https://doi.org/10.29309/TPMJ/2026.33.04.10184 www.theprofesional.com

ORIGINAL ARTICLE

Effectiveness of systemic voriconazole in reducing post-surgical recurrence of aspergillus mycotic rhinosinusitis.

Zahra Sarwar[1], Mavra Sarwar[2], Muhammad Sarwar Khan[3], Muhammad Yasir Khan[4], Rukaiya Sarwar[5], Hisham Shahid[6]

ABSTRACT… Objective: To determine voriconazole efficacy in postoperative FESS patients to prevent or minimize recurrence of Aspergillus associated rhinosinusitis. **Study Design:** Observational Prospective Analytical. **Setting:** Department of ENT and Head & Neck Surgery, KRL Hospital Islamabad. **Period:** 01.07.2021 to 30.06.2022. **Methods:** 57 patients (selected by simple random sampling technique) who underwent FESS for mycotic disease caused by Aspergillus species were followed prospectively as per the department's follow up protocols while receiving post-operative voriconazole. The initial dose and duration of oral drug advised depended on the severity and extent of disease at the time of surgery and the dose was adjusted on subsequent OPD reviews based on endoscopic nasal examination findings, visual analogue score for total nasal sinus symptoms as well as radiological findings where necessary. The success of treatment was monitored to check the efficacy of voriconazole in preventing post-surgical recurrence and the importance of response-based dose adjustments in patients suffering from mycotic rhinosinusitis. Data analysis was done using SPSS version 20. **Results:** Among 57 patients (mean age 32 years), systemic voriconazole after FESS showed high efficacy, with 89.5% remaining relapse-free at one year. Only six patients (10.5%) developed recurrence, mostly after tapering therapy, and three (5.3%) discontinued treatment due to adverse effects or noncompliance. Serial VAS, CT, and endoscopy scores demonstrated progressive improvement, with 35.1% achieving complete recovery by 12 weeks. **Conclusion:** We would like to conclude that voriconazole has proven highly effective in the treatment of sinonasal aspergillosis and has been proven to be the drug of choice to compliment thorough surgical clearance. Re-administration of voriconazole may be warranted at the slightest hint of recurrence noted on nasal endoscopic or radiological examination which may need to be biopsy proven.

Key words: Antifungal Therapy, Functional Endoscopic Sinus Surgery (FESS), Mycotic Rhinosinusitis (MRS), Visual Analogue Score (VAS).

Article Citation: Sarwar Z, Sarwar M, Khan MS, Khan MY, Sarwar R, Shahid H. Effectiveness of systemic voriconazole in reducing post-surgical recurrence of aspergillus mycotic rhinosinusitis. Professional Med J 2026; 33(04):667-673. https://doi.org/10.29309/TPMJ/2026.33.04.10184

INTRODUCTION

Underlying fungal aetiology is often the case in patients with chronic rhinosinusitis presenting with nasal polyps.[1] The inhalation of fungal spores and their presence in the sinonasal cavity triggers immunohistological responses that result in mucosal oedema subsequently developing into frank polyposis and the characteristic allergic mucin which is often found in these cases. Mycotic rhinosinusitis is a rather common condition in South East Asian population, mostly owing to the extensive agricultural landscape of this area. Thorough surgical clearance often combined with appropriate medical therapy like triazole antifungals makes the treatment modality of choice. Fungal sinusitis has been classified broadly into invasive and non-invasive forms. The invasive variety is further classified as chronic invasive, chronic granulomatous, and acute invasive forms, while the non-invasive type is subdivided into allergic type and fungal ball.[2] However, the most commonly encountered category in immunocompetent hosts is the chronic invasive form.[3]

The primary ecological niche of Aspergillus is vegetative decomposition[4], making its prevalence so common in agricultural lands. The incidence of this pathology is particularly high in the South East Asian demographic population as a vast majority live in agricultural areas and do not have access to specialized care.[5] Further insult is provided by injudicious use of antibiotics and steroid therapy, which is so common in primary peripheral healthcare. Various fungal types are implicated in sinonasal disease but the Aspergillus species is the most common isolate worldwide.[6]

