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Navigation-assisted, endonasal, endoscopic optic nerve decompression for the treatment of nontraumatic optic neuropathy

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A R T I C L E I N F O

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A B S T R A C T

Background: Many authors have reported on therapeutic strategies for traumatic optic neuropathy and their experience with endonasal endoscopic optic nerve decompression for traumatic optic neuropathy. However, to our knowledge, few have described the therapeutic strategies for nontraumatic optic neuropathy and navigation-assisted endoscopic optic nerve decompression as a treatment for nontraumatic, compressive optic neuropathy. The aim of this study was to examine the advantages in treating nontraumatic optic neuropathy with the minimally invasive, image-guided, navigation-assisted, endonasal endoscopic optic nerve decompression.

Methods: This was a retrospective study of 20 patients (21 eyes) diagnosed with nontraumatic optic neuropathy, undergoing an endonasal endoscopic approach to relieve space-occupying lesions and decompress the optic nerve under image-guided navigation. This article describes our research on the therapeutic strategies for nontraumatic optic neuropathy patients, with special focus on the advantages of navigation-assisted, endonasal, endoscopic optic nerve decompression for the treatment of nontraumatic optic neuropathy. Medical photographs were used to estimate the status of the patients.

Results: In 18 of the 20 cases, space-occupying lesions were completely resected. In two cases, they were partially resected. All 20 cases (21 eyes) underwent image-guided, navigation-assisted, endonasal endoscopic optic nerve decompression. Visual acuity improved in 20 eyes (95.2%) and remained stable in one eye. There were no intraoperative or postoperative complications.

Conclusions: Optic nerve decompression is the main treatment strategy for nontraumatic optic neuropathy, to relieve space-occupying lesions and decompress the optic nerve, and to retain and/or improve visual acuity. Image-guided navigation can help doctors pinpoint the optic nerve when facing anatomical deformation caused by a space-occupying lesion. Navigation-assisted, endonasal endoscopic optic nerve decompression is a feasible, safe, practical, and minimally invasive approach.

1. Introduction

Nontraumatic, compressive optic neuropathy is relatively rare and usually secondary to tumors, inflammation, cysts, fibrous dysplasia, and other space-occupying lesions of the paranasal sinus, orbit, and/or skull base. It is an impact injury to the optic nerve, resulting in partial or complete loss of vision. The principles of treatment of nontraumatic, compressive optic neuropathy are still controversial. In order to preserve optic nerve function or restore the visual function, some authors have advocated surgical optic nerve decompression (Pletcher and Metson, 2007; Kong et al.,

Abbreviations: PFD, polyostotic fibrous dysplasia; OD, oculus dexter; CT, computed tomography; MRI, magnetic resonance imaging; CTA, computed tomographic angiography; MR, magnetic resonance; FD, fibrous dysplasia.

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2011). However, after managing the space-occupying lesions and lifting pressure on the optic nerve, is optic nerve decompression surgery necessary?

Although several surgical approaches have been described for optic nerve decompression (Sleep et al., 2003; Bulters et al., 2009), recently the endonasal endoscopic approach has become popular (Berhouma et al., 2014; Song et al., 2014). This technique offers many advantages, including decreased morbidity, preservation of olfaction, rapid recovery time, and more acceptable cosmetic results, without external scars (Chen et al., 2006; Luxenberger et al., 1998). However, the minimally invasive, endonasal endoscopic approach for nontraumatic, compressive optic neuropathy needs further study. Endoscopic examination of the anatomy of the optic nerve has promoted the development of the endonasal endoscopic approach for optic nerve decompression, which has been favorable for accurately locating the optic nerve and reducing complications (Song et al., 2014; Abuzayed et al., 2009). However, it has been a challenge to pinpoint the optic nerve in the face of anatomical deformation caused by compression due to underlying space-occupying lesions.

This study presents 20 cases (21 eyes) of nontraumatic optic neuropathy treated with navigation-assisted, endonasal endoscopic optic nerve decompression. It highlights the efficacy of nontraumatic optic neuropathy, and the advantages of minimally invasive, image-guided, navigation-assisted, endoscopic optic nerve decompression.

