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Unusual complications of bone wax at the skull base

R Panicker[1], R K Moorthy[2] and V Rupa[1]

Departments of [1]ENT and [2]Neurological Sciences, Christian Medical College, Vellore, India

Abstract

Objective. This study aimed to describe the clinical presentation, microbiological profile and management of complications of bone wax usage for surgical procedures at the skull base.
Method. The case records of a series of five patients who developed post-operative surgical site complications because of bone wax usage during skull base surgery were reviewed.
Results. In all five patients, persistent site-specific clinical features were noted along with intra-operative presence of excessive bone wax. Three unique cases of presentation, one with a fungal brain abscess because of *Aspergillus flavus* infection, another with fungal osteomyelitis because of *Trichosporon beigelii* infection and a third with intradural migration of bone wax into the cerebellopontine angle cistern are highlighted.
Conclusion. The presentation of surgical site infection at the skull base because of excessive use of bone wax can be manifold. The need for testing appropriate cultures including fungal culture is highlighted.

Main Article

Dr V Rupa takes responsibility for the integrity of the content of the paper

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Author for correspondence:
Dr V Rupa, Department of ENT, Christian Medical College Hospital, Vellore 632004, India
E-mail: rupavedantam@cmcvellore.ac.in

Introduction

Bone wax, a commonly used haemostatic and mechanical sealant in surgical practice, was described as 'antiseptic wax' by Victor Horsley in the 1800s.[1] The composition of bone wax has changed over the ages. Although it was initially described as consisting of beeswax, almond oil and salicylic acid,[1] its composition currently consists of white beeswax (85 to 90 per cent) and isopropyl palmitate (10–15 per cent) with or without pure paraffin wax.[2]

This material has quickly grown in popularity because of its non-reactive and non-absorbable properties, but these very properties do, occasionally, result in complications. Animal experiments have shown that bone wax remains as a foreign body for years and reduces the ability of cancellous bone to clear bacteria.[3] Bone wax also inhibits new bone formation, thereby delaying healing.[2] Commonly described complications of bone wax usage are foreign body granuloma and bacterial infection.[4–9] Additionally, there are reports of delayed migration of bone wax to adjacent areas.[8–11]

As bone wax is a frequently used material in both otorhinolaryngological and neurosurgical procedures and because we noted certain rare post-operative complications as a result of its use in our practice, we decided to perform a retrospective review of all patients treated by us who had developed complications because of bone wax usage at the skull base. We also highlight the diverse infection profile and site-specific management of these complications.

Materials and methods

We conducted a retrospective study of all patients attending the ENT and neurosurgery sections of our hospital over the last 15 years and who had intra-operative evidence of complications following the use of bone wax at the primary surgery.

Our search strategy was to screen all patients who had post-operative wound infections during the study period from 2005 to 2019. Only those patients who had infections associated with bone wax at the skull base (as determined by the operation notes) were finally included. Data from the electronic medical records of these patients were extracted to note the clinical presentation, prior medical and surgical history, imaging findings, operative details at revision surgery, microbiology reports, histopathology results, treatment, and final outcomes.

Results

A total of five patients were found to have complications of bone wax use at the primary surgery. There were three males and two females, with ages ranging from 21 to 57 years (Table 1). A common feature in all five patients was the presence of copious amounts of bone wax at the surgical site. The wax was present in proximity to adjacent bone and lay interspersed with granulation tissue and bone in four cases (cases 1, 3, 4 and 5) and within the ethmoid sinuses in one case (case 2).

