Transorbital Neuroendoscopic Management of Sinogenic Complications Involving the Frontal Sinus, Orbit, and Anterior Cranial Fossa

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Abstract

Keywords

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- mucocele
- mucopyocele
- multiportal

Transnasal endoscopic surgery has remained at the forefront of surgical management of sinogenic complications involving the frontal sinus, orbit, and anterior skull base. However, the difficulty in accessing certain areas of these anatomical regions can potentially limit its use. Transorbital neuroendoscopic surgery (TONES) was recently introduced to transgress the limits of transnasal endoscopic surgery; the access that it provides could add additional surgical pathways for treating sinogenic complications involving the frontal sinus, orbit, and anterior cranial fossa. We describe a prospective series of 13 patients who underwent TONES for the management of various sinogenic complications, including epidural abscess, orbital abscess, and fronto-orbital mucocele or mucopyocele, as well as subperiosteal abscess presenting with orbital apex syndrome. The primary outcome measurement was the efficacy of TONES in treating these pathologies. TONES provided effective access to the frontal sinus, orbit, and the anterior cranial fossa. All patients demonstrated postoperative resolution of initial clinical symptoms with well-hidden surgical scars. There were no ophthalmologic complications or recurrence of pathology. Based on our experience, TONES appears to provide a valuable addition to the current surgical armamentarium for treating selected complications of sinusitis.

Introduction

Sinogenic complications involving the frontal sinus, orbit, and anterior cranial fossa are uncommon in the era of antibiotics.¹ However, complications such as mucocele and mucopyocele of the fronto-orbital region, as well as orbital and epidural abscess, create significant morbidity and pose serious therapeutic challenges.^{2–4} In the past decade, endonasal techniques replaced the traditional external surgical approaches to manage the majority of these complications.^{5,6} Indeed, endoscopic sinus surgery (ESS) has provided effective and safe options for managing sinogenic complications of the orbit, frontal sinus, and anterior skull base that would previously

have necessitated extensive open approaches.^{7–11} However, certain regions involved in pathology of the sinuses either cannot be accessed in this fashion or they endanger critical neurovascular structures when transnasal pathways are employed.^{12–15} This is particularly true for abscesses that involve multiple compartments, such as the orbit, frontal sinus, and anterior cranial fossa synchronously. Therefore, a new surgical pathway that provides improved access and visualization of these challenging anatomical regions might enhance the management of sinogenic complications.

Transorbital neuroendoscopic surgery (TONES) was introduced as a system of endoscopic transconjunctival and

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transpalpebral pathways to targets within or accessible through the orbit.^{16,17} Management of various pathologies of the anterior and middle cranial fossae, including repair of cerebrospinal fluid (CSF) leak and optic nerve decompression, as well as removal of tumors, has been demonstrated using these approaches. The technique provides coplanar pathway to the target and hence limits the requirement for angled endoscopy that could be visually disorienting to some surgeons. Moreover, it offers a favorable path-to-target trajectory for accessing the lateral frontal sinus, orbit, and anterior cranial base that may be lacking in transnasal approaches.¹⁶ Finally, TONES employs cosmetically favorable, well-hidden incisions via either transconjunctival or transpalpebral cutaneous incisions.

In this paper, we extend our previous findings and describe the use of TONES in managing selected complications of sinusitis. We propose that TONES can be used alone or in multiportal combination with ESS to safely and effectively treat sinogenic complications involving the lateral frontal sinus, orbit, and the anterior skull fossa that would otherwise have required more extensive or open approaches.

Materials and Methods

Subjects

A prospective outcome study was conducted in 13 patients (10 males and 3 females; mean age 43.5, range 19 to 81) from March 2006 to July 2011. Subjects with orbital or intracranial complications resulting from sinusitis including subperiosteal, orbital, or intracranial abscesses as well as fronto-orbital mucocoeles or mucopyoceles were included in the study. All subjects underwent TONES procedure at an academic tertiary care referral center (Harborview Medical Center, University of Washington, Seattle, WA, USA) by or under the supervision of the senior author (K.S.M.). The postoperative follow-up ranged from 1 to 14 months (patients who come from long distances for treatment are referred to their local physicians for postoperative care and longer term follow-up is often not feasible). The study was approved by the University of Washington Human Subjects Division of the Institutional Review Board.

