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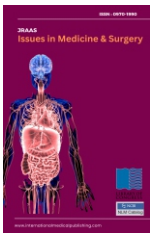

Research Article

Section: Ophthalmology

Intracameral use of Moxifloxacin in Prevention of Endophthalmitis after Cataract Surgery in a Tertiary Care Centre

Sadik Beniwale[1*], Akshay Padgilwar[1] & Umair Taibani[1]

[1]Department of Ophthalmology, Shri Vasantrao Naik Government Medical College, Yavatmal, Maharashtra, India

HIGHLIGHTS

- Low endophthalmitis incidence post cataract surgery.
- IC moxifloxacin showed limited preventive effect.
- PCR identified as major risk factor.
- Study supports safe surgical protocols.
- Findings align with global incidence trends.

Key Words:
Cataract surgery
Endophthalmitis
Intracameral moxifloxacin
Posterior capsule rent
Prophylaxis

ABSTRACT

Introduction: Postoperative endophthalmitis is a rare but vision-threatening complication of cataract surgery. The use of intracameral antibiotics, particularly moxifloxacin, has gained attention as a preventive measure due to its broad-spectrum coverage and safety profile. **Aim & Objective:** To determine the incidence of postoperative endophthalmitis following cataract surgery and to evaluate the preventive efficacy of intracameral moxifloxacin. **Material & Methods:** This prospective observational study was conducted over 18 months in a tertiary care ophthalmology department and included 2000 patients undergoing cataract surgery by a single surgeon to ensure consistency. Patients were divided into two groups: 1000 received intracameral moxifloxacin and 1000 served as controls. Adults above 18 years providing written consent were included, while those with traumatic or complicated cataracts, combined surgeries, or intraoperative complications were excluded. Data on demographics, intraoperative events, and postoperative infection were analyzed using STATA software. **Result:** The overall incidence of postoperative endophthalmitis was 0.25% (5/2000 patients). Among those, one case occurred in the moxifloxacin group and four in the control group. Most patients (over 90%) had uneventful surgeries, while posterior capsule rent was observed in 7–8% of cases. Causative organisms included *Streptococcus pneumoniae* and *Pseudomonas aeruginosa*. All affected patients presented with pain, lid edema, corneal edema, and hypopyon, with visual outcomes ranging from 6/60 to no light perception. **Conclusion:** The study observed a low incidence of postoperative endophthalmitis consistent with global data. Although intracameral moxifloxacin did not show a statistically significant reduction in infection rates, it remains a safe adjunct. Posterior capsule rent was a key risk factor, emphasizing meticulous surgical technique and infection control.

*** Corresponding Author**: Sadik Beniwale, e-mail: sadikbeniwale01@gmail.com
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INTRODUCTION

Cataract surgery stands as the most frequently conducted ocular procedure globally. A serious yet infrequent postoperative complication associated with it is endophthalmitis, an inflammatory condition of the intraocular cavity caused by microbial infection [1]. Notably, around 90% of endophthalmitis cases are linked to cataract surgeries, with an incidence ranging between 0.08% and 0.7% [1]. Preventive strategies, including strict aseptic techniques, preoperative use of topical povidone-iodine, and antibiotic prophylaxis, are essential in mitigating this risk [2]. Chemoprophylaxis against bacterial endophthalmitis may involve the use of antibiotics-topical or subconjunctival-administered at various points before, during, or after surgery. However, there remains ongoing debate regarding the optimal antibiotic choice and route of administration.

Traditionally, topical antibiotics are given pre- and postoperatively, while subconjunctival antibiotics are administered at the conclusion of surgery. Emerging data from a large-scale clinical trial and several observational studies highlight the safety and efficacy of intracameral antibiotic use in lowering the risk of postoperative endophthalmitis [3]. According to a survey conducted by the American Society of Cataract and Refractive Surgery (ASCRS), 50% of 1,147 ophthalmic surgeons worldwide reported using intracameral antibiotics at the end of surgery [4].