1. MBBS, MRCS-ENT (Edinburgh), Registrar ENT and Head and Neck Surgery, Queen's Medical Centre, Nottingham, United Kingdom.
2. MBBS, MRCS-ENT (England), Medical Officer ENT and Head and Neck Surgery, KRL Hospital, Islamabad.
3. MBBS, FRCS (England), FRCS (Glasgow), Consultant ENT and Head and Neck Surgery, KRL Hospital, Islamabad.
4. MBBS, FCPS (ENT), Consultant ENT and Head and Neck Surgery, KRL Hospital, Islamabad.
5. MBBS, Intern ENT and Head and Neck Surgery, KRL Hospital, Islamabad.
6. ACA, FCCA, BSc, Manager Internal Audit Mondelez International.

Correspondence Address:
Dr. Zahra Sarwar
MRCS-ENT (Edinburgh), Queens Medical Centre, Nottingham, United Kingdom.
zahrasarwar93@gmail.com

Article received on:
18/09/2025
Accepted for publication:
28/11/2025

The Aspergillus variety is documented to have more than 250 sub-species, making it the largest genre of filamentous fungi causing human disease.[7] Endoscopic examination combined with radiological, microbiological, and histopathological armament leads to established diagnosis. Thorough surgical intervention and appropriate medical management are crucial for positive outcomes.[8] Over the past many years, different antifungals have been employed to cure this notoriously resistant and recurrent condition with variable efficacies. However, voriconazole has been found to be more effective and relatively safe in both the management of chronic invasive as well as allergic types of Aspergillus infections.[9] Voriconazole is one of the newer indole antifungals which is very useful and yields better outcome compared with other antifungals like itraconazole.[2-4,7,9] It carries a huge advantage on account of the route of administration since its oral administration gives fairly good results when compared to amphotericin that is only administered intravenously and carries considerable cost considerations as well as undesirable side effects. Although voriconazole is recommended as first-line treatment in aspergillosis internationally, owing to the rarity of the condition, only limited data is available.[9]

In our tertiary care centre, we have had vast experience with voriconazole with high success rates. We have a workload of managing more than one hundred cases with mycotic rhinosinusitis (MRS) per year. Dose adjustment with close monitoring of these patients has yielded very satisfying results. Having such a huge database of this pathology and treatment outcomes on board, we would like to present the efficacy of voriconazole on the basis of disease-free sinonasal cavity on long-term follow-up.

METHODS

This observational prospective analytical study was conducted in the Otorhinolaryngology department at KRL Hospital Islamabad, a tertiary care referral centre in Pakistan over a period of one year. The research was conducted after approval by the Ethical Committee having reference number KRL-HI-ERC/May21/20 included patients who underwent FESS for biopsy proven mycotic rhinosinusitis. Fashioning of a well epithelialized and well aerated surgical FESS cavity was considered key to successful outcome.

The sample size calculated using WHO calculator was 57 with 95% confidence interval, population proportion 82.5 and absolute precision 10%. The patients were enrolled in the study using simple random sampling technique.

The study included patients whose CT paranasal sinuses showed characteristic double densities or fungal shadows, as well as microscopy and culture proven Aspergillus mycotic rhinosinusitis in patients aged 12-59 years without gender bias, having disease limited to sinus cavities only. All patients included in the study had undergone FESS by the Consultant specialised in endoscopic sinus and skull base surgery and a well aerated cavity with thorough clearance was ensured in every case. All patients were operated by the same consultant to ensure that all postoperative patients were assessed uniformly.

Patients with intolerance to voriconazole, pregnancy, pre-existing hepatic or renal impairment, biopsy proven mucormycosis, intracranial or intra-orbital extension were all excluded from the research.

Nasal endoscopic evaluation using Philpott Javer system was carried out in every post-operative case. The evaluation in initial post operative period was carried out weekly for the first month for to ensure smooth healing postoperatively. Then the findings were recorded on 6 weekly follow up for six months and then bimonthly thereafter.

