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Treatment strategies for inverted papillomas with intracranial or intraorbital involvement

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Main Article

Mr D Spinos takes responsibility for the integrity of the content of the paper

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Abstract

Objective. Sinonasal inverted papillomas are challenging benign tumours of the nasal cavity because of their high recurrence rates and the lifetime malignant transformation risk of 10 per cent as well as their locally aggressive behaviour. This study aimed to describe treatment strategies for inverted papillomas with intracranial or intraorbital involvement.

Method. This was a prospective case series study of 18 patients with inverted papilloma with intracranial or intraorbital involvement. Patient demographic data, imaging, pathology, surgical technique and recurrences were recorded prospectively over a period of seven years.

Results. A total of 83 per cent of the patients in this study had been previously operated on, consisting of 8 cases with intracranial involvement, 1 case with intraorbital involvement and 9 with both. During follow up with a medium of 37 months (range, 13–115 months) there were two recurrences.

Conclusion. It was postulated that intracranial or intraorbital involvement observed in this series was the result of multiple revisions. However, using accurate imaging protocols and the pedicle-oriented approach for tumour excision, complete tumour removal was achieved in most cases with minimal post-operative complications.

Introduction

Sinonasal inverted papillomas are benign tumours of the nasal cavity of ectodermal origin, described for the first time by Ward in 1854.[1] The low incidence of 0.2 to 1.5 new cases annually per 100 000 people contributes less than 5 per cent of sinonasal tumours, making them some of the rarer neoplasms of the nose and paranasal sinuses.[2] Inverted papillomas tend to expand locally, sometimes aggressively,[3] and have considerable recurrence rates after surgical excision, ranging between 12 and 20 per cent.[4]

The introduction of endoscopic techniques has resulted in a reduction of recurrence rates, as indicated by two meta-analyses.[4,5] It is believed that although intrinsic factors associated with the papillomas may play a role, recurrence is mostly the result of incomplete excision.[6] These features of inverted papillomas, coupled with a high risk of malignancy (either synchronous or metachronous) of between 3.4 and 9.7 per cent, render definitive management imperative.[7,8] However, this can be challenging, especially in the case of inverted papillomas invading structures such as the orbit and the skull base.[9] Such extensive papillomas pose significant challenges and may demand the use of multiple, novel techniques.[10,11]

We present prospectively collected data on a group of patients with inverted papillomas extending intracranially or intraorbitally and also identifying all literature cases of patients with such tumours.

Materials and methods

Demographic data were recorded upon admission. Date of the operation, details of the surgical technique and anatomical structures resected, time from initial diagnosis, follow ups, and revisions if there were any were prospectively collected. All operations were carried out by the senior author (C Georgalas).

We reported all cases of inverted papillomas invading the skull base (anterior cranial fossa, carotid-optic canal, dura) as 'intracranial invasion', and we reported all cases of inverted papillomas invading the orbit (lamina papyracea, periorbita) as 'intraorbital invasion'.

We excluded all cases of inverted papillomas with intraorbital invasion or skull base extension with no radiological, endoscopic or intra-operative invasion evidence (bony erosion, dura–brain parenchyma, orbit-periorbita infiltration), *in situ* carcinoma, or frank malignant transformation. All the resected structures that were radiographically or intra-operatively suspected for disease infiltration were sent for histology. A senior

