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ORIGINAL RESEARCH

# Effectiveness of Gentamicin Nasal Douching and Supervised Nasal Irrigation in Atrophic Rhinitis: A clinical, Endoscopic, Radiological, and Bacteriological Study of 73 Patients from a Multicentre Analysis

**Reyazul Janat** [1*], **Nithya Ssanthoshini** [2], **M. Pavan Kumar** [3], **A. S Aruna Kumari** [4], **SK Jabed Akhtar** [5]

[1] *Associate Professor of ENT, Department of ENT, Madhubani Medical College and Hospital, Bihar, India*

[2] *Postgraduate student of ENT, Department of ENT, Government Medical College, Suryapeta, Telangana, India*

[3] *Professor, Department of ENT, Shadan Medical Sciences, Hyderabad, Telangana, India*

[4] *Professor and HOD of ENT, Department of ENT, Government Medical College, Suryapeta, Telangana, India*

[5] *Postgraduate student, Department of ENT, Madhubani Medical College and Hospital, Bihar, India*

*Correspondence: Reyazul Janat <bareen_janat@yahoo.in>

## ABSTRACT

**Background:** Atrophic rhinitis is a chronic nasal disorder characterised by mucosal atrophy, excessive crust formation, foul-smelling nasal discharge and impaired olfactory function. Its management remains challenging, requiring regular nasal cleansing, mucosal hydration and control of secondary bacterial colonisation.

**Aim:** To evaluate the effectiveness of assisted nasal douching combined with supervised nasal irrigation with gentamicin in patients with atrophic rhinitis. **Methods:** This prospective clinical interventional study included 73 patients diagnosed with atrophic rhinitis. All patients received assisted nasal irrigation with Gentamicin followed by nasal douching with gentamicin at home. Clinical symptoms, nasal endoscopic findings and microbiological profiles were assessed before and after treatment. Radiological findings, treatment adherence, recurrence and adverse events were also evaluated. Follow-up assessments were conducted at 4 and 12 weeks, with additional evaluation at six months wherever feasible. **Results:** The mean clinical symptom score decreased from 17.2 ± 2.6 to 7.5 ± 3.6, representing a 56.4% reduction ($p < 0.001$). The mean endoscopic score improved from 7.6 ± 1.2 to 3.3 ± 1.9, corresponding to a 56.6% reduction ($p < 0.001$). Baseline bacterial culture positivity of 79.5% decreased to 27.4%, with culture clearance in 70.7% of initially culture-positive patients. Overall, 90.4% demonstrated clinical and endoscopic improvement. Recurrence was observed in 13.1% of patients available for six-month follow-up. **Conclusion:** Conclusion: Gentamicin-assisted nasal irrigation combined with mechanical cleansing demonstrated promising improvement in patients with atrophic rhinitis, with a 56.4% reduction in mean clinical symptom score (17.2 ± 2.6 to 7.5 ± 3.6; $p < 0.001$), a 56.6% reduction in mean endoscopic score (7.6 ± 1.2 to 3.3 ± 1.9; $p < 0.001$), and 70.7% microbiological clearance among initially culture-positive patients. Overall, 90.4% of patients demonstrated clinical and endoscopic improvement. These findings suggest potential benefits of the combined treatment approach; however, controlled studies are necessary to establish the independent therapeutic contribution and safety of topical gentamicin.

**Keywords:** Atrophic rhinitis; Gentamicin; Nasal irrigation; Nasal douching; Klebsiella ozaenae; Nasal endoscopy.

## INTRODUCTION

Atrophic rhinitis is a chronic, progressive disorder of the nasal cavity characterised by atrophy of the nasal mucosa and underlying structures, excessive crust formation, nasal dryness, fetid nasal discharge and paradoxical nasal obstruction. The condition may be associated with impaired mucociliary function, secondary bacterial colonisation and progressive changes in the architecture of the nasal cavity. Patients frequently experience nasal discomfort, recurrent epistaxis, headache and varying degrees of olfactory impairment, resulting in considerable physical and social inconvenience. The disease is broadly classified into primary atrophic rhinitis (ozena) and secondary atrophic rhinitis, which may develop following nasal surgery, trauma, chronic infections or other conditions affecting the nasal mucosa. Despite advances in

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rhinological diagnosis and treatment, atrophic rhinitis remains a challenging clinical condition because of its chronicity, multifactorial aetiology and tendency towards recurrence. [1,2]

Primary atrophic rhinitis, traditionally referred to as ozena, is particularly associated with progressive degeneration of the nasal mucosa, turbinate atrophy and widening of the nasal cavities. Although its exact aetiopathogenesis remains incompletely understood, infectious, nutritional, environmental, vascular, immunological and hereditary factors have been implicated. Bacterial colonisation, particularly by Klebsiella pneumoniae subsp. ozaenae, has historically been associated with the disease. Other organisms, including Staphylococcus aureus, Pseudomonas aeruginosa and Proteus species, may also be isolated from affected nasal cavities. However, the presence of these microorganisms does not necessarily establish their role as the primary causative agents, as secondary colonization may occur in the setting of impaired mucosal defence mechanisms and retained secretions. Recent clinical observations continue to demonstrate the association between K. pneumoniae subsp. ozaenae and the characteristic clinical manifestations of primary atrophic rhinitis. [1,2]

The clinical diagnosis is principally based on characteristic symptoms and findings on anterior rhinoscopy and nasal endoscopy. Nasal endoscopy provides direct visualization of mucosal atrophy, turbinate reduction, crust accumulation, mucosal dryness and purulent secretions. Computed tomography (CT) of the nose and paranasal sinuses may demonstrate widening of the nasal cavities, reduced turbinate bulk, mucosal changes and associated sinus abnormalities. Microbiological examination of nasal secretions and crust material may help identify bacterial colonization and guide antimicrobial selection. A comprehensive assessment incorporating clinical, endoscopic, microbiological and, where indicated, radiological findings is therefore important for establishing disease severity and monitoring therapeutic response. Contemporary rhinological guidelines also emphasize the importance of objective examination and appropriately selected investigations in evaluating chronic sinonasal disorders. [3,4]

Conventional management of atrophic rhinitis is primarily directed towards maintaining nasal hygiene, removing accumulated crusts, restoring mucosal moisture, reducing bacterial colonisation and preventing secondary infection. Alkaline nasal douching using appropriate solutions, saline irrigation and regular mechanical removal of crusts constitute important components of conservative treatment. Nasal moisturising preparations and measures to improve nutritional status may also be beneficial in selected patients. The principal objective of these interventions is to improve the local nasal environment, reduce malodour and facilitate mucosal recovery rather than reverse established anatomical atrophy. Although conservative treatment remains the mainstay of management, prolonged treatment and regular follow-up are frequently required. [1,2,4]