Table 1. Clinical features and radiology results of patients*

Parameter	Case 1	Case 2	Case 3	Case 4	Case 5
Age (years)	32	22	21	57	55
Sex	Female	Male	Female	Male	Male
Initial diagnosis	Chronic suppurative otitis media with dry central perforation	Post-traumatic anterior skull base fracture with extradural haematoma	Left vestibular schwannoma	Right vestibular schwannoma	Foramen magnum & C1-2 neurofibromas
Primary symptoms	1: Purulent left ear discharge, & 2: headache	Bilateral cerebrospinal fluid leak & recurrent meningitis	Left-sided hearing loss & headache	Right-sided hearing loss & headache	Neck pain & difficulty in walking
Symptoms at presentation of complication	1: Purulent left ear discharge, & 2: headache	Right-sided CSF leak & recurrent meningitis	Left-sided discharging postauricular fistula	Asymptomatic	Persistent fever
Symptom duration	1 month	2 years	2 years	6 months	3 months
Interval between initial surgery & complication	1 week	1 month	2 weeks	24 months	1 month
Initial surgery	Left mastoid exploration with tegmen injury & repair with bone wax	Bifrontal craniotomy & anterior cranial fossa repair with bone wax; bilateral endoscopic CSF leak repair	Retrosigmoid approach suboccipital craniectomy & excision of left-sided vestibular schwannoma with mastoid air cell penetration & repair with bone wax	Retrosigmoid approach suboccipital craniectomy & excision of right vestibular schwannoma with mastoid air cell penetration & repair with bone wax	Foramen magnum rim excision, C1 excision & removal of neurofibromas. Bone wax was used as a haemostatic seal
Radiological features at presentation CT & MRI scan	MRI with contrast: 20 × 12 mm temporal lobe abscess, with enhancing margins & central hypointensity in communication with an area of hyperintensity in the left epitympanum through a large tegmen defect	MRCT: multiple defects along the roof of ethmoid, orbit & cribriform plate bilaterally; meningocele in right ethmoid sinus	High-resolution CT temporal bone & MRI brain scan: erosion of the sinus plate in the inferior part of posterior wall of the left mastoid with mastoiditis	MRI with contrast: enhancing solid lesion within the cerebellopontine angle with oedema in the adjacent brain stem & middle cerebellar peduncle	MRI with contrast: area of enhancement with a hypointense centre, in the region where foramen magnum rim was removed

*$n = 5$. CSF = cerebrospinal fluid; MRI = magnetic resonance imaging; MRCT = magnetic resonance imaging with computed tomography; CT = computed tomography

Fig. 1. (a) Contrast enhanced MRI scan of the brain (coronal cut) showing a large temporal lobe abscess with enhancing wall (arrow) and surrounding brain oedema. (b) High-resolution computed tomography scan of the temporal bone showing a large defect of the tegmen (arrow).

Clinical presentation

In three patients who had the primary surgery performed elsewhere, operative details were unavailable. These patients presented for the first time to our hospital with discharging wounds (cases 1 and 3) and with cerebrospinal fluid (CSF) rhinorrhoea and recurrent meningitis in one patient (case 2). In all of these cases, the finding of large amounts of bone wax along the skull base was an unexpected finding.

Two other patients (cases 4 and 5) were operated on in our hospital: both had required the use of bone wax intra-operatively, one for sealing the mastoid air cells during retrosigmoid craniectomy for vestibular schwannoma excision and the other for haemostasis during removal of a part of the foramen magnum for excision of a C1-2 schwannoma. While one patient (case 3) presented with a discharging postaural fistula, which persisted for several months after the primary surgery, another patient (case 5) developed persistent fever one month after the primary surgery. Only one of the five patients (case 4) was asymptomatic at presentation and the presence of the complication was shown on a routine post-operative CT scan of the brain (Table 1).

Imaging findings

Contrast-enhanced magnetic resonance imaging (MRI) of the brain provided a pre-operative diagnosis of the extent of the complication in all patients (Table 1). In case 1, there was an abscess in the temporal lobe (Figure 1), and the extent of tegmen breach was well visualised on a combination of high-resolution computed tomography (CT) and MRI images of the temporal bone. In case 2, several anterior skull base defects

Fig. 2. (a) Plain computed tomography scan of the sinuses and brain (coronal cut) showing a defect of the roof of the right ethmoid with a soft tissue opacification in the ethmoid sinus suggesting the presence of a meningocele. (b) Multiple defects involving the left roof of ethmoid and cribriform plate (arrow) and roof of right orbit (arrow).

were present (Figure 2a and b), and because there was reactive sinusitis, the site of the meningocele was better demonstrated on high-resolution CT scan of the skull base (Figure 2a) than on MRI scan. In case 3, osteomyelitic bone in close proximity to the sigmoid sinus was evident on a high-resolution CT scan of the temporal bone, whereas the tract and its course as well as bone wax were well visualised on an MRI scan (Figure 3a and b). In case 4, there was an enhancing lesion in the cerebellopontine angle cistern mimicking a tumour with oedema of the adjacent brain stem not seen in an earlier post-operative MRI scan done six months after excision (Figure 4a–d).