Table 1. Patient demographics and structures involved

Patient number	Age (years)	Gender	Primary or recurrent (revision number)	Location (side)	Intracranial or intraorbital involvement	Follow up (months)	Recurrence
1	59	Male	Recurrent (3)	Bilateral	Paraclival carotid artery, parasellar carotid artery/optico-carotid recess, optic nerve canal	56	No
2	47	Female	Recurrent (8)	Bilateral	Anterior cranial fossa, cribriform plate, ethmoid roof, lamina papyracea, orbit, intradural invasion	45	Yes
3	66	Male	Recurrent (2)	Unilateral (right)	Orbit, lamina papyracea	37	No
4	43	Male	Recurrent (2)	Unilateral (right)	Lamina papyracea, orbit, ethmoid roof	28	No
5	68	Male	Recurrent (2)	Unilateral (right)	Planum sphenoidale, optic nerve canal, optico-carotid recess, paraclival carotid artery, parasellar carotid artery	39	No
6	59	Female	Recurrent (3)	Unilateral (right)	Planum sphenoidale, optic nerve canal, optico-carotid recess, paraclival carotid artery, parasellar carotid artery	32	No
7	43	Male	Recurrent (3)	Unilateral (right)	Lamina papyracea, orbit, anterior cranial fossa, ethmoid roof	29	No
8	64	Female	Primary	Unilateral (left)	Planum sphenoidale, optic nerve canal, optico-carotid recess, paraclival carotid artery, parasellar carotid artery, pterygopalatine fossa	45	No
9	60	Male	Recurrent (1)	Bilateral	Anterior cranial fossa, cribriform plate, ethmoid roof, lamina papyracea, orbit, intradural invasion	79	No
10	52	Male	Recurrent (2)	Unilateral (right)	Cribriform plate, anterior cranial fossa, ethmoid roof	37	No
11	54	Male	Recurrent (1)	Unilateral (right)	Optic nerve canal, optico-carotid recess, paraclival carotid artery, parasellar carotid artery, intradural invasion	115	No
12	59	Male	Recurrent (16)	Bilateral	Anterior cranial fossa, cribriform plate, ethmoid roof, lamina papyracea, orbit, optic nerve canal, optico-carotid recess, parasellar carotid artery, paraclival carotid artery, intradural invasion	73	Yes
13	37	Female	Recurrent (1)	Bilateral	Cribriform plate, lamina papyracea	50	No
14	29	Male	Primary	Bilateral	Cribriform plate	37	No
15	64	Male	Recurrent (1)	Unilateral (left)	Lamina papyracea	29	No
16	54	Female	Recurrent (1)	Unilateral (right)	Anterior cranial fossa, lamina papyracea, ethmoid roof	27	No
17	59	Female	Primary	Unilateral (right)	Anterior cranial fossa, lamina papyracea, orbit	25	No
18	61	Male	Recurrent (2)	Unilateral (left)	Anterior cranial fossa, ethmoid roof, intradural invasion	13	No

pathologist examined the whole specimen in all our cases, excluding any underlying malignant foci.

Computed tomography (CT) and magnetic resonance imaging (MRI) were used in all cases and magnetic resonance angiography was used only in carotid artery involvement. Visual acuity and fields were pre-operatively assessed in patients with optic nerve or orbital involvement.

Consent was received from the patients, and the Committee of the National and Kapodistrian University of Athens reviewed and approved the collection of their data and its use in this case series.

Results

Individual patient data are presented in Table 1. Out of a total of 65 patients with inverted papilloma who underwent operations performed by the senior author between 2011 and 2019, 18 patients met inclusion criteria. There were 13 males and 5 females with an average age of 54.3 and a range of 29 to 68 years at the time of surgery. The average time from initial diagnosis to surgery was 110 months (range, 5 to 468 months). Fifteen patients had been previously operated on, five of whom had undergone more than two revisions. The median

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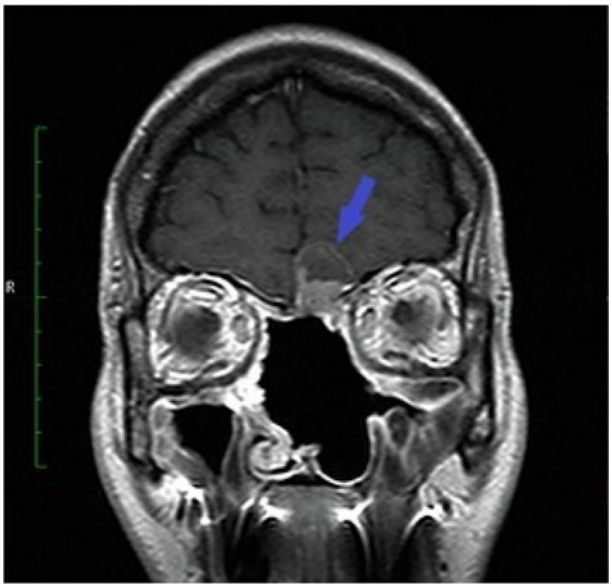

Fig. 1. (Patient 2). Coronal plane magnetic resonance image (T1-weighted with contrast) of an inverted papilloma with anterior skull base site of attachment. The inverted papilloma occupied the frontal sinuses and had invaded intracranially (blue arrow). R = right

number of previous operations was 2 (range, 0–16). Median follow-up time was 37 months and ranged between 13 to 115 months.

The follow-up protocol included endoscopy monthly for the first three months, then every two months for the next six months, then every six months for years two to five and yearly thereafter. Imaging studies, usually MRI, were requested in cases of suspected recurrence or when the anatomical area of initial involvement could not be endoscopically assessed.[3]

Overall, intracranial invasion involvement (anterior cranial fossa with or without intradural or intraparenchymal involvement, optico-carotid recess or parasellar or paraclival carotid artery) was identified in 16 out of the 18 patients (88.9 per cent), orbital extension was identified in 10 out of 18 patients (55.5 per cent) and both were identified in 8 patients (44.4 per cent of total cases) who presented with multiple sites of origin of the disease.