2. Material and methods

2.1. Subjects

This was a retrospective, case series study. The total endoscopic case load is more than 1500 per year in our department, and around 150 navigation cases are carried out every year. One image-guided, navigation-assisted, endonasal endoscopic optic nerve decompression takes around 2 h. The medical records of all patients who underwent navigation-assisted, endonasal endoscopic optic nerve decompression at the Department of Otolaryngology, Head and Neck Surgery, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, from January 2013 to December 2016, were reviewed. Data were collected from preoperative and postoperative ophthalmological examinations, as well as from operative reports and hospital charts. Patients who underwent decompression for traumatic optic neuropathy were excluded from the study population. The patients' demographics are displayed in Table 1. This study was approved by the ethical committee of our hospital, and written informed consent was obtained from each subject.

2.2. Surgical procedure

Each patient was supine, with the head in a neutral position and a 10–15° adduction to the patient's right. During the surgical procedure, a navigation system (Fusion, Medtronic, USA) was used for image guidance. Cotton pledgets soaked in xylometazoline solution were placed in the nasal cavity to ensure vasoconstriction. The surgical details varied considerably according to the primary space-occupying lesions encountered.

A standard endoscopic ethmoidectomy was performed at the start. The natural ostium of the sphenoid sinus was identified, opened, and enlarged to the sphenoid lateral wall and roof, and the orbital apex was clearly identified using a 0° endoscope. For fibro-osseous lesions, first, a limited posterior orbital and orbital apex decompression was performed with a diamond drill and a microcurette; the posterior extent of the decompression depended on the extent of fibro-osseous lesions. To avoid thermal injury to the optic nerve, copious irrigation with saline was required. In the case of an apex hemangioma, only orbital apex decompression was performed after removing the hemangioma. For sphenoid sinus mucoceles, fungal balls and cholesterol granulomas led to thinning of the wall of the optic canal, and compression of the optic nerve. After mucocele marsupialization and removal of the lesion, pressure on the optic nerve was eased. However, when the bone orbit overlying the apex transition to the optic canal was thick, orbital apex decompression was required. Incising the optic

Table 1
Summary of characteristics of 20 patients who underwent image-guided, navigation-assisted, endonasal endoscopic nerve and orbital apex decompressions between 2013 and 2016.

Case	Age, sex			Visual acuity	
No.	(yrs)	Side	Space-occupying lesion(s)	Preop	Postop
1	10, F	L	Albright syndrome	0.12	0.6
2	17, F	L	FD, cyst degeneration	Light perception	0.7
		R		No light Perception	0.3
3	55, M	R	FD	0.8	1.2
4	21, F	L	FD	0.5	1.0
5	42, M	R	Osteoma (recurrent)	0.8	1.2
6	38, M	L	Osteoma	0.6	1.0
7	19, F	L	Ossifying fibroma	0.1	0.6
8	29, F	L	Ossifying fibroma	0.4	0.8
9	30, F	R	Orbital apex hemangioma	0.6	1.0
10	47, F	L	Orbital apex hemangioma	0.8	1.2
11	44, F	L	Orbital apex hemangioma	0.1	0.3
12	48, F	R	Mucocele, NPC	No light perception	1 m finger counting
13	50, F	R	Mucocele, cholesterol granuloma, NPC	0.3	0.3
14	59, F	L	Mucocele	0.1	0.8
15	50, F	L	Mucopyocele, orbital apex syndrome	0.2	1.0
16	34, M	R	Mucocele polyps	0.6	1.2
17	23, M	R	Mucopyocele orbital apex syndrome	0.5	0.8
18	46, M	L	Mucocele, nasal polyps	0.4	0.8
19	62, M	L	Fungal ball, pyocele	0.3	0.7
20	15, M	L	Fungal ball	0.3	0.5

nerve sheath was not advocated for compressive optic neuropathy.