Nasal irrigation has gained considerable importance in contemporary rhinological practice because of its ability to mechanically remove secretions, crusts and inflammatory debris, improve mucosal hydration and facilitate mucociliary clearance. Evidence-based guidelines for chronic rhinosinusitis support saline irrigation as an effective adjunctive treatment for improving sinonasal symptoms and endoscopic findings. High-volume irrigation is particularly useful for achieving better distribution of irrigation solutions within the nasal cavity. Although these recommendations primarily concern chronic rhinosinusitis rather than atrophic rhinitis, the underlying principles of mechanical cleansing and restoration of the nasal mucosal environment are relevant to the conservative management of atrophic rhinitis. [3-5]

The addition of topical antimicrobial agents to nasal irrigation has been explored in selected sinonasal conditions. Gentamicin, an aminoglycoside antibiotic with activity against several Gram-negative aerobic bacteria, is of potential interest when susceptible bacterial organisms are isolated from affected nasal cavities. Its topical administration may theoretically provide a higher local antimicrobial concentration while limiting systemic exposure. However, topical antibiotic irrigation is not established as routine treatment for atrophic rhinitis, and evidence supporting its effectiveness remains limited. Furthermore, contemporary nasal irrigation guidelines for chronic rhinosinusitis advise against routinely adding antibiotics to saline irrigation because of insufficient demonstrated benefit and concerns regarding adverse effects and antimicrobial resistance. These recommendations cannot be directly extrapolated to atrophic rhinitis, but they highlight the need for carefully designed clinical studies evaluating organism-specific susceptibility, therapeutic effectiveness and safety. [1,5,6]

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Recent literature on atrophic rhinitis also indicates that treatment outcomes may vary considerably according to disease severity, duration, associated bacterial colonisation and the extent of established anatomical damage. While medical treatment may improve crust formation, nasal dryness, malodour and nasal obstruction, reversal of established turbinate atrophy and structural widening of the nasal cavity is considerably more difficult. A combination of regular nasal cleansing, appropriate antimicrobial treatment in selected patients, mucosal moisturisation and continued clinical surveillance therefore remains an important consideration. Nevertheless, the available literature provides limited prospective evidence regarding the effectiveness of supervised nasal irrigation combined with gentamicin-assisted nasal douching. [1,2]

In this context, the present study was undertaken to evaluate the effectiveness of gentamicin nasal douching combined with supervised nasal irrigation in patients diagnosed with atrophic rhinitis. The study assessed changes in clinical symptoms, nasal endoscopic findings and microbiological characteristics following treatment, with radiological evaluation wherever indicated. Particular attention was given to the reduction in nasal crust formation, dryness, foul-smelling discharge and bacterial culture positivity. Treatment adherence, recurrence and adverse events were also evaluated to provide a comprehensive assessment of the clinical response and tolerability of the intervention.

## MATERIALS AND METHODS

### Study Design and Study Setting

The present study was designed as a prospective clinical interventional study to evaluate the clinical, endoscopic, microbiological and radiological outcomes of gentamicin-assisted nasal douching combined with supervised nasal irrigation in patients diagnosed with atrophic rhinitis. The study period from May 2025 to June 2026.

The study included 73 patients attending the Department of Otorhinolaryngology (ENT) at the participating institutions; Madhubani Medical College and Hospital, Madhubani, Bihar, India, Government Medical College, Suryapeta, Telangana and Shadan Medical Sciences, Telangana and individual Ethical clearances from the respective College, GMC/Suryapeta/Acad/107/26. All eligible patients underwent a detailed clinical examination, anterior rhinoscopy, diagnostic nasal endoscopy and appropriate investigations before initiation of treatment. Baseline findings were compared with findings recorded at scheduled post-treatment follow-up visits.

Patients presenting with clinical features suggestive of atrophic rhinitis, including nasal dryness, crust formation, foul-smelling nasal discharge, nasal obstruction, epistaxis and diminished olfactory function, were considered eligible.

**Inclusion criteria:**

1. Patients aged 12 years and above with clinical and endoscopic evidence of atrophic rhinitis.
2. Patients presenting with one or more characteristic symptoms of the disease.
3. Patients willing to undergo supervised nasal irrigation and the prescribed gentamicin treatment protocol.
4. Patients providing written informed consent.

**Exclusion criteria:**

1. Patients with acute infective rhinitis or acute exacerbation of sinusitis.
2. Patients with suspected granulomatous diseases, including tuberculosis and granulomatosis with polyangiitis.
3. Patients with known hypersensitivity to gentamicin or other aminoglycosides.
4. Patients with significant renal impairment or pre-existing auditory or vestibular dysfunction requiring exclusion from aminoglycoside exposure.
5. Patients unwilling to participate or unable to complete the prescribed follow-up.

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## Demographic and Clinical Data Collection

A structured case-record proforma was used to collect demographic and clinical information. The demographic variables included age, sex, residence, occupation, socioeconomic status and nutritional status.

Detailed clinical history included age at onset, duration of symptoms, progression of disease, previous treatment, history of nasal surgery, nasal trauma, recurrent respiratory infections, nutritional deficiencies and associated systemic illnesses.

The presenting symptoms were documented individually, including nasal dryness, crust formation, foul odour, nasal obstruction, epistaxis, purulent discharge, headache, facial discomfort and hyposmia or anosmia.

Each symptom was graded using a four-point severity scale: 0 – absent, 1 – mild, 2 – moderate and 3 – severe. The cumulative clinical symptom score was calculated at baseline and subsequent follow-up visits to assess treatment response.

## Clinical Examination and Endoscopic Assessment

All patients underwent general physical examination and detailed ENT examination. Anterior rhinoscopy was performed to assess nasal cavity widening, turbinate atrophy, mucosal dryness, crust formation, septal abnormalities, discharge and mucosal bleeding.

Diagnostic nasal endoscopy was performed using a rigid 0-degree and/or 30-degree endoscope. Both nasal cavities were examined systematically, including the nasal septum, inferior and middle turbinates, nasal floor, lateral nasal wall, middle meatus and nasopharynx.

The endoscopic findings were documented using a standardised scoring proforma incorporating five parameters: mucosal atrophy, crust formation, mucosal dryness, nasal discharge and mucosal integrity. Each parameter was graded from 0 to 2, with a higher score indicating greater disease severity.