Among these, moxifloxacin is one of the most widely adopted antibiotics. It is a synthetic, broad-spectrum antibacterial agent that belongs to the fourth generation of fluoroquinolones, effective against both Gram-positive and Gram-negative bacteria. Moxifloxacin works by inhibiting bacterial DNA gyrase (type II topoisomerase) and topoisomerase IV, enzymes essential for DNA replication, thereby preventing bacterial cell proliferation [5]. Administered intracamerally as a 0.5% solution during cataract surgery, moxifloxacin has been shown to significantly reduce the incidence of postoperative endophthalmitis while maintaining a favorable safety profile. Additionally, it is highly cost-effective, with minimal added expense per patient [6]. The term "intracameral" refers to the injection of substances into a chamber of the eye, typically the anterior or posterior chamber. Endophthalmitis can be bacterial or fungal in origin. Most cases are bacterial, with gram-positive organisms (85.1%) dominating, followed by gram-negative bacteria (10.3%) and fungi (4.6%). The most frequent pathogens include *Staphylococcus epidermidis* (30.3%), *Streptococcus viridans* (12.1%), *Staphylococcus aureus* (11.1%), and less commonly *Enterobacteriaceae* (3.4%) and *Pseudomonas aeruginosa* (2.5). Causative organisms vary with source, mode of entry, geography, and host factors:

- **Post-traumatic**: *Staphylococcus* spp., *Bacillus cereus* [7].
- **Acute postoperative (<6 weeks)**: Usually adnexal flora, commonly *S. epidermidis* [8].
- **Chronic postoperative (>6 weeks)**: Indolent course mimicking panuveitis; caused by *Propionibacterium acnes*, coagulase-negative *Staphylococcus*, or fungi like *Aspergillus* /*Candida* [9].
- **Glaucoma surgery/bleb-related**: *Streptococcus* spp., *Haemophilus*.
- **Post-intravitreal injection**: Mostly coagulase-negative *Staphylococci*, occasionally *Streptococci*.
- **Exogenous (without full breach)**: Post–scleral buckle, LASIK, or contact lens keratitis.
- **Endogenous**: Commonly *Candida*; *Klebsiella pneumoniae* predominates in East Asia, while *Staphylococci* are more frequent in Western countries. *Pseudomonas* causes aggressive cases.
- **Secondary to infectious keratitis**: *Pseudomonas*, *Staphylococcus*, *Streptococcus*, and fungi such as *Aspergillus* or *Fusarium* [10].

Endophthalmitis occurs when pathogens breach the ocular blood barrier, usually after surgery, trauma, or systemic infection. In chronic postoperative cases, organisms such as *P. acnes* may remain sequestered in the capsular bag and reactivate after YAG capsulotomy [11]. Endogenous cases often arise from bacteremia or fungemia linked to endocarditis, urinary infections, catheters, or liver abscesses. Virulence is determined by toxin production (e.g., hemolysins, pneumolysin, LPS) [12], growth rate, and motility. Host immunity triggers an intense inflammatory response, which, though protective, can damage intraocular structures. High levels of cytokines (TNF-α, IL-1β, IFN-γ) and complement contribute to fibrin, hypopyon, synechiae, and retinal damage [13].

Classification and Clinical Evaluation

- **Visual acuity (EVS standards)**: Ranges from hand movements at 60 cm to light perception at 90 cm.
- **Adnexa**: Look for blepharitis, meibomitis, styes, or dacryocystitis.
- **Ocular motility**: Painful restriction with proptosis indicates panophthalmitis.
- **Anterior segment**: Assess wounds, corneal infiltrates, plaques, vitreous prolapse, hypopyon, fibrin, synechiae.
- **IOP**: Measured routinely.
- **Fundus**: If visible, evaluate for mimics (retained lens, IOFB).

Vitreous Haze (EVS grading) [14]

1. Retina seen to 20/40,
2. Second-order vessels visible,
3. Some vessels seen,
4. Only red reflex,
5. No red reflex.

Diagnostic Imaging

- **Slit-lamp & fundus photography**: Documentation.
- **FFA**: When fundus is visible, rules out mimics.
- **OCT / Anterior OCT**: Detects retinal, choroidal, or keratitis-related changes.
- **Ultrasound B-scan**: Detects vitreous opacities, retinal /choroidal detachment, IOFB, or subretinal abscess [15].
- **CT orbit**: Useful in trauma to localize IOFB.