2.3. Evaluation of visual acuity

All patients received regular postoperative follow-up care, including assessment of visual acuity. Data for visual acuity were taken at 4 months postoperatively, once the surgical field had been epithelialized. A patient's vision was considered to have improved if he or she showed any of the following: an improvement from no light perception to light perception or better; an improvement from light perception to hand motion or better; an improvement from hand motion to finger counting or better; or an improvement in reading a visual chart.

3. Results

Endonasal endoscopic optic nerve decompression was performed in 20 patients (21 eyes) from January 2013 to December 2016. The study population consisted of 12 female and eight male patients, with a mean age of 37 years (range 10–62 years). Preoperative and postoperative visual acuity, and the nature of the underlying compressive space-occupying lesions, are summarized in Table 1. No-one had eye motion impairment after the operation. Visual acuity improved in 20 eyes (95.2%) and remained stable in one case. Using image-guided navigation, the optic nerve could be pinpointed accurately in all cases. There were no intraoperative or postoperative complications, such as CSF leakage or ophthalmoplegia. Follow-up time was from 6 months to 48 months, with a mean follow-up time of 20.7 months.

3.1. Illustrative cases

3.1.1. Case 2

This 17-year-old girl was referred to our hospital in December 2013 as a result of progressive visual loss over a 25-day period. She complained of left proptosis and nasal obstruction, but no diplopia, obvious headache, rhinorrhea, or bleeding. She had a 9-year history of facial asymmetry, and was diagnosed with polyostotic fibrous dysplasia (PFD).

Physical examination showed bulging of the left craniofacial region, and protrusion of the left eye in the left lateral direction. Ophthalmological examination showed no light perception in her right eye, only light perception in her left eye, and normal intraocular pressure bilaterally. Her left eye was more prominent than her right eye, and both eye positions were oblique to the left. Bilaterally the pupils were fixed, with diameters of around 5–6 mm. Funduscopy showed a nearly normal optic disc bilaterally, with no obvious hemorrhage or exudation on the retinas.

The paranasal sinus CT scan showed extensive changes due to craniofacial PFD involving the left maxillary bone, left ethmoid bone, zygomatic bone, frontal bone, occipital bone, and sphenoid bone, with compression of the bilateral optic nerve by a cystic structure (Fig. 1a,b). Routine laboratory data, including serum calcium, phosphorus, and alkaline phosphatase, were within normal limits.

The patient underwent endonasal, endoscopic, subtotal removal of the left ethmoid and sphenoid FD, with drainage of the cyst and double optic nerve decompression in December 2013 (Fig. 1c,d). 7 days after the surgery, the patient was treated with hyperbaric oxygen for another 3 weeks. At this point, her right eye visual acuity reached 0.1 and the left reached 0.3. At 4 months postoperatively, both surgical fields were epithelialized (Fig. 1e,f); the patient's right and left eye visual acuity had reached 0.3 and 0.7, respectively. Follow-up every 6 months was sustained for 3 years. The patient's vision remains stable.

3.1.2. Case 9

This 30-year-old woman was referred to our hospital in January 2015 as a result of progressively decreased vision in her right eye over a 3-month period. She also complained of right proptosis, but no diplopia, rhinorrhea, or nasal obstruction. Ophthalmological examination showed OD 0.6 in her right eye, and a visual field defect. The orbital CT scan showed a soft tissue mass of about 18 mm × 21 mm between the right medial rectus and the right