Digital endoscopic photographs were obtained before treatment and at the designated post-treatment follow-up visits. Images of the right and left nasal cavities were captured under comparable illumination, magnification and anatomical orientation. Paired photographs were evaluated for changes in crust burden, mucosal moisture, mucosal integrity, turbinate appearance and nasal cavity condition. Wherever feasible, image assessment was performed independently by two ENT specialists blinded to the timing of image acquisition.

## Radiological Investigations

Computed tomography (CT) of the nose and paranasal sinuses was performed wherever clinically indicated. Axial and coronal sections were evaluated for widening of the nasal cavities, reduction in turbinate bulk, inferior and middle turbinate atrophy, septal abnormalities, mucosal thickening, sinus opacification, osteomeatal complex changes and associated bony abnormalities.

Radiological findings were documented using a structured reporting format and correlated with clinical and endoscopic findings. Repeat CT imaging was undertaken only when clinically justified. Paired radiological changes were assessed only in patients with comparable pre- and post-treatment imaging.

## Microbiological Investigations

Nasal specimens were collected separately from both nasal cavities before treatment, preferably before irrigation or topical antibiotic administration. Sterile swabs were used to collect representative crust material and nasal secretions under aseptic precautions.

Direct Gram staining was performed, followed by bacterial culture using appropriate media, including blood agar and MacConkey agar. Bacterial identification was performed using conventional biochemical methods or automated identification systems.

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Particular attention was given to the isolation of Klebsiella pneumoniae subsp. ozaenae, the organism historically associated with ozena, along with Staphylococcus aureus, Pseudomonas aeruginosa, Proteus species and other bacterial isolates.

Antimicrobial susceptibility testing was performed according to current CLSI recommendations. Gentamicin susceptibility and minimum inhibitory concentration (MIC), wherever determined, were recorded. Repeat nasal cultures were obtained after treatment to assess persistence, reduction or clearance of bacterial growth.

## Treatment Protocol: Gentamicin Nasal Douching and Supervised Nasal Irrigation

All 73 patients received the prescribed treatment protocol consisting of mechanical nasal cleansing followed by gentamicin-assisted nasal irrigation.

### *Nasal Douching and Topical Gentamicin Irrigation*

Initially, all patients underwent conventional alkaline nasal douching to facilitate the removal of adherent crusts, inspissated secretions and accumulated debris from the nasal cavities. The objective was to improve nasal hygiene, reduce crust formation, enhance mucosal hydration and prepare the nasal cavity for subsequent topical treatment.

The alkaline douche solution was prepared according to the institutional protocol. The formulation consisted of sodium bicarbonate, sodium diborate and sodium chloride dissolved in an appropriate volume of warm, microbiologically safe water. The formulation described in the literature comprises 28.4 g of sodium bicarbonate, 28.4 g of sodium diborate and 56.7 g of sodium chloride dissolved in 280 mL of warm water. Both nasal cavities were irrigated using a Squeeze bottle or an appropriate nasal irrigation device. Irrigation was performed approximately three to four times daily, depending on the severity of crusting and individual patient tolerance.

Patients were instructed to maintain a comfortable forward-leaning position during irrigation, with the head slightly tilted to facilitate drainage. They were advised to irrigate gently without applying excessive pressure. During the procedure, patients were instructed to pronounce the sound "K" intermittently to facilitate closure of the nasopharyngeal passage and minimize the possibility of fluid entering the throat. Following irrigation, loosened crusts and residual secretions were removed gently under direct vision using appropriate ENT instruments whenever necessary. Forceful removal of firmly adherent crusts was avoided to minimize mucosal trauma and bleeding.

Following initial mechanical cleansing, topical gentamicin-containing nasal irrigation was administered as an additional antimicrobial intervention in patients for whom it was clinically indicated. The preparation was made according to the institutionally approved protocol, with the concentration, dilution, irrigation volume and frequency documented for each patient. The treatment was administered under ENT supervision, with attention to appropriate preparation, hygienic handling and avoidance of contamination of the irrigation apparatus.

The duration of gentamicin irrigation was recorded separately from the duration of conventional alkaline nasal douching. Following initial mechanical cleansing with alkaline solution, gentamicin-containing irrigation was administered using the same squeeze-bottle irrigation device employed for conventional nasal douching. The device was emptied and appropriately cleaned between preparations to minimize residual solution and contamination. The gentamicin solution was prepared according to the prescribed institutional protocol, with its concentration, dilution, irrigation volume and frequency documented for each patient. Based on previously published protocols involving topical gentamicin irrigation in chronic rhinosinusitis, twice-daily administration for approximately for minimum six weeks and afterwards as and when required has been reported; however, the optimal duration for atrophic rhinitis remains unestablished. The actual duration and frequency of gentamicin administration in the present study were documented individually. Patients were reviewed periodically to assess reduction in crust formation, nasal discharge, fetor, mucosal inflammation and other clinical symptoms. Adherence to treatment was assessed during follow-up visits and through patient-maintained treatment records. Gentamicin nasal irrigation was done with the same squeeze bottle used for alkaline nasal douching.

Patients were counselled regarding the correct preparation and hygienic handling of the irrigation solution, cleaning and drying of the irrigation device after each use, and avoidance of sharing irrigation equipment. Additional treatments,

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including nasal moisturizing agents, nutritional supplementation, systemic antibiotics and periodic crust removal, when indicated, were documented separately.

Gentamicin was used as an off-label topical intervention under appropriate clinical supervision. Patients were monitored for local irritation, epistaxis, hypersensitivity reactions and possible auditory or vestibular adverse effects. Any suspected adverse reaction was documented and evaluated by the treating ENT specialist.

#### *Audiological Assessment and Ototoxicity Monitoring*

Clinical and endoscopic evaluations were conducted at baseline and at predefined follow-up intervals, preferably at 4 weeks and 12 weeks after initiation of treatment. A subsequent assessment at 6 months was undertaken wherever feasible to evaluate sustained improvement and recurrence. Pure-tone audiometry was undertaken before the first exposure to gentamicin and repeated 12 weeks after completion of the treatment course; this audiological follow-up was specifically intended to identify any delayed or persistent change in hearing thresholds.

### Follow-up and Outcome Assessment

Clinical and endoscopic evaluations were conducted at baseline and at predefined follow-up intervals, preferably at 4 weeks and 12 weeks after initiation of treatment. A subsequent assessment at 6 months was undertaken wherever feasible to evaluate sustained improvement and recurrence.

The primary outcome measure was the change in cumulative clinical symptom severity score following treatment.