Radiological assessment according to Modified Lund-Mackay Score was considered in patients where direct endoscopic review of sinuses was not possible as in the case of frontal sinuses and depth of sphenoid and maxillary sinuses. Modified Lund-Mackay scores were used for analysis of CT findings.

Patients were questioned on how bothersome their sinonasal symptoms (symptoms of headache, nasal obstruction, olfaction, postnasal drip) were and scored from zero (no symptoms) to 10 (severe).

The Visual Analogue Scores were calculated at 6 weeks post operatively and then on subsequent follow up visits.

Complete post operative review follows a strict regime as weekly for the first two weeks, two weekly for the next six weeks and then monthly for four months. Then onwards the follow up interval was increased to bimonthly for six months if everything would be going well.

A careful and long term follow up is particularly needed in cases of mycotic rhinosinusitis so that regular decrusting is carried out and any possible nidus of infection is eradicated and, at the same time, any signs of recurrence are picked up early on endoscopic examination and if necessary, radiologically. Any signs of recurrence would warrant dose adjustment of voriconazole with or without steroid support. Sometimes in cases of infection antibiotic may be required. Topical support with steroid sprays, however, would be continued in the postoperative period up to six months.

Target outcome would be a complete remission of disease without any endoscopic/ radiological recurrence on a one year follow up.

Persistence of mucosal oedema in the surgically fashioned cavity likely to progress or frank progress to recurrent polyposis was considered as failure of treatment and the causative factors were analysed and determined.

SPSS 20.0 was used for data analysis.

RESULTS

Patient Demographics

A total of 57 patients were included in the study. The mean age was 32.1 ± 12.1 years (range, 12–59), with 30 males (52.6%) and 27 females (47.4%). Allergic fungal rhinosinusitis accounted for 26 patients (45.6%), while chronic invasive mycotic sinusitis was observed in 31 patients (54.4%). Most patients received voriconazole for up to six months (65.0%), while about one-third required 6–12 months of therapy.

TABLE-I

Baseline demographic and clinical characteristics of patients (n = 57)

Variable	Value (n=57)
Age (years), mean ± SD (range)	32.1 ± 12.1 (12–59)
Gender, n (%)	Male: 30 (52.6%), Female: 27 (47.4%)
Extent of disease (Philpott–Javer derived, 1–10)	Median 5 (IQR 3–8)
Duration of treatment	≤3months: 14 (24.6%), ≤6 months: 23 (40.4%), 6–12 months: 20 (35.1%)
Type of disease, n (%)	Allergic fungal rhinosinusitis: 26 (45.6%), Chronic invasive mycotic sinusitis: 31 (54.4%)

Treatment Outcomes

During follow-up, six patients (10.5%) developed recurrence of fungal sinusitis requiring reinitiation of systemic voriconazole, most occurring at 24 weeks after tapering and one at nine months due to noncompliance. Voriconazole therapy was discontinued in three patients (5.3%): two due to severe derangement of liver function tests (more than three times the upper limit of normal) and one due to noncompliance. The latter subsequently presented with recurrence at nine months postoperatively. Overall, six patients (10.5%) required reinitiation of systemic voriconazole due to recurrence, while two patients (3.5%) were managed with systemic and topical steroids at six weeks for polyps in the frontoethmoidal recess. At 12 weeks, 20 patients (35.1%) demonstrated complete recovery with healthy bilateral functional endoscopic sinus surgery (FESS) cavities. Treatment outcomes are summarized in Table-II.

Longitudinal Outcomes

At six weeks, mucosal oedema was rarely observed. Ten patients (17.5%) showed mild oedema, and two of these developed small polyps in the frontoethmoidal recess that were successfully managed with systemic and topical steroids.

At 12 weeks, 20 patients (35.1%) had completely recovered with healthy FESS cavities. The remaining 37 patients (64.9%) demonstrated residual mild mucosal oedema with mucin secretions,

corresponding to a Philpott–Javer classification of 12/40.