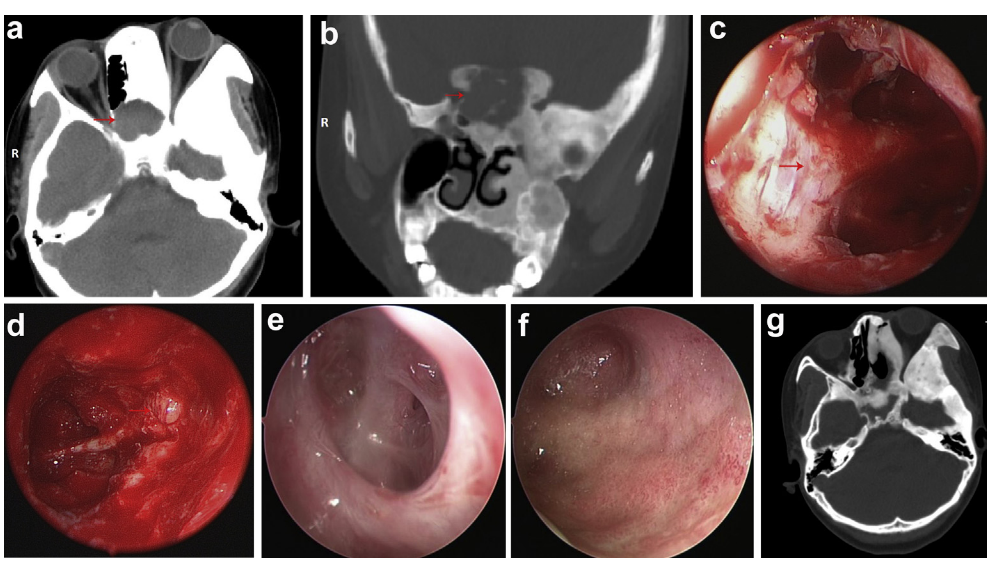

Fig. 1. a. A paranasal sinus CT scan showing extensive changes due to craniofacial PFD involving the left maxillary bone, left ethmoid bone, zygomatic bone, frontal bone, occipital bone, and sphenoid bone. The red arrow shows the region of interest. b. A coronal CT scan showing the bilateral optic nerve compressed by a cystic structure. The red arrow shows the region of interest. c. The patient underwent endoscopic endonasal subtotal removal of the right ethmoid and sphenoid FD, with drainage of the cyst and optic nerve decompression. The red arrow shows the region of interest. d. The patient underwent endoscopic endonasal subtotal removal of the left ethmoid and sphenoid FD, with drainage of the cyst and optic nerve decompression. The red arrow shows the region of interest. e. After 4 months postoperatively, the left surgical field had been epithelialized. f. After 4 months postoperatively, the right surgical field had been epithelialized. g. An axial CT scan showing the surgical field about 1 year after the operation.