Erosion was found in six patients with paraclival or parasellar carotid artery and in five patients with anterior cranial fossa with intradural invasion (Figure 1). Erosion was also seen at the attachment at the optico-carotid recess in six patients (Figure 2), and the frontal sinus posterior wall was eroded in six patients. Four patients had attachment to the sphenoid sinus walls related to the skull base, either planum sphenoidale or lateral wall or sella, without any attachment to the carotid artery.

Ten of our patients presented with extended disease invading the orbit, amongst whom four had either diplopia or decreased visual acuity or impaired visual fields because of the entrapment of the optic nerve or artery or orbital involvement (Figure 3). Pre-operative and post-operative visual fields were assessed in all these cases (Figure 4). In four of our patients, disease involved the bony carotid canal within the sphenoid or the clivus; in three patients the inverted papilloma was attached to it, whereas in one patient it had eroded the bony carotid canal, encroaching but not invading the artery itself.

All patients were treated via endoscopic endonasal resection, using CT and MRI fusion neuronavigation. We followed the pedicle targeted surgery,[12] which allowed us to undertake a far less invasive dissection with greater radicality of the areas the inverted papilloma had invaded. Access was maximised with the use of the Draf III procedure in anterior cranial fossa or frontal sinus involvement, rostrum removal and bilateral extensive sphenoidotomies in sphenoid, optico-carotid recess or carotid artery involvement. A bi-nostril approach and the three or four hands technique were applied in most cases.[13] Extended biopsies from multiple locations of the tumour were undertaken pre-operatively in order to confirm that there was no focal malignant transformation.[14] Strategy management according to tumour extension is shown in Table 2.

Intra-operatively, the pedicle of the inverted papilloma was identified and, if required for better exposure, the mass of papilloma was debulked, without removing the mucosa, in order to identify the site of origin. Upon identification, the involved bone was drilled with rough diamond burr and removed. Specifically, the cribriform plate and the periorbita were completely excised when the inverted papilloma invaded them. The involved mucosa was excised with macroscopically clear margins, while frozen sections were sent to the pathology laboratory to exclude microscopic infiltration. When the tumour was compressing neighbouring structures as a space-occupying lesion, without truly invading structures, the involved mucosa that was in contact but not invaded by the papilloma was preserved. We used a variety of drills, including 15-, 45- and 70-degree drills that were mostly rough diamond (non-cutting) while also using a 30° rigid endoscope supplemented by 45° and 70° rigid endoscopes. Nasal packing was not used, although a temporary rolled silastic sheet was used in cases with Draf III procedures.

No major post-operative complications (cerebrospinal fluid leak, orbital injury or bleeding, major haemorrhage, meningitis) were encountered. One of our patients developed a post-operative mucocele in the right orbit that was subsequently drained as an out-patient procedure under local anaesthesia.

During the follow-up period, we report two recurrences: patients number 2 and 12 (Table 1). Patient 2 was previously operated on a total of 8 times over a period of 20 years. The inverted papilloma was invading the intradural space and an extended dissection of this area in the form of a combined approach (craniotomy and endoscopy) was required, which the patient declined. Patient number 12 had undergone 16 previous operations, and disease had undergone intraorbital and anterior cranial fossa invasion, making radical surgery not a viable option.

Discussion

The current strategy for treating inverted papillomas is focused on tumour pedicle removal. This means that simple extension, without invasion, does not affect surgical decision making.[12] In fact, the term ‘extent of disease’ may be misleading, as it is in fact space occupation instead of frank invasion. Although the Krouse staging system[15] is widely accepted, it provides little assistance in planning a complete excision of inverted papilloma. Like most staging systems, it refers to the anatomical subsites (frontal sinus, sphenoid sinus) occupied by the papilloma; however, primary papillomas usually grow in an exophytic, non-invasive way, and as a result their site of attachment is what needs to be resected with oncological principles. Once this has been dealt with, the remainder of the papilloma can be removed and has minimal impact on the extent of surgery. The pedicle-oriented surgical excision