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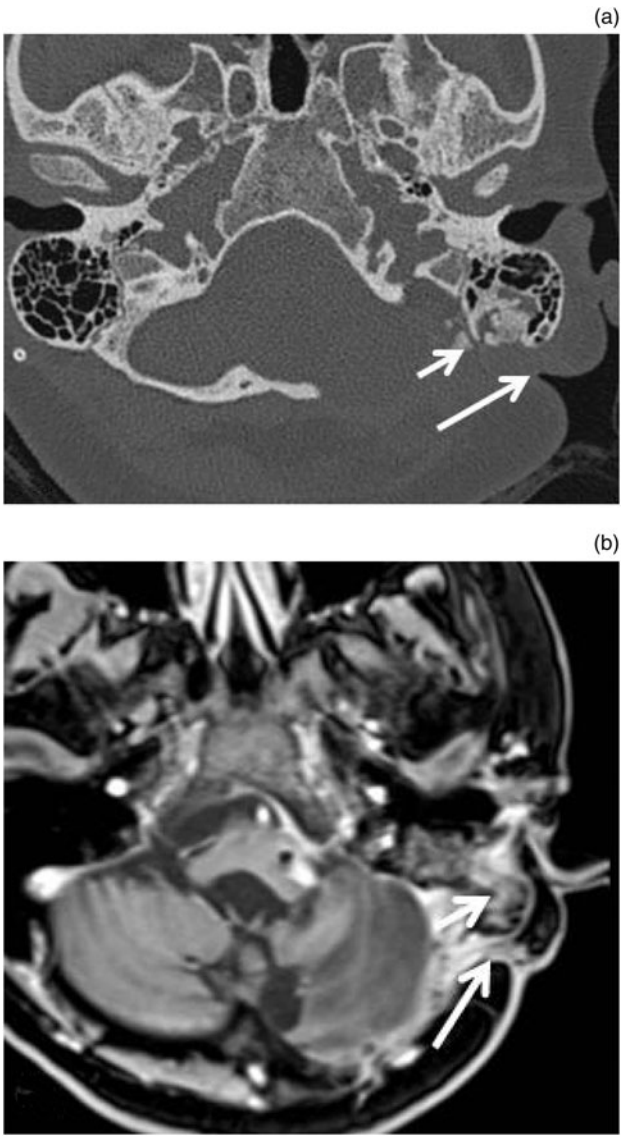

Fig. 3. (a) Plain computed tomography scan of the brain (axial cut) showing a defect in the posterior wall of left mastoid with opacified mastoid air cells (short arrow) and sinus tract (long arrow); (b) axial enhanced T1-weighted magnetic resonance imaging scan showing enhancing sinus tract (long arrow) extending to extradural region close to the sigmoid sinus. The short arrow points to hyperintense bone wax and granulations in the mastoid air cells.

In case 5, there was enhancement adjacent to the foramen magnum, suggesting an infective process (Figure 5a and b).

Bacteriology and mycology

Staphylococcus aureus was the commonest organism isolated with methicillin resistant *S aureus* (MRSA) isolates seen in two patients. Case 3, who had MRSA cultured from the pre-operative swab, underwent a two-week course of linezolid and cotrimoxazole pre-operatively, and re-exploration was performed after the repeat swab was negative. A negative culture was seen in one patient (case 4) (Table 2).

Fungal infections were noted in two of the five cases. In case 1, *Aspergillus flavus* was isolated from the brain abscess. Intra-operative findings in this patient included the presence of a 20×12 mm thick walled temporal lobe abscess full of thick, gelatinous pus which prompted us to request bacterial, fungal and mycobacterial cultures. In case 5, *Trichosporon beigelii,* a yeast-like fungus, was grown in culture from the granulation tissue.

Histopathology results

Histopathology showed granulation tissue with chronic inflammation in all patients. In case 1, with the fungal brain abscess, filamentous fungal forms were seen in the abscess wall, and in the patient with fungal osteomyelitis, yeast-like forms were seen to infiltrate bone.