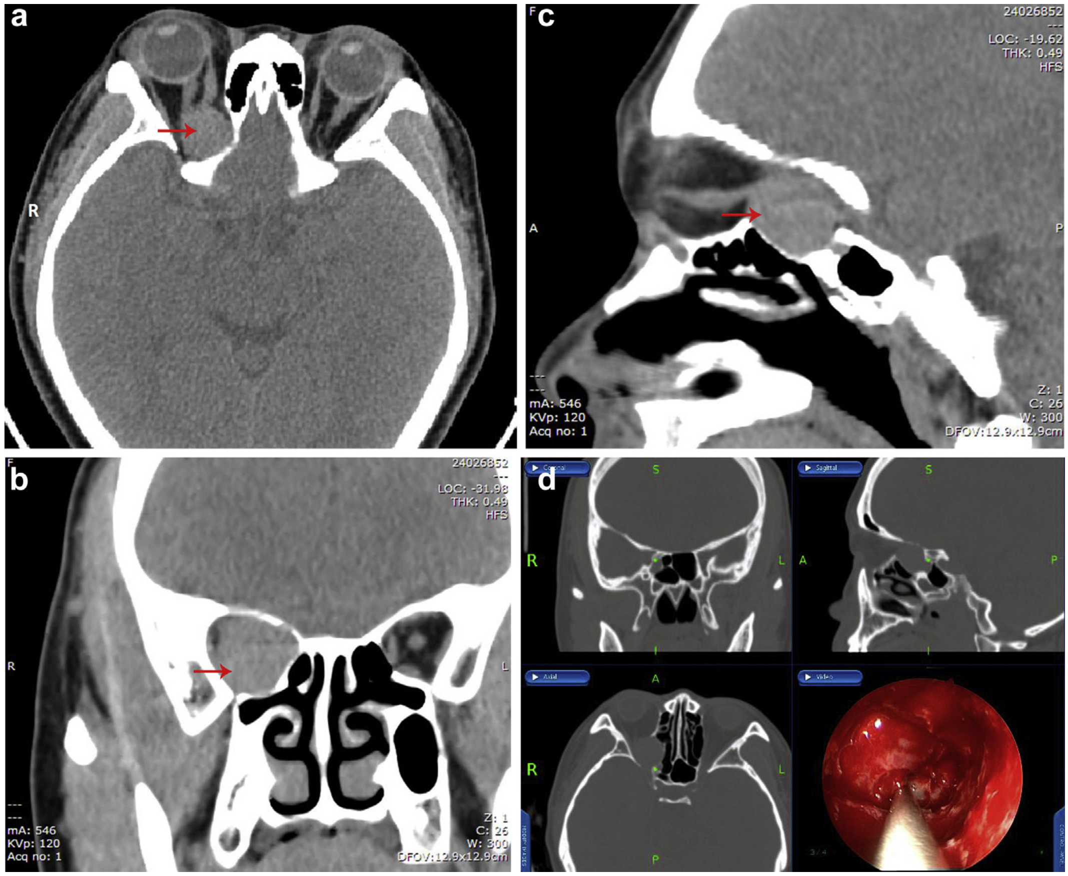

Fig. 2. a. An axial orbit CT scan showing a soft tissue mass of about 18 mm × 21 mm between the medial rectus and the orbital medial wall. The optic nerve and the medial rectus have been compressed and shifted laterally. The red arrow shows the mass. b. A coronal orbit CT scan showing the soft tissue mass. c. A sagittal orbit CT scan showing the soft tissue mass. d. Images used during the navigation-assisted operation: sagittal, coronal, and axial scans, and the video. The patient underwent a total endoscopic endonasal right ethmoidectomy, excision of the orbital mass, and orbital apex decompression.

orbital medial wall, and that the optic nerve and the medial rectus were compressed and shifted laterally (Fig. 2a–c).

The patient received total right endonasal endoscopic ethmoidectomy, excision of the orbital mass, and orbital apex decompression (Fig. 2d). The pathological diagnosis of the right orbital mass was a hemangioma. At 4 months postoperatively, the visual acuity of her right eye had reached OD 1.0, with an improvement in the visual field defect.

3.1.3. Case 18

In June 2015, this 46-year-old man complained of progressively decreasing vision in the left eye over a 5-month period, accompanied by proptosis and diplopia. He also complained of nasal obstruction, rhinorrhea, and headache, but no nasal bleeding. He underwent left sinus endoscopic surgery for chronic rhinosinusitis with polyps 10 years ago. The paranasal sinus CT scan showed a slightly higher-density soft tissue mass shadow of approximate dimensions 54 mm × 51 mm × 64 mm in the left nasal cavity, ethmoid sinus, and sphenoid sinus, with the adjacent bone destroyed. The mass had broken into the left orbit and compressed the optic nerve, the medial rectus, and inferior rectus, resulting in a prominent left eye. The mass had also broken into the anterior cranial fossa, saddle area, and parasellar (Fig. 3a). The paranasal sinus MR scan revealed extensive changes to the mucocele, involving the left nasal cavity, ethmoid sinus, and sphenoid sinus (Fig. 3b,c). The patient received mucocele marsupialization and orbital apex decompression via an endonasal endoscopic approach (Fig. 3d). The final pathological diagnosis of the mass was a mucocele with nasal polyps. At 4 months postoperatively, visual acuity in his right eye had reached OD 0.8, with no proptosis or diplopia.