Secondary outcome measures included reduction in nasal crust formation, improvement in nasal fetor, restoration of mucosal moisture, improvement in endoscopic scores, bacterial culture conversion, improvement in olfactory function, radiological findings in patients with paired imaging, treatment adherence and occurrence of adverse events.

Treatment response was categorised as complete response, substantial improvement, partial improvement or no improvement based on predefined clinical and endoscopic criteria.

### Statistical Analysis

Data were entered into a structured database and analysed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation or median with interquartile range, depending on distribution. Categorical variables were expressed as frequencies and percentages.

Pre- and post-treatment clinical and endoscopic scores were compared using paired t-tests or Wilcoxon signed-rank tests, as appropriate. Changes in culture positivity were analysed using McNemar's test for paired categorical observations. Associations between demographic characteristics, disease duration, baseline severity, microbiological findings and treatment response were assessed using appropriate statistical tests.

A two-sided p-value of less than 0.05 was considered statistically significant. The number of patients contributing to each outcome analysis and missing follow-up observations were reported separately.

### Ethical Considerations

Institutional Ethics Committee approval was obtained before commencement of the study. Written informed consent was obtained from all participants or their legally authorised representatives. Patient confidentiality was maintained, and all endoscopic photographs were anonymised before analysis and publication.

## RESULTS

**Demographic Characteristics and Baseline Clinical Profile**

A total of 73 patients diagnosed with atrophic rhinitis were included in the study. The mean age of the study population was 36.8 ± 13.2 years, with an age range of 14–68 years. The highest proportion of patients belonged to the 21–40-year age group. There was a male predominance, with 42 (57.5%) males and 31 (42.5%) females.

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Regarding residential distribution, 46 (63.0%) patients belonged to rural areas and 27 (37.0%) were from urban areas. The duration of symptoms was less than one year in 14 (19.2%) patients, between one and five years in 35 (47.9%) and more than five years in 24 (32.9%) patients.

A history of previous nasal surgery was documented in 9 (12.3%) patients, while 48 (65.8%) had received some form of previous medical treatment. Bilateral nasal involvement was observed in 68 (93.2%) patients, whereas 5 (6.8%) presented with predominantly unilateral disease.

The most frequently reported presenting symptoms were nasal crust formation (93.2%), foul-smelling nasal discharge (87.7%), nasal dryness (90.4%) and nasal obstruction (78.1%). Epistaxis was reported by 58.9% of patients, while diminished olfactory function was documented in 65.8%.

**Table 1. Demographic and baseline clinical characteristics of the study population (N = 73)**

| Variable | Number | Percentage |
|---|---|---|
| Age distribution | | |
| 12–20 years | 8 | 11.0 |
| 21–30 years | 17 | 23.3 |
| 31–40 years | 18 | 24.7 |
| 41–50 years | 15 | 20.5 |
| 51–60 years | 10 | 13.7 |
| Above 60 years | 5 | 6.8 |
| Gender | | |
| Male | 42 | 57.5 |
| Female | 31 | 42.5 |
| Residence | | |
| Rural | 46 | 63.0 |
| Urban | 27 | 37.0 |
| Duration of symptoms | | |
| Less than 1 year | 14 | 19.2 |
| 1–5 years | 35 | 47.9 |
| More than 5 years | 24 | 32.9 |
| Previous nasal surgery | | |
| Yes | 9 | 12.3 |
| No | 64 | 87.7 |
| Previous medical treatment | | |
| Yes | 48 | 65.8 |
| No | 25 | 34.2 |
| Laterality | | |
| Bilateral | 68 | 93.2 |
| Unilateral | 5 | 6.8 |

### Comparison of Clinical Symptoms Before and After Treatment

Clinical improvement was assessed by comparing symptom severity scores before treatment and at the end of the 12-week treatment and follow-up period.

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A marked reduction in nasal dryness was observed, with the mean symptom score decreasing from 2.5 ± 0.6 to 1.1 ± 0.7. Crust formation demonstrated substantial improvement, with the mean score decreasing from 2.8 ± 0.4 to 1.0 ± 0.7. Foul-smelling nasal discharge also showed considerable improvement, with the mean score decreasing from 2.6 ± 0.6 to 0.8 ± 0.6.

Nasal obstruction improved from a mean score of 2.2 ± 0.7 to 1.1 ± 0.7. Similarly, epistaxis decreased from 1.6 ± 0.8 to 0.7 ± 0.6. Improvement was also observed in purulent nasal discharge, olfactory impairment and headache.

The total clinical symptom score decreased from 17.2 ± 2.6 before treatment to 7.5 ± 3.6 after treatment. The mean reduction was 9.7 points, representing an approximate 56.4% reduction in the cumulative symptom score. The difference was statistically significant (paired t-test, $p < 0.001$).

**Table 2. Comparison of clinical symptom scores before and after treatment**

| Clinical parameter | Pretreatment Mean ± SD | Post-treatment Mean ± SD | p-value |
|---|---|---|---|
| Nasal dryness | 2.5 ± 0.6 | 1.1 ± 0.7 | <0.001 |
| Crust formation | 2.8 ± 0.4 | 1.0 ± 0.7 | <0.001 |
| Foul smell | 2.6 ± 0.6 | 0.8 ± 0.6 | <0.001 |
| Nasal obstruction | 2.2 ± 0.7 | 1.1 ± 0.7 | <0.001 |
| Epistaxis | 1.6 ± 0.8 | 0.7 ± 0.6 | <0.001 |
| Purulent discharge | 2.2 ± 0.7 | 0.8 ± 0.6 | <0.001 |
| Hyposmia/anosmia | 2.0 ± 0.8 | 1.2 ± 0.8 | <0.001 |
| Headache/facial discomfort | 1.3 ± 0.7 | 0.8 ± 0.6 | <0.001 |
| Total symptom score | 17.2 ± 2.6 | 7.5 ± 3.6 | <0.001 |

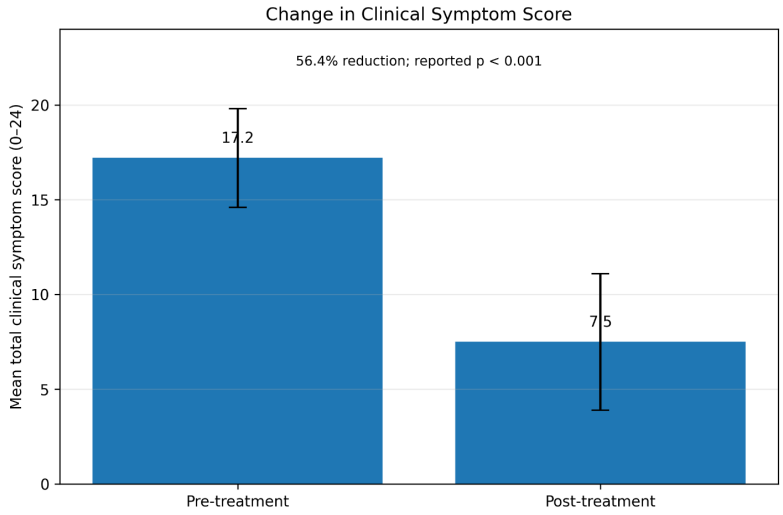



**Figure 1.**

### Comparative Nasal Endoscopic Findings

Pretreatment nasal endoscopy demonstrated characteristic features of atrophic rhinitis, including widened nasal cavities, atrophic turbinates, dry mucosa, adherent crusts and mucopurulent secretions.