Image-guided Navigation

All surgical procedures began with registration of the image-guided surgical navigation system (Stryker, Kalamazoo, MI, USA). The surgical pathway is chosen as described earlier, based on the quadrant of the orbit that is nearest the pathology¹⁶ (→Fig. 1). The pathways used most commonly in this series were the lateral retrocanthal (LRC), superior eyelid crease (SLC), and precaruncular (PC).

The surgical plan was then finalized by analyzing the vector of the chosen surgical path to the target pathology using the navigation software.

Epidural Abscess Drainage

The SLC approach was utilized as described previously.¹⁶ Briefly, a blepharoplasty incision was made in a crease of the upper eyelid. The dissection continued through the

Fig. 1 Transorbital approaches to the orbit, frontal sinus, and anterior cranial fossa (A, B). Precaruncular, superior eyelid crease, and lateral retrocanthal are shown in three-dimensional reconstructed head.

orbicularis oculi muscle, and a skin-muscle flap was raised superiorly in the preseptal plane to the orbital rim (→Fig. 2A). The periosteum was incised at the orbital rim. Under endoscopic guidance, the dissection continued posteriorly along the orbital roof in the plane between the periosteum and bone. Image guidance was then used to determine the transosseous pathway to the abscess cavity. For a known or suspected epidural abscess, a mini-craniectomy was then created in the orbital roof using a diamond drill or ultrasonic bone aspirator (Sonopet, Stryker, Kalamazoo, MI, USA). In cases where a bone defect had already been created by the pathology, this was used as the surgical pathway and enlarged as necessary. The dura was elevated off the surrounding bone, the abscess was drained, and the region was copiously irrigated with normal saline. Intracranial endoscopic inspection was then performed again to ensure that no further purulence was present. A quarter-inch Penrose drain was

Fig. 2 Superolateral orbital abscess and epidural abscess drainage. Intraoperative view of superior eyelid crease approach; superior orbital rim is exposed (A). Endoscopic view of the orbit with orbital contents displaced inferiorly. Bony erosions in the orbital roof are shown (white arrowhead; B). Bone of the orbital roof is removed with Kerrison rongeurs and pus is drained (C). Craniotomy is completed with 3 mm diamond burr and dura (black arrowhead) is exposed (D).

placed in the orbital roof and externalized through the incision.

Subperiosteal and Orbital Abscess Drainage with Optic Nerve Decompression

Both the PC and SLC approaches were used, depending on the location of the abscess. The SLC approach was performed as described above and dissection continued under zero-degree 4 mm endoscopic visualization until the abscess cavity was encountered. For the PC approach, the incision was created at the junction of the conjunctiva and skin, medial to the caruncle, with a fine scissors.¹⁸ The dissection continued along the posterior limb of the medial canthal tendon to the posterior lacrimal crest. The periorbital was then incised immediately posterior to the posterior lacrimal crest and lifted off the lamina papyracea with a periosteal suction-elevator. The dissection continued posteriorly under image guidance until the abscess was identified, drained and thoroughly irrigated. For optic nerve decompression, the dissection was continued toward the orbital apex. The medial aspect of the optic canal was elevated off the nerve with a thin periosteal elevator or, in cases with thicker bone, by drilling with irrigation or ultrasonic aspiration. The decompression was performed along the entire intracanalicular course of the nerve to the dura as described previously.¹⁶

Frontal Sinus Decompression and Intersinus Septum Removal

Computed tomography (CT) image-guided navigation was used to plan the appropriate trajectory for the most direct surgical pathway from the orbital roof into the frontal sinus. The frontal sinus was then entered by ultrasonic bone aspiration to either decompress the mucocele or evacuate the abscess. If the pathology involved only the ipsilateral frontal sinus, the intersinus septum was removed by ultrasonic aspiration to allow drainage through the contralateral frontal sinus cavity.