4. Discussion

Nontraumatic optic neuropathy is a relatively rare pathological condition that can be caused by a variety of space-occupying lesions, including tumors, fibro-osseous lesions, endocrine orbitopathy, mucocele, and infectious lesions involving the paranasal sinus, orbit, and/or skull base (Robinson et al., 2011; Carlson et al., 2013). These space-occupying lesions can compress the optic nerve, leading to chronic partial or complete loss of vision. The cases presented here included eight cases of fibro-osseous lesions, seven cases of mucocele, three cases of orbital apex hemangioma, and two cases of sphenoid sinus fungal ball. To our knowledge, this is the first study to report such an operation load for this disease. There is no evidence that high-dose corticosteroids are useful in nontraumatic optic neuropathy.

Despite disagreements over surgical time, studies have shown that the therapeutic efficacy of decompression is greatly reduced after the onset of optic nerve atrophy (Carlson et al., 2013). We therefore advocate surgical management as early as possible in such cases, especially once vision has deteriorated. This is consistent with the views of other authors (Berhouma et al., 2014).

Once the surgical decision to carry out endonasal endoscopic decompression is made, it is necessary to understand the complex anatomy of the optic nerve, and the anatomical landmarks of the paranasal sinus and skull base, in order to optimize decompression.

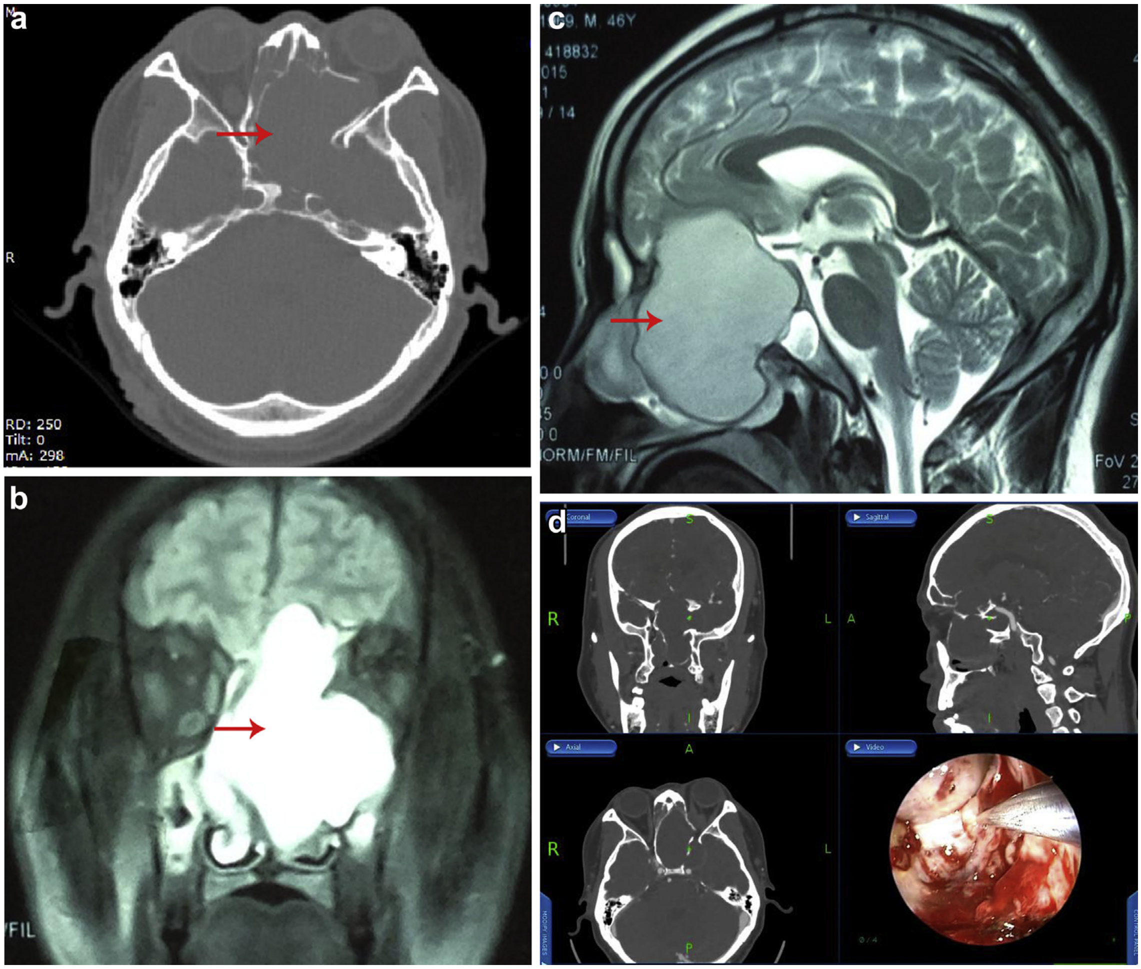

Fig. 3. a. An axial CT image showing how the mass had also broken into the anterior cranial fossa, and sellar and parasellar areas. Red arrows show the mass. b. T1-weighted coronal MR image of the paranasal sinus revealing extensive changes in the mucocele involving the left nasal cavity, ethmoid sinus, and sphenoid sinus. The red arrow shows the mucocele. c. T1-weighted sagittal MR image of the paranasal sinus revealing extensive changes in the mucocele involving the left nasal cavity, ethmoid sinus, and sphenoid sinus. The red arrow shows the mucocele. d. Images used during the navigation-assisted operation: sagittal, coronal, and axial scans, and the video. The patient received mucocele marsupialization and orbital apex decompression using an endoscopic endonasal approach.