TABLE-II

Treatment outcomes during follow-up (n = 57)

Outcome	n (%)
Relapse requiring voriconazole reinitiation	6 (10.5)
• At 24 weeks (after tapering)	5 (8.8)
• At 9 months (noncompliance)	1 (1.8)
Steroid reinitiation (polyps at 6 weeks)	2 (3.5)
Discontinuation of voriconazole	3 (5.3)
• Liver function derangement	2 (3.5)
• Noncompliance (relapse at 9 months)	1 (1.8)
Complete recovery at 12 weeks	20 (35.1)

TABLE-III

Serial changes in VAS, CT, and endoscopy scores (n = 57)

Time Point	VAS Score (Mean±SD)	CT Score (Mean±SD)	Endoscopy Score (Mean±SD)
6 weeks	2.5 ± 1.1	10.5 ± 5.6	1.1 ± 2.4
12 weeks	1.0 ± 0.9	2.8 ± 2.7	3.0 ± 3.1
24 weeks	0.7 ± 1.2	1.5 ± 2.6	2.0 ± 3.4
52 weeks	0.6 ± 1.4	1.5 ± 3.7	1.9 ± 3.9

At 24 weeks, further improvement was seen in most patients. However, six patients (10.5%) in whom voriconazole had been tapered at 12 weeks developed mucosal oedema with mucin secretions typical of fungal recurrence. All six required reinitiation of voriconazole, which resulted in clinical improvement on subsequent follow-up.

Serial changes in symptom (VAS), radiological (CT), and endoscopic scores are presented in Table-III and illustrated in Figure-1.

Survival Analysis

Kaplan–Meier analysis demonstrated that 89.5% of patients remained relapse-free at 52 weeks. All relapses occurred within nine months of surgery: five cases (8.8%) at 24 weeks, following tapering of voriconazole, and one case (1.8%) at nine months due to noncompliance. Median relapse-free survival was not reached during the follow-up period. The mean relapse-free survival was 49.7 weeks (95% CI: 47.0 - 51.2). The Kaplan–Meier survival curve is shown in Figure-2.

FIGURE-1

Mean VAS, CT, and endoscopy scores at 6, 12, 24, and 52 weeks, demonstrating progressive improvement with voriconazole therapy. Error bars represent ± standard deviation (SD).

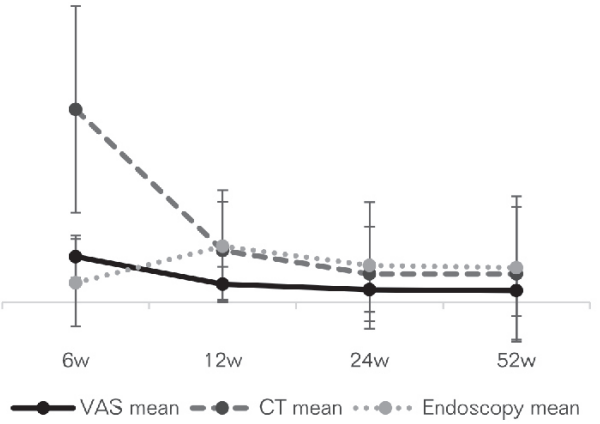
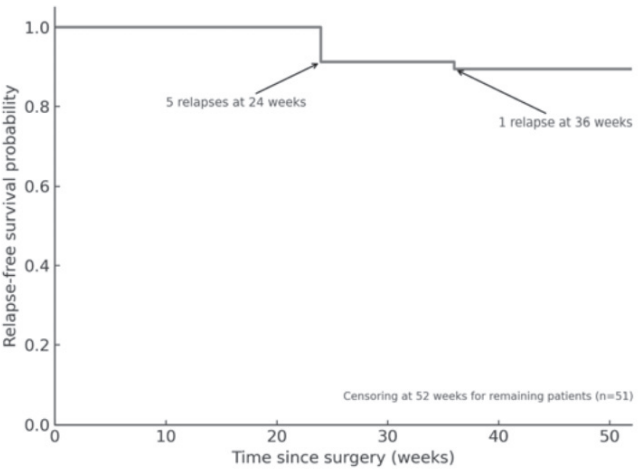


FIGURE-2

Kaplan–Meier survival curve showing relapse-free survival over 52 weeks in patients treated with systemic voriconazole. Relapses occurred in five patients (8.8%) at 24 weeks following tapering of therapy, and in one patient (1.8%) at nine months due to noncompliance.