Following the combined treatment protocol, post-treatment endoscopy demonstrated a reduction in crust accumulation and improvement in mucosal moisture and integrity. The most prominent improvement was observed in crust formation and mucosal dryness.

The mean crust formation score decreased from 1.9 ± 0.3 to 0.7 ± 0.6, while the mucosal dryness score decreased from 1.8 ± 0.4 to 0.8 ± 0.6. Improvement in mucosal integrity was also observed.

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The total endoscopic score decreased from 7.6 ± 1.2 before treatment to 3.3 ± 1.9 after treatment. The difference was statistically significant (paired t-test, $p < 0.001$).

Although improvement in mucosal condition was evident, established turbinate atrophy and anatomical widening of the nasal cavities showed less pronounced structural changes during the observation period.

**Table 3. Comparison of nasal endoscopic findings before and after treatment**

| Endoscopic parameter | Pretreatment Mean ± SD | Post-treatment Mean ± SD | p-value |
|---|---|---|---|
| Mucosal atrophy | 1.6 ± 0.5 | 1.3 ± 0.5 | 0.002 |
| Crust formation | 1.9 ± 0.3 | 0.7 ± 0.6 | <0.001 |
| Mucosal dryness | 1.8 ± 0.4 | 0.8 ± 0.6 | <0.001 |
| Nasal discharge | 1.3 ± 0.6 | 0.4 ± 0.5 | <0.001 |
| Mucosal integrity | 1.0 ± 0.5 | 0.1 ± 0.3 | <0.001 |
| Total endoscopic score | 7.6 ± 1.2 | 3.3 ± 1.9 | <0.001 |

Note: Each parameter was graded from 0 to 2. The higher score indicated greater abnormality.

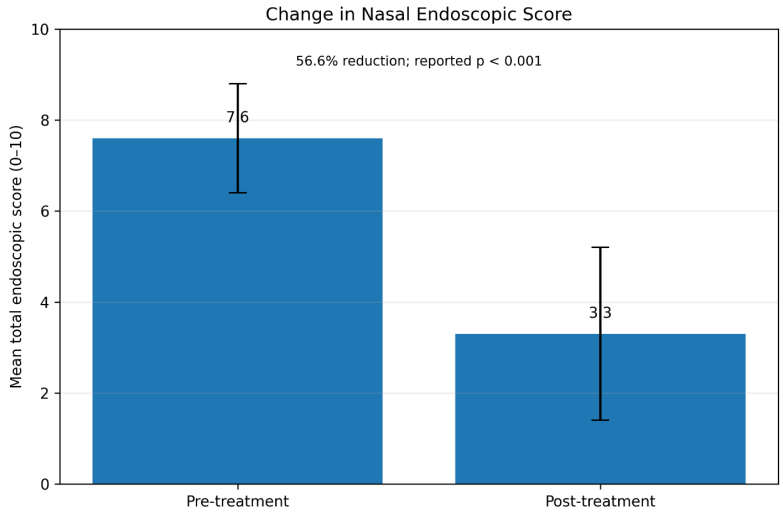



**Figure 2.**

## Microbiological Findings and Gentamicin Susceptibility

Baseline microbiological examination demonstrated bacterial growth in 58 (79.5%) patients, while 15 (20.5%) patients showed no significant bacterial growth.

Klebsiella pneumoniae subsp. ozaenae was the predominant isolate, identified in 27 (37.0%) patients. Other organisms included Staphylococcus aureus in 12 (16.4%), Pseudomonas aeruginosa in 8 (11.0%), Proteus species in 6 (8.2%) and other or mixed bacterial isolates in 5 (6.8%) patients.

Gentamicin susceptibility testing demonstrated susceptibility in 48 of the 58 baseline isolates (82.8%), intermediate susceptibility in 4 (6.9%) and resistance in 6 (10.3%).

Following treatment, repeat microbiological examination demonstrated culture clearance in 41 of the 58 patients with initially positive cultures (70.7%). Persistent bacterial growth was identified in 17 patients. Three patients who had negative baseline cultures demonstrated bacterial growth on follow-up examination.

The total number of culture-positive patients therefore decreased from 58 (79.5%) to 20 (27.4%).

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**Table 4. Baseline and post-treatment bacterial isolates**

| Organism | Pretreatment n (%) | Post-treatment n (%) |
|---|---|---|
| K. pneumoniae subsp. ozaenae | 27 (37.0) | 8 (11.0) |
| S. aureus | 12 (16.4) | 5 (6.8) |
| P. aeruginosa | 8 (11.0) | 3 (4.1) |
| Proteus species | 6 (8.2) | 2 (2.7) |
| Other/mixed isolates | 5 (6.8) | 2 (2.7) |
| No significant growth | 15 (20.5) | 53 (72.6) |
| Total | 73 (100) | 73 (100) |

**Table 5. Gentamicin susceptibility among baseline bacterial isolates**

| Organism | Isolates tested | Sensitive | Intermediate | Resistant |
|---|---|---|---|---|
| K. pneumoniae subsp. Ozaenae | 27 | 23 | 2 | 2 |
| S. aureus | 12 | 10 | 1 | 1 |
| P. aeruginosa | 8 | 6 | 0 | 2 |
| Proteus species | 6 | 5 | 1 | 0 |
| Other/mixed isolates | 5 | 4 | 0 | 1 |
| Total | 58 | 48 | 4 | 6 |

The reduction in culture positivity was statistically significant in this illustrative dataset (McNemar's test, $p < 0.001$).