Kong et al. thought that full exposure of the intracanalicular portion of the optic nerve was essential for effective surgical decompression, and that, to achieve this, decompression of the roof as well as the medial wall of the intracanalicular portion was critical (Kong et al., 2011). However, in our experience, decompression strategies should be personalized, depending on the nature of the space-occupying lesions. For example, a patient with a compressive optic neuropathy caused by expansion of a paranasal sinus mucocele or mucopyocele experienced compression and thinning of the sphenoid sinus bone walls. The cyst's wall was directly attached to the optic nerve, but the orbital apex was very thick. For this patient, the surgical strategy was to carry out cyst marsupialization and orbital apex decompression. However, the surgical strategy for PFD is to carry out full decompression from orbital apex to optic chiasm, as it often envelops and compresses the entire intracanalicular portion of the optic nerve.

While several cases of endoscopic optic nerve decompression for nontraumatic optic neuropathy have been reported in the literature, details regarding the procedures and results are extremely limited. Pletcher and Metson described 10 cases of endonasal endoscopic optic nerve decompression in seven patients with various underlying pathology, with an improvement of visual acuity reported for 70% of the patients (Pletcher and Metson, 2007). Kong et al. reported five cases of compressive optic neuropathy, three with nontraumatic optic neuropathy. Three patients had markedly improved visual acuity and visual fields, one patient only had improved visual acuity, and one patient only had an improved visual field (Kong et al., 2011). Another report described 11 cases, with an improvement of the visual acuity in 54% of them at the 6-month follow-up (Berhouma et al., 2014).

A systematic review and meta-analysis has demonstrated that 60% of patients will have at least some improvement in vision after optic nerve decompression for chronic compressive neuropathy (Carlson et al., 2013). Our study showed that visual acuity had improved in 20 eyes (95.2%), and remained stable in one case, following endonasal endoscopic optic nerve decompression. Endonasal endoscopic optic canal decompression is regarded as a minimally invasive, safe, and efficient treatment for compressive optic neuropathies, regardless of etiology (Pletcher and Metson, 2007; Kong et al., 2011; Berhouma et al., 2014).

Resection of these space-occupying lesions and endoscopic optic nerve decompression are associated with increased perioperative morbidity, due to the proximity and variability of highly vital structures, including the carotid arteries, optic nerve, pituitary gland, and cavernous sinus. Furthermore, compression of the space-occupying lesions leads to gross distortions of the normal anatomy. Our study showed that intraoperative image guidance allowed total or near-total resection of the hyperostotic skull base around the cranial nerve foramina, with minimal morbidity.