DISCUSSION

The incidence of aspergillus rhinosinusitis is on the rise in agricultural areas. A definitive management strategy is therefore required to effectively guide the principles of treatment.

Several study designs are available to assess effectiveness of a drug. These include naturalistic clinical trials, database analysis and cross design synthesis. We opted for database analysis in our

study because in our department the efficacy of voriconazole has been established by the successful outcomes of many a patient over a long period of time. We henceforth prescribe this to all postoperative patients with invasive sinonasal aspergillosis.

In previous studies like that by Santosh et al.[1] low sample size has been a limitation. However, we present a significantly large prospective database analysis assessing the effectiveness of voriconazole.

Seema et al.[2] administered amphotericin B 1 mg/kg up to 5 g in patients diagnosed with Aspergillus Granulomatous invasive fungal sinusitis and then after completion of treatment kept the patients on oral voriconazole 200 mg for 3 months. The patients did not develop recurrence on a one-year follow up. We, in our research, have not noted any increased benefit in initiating treatment with amphotericin and start our patients on oral voriconazole immediately after surgery. This has yielded very good results.

Shivaprakash et al.[3], in Journal of Fungi, studied aspergillus resistance mechanisms and concluded that voriconazole was the drug of choice for all forms of invasive aspergillosis and was superior to itraconazole and amphotericin. Resistance to the latter was notable. This is consistent with recent literature showing that azole derivatives (voriconazole or itraconazole) outperform amphotericin B in chronic granulomatous invasive fungal sinusitis (CGIFS), with typical voriconazole treatment durations ranging from 6–18 months.[11,14,15]

In our study we gave all our patients oral steroids post operatively tapered over 3 to 5 weeks depending on the disease severity. Topical steroid therapy was commenced 1 week after surgery. All patients were started on voriconazole therapy postoperatively. Frequent follow up and medical management is key to success to avoid recurrence.

In the case of invasive mycotic infections particularly involving the frontal and sphenoid sinuses, it is extremely important to anticipate flare up of infection at any time in the postoperative period particularly after cessation of standard voriconazole regimes. If endoscopic findings highlight possible recurrence like unexplained mucosal oedema or accumulation of fungal secretions in the FESS cavity or any sinus(es), voriconazole may have to be reinstituted for a certain length of time until a healthy cavity is achieved. Fungal spores may survive in the mucosal lining and tend to regrow in favourable local and host factors. Such anticipation based on thorough nasendoscopy and timely appropriate treatment is a significant factor in reducing frank recurrence of disease. Hesham et al.[7] inferred in their study to opt for a 3-week course of voriconazole in Allergic fungal rhinosinusitis and a 3-month duration of intravenous administration in chronic granulomatous infection. We have in our set up found equally good response to long term oral voriconazole in cases of chronic invasive rhinosinusitis. This is supported by other reports showing that endoscopic debridement combined with long-term oral voriconazole leads to durable remission in chronic invasive fungal sinusitis.[13,18] In addition, for localized rhinosinusal aspergilloma, early diagnosis and emergency surgical debridement, often coupled with systemic antifungal therapy, remain the cornerstone of successful outcomes.[12]

We have found that a regular long term follow up is essential even after cessation of voriconazole treatment. Various authors recommend 1-year follow up[3] in sinonasal aspergillosis, while some other studies suggest up to 46 months follow up.[5] A recent systematic review reported an overall remission rate of 87.2% with combined surgical and medical management of granulomatous invasive fungal sinusitis, with voriconazole-based regimens showing higher recovery rates compared to other protocols.[16] We conclude that a lifelong maintenance follow up might actually be the best way forward in patients with invasive mycotic rhinosinusitis.

FESS is performed to achieve meticulous clearance of all sinuses and patients are to be kept under regular surveillance to ensure that mucosal oedema does not lead to hypoperfusion of any sinus cavity. Any crusts or fungal debris is carefully cleared on each outpatient visit to prevent frank recurrence of the disease.