MATERIAL & METHODS

This prospective observational study was conducted in the Department of Ophthalmology at a tertiary care teaching and research institute over a period of 18 months. The study population comprised patients admitted in the ophthalmology ward who fulfilled the eligibility criteria. Based on the prevalence of cataract (53.6%) reported by Shubhada Sunil Avachat et al., the sample size was calculated using the formula $n = Z^2pq/d^2$ with a confidence level of 95% (Z = 1.96), allowable error of 4%, $p = 53.6\%$ and $q = 46.4\%$, which yielded a minimum required sample size of 597. However, considering the larger number of cataract surgeries performed at the institute, a total of 2000 patients were included. Among them, 1000 patients received intracameral moxifloxacin and 1000 patients did not, allowing for comparative analysis. Patients were enrolled by convenience sampling, selecting consecutive cases meeting inclusion criteria.

All patients above 18 years of age undergoing cataract surgery, either by phacoemulsification or manual small incision cataract surgery (SICS), and who provided written informed consent, were included in the study. Patients with traumatic or complicated cataract, those undergoing combined surgeries, those unwilling to participate, and cases with intraoperative complications such as posterior capsular rent, zonular dialysis, whole bag removal, or nucleus/cortex drop were excluded.

All surgeries were performed by a single surgeon to maintain uniformity. Records of cases receiving intracameral moxifloxacin and those not receiving it were analyzed, and the incidence of postoperative endophthalmitis was studied. Detailed ophthalmic history was obtained, including onset, duration, and course of visual symptoms, history of ocular medications or surgeries, and relevant systemic history such as diabetes, hypertension, or cardiac disease. Preoperative evaluation included uncorrected visual acuity (UCVA), refraction, best-corrected visual acuity (BCVA), slit-lamp examination, B-scan ultrasonography for posterior segment assessment, keratometry to assess corneal astigmatism, intraocular pressure (IOP) measurement, and intraocular lens (IOL) power calculation. Postoperative evaluation included UCVA, BCVA, IOP measurement, and assessment of immediate complications such as corneal edema and hyphaema.

Data were systematically coded and analyzed using STATA software (version 10.1, StataCorp, Texas, USA). Descriptive statistics such as mean and standard deviation were used for quantitative variables, while frequencies and percentages were used for qualitative variables. Inferential statistics, including tests of significance with *p* values, were applied to compare outcomes between groups.

RESULT

The above findings presents the distribution of cases and controls by age and gender, with each group comprising 1000 individuals. For the age distribution of cases, the majority of patients are in the 61–70 age group, with a frequency of 500 (50.00%). The 50–60 age group includes 300 patients (30.00%), and those above 70 years account for 200 patients (20.00%). The mean age of cases is 64 years with a standard deviation of 7 years. In the control group, the 60–70 age category has the highest frequency, with 450 individuals (45.00%), followed by 330 individuals (33.00%) in the 61–70 age group, and 220 individuals (22.00%) above 70 years. For the gender distribution, females are slightly more prevalent among cases, with 550 individuals (55.00%) compared to 450 males (45.00%). Similarly, in the control group, females predominate with 560 individuals (56.00%), while males account for 440 individuals (44.00%) (Table 1).

The distribution of intraoperative events and endophthalmitis occurrence among cases and controls, with each group comprising 1000 individuals, except for the endophthalmitis data, which includes both groups (2000 individuals). In the cases group, the majority of individuals (905, 90.5%) experienced no intraoperative complications. Posterior capsule rent (PC rent) occurred in 80 cases (8.0%), nucleus drop in 10 cases (1.0%), and aphakia in 5 cases (0.5%). In the control group, no complications were reported in 913 individuals (91.3%), with PC rent occurring in 75 individuals (7.5%), nucleus drop in 7 individuals (0.7%), and aphakia in 5 individuals (0.5%). Both groups show a similar pattern, with no complications being the most common outcome, followed by PC rent as the most frequent complication. Across both cases and controls (combined total of 2000 individuals), endophthalmitis was extremely rare, with 1995 individuals (99.75%) reporting no occurrence. Only 5 individuals (0.25%) developed endophthalmitis, indicating a very low incidence rate in the combined population (Table 2).