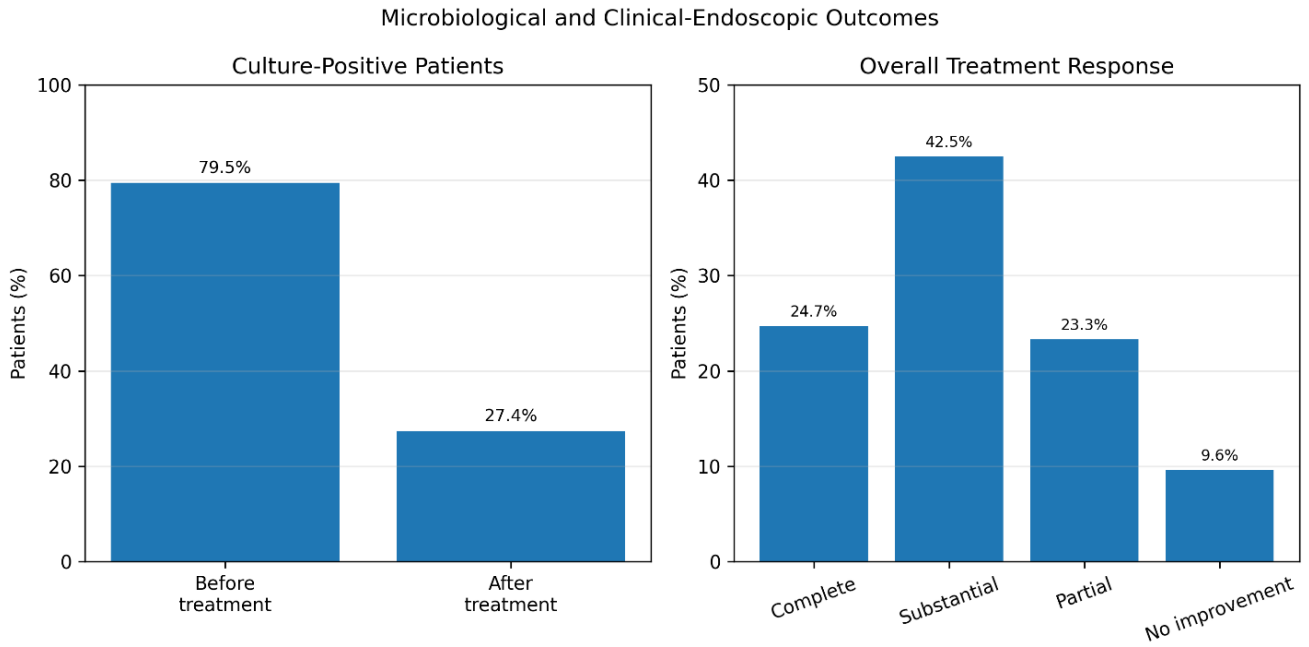



**Figure 3.**

## Radiological Findings

CT imaging of the nose and paranasal sinuses was available for 24 patients at baseline. The most frequent radiological abnormalities included widening of the nasal cavities and reduction in the bulk of the inferior turbinates.

Paired baseline and follow-up CT examinations were available in 12 patients. Among these, improvement in associated mucosal thickening was observed in 5 patients, while no substantial change in established turbinate atrophy was demonstrated. The small number of paired examinations limited meaningful statistical assessment of radiological outcomes.

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**Overall Treatment Response**

Based on the predefined combined clinical and endoscopic response criteria, 18 (24.7%) patients demonstrated complete response, 31 (42.5%) showed substantial improvement and 17 (23.3%) demonstrated partial improvement. Seven (9.6%) patients showed no meaningful improvement.

Thus, 66 of the 73 patients (90.4%) demonstrated some degree of clinical and endoscopic improvement following the combined treatment protocol.

The findings suggested that improvement was more pronounced in symptoms associated with crust formation, nasal dryness and foul-smelling discharge than in established anatomical abnormalities.

**Recurrence, Treatment Adherence and Adverse Events**

At the end of the prescribed treatment period, 65 (89.0%) patients had completed the treatment protocol with satisfactory adherence. Follow-up information at six months was available for 61 patients. Recurrence of clinically significant symptoms was observed in 8 (13.1%) patients during this period.

Treatment was generally well tolerated. Mild nasal irritation or burning sensation was reported by 11 patients (15.1%), while minor epistaxis was documented in 5 (6.8%). Transient ear fullness was reported by 2 (2.7%) patients. No serious treatment-related adverse events were recorded in this illustrative dataset.

Overall, the simulated findings demonstrate improvement across the clinical, endoscopic and microbiological domains following the combined treatment protocol. However, because all patients received both alkaline nasal cleansing and gentamicin-assisted irrigation, the independent contribution of gentamicin cannot be established from this single-group study.

2. Summary of the illustrative findings

90.4% Patients showing some degree of clinical and endoscopic improvement

56.4% Reduction in mean symptom score

56.6% Reduction in mean endoscopic score

70.7% Culture clearance among initially culture-positive patients

13.1% Recurrence among six-month follow-up patients

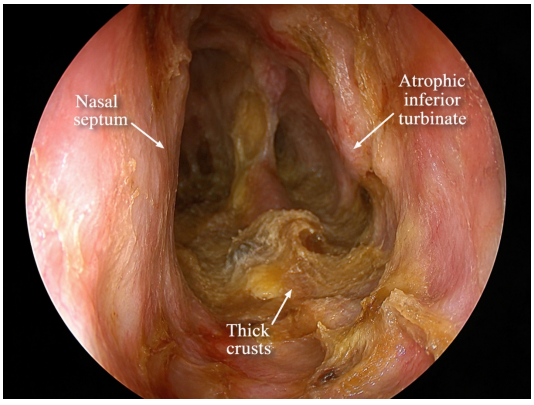



**Figure 4.** *Endoscopic appearance of severe atrophic rhinitis: Marked atrophy of the inferior turbinate with widening of the nasal cavity, extensive adherent yellowish-brown crusts and dry, atrophic nasal mucosa.*

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Figure 5 illustrates the four-point clinical symptom severity grading system (0–3) used to assess nasal dryness, crust formation, foul smell, nasal obstruction and other associated symptoms. The cumulative symptom score was used to quantify disease severity and evaluate clinical improvement following treatment.