Treatment and outcome

Re-exploration of the surgical site with removal of bone wax was performed in all patients (Table 2). In case 2, this was done twice. Following endoscopic repair of a right-sided foveal defect and excision of bone wax in the sinuses, the patient presented three months later with bilateral grade 2 sinonasal polyposis. He underwent bilateral endoscopic polyp excision and was noted to have bone wax in the frontal recesses bilaterally, which appeared to have been left behind at the previous surgery. After removal of this residual bone wax and polyps and commencing steroid nasal sprays, the patient was asymptomatic at five years' follow up.

Case 3, whose culture from the postaural fistula had grown MRSA, was given oral linezolid and cotrimoxazole for two weeks pre-operatively and one week post-operatively. Based on intra-operative bacterial culture reports of *Klebsiella* species growth, antibiotics were changed post-operatively to intravenous cefoperazone and amikacin for one week followed by oral amoxicillin clavulanate for two weeks. Case 4 had a cerebellopontine angle mass that mimicked a recurrent tumour but was actually a sterile foreign body granuloma in the cerebellopontine angle cistern. After partial excision, the mass disappeared at the follow-up visit.

With regard to antifungal therapy, case 1 responded well to a three-month course of itraconazole at a dose of 200 mg twice daily; however, case 5 refused antifungal therapy and was lost to the follow up.

Discussion

Traditionally, during mastoid surgery or craniotomy, a small amount of bone wax has been used by surgeons to provide a haemostatic seal when there is bleeding from emissary veins or bone which cannot be controlled by pressure or the use of cautery. Its use is not free from complications, however, as outlined by several authors.[4–11]

Bone wax may also be used as a mechanical sealant in some cases. In four patients (cases 1 to 4), despite the lack of operative details in three, it appeared that bone wax had been used as a mechanical sealant to prevent CSF leak rather than for haemostasis. In case 5, however, it was used as a haemostatic agent. Neurosurgeons describe the use of a thin layer of bone wax as a mechanical sealant to plug the small mastoid cells that are inadvertently opened during retromastoid craniectomy or temporal craniotomy.[10] If larger exposure of cells is encountered, plugging with fat or muscle is advised, rather than bone wax.[12] In our series, the use of excessive bone wax appears to be the predisposing cause for complications in all the cases. Further, the use of bone wax as a layer of repair to prevent CSF leak is not advisable. This appears to have been the cause for complications in cases 1 and 2.

Migration of bone wax with resultant development of complications has been described by some authors.[8–11] In one of our patients (case 4), bone wax that was used to seal mastoid cells that were opened during vestibular schwannoma surgery