The essential information from multiple original tables to provide a comprehensive overview of the five patients who developed endophthalmitis. Each patient is represented individually, with key clinical characteristics and outcomes summarized systematically. The table 3 records the post-operative onset, denoting the exact day when symptoms appeared, alongside the culture results, which specify microbial findings such as *Streptococcus pneumoniae*, *Pseudomonas aeruginosa*, or "No growth." It also highlights whether intracameral moxifloxacin was administered, categorized as "GIVEN" or "NOT GIVEN."

Additionally, any intraoperative events like posterior capsular (pc) rent or the absence of complications. The visual outcome for each patient is detailed, reflecting the final visual acuity following treatment, with variations such as "6/60," "PL present with faulty projection," or "PL negative." Importantly, all five patients demonstrated the hallmark clinical features of endophthalmitis at presentation, including pain, lid oedema, corneal oedema, and hypopyon. By integrating these parameters into a single structured format, the combined table enhances clarity and allows for a more effective understanding of the onset, microbial profile, intraoperative factors, treatment variables, and final outcomes of the endophthalmitis cases documented in the study.

Table 1: Distribution of Cases and Controls by Age and Gender

Variable	Category	Cases (n=1000)	Percentage	Controls (n=1000)	Percentage
Age Distribution	50–60 years	300	30.0%	–	–
	60–70 years	–	–	450	45.0%
	61–70 years	500	50.0%	330	33.0%
	>70 years	200	20.0%	220	22.0%
	Total	1000	100.0%	1000	100.0%
Gender Distribution	Male	450	45.0%	440	44.0%
	Female	550	55.0%	560	56.0%
	Total	1000	100.0%	1000	100.0%

Table 2: Distribution of Intraoperative Events and Endophthalmitis Occurrence in Cases and Controls

Category	Cases Frequency	Percentage	Controls Frequency	Percentage
Intraoperative Events				
Posterior Capsule Rent (PC Rent)	80	8.0%	75	7.5%
Nucleus Drop	10	1.0%	7	0.7%
Aphakia	5	0.5%	5	0.5%
No Complications	905	90.5%	913	91.3%
Total	1000	100.0%	1000	100.0%
Endophthalmitis Occurrence				
No	1995	99.75%		
Yes	5	0.25%		
Total	2000	100.0%		

Table 3: Distribution of Culture result groups

Patient ID	Postop Onset (Day)	Culture Results	Intracameral Moxifloxacin	Intraoperative Event	Visual Outcome	Presentation Symptoms (Pain, Lid Oedema, Corneal Oedema, Hypopyon)
1	14	No growth	Not given	None	6/60	All present (100%)
2	3	Streptococcus pneumoniae	Not given	PC rent	PL present, PR faulty	All present (100%)
3	5	No growth	Not given	PC rent	PL-	All present (100%)
4	2	Pseudomonas aeruginosa	Not given	None	PL present, PR faulty	All present (100%)
5	7	No growth	Given	PC rent	6/60	All present (100%)

DISCUSSION

Postoperative endophthalmitis (POE) remains a rare yet devastating complication of cataract surgery, often resulting in significant vision loss. Prophylactic strategies, particularly the use of intracameral antibiotics, have been widely adopted to mitigate this risk. Our study observed a remarkably low incidence of endophthalmitis (0.25%) among 2000 individuals, a finding that reflects the success of modern surgical and prophylactic protocols. By comparing these results with those from multiple large-scale studies, randomized controlled trials,

and meta-analyses, this discussion provides a nuanced understanding of the efficacy and safety of intracameral moxifloxacin, highlights areas of consistency and divergence, and contextualizes our contribution to the existing literature.

The observed incidence of endophthalmitis in our study was 0.25% (5 cases out of 2000 individuals). While commendably low, this rate warrants comparison with reported incidences in other studies to fully appreciate its significance within the broader ophthalmological landscape. Modern cataract surgery, characterized by refined surgical techniques, stringent sterilization protocols, and widespread adoption of prophylactic antibiotics, has dramatically reduced the incidence of POE. This trend is consistently reflected across numerous studies.