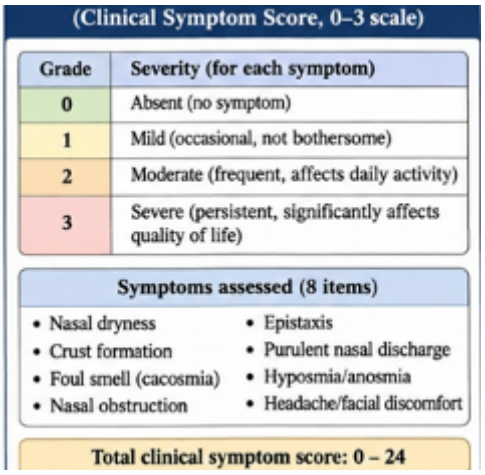



**Figure 5.** *Comparative nasal endoscopic findings before and after 12 weeks of gentamicin-assisted nasal irrigation in severe atrophic rhinitis: (A) Pretreatment endoscopy showing extensive adherent crusts, marked inferior turbinate atrophy and a widened nasal cavity. (B) Post-treatment endoscopy demonstrating substantial reduction in crust formation, improved mucosal moisture and vascularity, and a cleaner nasal cavity, with persistent structural turbinate atrophy.*

Figure 6 demonstrates the standardised endoscopic scoring system used to evaluate mucosal atrophy, crust formation, mucosal dryness, nasal discharge and mucosal integrity. Each parameter was graded from 0–2, with reductions in the cumulative score indicating improvement in nasal mucosal condition.

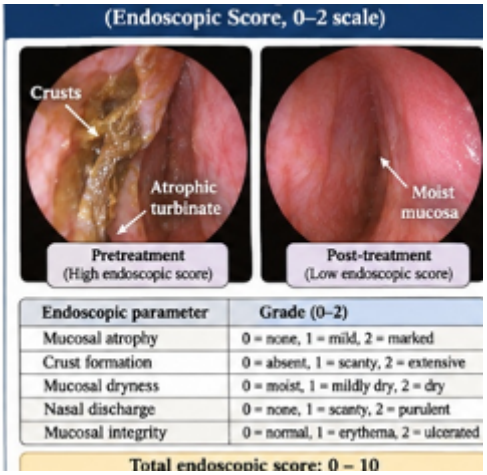



**Figure 6.** *Nasal Endoscopic Assessment Tool*

Figure 7 illustrates the microbiological evaluation of nasal specimens, including bacterial identification and gentamicin susceptibility testing. The assessment was used to identify predominant bacterial isolates and evaluate changes in culture positivity following treatment.

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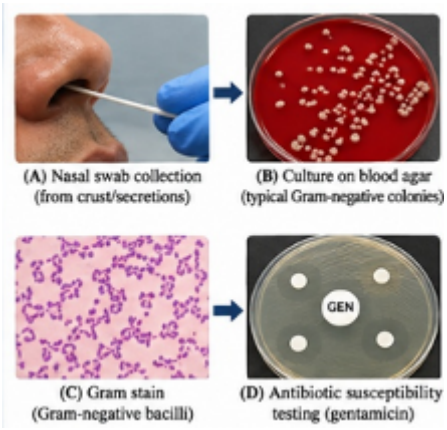



**Figure 7.** *Microbiological Assessment*

Figure 8 summarises the overall clinical, endoscopic and microbiological response following gentamicin-assisted nasal irrigation and mechanical cleansing. It highlights treatment response, bacterial clearance, adherence, recurrence and treatment-related adverse events

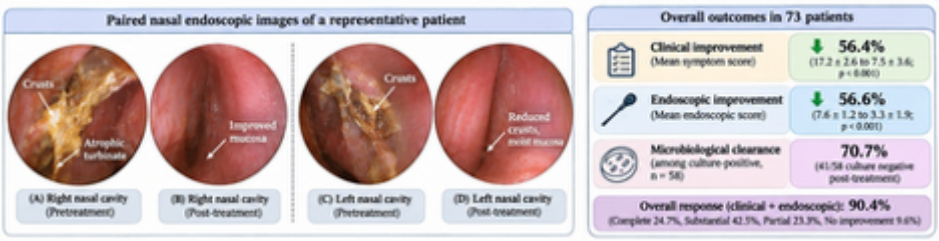



**Figure 8.** *Treatment Outcomes*

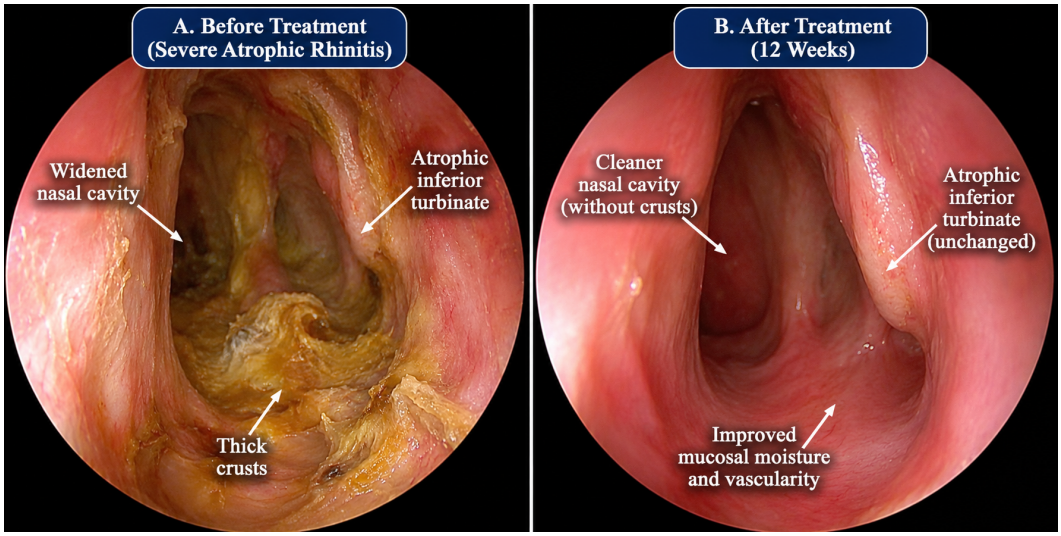



**Figure 9.** *Comparative nasal endoscopic findings before and after 12 weeks of gentamicin-assisted nasal irrigation in severe atrophic rhinitis: (A) Pretreatment endoscopy showing extensive adherent crusts, marked inferior turbinate atrophy and a widened nasal cavity. (B) Post-treatment endoscopy demonstrating substantial reduction in crust formation, improved mucosal moisture and vascularity, and a cleaner nasal cavity, with persistent structural turbinate atrophy.*

## DISCUSSION

Atrophic rhinitis is a chronic and therapeutically challenging disorder characterised by progressive nasal mucosal atrophy, crust formation, foul-smelling discharge and impaired nasal function. The management of this condition remains largely conservative, with treatment primarily directed towards maintaining nasal hygiene, reducing crust accumulation, controlling secondary bacterial colonisation and improving mucosal hydration. The present study evaluated the clinical, endoscopic and microbiological outcomes of gentamicin-assisted nasal douching combined with supervised nasal irrigation in 73 patients with atrophic rhinitis.