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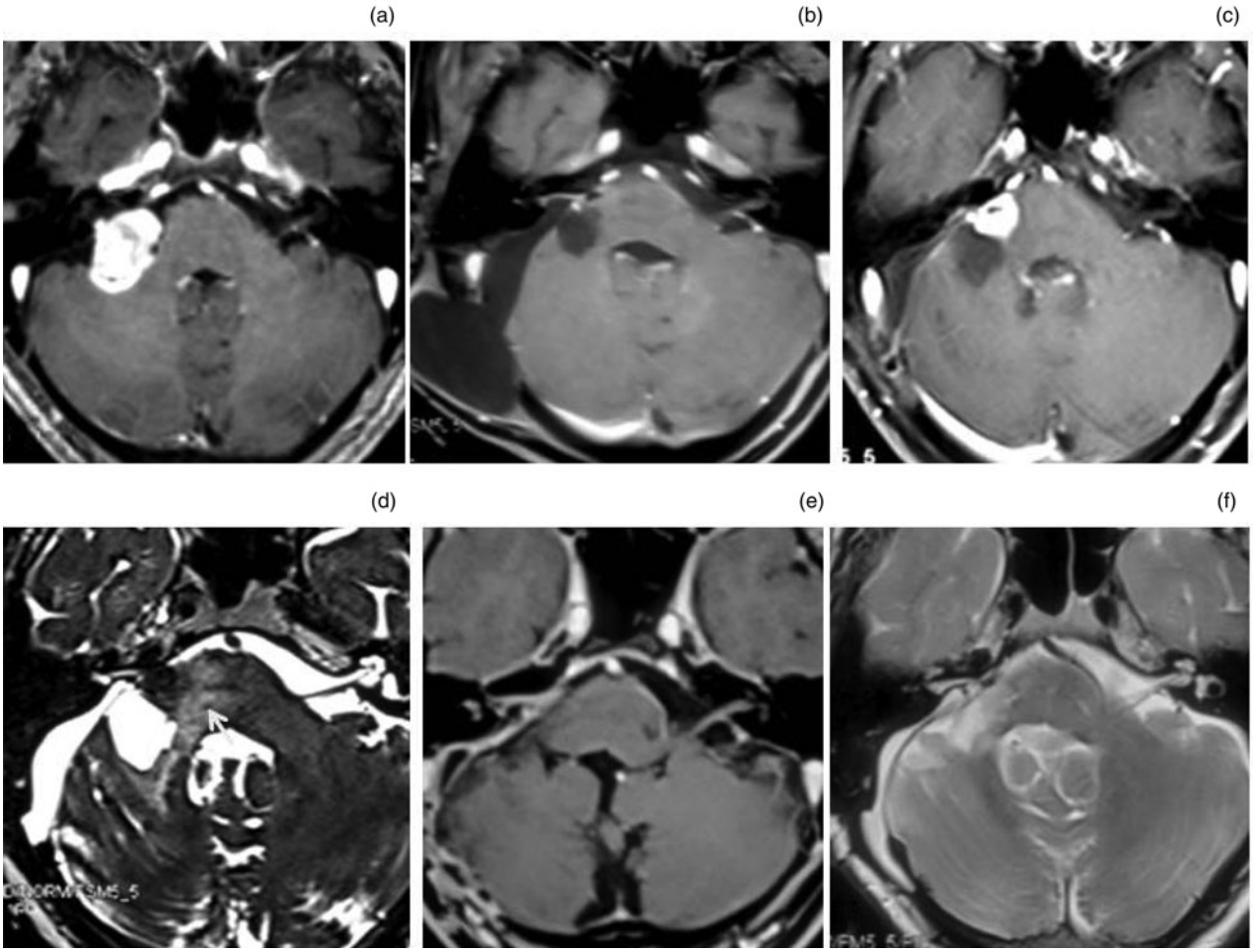

Fig. 4. Axial magnetic resonance imaging (MRI) of case 4. (a) Pre-operative T1-weighted MRI post-contrast image showing a homogeneously enhancing right vestibular schwannoma. (b) Post-operative T1-weighted MRI post-contrast image six months later showing no abnormal enhancement or tumour residue. (c) Post-operative T1-weighted MRI post-contrast image one year later showing an area of enhancement in the cerebellopontine angle cistern. (d) T2-weighted MRI sequence done at same time showing the oedema within the brain stem (white arrow). The patient was asymptomatic at this time and underwent re-exploration and removal of granulation tissue at this time. The cultures were sterile. (e) T1-weighted MRI post-contrast image six months later demonstrating resolution of the lesion and (f) resolution of the oedema on T2-weighted MRI sequences.

was found to have migrated intradurally causing an inflammatory reaction and granuloma formation that required subsequent surgery. Bone wax present at the internal auditory meatus causing cerebellopontine angle granuloma formation has been reported earlier,[5] but there was no mention of intradural migration from the mastoid air cells as was observed in our case in that report.

In our patient, although the location and appearance of the enhancing lesion mimicked a recurrent schwannoma, we felt that it was important to recognise the possibility of an inflammatory pathology too as it was unlikely that a schwannoma would have recurred at this size when an MRI scan done one year earlier had shown no evidence of residual tumour. Further, the presence of new onset oedema in the repeat MRI scan is atypical for a recurrent schwannoma. We thus decided to re-explore the previous surgical site. Failure to consider the possibility of a new pathology in this patient may have resulted in him being unnecessarily subjected to stereotactic radiosurgery that may have worsened his neurological status. Foreign body granuloma formation in the medulla, secondary to bone wax inadvertently being left behind in the subarachnoid space, has also been reported.[13] In case 2, inadequate primary repair and excessive bone wax in the anterior skull base caused a triad of complications of infection leading to recurrent meningitis, sinonasal polyposis and wax migration into the ethmoid sinuses.