For instance, a pivotal randomized controlled trial by Melega et al., [16] reported an endophthalmitis incidence of 0.05% (1 out of 1818 eyes) in the intracameral moxifloxacin group, significantly lower than the 0.38% (7 out of 1822 eyes) observed in the control group. Similarly, the extensive real-world data from Haripriya et al., [17] encompassing 2 million cataract surgeries, demonstrated a remarkable decline in the overall POE rate from 0.07% (692 out of 993,009 eyes) to 0.02% (185 out of 1,069,63 4 eyes) with the implementation of intracameral moxifloxacin prophylaxis (ICMP). This substantial reduction, observed across a massive cohort, highlights the profound impact of ICMP on population-level endophthalmitis rates.

A systematic review and meta-analysis by Huang et al., [21] which included 34 studies and over 1.2 million eyes, further supported these findings. Their analysis revealed that endophthalmitis occurred in 1 out of 6177 eyes when intracameral vancomycin/moxifloxacin was used, compared to 1 out of 1517 eyes when it was not. This translated into a significant reduction in relative risk (RR = 0.20, 95% CI: 0.10–0.42; $p<0.0001$) with intracameral antibiotics. Another comprehensive systematic review and network meta-analysis by Kato et al., [22] analyzing 6.8 million eyes, reported an overall POE incidence of 0.066% (4502 cases). They concluded that intracameral moxifloxacin had a preventive effect with an odds ratio (OR) of 0.36 (99.6% CI: 0.16–0.79, corrected $p = 0.003$), placing it alongside other effective intracameral antibiotics such as vancomycin, cefazoline, and cefuroxime.

Our study's incidence of 0.25% falls within the range reported in the literature, albeit on the higher side compared with the lowest reported rates from large-scale studies. This may be attributed to factors such as the specific patient population, surgical practices, or reporting methodologies unique to a single tertiary care center. For instance, Shorstein et al., [20] reported an incidence of 0.020% in moxifloxacin-injected eyes and 0.013% in cefuroxime-injected eyes among 216,141 surgeries, demonstrating even lower rates. Similarly, the Aravind Eye Hospital study Chang DF et al., [19] a retrospective registry of over 116,000 eyes, showed a reductionfrom 0.08% (no IC moxifloxacin) to 0.02% (with IC moxifloxacin). The consistency of low incidence rates across such diverse studies, ranging from large population-based analyses to single-center experiences, underscores the effectiveness of current prophylactic strategies in minimizing the risk of POE.

The Role of Intracameral Moxifloxacin: Efficacy & Considerations

Our study's observation that only one of the five endophthalmitis cases had received intracameral moxifloxacin is a critical point for discussion. At first glance, this might suggest a limited protective effect; however, it must be interpreted within the study's observational design and the broader evidence base. The overall very low incidence rate (0.25%), even with varied moxifloxacin administration, still reflects effective prophylactic measures.

In contrast, numerous studies provide compelling evidence for the direct efficacy of intracameral moxifloxacin. As noted earlier, the randomized controlled trial by Melega et al., [16] explicitly demonstrated its effectiveness, with an incidence of 0.05% in the moxifloxacin group compared with 0.38% in the control group ($p = 0.035$). The large-scale study by Haripriya et al., [17] reinforced this, showing a dramatic reduction in POE rates from 0.07% to 0.02% with ICMP. Their data revealed a 3.5-fold reduction overall, with nearly a 6-fold reduction for phacoemulsification.

The meta-analysis by Huang et al., [21] and the network meta-analysis by Kato et al., [22] further support this protective role, with both demonstrating significant reductions in risk. Still, our finding of a case developing endophthalmitis despite moxifloxacin administration reflects an important reality: no prophylactic strategy is infallible. Similar findings have been reported by Shorstein et al., [20] who noted endophthalmitis even in antibiotic-injected eyes, attributing failures to factors such as organism resistance or insufficient dosing in eyes with larger anterior chamber volumes. Likewise, the Aravind Eye Hospital study et al Chang, D. F et al., [19] observed six cases of endophthalmitis despite IC moxifloxacin.

The bacterial isolates in our cases (including *Streptococcus pneumoniae* and *Pseudomonas aeruginosa*), along with intraoperative events like posterior capsule rent (PCR), emphasize the multifactorial nature of POE. Haripriya et al., [22] also demonstrated higher rates of POE in complicated surgeries, even with ICMP (0.18% after PCR vs. 0.02% overall). This highlights that while intracameral moxifloxacin is highly effective, surgical complications remain an independent risk factor.