The dosage of voriconazole as advised by infectious disease society of America in invasive aspergillosis

of the sinonasal tract is 400 mg BD for the first 24 hours followed by 200 mg BD maintenance dose.[4] Population pharmacokinetic modelling suggests that dose adjustment based on liver function (ALBI score) may further optimize therapeutic safety.[20]

Azole resistance particularly in Aspergillus flavus isolates has been reported sporadically due to multidrug efflux pumps especially Cdr1 B overexpression as concluded in a research by Raees et al.[6] In our prospective analysis as well as a significant magnitude of past experience, patients responded well to voriconazole. Hence, in our population the resistance to voriconazole was not found to be significant. This aligns with evidence that azole therapy, regardless of MIC, is strongly associated with better clinical outcomes in Aspergillus infections.[17]

Meta-analyses also confirm that voriconazole remains highly effective compared to amphotericin B, though posaconazole and isavuconazole have shown comparable efficacy in invasive aspergillosis.[19-21] Nevertheless, the robust body of evidence still positions voriconazole as the preferred antifungal in sinonasal aspergillosis.

The limitation of our study is that there was no control group for comparison of outcomes. The reason for avoiding a control group was in the best interest of our patients. All patients in this study with MRS were offered systemic voriconazole in an attempt to cure this potentially invasive and, if left unchecked, life-threatening disease.

CONCLUSION

We would like to conclude that voriconazole has proven highly effective in the treatment of sinonasal aspergillosis and has been proven to be the drug of choice to compliment thorough surgical clearance. Re-administration of voriconazole may be warranted at the slightest hint of recurrence noted on nasal endoscopic or radiological examination which may need to be biopsy proven.

ACKNOWLEDGEMENT

We would like to acknowledge Dr. Mudassir Altaf for reviewing statistical analysis.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SOURCE OF FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

1. Debbarma S, Gupta R, Patro SK, Gupta AK, Pandhi P, Shafiq N. **Randomised comparison of safety profile and short term response of itraconazole, voriconazole and amphotericin B in the management of chronic invasive fungal rhinosinusitis.** Indian J Otolaryngol Head Neck Surg. 2019 Nov; 71(Suppl 3):2165-2175.
2. Monga S, Malik JN, Sharma A, Agarwal D, Priya R, Naseeruddin K. **Management of fungal rhinosinusitis: Experience from a Tertiary Care Centre in North India.** Cureus. 2022 Apr 4; 14(4):e23826.
3. Rudramurthy SM, Paul RA, Chakrabarti A, Mouton JW, Meis JF. **Invasive aspergillosis by aspergillus flavus: Epidemiology, diagnosis, antifungal resistance, and management.** J Fungi (Basel). 2019 Jul 1; 5(3):55.
4. Patterson TF, Thompson GR 3rd, Denning DW, Fishman JA, Hadley S, Herbrecht R, et al. **Practice guidelines for the diagnosis and management of aspergillosis: 2016 Update by the infectious diseases Society of America.** Clin Infect Dis. 2016 Aug 15; 63(4):e1-e60.
5. Slonimsky G, McGinn JD, Goyal N, Crist H, Hennessy M, Gagnon E, et al. **A model for classification of invasive fungal rhinosinusitis by computed tomography.** Sci Rep. 2020 Jul 28; 10(1):12591.
6. Paul RA, Rudramurthy SM, Dhaliwal M, Singh P, Ghosh AK, Kaur H, et al. **Magnitude of voriconazole resistance in clinical and environmental isolates of aspergillus flavus and investigation into the role of multidrug efflux pumps.** Antimicrob Agents Chemother. 2018 Oct 24; 62(11):e01022-18.
7. El-Adl HM, Awad MA, El-Morsy SM, Khafagy YW. **Efficacy of voriconazole in nonsurgical treatment of allergic and chronic granulomatous fungal rhinosinusitis: A preliminary study.** The Egyptian Journal of Otolaryngology. 2018 Jan; 34(1):15-20.
8. Nakaya K, Oshima T, Kudo T, Aoyagi I, Katori Y, Ota J, et al. **New treatment for invasive fungal sinusitis: Three cases of chronic invasive fungal sinusitis treated with surgery and voriconazole.** Auris Nasus Larynx. 2010 Apr; 37(2):244-9.
9. Singh V. **Fungal rhinosinusitis: Unravelling the disease spectrum.** J Maxillofac Oral Surg. 2019 Jun; 18(2):164-79.
10. Shetty S, Chandrashekar S, Aggarwal N. **A study on the prevalence and clinical features of fungal sinusitis in chronic rhinosinusitis.** Indian J Otolaryngol Head Neck Surg. 2020 Mar; 72(1):117-22.