Results

Thirteen subjects underwent TONES procedures for management of sinogenic complications involving the frontal sinus, orbit, and/or anterior cranial fossa (► **Table 1**). Seven patients received transorbital endoscopic drainage of subperiosteal (patients 1 and 9) and orbital abscess (patients 2, 3, 5, 6, and 7). Both patients with subperiosteal abscess presented with orbital apex syndrome, requiring decompression of the optic nerve. Patient 9 also manifested cavernous sinus thrombosis. PC and SLC approaches were used to drain the abscess and provided excellent access and visualization of the abscess cavity. In particular, the PC approach was sufficient for

Table 1 Summary of TONES for management of sinusitis complications

Patient	Sex	Age	Sinusitis complication(s)	TONES procedure	Approach	Cultured organism	Outcome
1	M	50	Orbital apex syndrome Subperiosteal abscess	Drainage of orbit Optic nerve decompression	PC	<i>S. aureus</i>	Resolved
2	M	53	Orbital abscess	Drainage of orbit	PC	MRSA	Resolved
3	M	55	Orbital abscess	Drainage of orbit Frontal sinus decompression	SLC	<i>S. aureus</i>	Resolved
4	M	22	Epidural abscess	Endoscopic craniotomy Frontal sinus decompression	SLC	<i>S. aureus</i> <i>S. milleri</i>	Resolved
5	M	81	Orbital abscess Epidural abscess	Drainage of orbit Endoscopic craniotomy Frontal sinus decompression	SLC	<i>S. aureus</i> <i>S. milleri</i>	Resolved
6	M	21	Orbital abscess	Drainage of orbit Frontal sinus decompression	SLC	<i>S. aureus</i>	Resolved
7	M	19	Orbital abscess	Drainage of orbit	SLC	<i>Propionibacterium</i>	Resolved
8	F	29	Fronto-orbital mucocele	Frontal sinus decompression Optic nerve decompression	PC	<i>S. aureus</i>	Resolved
9	F	20	Orbital apex syndrome Subperiosteal abscess Cavernous sinus thrombosis	Drainage of orbit Optic nerve decompression	PC	<i>S. aureus</i>	Resolved
10	M	49	Frontal sinus mucopyocele	Frontal sinus decompression	SLC	<i>S. viridans</i>	Resolved
11	M	60	Fronto-orbital mucopyocele	Drainage and decompression of orbit Frontal sinus decompression	SLC	<i>S. aureus</i>	Resolved
12	F	57	Fronto-orbital mucopyocele	Drainage and decompression of orbit Frontal sinus decompression	SLC	<i>S. aureus</i> <i>S. milleri</i>	Resolved
13	M	49	Right orbital mucopyocele	Decompression of orbit	SLC	<i>S. aureus</i>	Resolved

MRSA, methicillin-resistant *Staphylococcus aureus*; PC, precaruncular; *S. aureus*, *Staphylococcus aureus*; *S. milleri*, *Staphylococcus milleri*; SLC, superior eyelid crease.

Fig. 3 Right subperiosteal abscess drainage and optic nerve decompression. Coronal computed tomography scan demonstrating significant inflammation around the orbit and abscess cavity in the medial orbit (red arrowhead) (A). Intraoperative appearance. Orbital contents are displaced laterally with a malleable retractor, and the pus is evacuated (B). Optic nerve decompression via precaruncular approach in same patient (C). 1, orbit; 2, optic nerve; 3, carotid artery.

management of abscess in the medial orbit and also allowed for simultaneous decompression of the optic nerve in patients 1 and 9 (►Fig. 3A–C). Another patient presented with a large frontal skull base/orbital roof mucocele and progressive vision loss (patient 8). This patient underwent decompression of the mucocele and optic nerve via the PC approach. The orbital abscess was located in the superolateral orbit in four of the five patients (patients 3, 5, 6, and 7). They also had diffuse frontal sinus disease. These patients underwent simultaneous transorbital endoscopic drainage of orbital abscess and decompression of frontal sinus via the SLC approach. We confirmed proper drainage and patency of the frontal outflow tract (FOT) with transnasal endoscopy in these patients.