The overall low incidence of endophthalmitis (0.25%) in our tertiary care center, though slightly higher than the lowest reported rates in large meta-analyses (e.g., 0.02% in Haripriya et al., [18] and 0.05% in Melega et al., [16] still indicates robust surgical practices and adherence to prophylactic protocols. The systematic review by Anderson et al., [19] reported overall POE rates of 0.08–0.14%, and our study falls within a reasonable ran-

ge, especially given that tertiary care centers often handle complex cases, which inherently carry higher risks. Collectively, the consistency of low incidence rates across diverse settings reinforces the effectiveness of modern cataract surgery combined with appropriate prophylaxis in minimizing this devastating complication.

Future research, as suggested by Anderson et al., [19] should focus on rigorous studies across diverse settings, particularly in regions where data is limited. Such efforts would help refine optimal dosing strategies, identify specific high-risk populations, and monitor emerging patterns of antibiotic resistance. Our study, by carefully documenting its cases and outcomes, contributes valuable real-world data to this evidence base and highlights the continued importance of vigilant prophylaxis in cataract surgery.

Our study, conducted in a tertiary care center, provides valuable real-world data on the incidence of endophthalmitis following cataract surgery and its relationship with intracameral moxifloxacin use. The observed low incidence of 0.25% aligns with global trends of significantly reduced POE rates, reflecting advancements in surgical techniques and prophylactic strategies. When compared with findings from randomized controlled trials, large-scale observational studies, and comprehensive meta-analyses, our results reinforce the critical role of intracameral moxifloxacin in reducing the risk of post-cataract endophthalmitis. While cases of endophthalmitis occurring despite moxifloxacin administration, both in our study and in others, highlight that no prophylactic measure offers absolute protection, the overwhelming evidence supports its routine use as a standard of care. Continued adherence to established prophylactic protocols, judicious use of intracameral antibiotics, and meticulous management of intraoperative complications remain essential to maintaining low rates of this vision-threatening complication and ensuring optimal surgical outcomes.

CONCLUSION

The study demonstrates a very low incidence of endophthalmitis (0.25%) following ocular surgery, with no significant differences in intraoperative complications or demographic characteristics between cases and controls. Intracameral moxifloxacin did not show a statistically significant protective effect against endophthalmitis, though the low event rate limits definitive conclusions. Endophthalmitis cases were associated with severe symptoms (pain, lid edema) and variable outcomes, with bacterial infections (*Streptococcus pneumoniae, Pseudomonas aeruginosa*) linked to worse prognoses. PC rent was a common intraoperative event in endophthalmitis cases, suggesting a potential risk factor.

LIMITATIONS & FUTURE PERSPECTIVES

The study was limited by its single-centre design, relatively small sample size, and short duration, which may restrict generalizability. Future research could focus on multicenter studies with larger cohorts to validate findings, evaluate long-term outcomes, and explore innovative diagnostic and management strategies for appendicular perforation, improving patient prognosis and reducing complications.

CLINICAL SIGNIFICANCE

Timely detection and management of acute appendicitis are crucial to prevent perforation, reducing morbidity and mortality. The study identifies high-risk groups, such as males and individuals at age extremes, highlighting the need for targeted preventive strategies and clinical vigilance. Delayed presentation significantly increases perforation risk, under-scoring the importance of early healthcare access and dawa-reness campaigns. Postoperative complications, including surgical site infections and prolonged ileus, emphasize the need for thorough preoperative risk assessment and tailored postoperative care. Recognizing the distal third of the appendix as the most common perforation site aids surgeons in effective intraoperative planning and management.

AUTHOR INFORMATION

Dr. Sadik Beniwale: Junior Resident 3
Dr. Akshay Padgilwar: Assistant professor
Dr. Umair Taibani: Senior Resident

AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

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All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a reasonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in thewriting or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

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This article serves as an important educational tool for the scientific community, offering insights that may inspire future research directions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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[2]CSIR-National Botanical Research Institute, Lucknow, India.

HANDLING EDITOR

Dr. Dinesh Kumar Verma
Research Assistant Professor, School of Allied Health Sciences, Boise State University, Boise, Indiana, USA
e-mail: dineshkumarverma@boisestate.edu

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