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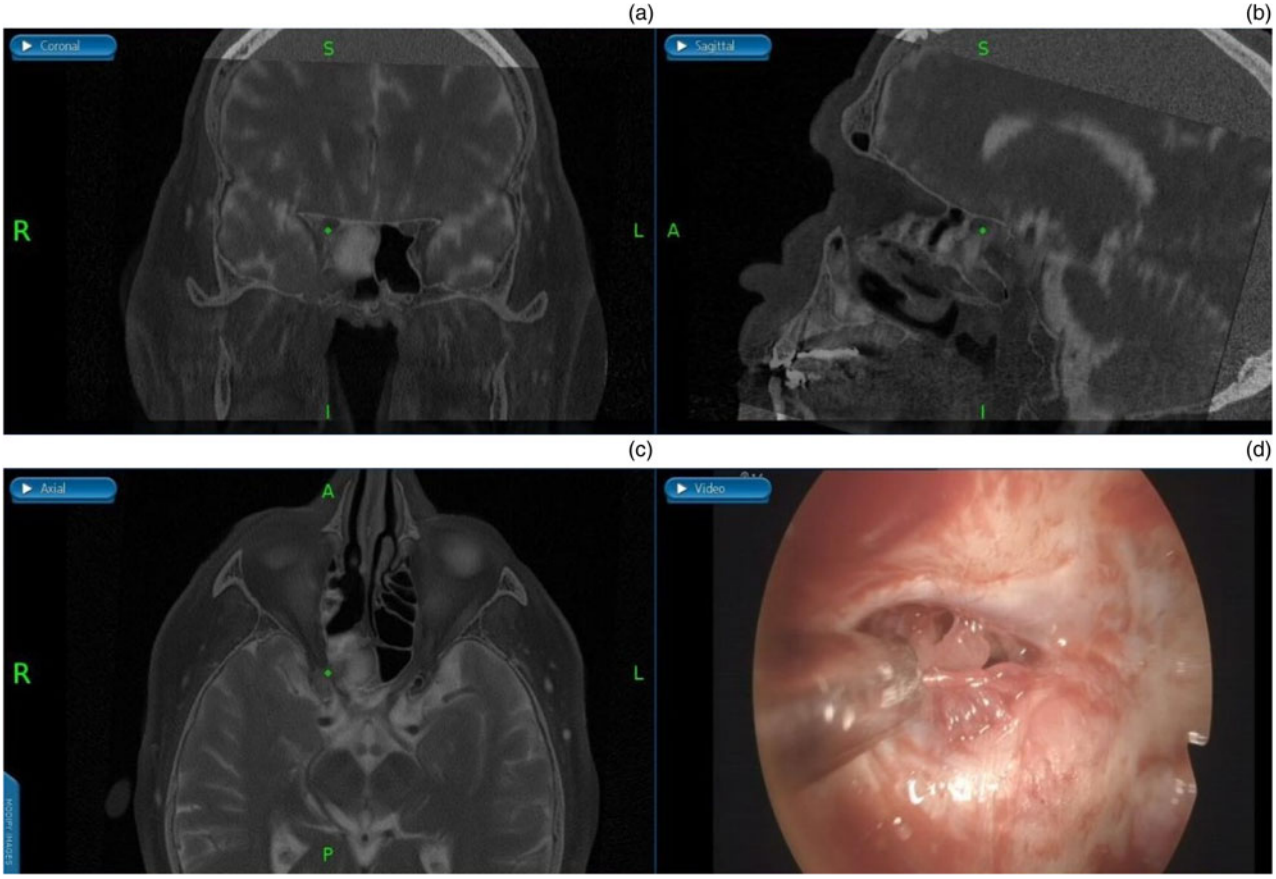

Fig. 2. (Patient 5). Intra-operative neuronavigation image of inverted papilloma invading the medial optico-carotid recess and associated with a secondary sphenoid mucocele. (a) Coronal plane fusion-merged magnetic resonance image (MRI) and computed tomography (CT) image showing an inverted papilloma invading the medial optico-carotid recess and associated with a secondary sphenoid mucocele. (b) Sagittal plane fusion-merged MRI and CT image showing the same pathology. (c) Axial plane fusion-merged MRI and CT image showing the same pathology. (d) Intra-operative neuronavigation image showing the same pathology with the suction tip at the right optico-carotid recess. R = right; L = left; A = anterior; S = superior; I = inferior; P = posterior

technique is the current standard in inverted papilloma excision, allowing residual foci removal with minimally invasive surgery.

In most cases, the inadequate surgical access leads to recurrence and more aggressive behavior.[16] Indeed, just 3 of our 18 patients had primary disease, while all the remaining patients had been operated upon multiple (as many as 16) times, thus highlighting the importance of 'getting it right the first time' or risk having to deal with difficult to treat areas later. A common pattern observed in some of our patients who had undergone previous operations in the area of the sphenoid was inadequate exposure (unilateral approach).

The importance of the bi-nostril approach cannot be understated in these cases as a way to ensure that we can reach all the walls of the sphenoid and can perform all the required manoeuvres for the excision using the three or four hands technique. The same wide exposure can be achieved in the frontal sinus, skull base and orbit by a Draf III procedure. In cases of inverted papillomas involving the sphenoid, a posterior septectomy and wide bilateral sphenoidectomy was performed to allow for wide visualisation and contralateral bimanual access. For the same reasons, in all the cases of inverted papillomas involving the lateral part of the frontal sinus, the posterior table or posterior wall of frontal sinus, a Draf III technique was employed with use of the contralateral nostril for bimanual lateral access.