- Bone wax use during skull base surgery may result in infection, foreign body granuloma or migration, but the complication may occur several weeks later
- All cases require surgical re-exploration with excision of bone wax and infected tissue
- Excised pus and granulation should be sent for bacterial, fungal and mycobacterial cultures
- Asymptomatic, sterile foreign body granuloma mimicking a tumour is, rarely, seen too
- Methicillin resistant *Staphylococcus aureus* infection, which is common, also requires appropriate combination antibiotic therapy
- Invasive fungal infection is a rare complication that requires appropriate antifungal therapy in addition

One of the prime complications of bone wax use is surgical site infection with staphylococcal infections being predominant. Bone wax has been shown to impair clearance of staphylococcal bacteria when compared with either a synthetic polymer or controls in a rabbit model, wherein defects created in the tibia were inoculated with *S aureus.* All the animals who received bone wax developed features of osteomyelitis compared with controls or the polymer group.[14] Intraventricular migration of bone wax from the burr hole site, found during placement of a ventricular catheter, had been reported to result

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Fig. 5. T1-weighted MRI post-contrast MRI scans of case 5. (a) Coronal image showing an area of enhancement just right of midline (arrow mark). (b) Axial image showing the same area just adjacent to the foramen magnum rim.

in repeated episodes of *Staphylococcus epidermidis* meningitis and shunt infections that abated only once the bone wax was removed endoscopically.[7] The retrieved bone wax, which had also been cultured, was found to be positive for *S epidermidis*.[7] In our series, while MRSA was the infecting organism in two patients, a sterile granuloma was also seen in one patient (case 4).

A unique feature in our series was the presence of serious fungal infections in two patients. In fact, case 1 is the first report in the literature of a fungal brain abscess as a result of *A flavus* and case 5 is the first case of *T beigelii* infection, both secondary to the use of bone wax. A high index of suspicion because of the viscous appearance of the pus within the abscess led to the request for fungal culture in addition to bacterial and mycobacterial culture along with histopathology. Invasive fungal

Table 2. Surgical and medical management, microbiology and outcome in case series*

Parameter	Case 1	Case 2	Case 3	Case 4	Case 5
Surgery performed	Temporal craniotomy & evacuation of abscess with mastoidectomy & bone wax removal & repair with fascia lata & pericranium	Endoscopic CSF leak repair, polypectomy & bone wax removal	Wound exploration, left cortical mastoidectomy, excision of granulations & bone wax & closure of the postaural fistula	Re-exploration & partial excision of lesion within the cerebellopontine angle cistern	Re-exploration of surgical site, with removal of bone wax & granulation tissue
Site of infection	Left temporal lobe	Roof of ethmoids bilaterally	Left mastoid cortex adjacent to sigmoid sinus	Right cerebellopontine angle	Area of foramen magnum rim sealed with bone wax
Organism	*Aspergillus flavus*	MRSA	MRSA alone seen on pre-operative cultures; klebsiella species & MRSA seen on post-operative cultures	Sterile culture	*Trichosporon beigelii*
Medical therapy	Oral itraconazole 200 mg twice daily × 3 months	Oral linezolid + cotrimoxazole × 2 weeks	Oral linezolid & cotrimoxazole for 2 weeks; later drugs changed	Nil	Did not consent for antifungal therapy
Outcome with regards to infection/aseptic complication of bone wax usage	Cure	Cure	Cure	Cure	Lost to follow up

*$n = 5$. CSF = cerebrospinal fluid; MRSA = methicillin resistant *Staphylococcus aureus*

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infections may be introduced by the use of in-dwelling catheters and devices around which fungi can form a biofilm.[15] Although this has not been described before, it is possible that fungal biofilm development occurs with the use of bone wax too, and cases 1 and 5 are illustrative of this phenomenon. While *Aspergillus* species usually respond well to the administration of azoles (as seen in case 1), the treatment of *T beigelii* is more challenging. Triazoles appear to have better *in vitro* and *in vivo* activity against the organism than amphotericin B.[15] Unfortunately, our patient (case 5) was lost to follow up and hence his response could not be assessed.

Conclusion

Excessive use of bone wax in the skull base for haemostasis or as a sealant for mastoid air cells can result in infective and non-infective complications that may mimic a tumour. Fungal pathogens may be a cause for serious, invasive infection, and it is mandatory to send fungal and bacterial cultures in all cases. Treatment of the complication will require re-exploration and removal of bone wax along with appropriate antibiotic or antifungal therapy.

Competing interests. None declared

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