporary DI encountered in two patients was resolved with no long-term sequelae. Permanent DI is rare and was not encountered. Anesthetic complications associated with the transsphenoidal operative technique are relatively rare. We did encounter one patient who became hemodynamically compromised after submucosal injection of 1% lidocaine plus 1:100 000 adrenaline. We elected to abort her surgery. After extensive negative investigations, she underwent a successful procedure without local anesthesia.

Discussion

Minimally invasive transnasal transsphenoidal pituitary surgery has developed into a safe and effective technique with low morbidity. The technique obviates the need for packing associated with the transseptal and sublabial approaches. Straight and angled endoscopes provide unparalleled visualization of the sella, the carotid arteries, and lateral recesses of the sphenoid sinus, which was previously not possible with the standard microsurgical technique. In a recent review, Mehta and colleagues indicated several advantages of an endoscopic approach, including quicker recovery time and a decrease in nasal, dental, and cosmetic complications.[10] At our institution, the trend is gradually moving toward the less morbid endoscopic transnasal approach in favour of the transseptal endoscopic approach as the surgeons become more comfortable working via a biportal approach. Total preservation of the middle turbinates has been possible in every case. Turbinate preservation reduces the obvious morbidities of anosmia, dryness, and crusting and the empty nose syndrome. A wide sphenoidotomy is carried out at the end of every procedure and allows for endoscopic monitoring of the surgical site in the office and simplifies access if the need for a reoperation arises.

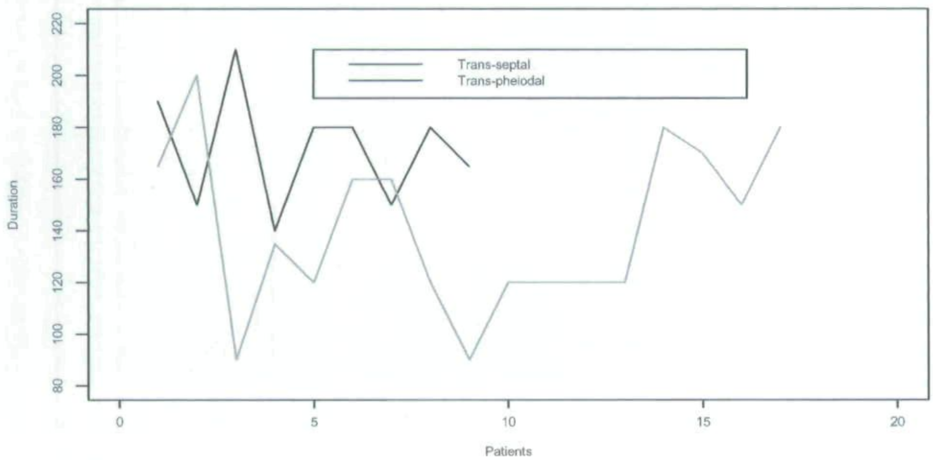

Figure 5. Comparison of the operative time between the transseptal group versus the transnasal group.

Table 1. Complications of Image-Guided Endoscopic Pituitary Surgery

Surgical Complications	*Percent Reported in This Study*	*Percent Reported in National Survey*
CSF leak	10.8	9–15
Anesthetic complication	2.9	Rare
Diabetes insipidus	6.8	10–60
Regrowth of residual tumour	10.8	0–43
Carotid injury	0	0.4–1.4
Meningitis	0	1.5
Epistaxis	0	0.4–4.3
Visual loss	0	0.6–1.6
Death	0	0.2–1.43

CSF = cerebrospinal fluid.

Modern optical and navigation systems provide an unparalleled panoramic view of the sellar and suprasellar anatomy and map the essential anatomic bony structures with reliability and accuracy, with excellent outcomes.

Frameless three-dimensional image localization technology first introduced in the early 1990s is a state-of-the-art advancement in endoscopic sinus surgery. This technology provides continuous real-time localization, allowing for an appropriate midline surgical approach. It also provides an excellent teaching tool that enhances education for residents and medical students. A direct comparison by Cappabianca and colleagues, in revision endoscopic pituitary surgery, found no distinct improvements in morbidity or mortality with the use of image guidance.[11] They did, however, find a shorter operative time with improved efficiency. We find the Instatrak 3500 Plus image guidance system to be reliable and highly accurate, with minimal addition to the set-up time. CT scans and/or MRIs are used and may be fused to provide good bony detail and excellent resolution of the tumour tissue. Image guidance in our experience provides an additional tool that is useful in delineating crucial bony landmarks, especially in revision cases, and is superior to fluoroscopy even though it is not real time.

It is important to state that these modern intraoperative imaging technologies cannot supplant the surgeon's basic anatomic knowledge. Image guidance has been found to be a valuable tool in minimally invasive pituitary gland surgery and is very useful for complex and revision cases. However, as for any surgical technology, navigation must be used in conjunction with sound clinical judgment. It does not replace surgical technique or knowledge of the endoscopic anatomy.

We found a significant difference in mean operative time between the transseptal approach and the endoscopic endonasal approach. We feel that the septal part of the transseptal procedure was clearly responsible for the increased 30 minutes in that group of patients.

The postoperative hospitalization period in this study was 4.7 days. White and Sonnenburg found the average hospital stay decreased from 5.4 to 3.7 days when the technique changed from a sublabial approach to a minimally invasive approach.[12] The most common indications for longer hospitalization in our group included temporary DI and prior comorbid conditions, which required extended monitoring or rehabilitation.

Few surgical complications were observed in this study. The most common complication was intraoperative CSF leak (10.8%). This is comparable to what has been reported in the literature.[13,14] Table 1 summarizes our complication rates and compares them with those from a national survey by Ciric and colleagues of over 1162 surgeons who perform transseptal-transsphenoidal pituitary surgery.[9] The most common complications of this operation are CSF leak, DI, hypopituitarism, and meningitis.[9,12] A recent review by White and Sonnenburg showed little difference in complication rates between the minimally invasive and traditional approaches but noted an improvement in patient morbidity, including lip anesthesia, epistaxis, and nasal obstruction with the minimally invasive approach.[12] Temporary posttranssphenoidal surgery DI has been reported to occur in 10 to 60% of cases.[15] The percentage of transsphenoidal operations resulting in carotid artery injuries varied from 0.4 to 1.4%.[9] We did not encounter carotid injuries, visual loss, meningitis, epistaxis, or death in our cohort.

Conclusion

Image guidance can be applied during transnasal transsphenoidal endoscopic surgery and requires a minimal amount of additional time. It likely reduces the morbidity and makes the operation safer, with minimal postoperative discomfort and a significant reduction in postoperative hospital stay, resulting in a significantly reduced cost to the medical system.

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