Pre-operative imaging is also of paramount importance when treating inverted papillomas, with CT and MRI being complementary. We use CT imaging to identify the presence of osteitis, thus predicting the site of attachment of the inverted papilloma. Nevertheless, CT cannot distinguish the inverted papilloma from adjacent soft tissue, such as mucosa and retained secretions. MRI on the other hand cannot provide detailed data on sinus wall destruction, but tumour invasion in dura-carotid-orbit is easily recognisable. The optimal modality is T1-weighted MRI sequence before and after gadolinium administration with sinus protocol, using fat suppression. A T2-weighted MRI sequence can be complementary to differentiate the inverted papilloma from secretions and secondary mucoceles. Dura or periorbita infiltration can be assessed by these imaging techniques.[17] Although the radiological osteitis sign is useful,[18] the site of attachment needs to be additionally confirmed intra-operatively. In patients who have undergone multiple operations, bone thickening and osteitis at the site of inverted papilloma origin is sometimes difficult to differentiate from the scar tissue and remodelling related to previous operations.

As shown by the findings of the present study, but also by other series in the literature,[7,19–21] patients with inverted papilloma attached to the skull base commonly undergo several operations. This highlights either inadequate technique during the primary surgery, resulting in recurrence and tumour seeding or an innate aggressiveness of the tumour. Adequate excision of the tumour the first time is of paramount importance. Close to the site of attachment, inflammatory bony reaction leads to loss of lamellar bone and production of new immature

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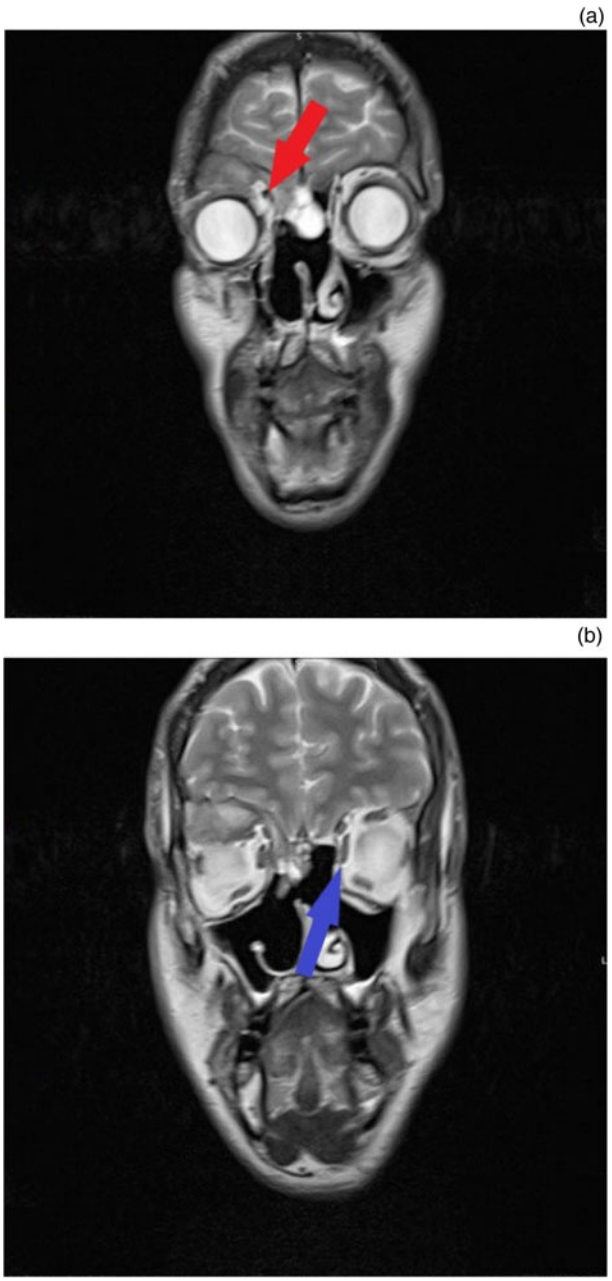

Fig. 3. T2-weighted coronal magnetic resonance image demonstrating (a) the presence of the inverted papilloma at the area of the right lamina papyracea (red arrow) and (b) the fat pad medially to the medial rectus muscle is absent while present at the normal left side (blue arrow). The mucocele invades the orbit displacing the eye inferiorly and anteriorly. The desiccated and high protein content make it appear hypointense in T2-weighted images. Two years later the orbit has returned to its normal position and there are no signs of recurrence. R = right; L = left; I = inferior