Terpolilli et al. reported that intraoperative CT combined with neural navigation can help to improve the extent of maximal safe resection (Terpolilli et al., 2016). Our study showed that combined CT and CTA images can help to pinpoint the vital anatomical structures, and that combined CT and MRI can help to identify the extent of the space-occupying lesions. In case 18 presented here, the optic nerve and the internal carotid artery distortion could be pinpointed during intraoperative navigation using fused CT and CTA images.

5. Conclusion

Nontraumatic optic neuropathy is a relatively rare pathological condition that can be caused by a variety of space-occupying lesions involving the paranasal sinus, orbit, and/or skull base. High-dose corticosteroids are not very useful in nontraumatic optic neuropathy. Therefore, the main treatment strategies are to relieve space-occupying lesions, and to decompress the optic nerve, in order to retain and/or improve visual acuity. Image-guided navigation can help doctors pinpoint the optic nerve in the face of anatomical deformation caused by compression from the space-occupying lesion. This navigation-assisted, endonasal endoscopic optic nerve decompression approach is regarded as feasible, safe, practical, and minimally invasive.

Ethical approval and consent to participate

This study was approved by the Tongji Hospital Research Ethics Board.

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Conflicts of interest

The authors have no competing interests.

Availability of data and materials

Methods and data are available from the corresponding author and co-authors.

Consent for publication

Not applicable.

Declarations

None.

Authors' contributions

Liu Y and Zhen HT designed the study. Zhen HT performed the operations and collected the data. Yu HJ and Liu Y prepared the manuscript and analyzed the data. All authors read and approved the final manuscript.

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References

Abuzayed B, Tanriover N, Gazioglu N, Eraslan BS, Akar Z: Endonasal endoscopic approach to the orbital apex and medial orbital wall: anatomic study and clinical applications. J Craniofac Surg 20: 1594–1600, 2009

Berhouma M, Jacquesson T, Abouaf L, Vighetto A, Jouanneau E: Endonasal endoscopic nerve and orbital apex decompression for nontraumatic optic neuropathy: surgical nuances and review of the literature. Neurosurg Focus 37: E19, 2014

Bulters DO, Shenouda E, Evans BT, Mathad N, Lang DA: Visual recovery following optic nerve decompression for chronic compressive neuropathy. Acta Neurochir 151: 325–334, 2009

Carlson AP, Stippler M, Myers O: Predictive factors for vision recovery after optic nerve decompression for chronic compressive neuropathy: systematic review and meta-analysis. J Neurol Surg B 74: 20–38, 2013

Chen C, Selva D, Floreani S, Wormald PJ: Endoscopic optic nerve decompression for traumatic optic neuropathy: an alternative. Otolaryngol Head Neck Sur 135: 155–157, 2006

Kong DS, Shin HJ, Kim HY, Chung SK, Nam DH, Lee JI, et al: Endoscopic optic canal decompression for compressive optic neuropathy. J Clin Neurosci 18: 1541–1545, 2011

Luxenberger W, Stammberger H, Jebeles JA, Walch C: Endoscopic optic nerve decompression: the Graz experience. Laryngoscope 108: 873–882, 1998

Pletcher SD, Metson R: Endoscopic optic nerve decompression for nontraumatic optic neuropathy. Arch Otolaryngol Head Neck Surg 133: 780–783, 2007

Robinson D, Wilcsek G, Sacks R: Orbit and orbital apex. Otolaryngol Clin North Am 44: 903–922, 2011

Sleep TJ, Hodgkins PR, Honeybul S, Neil-Dwyer G, Lang D, Evans B: Visual function following neurosurgical optic nerve decompression for compressive optic neuropathy. Eye 17: 571–578, 2003

Song Y, Song J, Liu Q, Li YQ, Yao D: Study on measurements for margin of safety in lateral operation of a transnasoethmoid-sphenoid approach to decompress the optic canal. J Craniofac Surg 25: 243–246, 2014

Terpolilli NA, Rachinger W, Kunz M, Thon N, Flatz WH, Tonn JC, et al: Orbit-associated tumors: navigation and control of resection using intraoperative computed tomography. J Neurosurg 124: 1319–1327, 2016