11. Rupa V, Maheswaran S, Ebenezer J, Mathews SS. **Current therapeutic protocols for chronic granulomatous fungal sinusitis.** Rhinology. 2015 Jun; 53(2):181-6.
12. Vrinceanu D, Dumitru M, Patrascu OM, Costache A, Papacocea T, Cergan R. **Current diagnosis and treatment of rhinosinusal aspergilloma (Review).** Exp Ther Med. 2021 Nov; 22(5):1264.
13. D'Anza B, Stokken J, Greene JS, Kennedy T, Woodard TD, Sindwani R. **Chronic invasive fungal sinusitis: characterization and shift in management of a rare disease.** Int Forum Allergy Rhinol. 2016 Dec; 6(12):1294-300.
14. Alarifi I, Alsaleh S, Alqaryan S, et al. **Chronic granulomatous invasive fungal sinusitis: A case series and literature review.** Ear Nose Throat J. 2020; 100(5 Suppl):720S-7S.
15. Rupa V, Maheswaran S, Ebenezer J, Mathews SS. **Current therapeutic protocols for chronic granulomatous fungal sinusitis.** Rhinology. 2015 Jun; 53(2):181-6.
16. Baqays A, Almutawa S, Alsabti R, Alsughayer L, Campbell S, Almaflehi N, et al. **Systematic review of granulomatous invasive fungal sinusitis management.** Laryngoscope Investig Otolaryngol. 2025 Jan 25; 10(1):e70086.
17. Mammen MD, Sahni RD, Varghese GM, Rupa V. **Clinical utility of antifungal susceptibility testing in patients with fungal rhinosinusitis.** Indian J Med Microbiol. 2021 Jul; 39(3):328-33.
18. Rupa V, Peter J, Michael JS, Thomas M, Irodi A, Rajshekhar V. **Chronic granulomatous invasive fungal sinusitis in patients with immunocompetence: A review.** Otolaryngol Head Neck Surg. 2023 Apr; 168(4):669-80.
19. Zhu L, Yang X, Li K, Li X, Chen X. **Efficacy and safety of antifungal medicines in the treatment of invasive aspergillosis: A network meta-analysis.** J Coll Physicians Surg Pak. 2025 Sep; 35(9):1173-9.
20. Nashimoto S, Sugawara M, Takekuma Y. **Optimization of voriconazole dosage via population pharmacokinetic analysis based on the albumin–bilirubin (ALBI) score of patients with liver dysfunction.** Journal of Infection and Chemotherapy. 2025 Aug 1; 31(8):102766.
21. Weng J, Du X, Fang B, Li Y, Huang L, Ju Y. **Efficacy and safety of isavuconazole versus voriconazole for the treatment of invasive fungal infections: A meta-analysis with trial sequential analysis.** BMC Infect Dis. 2025 Feb 18; 25(1):230.

AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Zahra Sarwar:** Literature review, data collection, data entry, data analysis, drafting.
2	**Mavra Sarwar:** Literature review, manuscript drafting, formatting and editing.
3	**Muhammad Sarwar Khan:** Primary surgeon of all the patients, pioneered the use of this pharmacological intervention as an adjunct to surgery.
4	**Muhammad Yasir Khan:** Contributed towards the surgical work done.
5	**Rukaiya Sarwar:** Literature review, data entry.
6	**Hisham Shahid:** Data entry, data analysis, final formatting.