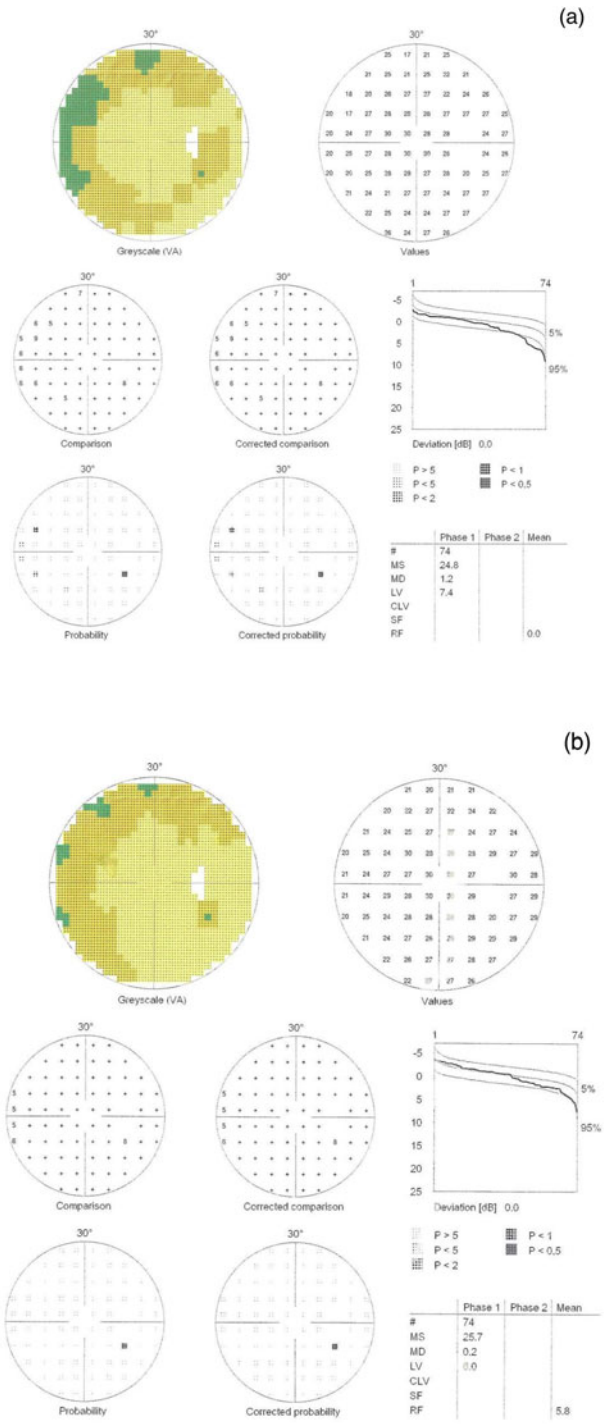

Fig. 4. Pre- (a) and post-operative (b) visual field examination of patient 5 with inverted papilloma originating from optico-carotid recess extending into the optic canal. VA = visual acuity; MS = mean sensitivity; MD = mean defect; LV = loss variance; CLV = corrected loss variance; SF = short-term fluctuations; RF = reliability factor

bone. The process leads to the entrapment of affected mucosa in small crevices. It is postulated that the extension of inverted papilloma to the structures discussed in this case series is facilitated by the entrapment of residual mucosal foci because of partial previous excision of the primary disease.[22] This embedded mucosal epithelium should also be removed during the inverted papilloma excision, as it will become the locus of future recurrences. Proper surgical excision of the inverted papilloma requires not only drilling off the affected bone superficially but diligently going deeper than the affected periosteum and also cauterising the surrounding mucosa.

The techniques followed in the present series are only possible because of the evolution in surgical instruments during recent years. Angled scopes, curved debriders and endonasal drills, as well as a plethora of sophisticated graspers, micro-scissors and curettes of variable sizes and angles, allow us to work with precision in inaccessible areas, such as the extreme lateral part of frontal sinus.[12,23] Regarding sphenoid sinus surgery and resection in close proximity to the internal carotid, the 'two nostrils four hands' technique[13] is, in our view, ideal for subtle manipulation of these structures in addition to careful pre-operative planning with CT mapping of the bony walls of the internal carotid. Regarding inverted papillomas invading the lamina papyracea, if no signs of orbital infiltration are present, using a fine dissector-elevator the inverted papilloma is carefully detached from the

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Table 2. Treatment strategies depending on structures involved