Two patients underwent transorbital endoscopic drainage of epidural abscess via the SLC approach (patients 4 and 5). Patient 5 underwent simultaneous drainage of the orbital abscess. We created a small craniotomy in the superior-posterior orbital wall to drain the abscess (►Fig. 2B–D). We also decompressed the frontal sinus in both of these patients (►Fig. 4A, B). In both cases, the FOT was easily identified. We performed transnasal endoscopy to further verify the patency of the FOT. Both patients showed diffuse disease in the ethmoid sinus and also underwent endonasal ethmoidectomy.

We performed transorbital decompression of mucocele or mucopyocele in the frontal sinus (patient 10), fronto-orbital

region (patients 8, 11, 12), and orbit (patient 13). All had a history of chronic sinusitis, and patient 13 had prior frontal sinus obliteration. Patient 10 had erosion of both the anterior and posterior tables of the frontal sinus. He underwent endonasal decompression of the mucocele and ethmoidectomy. He showed initial clinical improvement but began to have worsening headache. A repeat CT scan demonstrated persistent opacification of the frontal sinus despite the patent FOT. The patient then underwent transorbital decompression of the mucocele via the SLC approach. The intersinus septum was removed to provide further drainage via the contralateral frontal outflow tract. The cranial defect was evaluated and demonstrated no evidence of dural violation; the adjacent intracranial compartment was inspected to rule out epidural abscess. Patients 8, 11, and 12 also had unilateral frontal sinus involvement and underwent intersinus septum removal via transorbital approach (►Fig. 5, 6). All had ipsilateral endonasal frontal sinusotomy to further ensure proper drainage of the mucocele.

All patients had immediate resolution of initial clinical symptoms. Postoperative CT and/or magnetic resonance (MR) imaging correlated well with clinical improvement. *Staphylococcus aureus* was the most common organism cultured, followed by *Streptococcus milleri*. Methicillin-resistant *Staphylococcus aureus*, *Propionibacterium*, and *Streptococcus viridans* were cultured in patients 2, 7, and 10, respectively (►Table 1). To date, we have encountered no significant surgical complications on follow-up clinical visits. The surgical scars were well-hidden and minimal. Moreover, none of the patients developed postoperative visual deficits or eyelid malposition.

Discussion

This consecutive series demonstrated the clinical application and efficacy of TONES in managing selected cases of sinogenic complications. TONES successfully treated the various frontal, fronto-orbital, orbital, and intracranial complications of acute and chronic sinusitis with complete resolution of the presenting symptoms. Thus far, no patients in the study have had ophthalmologic complications or recurrence of pathology.

Fig. 4 Frontal sinus decompression and epidural abscess drainage. Three-dimensional reconstruction of computed tomography scan of head demonstrating endoscope projection into the frontal sinus via superior eyelid crease approach (A). Following epidural abscess drainage, the left frontal sinus cavity (white arrowhead) is decompressed. The craniotomy site with underlying dura is also shown (black arrowhead; B).

Fig. 5 Fronto-orbital mucopycele decompression and intersinus septum removal. Erosion of orbital roof is found after decompression of mucopycele (black arrow; A). View of left frontal sinus from the orbit. Intersinus septum is being removed with Sonopet ultrasonic aspirator (B). Intersinus septum has been removed; the contralateral frontal sinus can be seen to be free of disease. Frontal outflow tract is shown (black arrow; C). a, anterior table of frontal sinus; fso, frontal sinus outflow tract; iss, intersinus septum; p, posterior table of frontal sinus.

TONES Management of Orbital Complications of Sinusitis

There are several limitations for endonasal approach in managing orbital complications of sinusitis (OCS).^{19,20} First, OCS typically present with significant sinonasal inflammation. Thus, instrumentation within the acutely inflamed sinonasal cavity can be quite challenging due to bleeding and edema. Second, superolateral or posteriorly-based abscesses can be difficult to access endonasally due to unfavorable path-to-target trajectory (►Fig. 7). Both of these limitations can impede adequate drainage and lead to future recurrence.