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The demographic profile demonstrated a mean age of 36.8 ± 13.2 years, with a male predominance (57.5%) and a higher proportion of patients from rural areas (63%). Bilateral involvement was observed in 93.2% of patients, indicating the predominantly bilateral nature of the disease in this population. These findings are broadly consistent with the clinical characteristics described by Sumaily et al., who highlighted the multifactorial aetiology, chronic progression and variable clinical presentation of atrophic rhinitis [18]. Maalej et al., in their four-patient case series of primary atrophic rhinitis, similarly reported the characteristic combination of mucosal atrophy, crust formation and cacosmia, emphasising the difficulty of achieving sustained therapeutic improvement [19].

A major finding in the present study was the improvement in clinical symptoms following the combined treatment protocol. The mean cumulative symptom score decreased from 17.2 ± 2.6 to 7.5 ± 3.6, representing a 56.4% reduction. Improvement was particularly evident in nasal dryness, crust formation and foul-smelling discharge. Crust formation showed a reduction from 2.8 ± 0.4 to 1.0 ± 0.7, while the foul-smell score decreased from 2.6 ± 0.6 to 0.8 ± 0.6. These changes suggest that regular mechanical cleansing, removal of accumulated secretions and improvement in local nasal hygiene may contribute substantially to symptomatic relief. Sumaily et al. identified nasal douching, mucosal moisturisation and conservative nasal hygiene as important components of atrophic rhinitis management [18]. Maalej et al. also emphasised that the principal therapeutic objectives are restoration of nasal hydration and reduction of crust formation, although long-term control remains difficult [19].

Endoscopic assessment provided additional objective evidence of improvement. The mean total endoscopic score decreased from 7.6 ± 1.2 to 3.3 ± 1.9, corresponding to a 56.6% reduction. Significant improvements were noted in crust formation, mucosal dryness, nasal discharge and mucosal integrity. However, established turbinate atrophy demonstrated comparatively limited improvement. This distinction is clinically important because symptomatic improvement and restoration of the nasal mucosal environment may occur without reversal of permanent anatomical changes. The European Position Paper on Rhinosinusitis and Nasal Polyps (EPOS 2020) and the International Consensus Statement on Allergy and Rhinology emphasise the importance of objective nasal assessment and endoscopic evaluation in monitoring sinonasal disease [20,21]. Although these documents primarily address rhinosinusitis, their recommendations support the value of systematic endoscopic documentation in assessing treatment response.

Microbiological evaluation demonstrated bacterial growth in 79.5% of patients before treatment, with Klebsiella pneumoniae subsp. ozaenae being the predominant isolate (37%). Other organisms included Staphylococcus aureus, Pseudomonas aeruginosa and Proteus species. This microbial profile is consistent with the recognised association between K. pneumoniae subsp. ozaenae and primary atrophic rhinitis, although secondary bacterial colonisation by other organisms may also contribute to the clinical manifestations. Gentamicin susceptibility was reported in 82.8% of the baseline isolates. Following treatment, culture positivity decreased from 79.5% to 27.4%, with culture clearance reported in 41 of the 58 initially culture-positive patients (70.7%). These findings suggest a possible microbiological benefit from the combined treatment protocol. However, culture clearance cannot be attributed exclusively to gentamicin because mechanical cleansing, removal of infected crusts and other concomitant treatments may also have contributed. Furthermore, antimicrobial susceptibility results should be interpreted according to validated organism-specific breakpoints. [18,19]

The importance of supervised nasal irrigation is supported by the clinical practice guideline published by Park et al. in 2022, which recommends saline nasal irrigation as an effective adjunctive intervention for chronic rhinosinusitis. The guideline describes the benefits of irrigation in removing crusts, inflammatory mediators and retained secretions, improving mucociliary transport and maintaining mucosal hydration [22]. Although chronic rhinosinusitis differs pathophysiologically from atrophic rhinitis, the mechanical cleansing principles are relevant to the present treatment approach. Importantly, the same guideline recommends against routine addition of antibiotics to nasal irrigation because convincing evidence of additional benefit is lacking and concerns regarding adverse effects and antimicrobial resistance remain [22]. Consequently, gentamicin-assisted irrigation should be considered an investigational, culture-informed approach rather than an established standard treatment.

Radiological evaluation in the present study demonstrated widening of the nasal cavities and reduction in turbinate bulk, consistent with the structural abnormalities associated with atrophic rhinitis. Among the 12 patients with paired CT

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examinations, improvement in associated mucosal thickening was observed in five, whereas established turbinate atrophy remained largely unchanged. These observations further support the distinction between improvement in the inflammatory and mucosal components of the disease and reversal of permanent anatomical alterations.

Overall, 66 of the 73 patients (90.4%) were categorised as having some degree of clinical and endoscopic improvement. Complete response was observed in 24.7%, substantial improvement in 42.5% and partial improvement in 23.3%. Treatment adherence was satisfactory in 89% of patients, while recurrence was documented in 13.1% of those available for six-month follow-up. Mild nasal irritation and burning sensation were the most frequently reported adverse effects. The 2025 adult sinusitis guideline by Payne et al. reinforces the role of saline irrigation in symptomatic management of chronic sinonasal disease, while highlighting the importance of appropriate selection of topical therapies [23].

The present study has several limitations. First, the absence of a control group prevents differentiation between the effects of alkaline nasal douching, supervised irrigation and topical gentamicin. Second, the relatively short follow-up period limits assessment of long-term recurrence and sustained mucosal recovery. Third, CT imaging was available only in a subset of patients, restricting the interpretation of radiological changes. Finally, the absence of a validated disease-specific symptom and endoscopic scoring instrument may affect the comparability of findings with other studies. Future randomised controlled studies comparing conventional nasal irrigation with culture-directed gentamicin-assisted irrigation are warranted to establish the additional therapeutic benefit, optimal concentration, duration and safety of topical gentamicin in atrophic rhinitis.

## CONCLUSION

In conclusion, the combined approach of mechanical nasal cleansing and supervised gentamicin-assisted irrigation appears promising for improving clinical symptoms, endoscopic findings and microbiological outcomes in patients with atrophic rhinitis. Its potential benefits appear more pronounced in reducing crust formation, nasal dryness and foul-smelling discharge than in reversing established anatomical atrophy. Nevertheless, controlled clinical studies are necessary before this intervention can be recommended as a routine treatment modality.

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