Site of attachment	Management
Bone	Drilling of bony attachment and surrounding mucosa cauterisation
Bone erosion. Dura or periorbita exposed	Drilling of bony attachment and surrounding mucosa cauterisation. If dura or periorbita intact, no need for reconstruction[23]
Infiltrated dura	Infiltrated dura excision; multi-layer reconstruction
Infiltrated periorbita	Infiltrated periorbita excision. In wide excision, silicon sheet in touch with fat prevents prolapse and induces healing

structures adjacent to the lamina along with the lamina itself, leaving the periorbita intact with no reconstruction needed. However, in case of frank invasion, periorbita should be removed and periorbital fat needs to be cauterised. Silicone sheets may be used to support the orbital structures providing a substrate for fibrosis, and these are removed after 2–3 weeks. Similarly, in cases of dural infiltration, after the resection of the dura, the defect can be closed using the inlay-onlay fascial lata.[24]

It can be argued that since inverted papilloma is a benign disease, barriers such as periorbita or dura should not be resected, and the barrier should be allowed to remain intact. Although this argument is valid, our experience, as reflected by the current series, suggests that if these barriers have been breached by the tumour, when left in place they would invariably lead in a recurrence of the disease with greater local infiltration of neighbouring structures, requiring a more challenging and invasive revision.

- Management of inverted papillomas invading intracranial or intraorbital structures is complex
- Partial disease excision leads to recurrence of inverted papillomas with locally more aggressive behaviour
- Pre-operative computed tomography, magnetic resonance imaging and neuronavigation are necessary for operation planning
- Appropriate exposure and recognition of the pedicle of origin of inverted papilloma is necessary for radical resection
- Tight follow up with endoscopy and imaging if necessary is required for early recognition of recurrence

Through this series, we would like to illustrate that the endonasal endoscopic approach provides a safe means of treating revision cases too. Moreover, the most recent meta-analysis[4] also shows that the endoscopic approach has significantly reduced recurrence rates compared with the open resection. These results, along with the well-established reduced morbidity and hospitalisation that endoscopic techniques offer,[25] shape the endoscopic resection as being the ideal option for inverted papilloma treatment. Some of the features of endoscopy leading to those results are probably related to the ability to magnify as well as the excellent illumination of the surgical field and the ability to view around the corner.[5] The location of the disease in the frontal sinus has traditionally been a limitation to the use of endoscopic techniques. However, the development of sophisticated surgical instruments and the greater experience earned by sinus surgeons led to transnasal approaches even in the far lateral portion of the frontal sinus or in the supraorbital recess.[26]

Limitations

This case series consists of strictly selected cases representing a very specific population which led to a rather limited number of cases being included. Moreover, follow up for one patient in our study was only 13 months, which may affect the results. Another limitation of this study concerns the number of cases, which is limited because of the rarity of the disease fitting our selection parameters.

Conclusion

Patients with inverted papilloma extending intracranially or intraorbitally represent a challenging patient cohort that commonly undergoes multiple operations or revisions. Understanding inverted papilloma anatomy and pathophysiology is vital in guiding their management. Meticulous pre-operative surgical planning, including imaging, pedicle-tailored surgery, use of the bi-nostril technique, adequate exposure including Draf III and extended sphenoidotomies, and dura and periorbita excision as required, is key in dealing with complex tumours. Although we report only 2 recurrences with the remaining 16 patients being free of disease during a mean follow up of more than 3 years, larger series and randomised trials are required to provide stronger evidence of the safety and efficacy of endoscopic resection in inverted papillomas.[27]

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Competing interests. None declared

References

1 Ward N. A mirror of the practice of medicine and surgery in the hospitals of London: London Hospital. *Lancet* 1854;**64**:480–2
2 Re M, Gioacchini FM, Bajraktari A, Tomasetti M, Kaleci S, Rubini C *et al.* Malignant transformation of sinonasal inverted papilloma and related genetic alterations: a systematic review. *Eur Arch Otorhinolaryngol* 2017;**274**:2991–3000
3 Lund VJ, Stammberger H, Nicolai P, Castelnuovo P, Beal T, Beham A *et al.* European position paper on endoscopic management of tumours of the nose, paranasal sinuses and skull base. *Rhinol Suppl* 2010;**22**:1–143
4 Peng R, Thamboo A, Choby G, Ma Y, Zhou B, Hwang PH. Outcomes of sinonasal inverted papilloma resection by surgical approach: an updated systematic review and meta-analysis. *Int Forum Allergy Rhinol* 2019;**9**:573–81
5 Busquets JM, Hwang PH. Endoscopic resection of sinonasal inverted papilloma: a meta-analysis. *Otolaryngol Head Neck Surg* 2006;**134**:476–82
6 Attlmayr B, Derbyshire SG, Kasbekar AV, Swift AC. Management of inverted papilloma: review. *J Laryngol Otol* 2017;**131**:284–9
7 Grayson JW, Khichi SS, Cho D-Y, Riley KO, Woodworth BA. Management strategies for skull base inverted papilloma. *Otolaryngol Head Neck Surg* 2016;**155**:179–83
8 Wood JW, Casiano RR. Inverted papillomas and benign nonneoplastic lesions of the nasal cavity. *Am J Rhinol Allergy* 2012;**26**:157–63
9 Georgalas C, Wytske F. Rhinology and skull base surgery: from the lab to the operating room - an evidence-based approach. THIEME;2013
10 Bathma S, Harvinder S, Philip R, Rosalind S, Gurdeep S. Endoscopic management of sinonasal inverted papilloma. *Med J Malaysia* 2011;**66**:15–8
11 Castelnuovo P, Dallan I, Battaglia P, Bignami M. Endoscopic endonasal skull base surgery: past, present and future. *Eur Arch Otorhinolaryngol* 2010;**267**:649–63
12 Pagella F, Pusateri A, Giourgos G, Tinelli C, Matti E. Evolution in the treatment of sinonasal inverted papilloma: pedicle-oriented endoscopic surgery. *Am J Rhinol Allergy* 2014;**28**:75–81