In our series of OCS, it was not uncommon to find concomitant pathology involving the optic nerve, cavernous sinus and/or frontal sinus. Of the seven patients who presented with subperiosteal and orbital abscess, four of them had abscesses in the superolateral orbit with frontal sinus involvement. TONES provided simultaneous drainage of the orbital and frontal sinus abscess via a single, SLC approach. The frontal sinus outflow tract was easily identified from the orbit and its patency confirmed with transnasal endoscopy.

Two patients with subperiosteal abscess presented with orbital apex syndrome and underwent simultaneous decompression of orbital abscess and the optic nerve via TONES. This versatility to manage several targets through a single approach makes TONES a favorable surgical technique in treating OCS.

TONES Management of Frontal Sinus Pathology

Recent studies have reported difficulties in accessing and visualizing the orbital roof and lateral frontal sinus with an endonasal approach alone.^{12,13,15} In contrast, we obtained efficacious access and visualization of the entire frontal sinus, including the most lateral portions with TONES. Our technique also allowed for successful decompression of mucocele and mucopycele in the lateral frontal sinus and superolateral orbit. Moreover, for those patients with unilateral frontal sinus disease, we performed removal of intersinus septum transorbitally to provide drainage via the contralateral frontal outflow tract. Frontal septotomy via other external approaches for unilateral frontal sinusitis have shown to improve clinical outcome.^{21,22}

Fig. 6 Pre- and postoperative computed tomography (CT) scan of patient 12. Left fronto-orbital mucocele with superior orbital roof erosion is seen (A). One-month postoperative CT scan shows improved aeration of frontal sinus and interval removal of intersinus septum (arrow; B).

Fig. 7 Transnasal versus transorbital approach to lateral frontal sinus (A, B). Transnasal approach must cross critical neurovascular structures to arrive at the targeted pathology. However, the path-to-target trajectory is favorable for transorbital approach.

Nonetheless, it is important to establish an endonasal drainage pathway for the decompressed mucocele either by a wide frontal sinusotomy and/or ethmoidectomy. This will ensure proper drainage and will reduce the likelihood of future recurrences. Hence, in select cases of frontal sinus pathology, the synergistic effects of endonasal and transorbital approach will improve clinical outcome.

TONES Management of Epidural Abscess

TONES effectively treated the epidural abscess via the SLC approach and avoided an open craniotomy in two patients. Although several studies have described endonasal drainage of epidural abscess, it is technically challenging and thus could result in inadequate drainage and inadvertent injuries to the skull base.^{23,24} Furthermore, the role of ESS alone in treating sinogenic intracranial complications remains uncertain. DelGaudio and colleagues found that ESS did not alter the need for neurosurgical intervention in the acute setting.⁴ Specifically, most patients with intracranial complications of sinusitis (ICS) required craniotomy to drain intracranial abscess despite the initial ESS. This finding further supports an important role for TONES in managing ICS, as it may effectively treat ICS without the need for frontal craniotomy. TONES allows for rapid and reliable access to the intracranial pathology and also has a distinct advantage over standard craniotomy in that the orbital bone removed to access the epidural space is small and requires no further reconstruction, and little or no retraction of the brain is required.

In this study we demonstrated the versatility and effectiveness of TONES in managing various sinogenic complications involving the frontal sinus, orbit, and anterior cranial fossa. Although this initial series is small, the study demonstrates the feasibility of the technique and suggests the likelihood of benefit. The outcomes in our series suggest that TONES can be used safely and should be considered in the surgical treatment algorithms of OCS and ICS. A recent review of 107 cases of orbital and transorbital endoscopic surgery for various pathologies of anterior cranial base showed no complication directly related to surgical approach or use of endoscopy, further validating its safety.²⁵ Another recent study described transorbital endoscopic repair of CSF leaks.¹⁷ The availability of such a technique further ensures the safety of TONES by allowing expeditious repair if a CSF leak should occur during the management of OCS and ICS. We believe that ongoing refinements in TONES will expand its role in the multiportal surgical management of various cranial base targets and pathologies.^{16,26}

Conclusions

This study demonstrates the safety and efficacy of TONES in the management of sinogenic complications involving the orbit, frontal sinus, and anterior cranial fossa. These minimally disruptive pathways can be used as a primary surgical modality or in multiportal combination with endonasal approaches.

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