https://doi.org/10.1017/S0022215121002152 Published online by Cambridge University Press

13 Castelnuovo P, Pistochini A, Locatelli D. Different surgical approaches to the sellar region: focusing on the "two nostrils four hands technique". *Rhinology* 2006;**44**:2–7
14 Landsberg R, Cavel O, Segev Y, Khafif A, Fliss DM. Attachment-oriented endoscopic surgical strategy for sinonasal inverted papilloma. *Am J Rhinol* 2008;**22**:629–34
15 Krouse JH. Development of a staging system for inverted papilloma. *Laryngoscope* 2000;**110**:965–8
16 Adriaensen GFJPM, Lim K-H, Georgalas C, Reinartz SM, Fokkens WJ. Challenges in the management of inverted papilloma: a review of 72 revision cases. *Laryngoscope* 2016;**126**:322–8
17 Savy L, Lloyd G, Lund VJ, Howard D. Optimum imaging for inverted papilloma. *J Laryngol Otol* 2000;**114**:891–3
18 Yousuf K, Wright ED. Site of attachment of inverted papilloma predicted by CT findings of osteitis. *Am J Rhinol* 2007;**21**:32–6
19 Karligkiotis A, Lepera D, Volpi L, Turri-Zanoni M, Battaglia P, Lombardi D *et al.* Survival outcomes after endoscopic resection for sinonasal squamous cell carcinoma arising on inverted papilloma. *Head Neck* 2016;**38**:1604–14
20 Suh JD, Ramakrishnan VR, Thompson CF, Woodworth BA, Adappa ND, Nayak J *et al.* Inverted papilloma of the sphenoid sinus: risk factors for disease recurrence. *Laryngoscope* 2015;**125**:544–8
21 Thaler ER, Kotapka M, Lanza DC, Kennedy DW. Endoscopically assisted anterior cranial skull base resection of sinonasal tumors. *Am J Rhinol* 1999;**13**:303–10
22 Chiu AG, Jackman AH, Antunes MB, Feldman MD, Palmer JN. Radiographic and histologic analysis of the bone underlying inverted papillomas. *Laryngoscope* 2006;**116**:1617–20
23 Adriaensen GFJPM, van der Hout MW, Reinartz SM, Georgalas C, Fokkens WJ. Endoscopic treatment of inverted papilloma attached in the frontal sinus/recess. *Rhinology* 2015;**53**:317–24
24 Geyik M, Erkutlu I, Alptekin M, Gezgin I, Mizrak A, Dokur M *et al.* Anterior skull base defects reconstructed using three-layer method: 78 consecutive cases with long-term follow-up. *J Neurol Surg Part B Skull Base* 2016;**77**:499–502
25 Larget I, Bastier PL, De Gabory L. External versus endoscopic approach in the management of 131 sinonasal inverted papillomas. *Rev Laryngol Otol Rhinol* (*Bord*) 2015;**136**:3–7
26 Karligkiotis A, Pistochini A, Turri-Zanoni M, Terranova P, Volpi L, Battaglia P *et al.* Endoscopic endonasal orbital transposition to expand the frontal sinus approaches. *Am J Rhinol Allergy* 2015;**29**:449–56
27 van Samkar A, Georgalas C. Long-term quality of life after endoscopic removal of sinonasal inverted papillomas: a 6-year cohort analysis in a tertiary academic hospital. *Eur Arch Otorhinolaryngol* 2016;**273**:1433–7

https://doi.org/10.1017/S0022215121002152 Published online by Cambridge University Press