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SHORT COMMUNICATION

Inhalation therapy with sulfur-rich thermal water for rhinogenic deafness: a series of case reports

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Abstract
The study analyzed the effectiveness of a two-week cycle of sulfurous water therapy at Frasassi Thermal Springs ("Terme di Frasassi - S. Vittore", located in the Province of Ancona, Italy) on 8 patients suffering from rhinogenic deafness caused by chronic rhinosinusitis associated with nasal polyps and respiratory allergies. Patients underwent 12 sessions of sulfurous aerosol therapy and 12 bilateral tubal insufflations (1 aerosol and 1 insufflation per day). Pre- and post-treatment assessments included tympanometric measurements and a subjective evaluation of symptomatic improvement on a scale from 1 to 10. The median reported improvement was 9.5 (min: 7; max: 10). By the end of the treatment, all patients achieved a bilateral type A/A tympanogram, indicating restored tubal function. The results suggest that sulfurous water thermal therapy can be a useful treatment for rhinogenic deafness associated with chronic rhinosinusitis, nasal polyps, and respiratory allergies, with significant improvements in both auditory function and quality of life. Further studies are needed to compare this treatment with other therapies and to precisely evaluate the duration of the benefit over time.

Keywords Hydrothermal therapy · Rhinogenic deafness · Chronic rhinosinusitis · Sulfurous waters · Tympanogram

Introduction

Rhinogenic deafness is a pathological condition characterized by hearing loss due to chronic inflammation of the upper respiratory tract. In this condition, persistent inflammation of the nasal mucosa and paranasal sinuses causes obstruction of the Eustachian tube, leading to mucus accumulation in the middle ear and a reduction in hearing ability due to a conductive mechanism (Costantino et al. 2006; Costantino 2008). Patients with chronic rhinosinusitis are particularly prone to developing this form of deafness, which can significantly impact quality of life and present with symptoms such as ear fullness, hearing loss, autophony, posterior rhinorrhea, and a feeling of obstruction in the upper airways. In particular, sulfurous thermal treatments are a well-established therapeutic option for the treatment of otolaryngological disorders (Salami et al. 2008; Keller et al. 2014; Antonelli et al. 2021) and sulfurous waters are renowned for their anti-inflammatory, mucolytic, antiseptic, and decongestant properties (Benedetti et al. 2009; Giampaoli et al. 2013; Viegas et al. 2019). Their use in inhalation therapies helps to thin nasal secretions and improve upper respiratory tract function by reducing inflammation and promoting mucociliary clearance (Salami et al. 2010; Carubbi et al. 2019). Inhalations with sulfur aerosol act directly on the airways' mucosa, helping restore normal drainage of the paranasal sinuses and reduce local inflammation. Tubaric insufflations, on the other hand, are a specific technique used in thermal treatments to improve Eustachian tube function (Costantino et al. 2006; Costantino 2008; Mirandola et al. 2013; Fermo et al. 2022). This procedure involves blowing air mixed with the properties of thermal waters directly into the Eustachian tubes: this helps restore tube patency, eliminate blockages, and normalize pressure in the middle ear,

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thus alleviating symptoms related to rhinogenic deafness. The water from the Frasassi Thermal Springs is a sulfur-sodium mineral type (Table 1), meaning it is rich in sulfur, flows at a temperature of about 14 °C, and is channeled directly to the health resort, where it is used to treat oto-laryngological, respiratory, dermatological, and rheumatic conditions.

The aim of this study is to evaluate the clinical efficacy and safety of a cycle of sulfurous thermal treatments at the Frasassi Thermal Springs in patients with rhinogenic deafness. The need for this research also arises from the desire to compare traditional ministerial guidelines regarding the use of thermal treatments with updated scientific evidence gathered according to the principles of Evidence-Based Medicine (EBM).

Methods

This series of case reports involved 8 adult patients with rhinogenic deafness. The subjects were referred by their General Practitioner during the 2024 thermal season (April-October) to undergo a treatment cycle at the Frasassi Thermal Springs ("Terme di Frasassi - S. Vittore", located in the Province of Ancona, Italy), using sulfurous waters administered via aerosol and bilateral tubaric insufflations. The patients involved in the study gave their informed consent for the anonymous processing of their data for scientific purposes and met the following criteria:

- Clinical diagnosis of rhinogenic deafness associated with chronic rhinosinusitis, nasal polyposis, and seasonal respiratory allergies related to pollen.
- Adult age, i.e., 18 years or older.
- No absolute contraindications for thermal treatments, such as acute or infectious inflammatory diseases.

Table 1 Chemical-physical characteristics of the Frasassi Thermal Springs water at the source (analysis dated 03/19/2024)

Type of thermal water	Sulfur-sodium
Temperature	14.3 °C
pH	7.25
Residue at 180 °C	1673 mg/L
Free carbon dioxide at the source	26.09 mg/L
Bicarbonates	287.6 mg/L
Chlorides	698.1 mg/L
Sulfates	177.0 mg/L
Sulphidrometric degree	24.80 mg/L
Sodium	425.6 mg/L
Potassium	19.23 mg/L
Calcium	131.5 mg/L
Magnesium	32.74 mg/L

- Presence of Eustachian tube dysfunction, as indicated by abnormal tympanogram results prior to treatment (type B or C).

Each patient underwent a two-week treatment cycle (one session per day, including a sulfur aerosol and a bilateral tubaric insufflation, with a break on the seventh day to avoid thermal crisis), divided into two types of therapy:

1. 12 sessions of sulfur aerosol (15 min per session) administered via nasal cannula, to promote mucus thinning and reduce inflammation of the upper airways.
2. 12 bilateral tubaric insufflations (1 min per side, 2 min per session): this technique, performed with an Itard nasal catheter, aimed to restore Eustachian tube patency and improve middle ear ventilation.

Patients were evaluated clinically before and after the treatment cycle. At the start of the treatment, during the acceptance visit, tympanogram values were recorded for both ears (left and right), classifying them into type A (normal), B (indicative of effusion, tube dysfunction, or tympanosclerosis), and C (indicative of negative pressure in the middle ear). At the end of the treatment cycle, new tympanogram measurements were taken to assess the efficacy of the treatment. Comparing the pre- and post-treatment data allowed for an evaluation of whether the patients' conditions had improved. Each patient also provided a subjective assessment of their ear fullness symptoms improvement on a scale from 1 to 10, where 1 indicated no improvement and 10 indicated complete improvement. Finally, for each patient, comorbidities and any use of chronic medication were recorded to evaluate possible contraindications or the influence of other conditions on the efficacy of the thermal treatment.

Results

Among the subjects, there were four males and four females, with ages ranging from 29 to 85 years (median: 65). Three patients had no comorbidities, while the others included two with type 2 diabetes, one with rheumatoid arthritis and hypertension, one with multiple sclerosis, and one with hypertension and hypercholesterolemia (see Table 2 for further details). No individuals had taken steroids, antihistamines, NSAIDs, or mucolytics immediately before or during the thermal treatment cycle. Before treatment, the patients displayed tympanometric curves of type B or C (unilateral or bilateral), indicating tubal dysfunction and fluid accumulation in the middle ear. After the treatment cycle, a significant improvement was observed, with

Table 2 Characteristics and outcomes of patients with rhinogenic deafness associated with chronic rhinosinusitis, nasal polyposis, and respiratory allergies treated with a cycle of thermal treatments

Gender (M/F)	Age (years old)	Other diseases	Chronic medication	Tg PRE-treatment: Left Ear	Tg PRE-treatment: Right Ear	Tg POST-treatment: Left Ear	Tg POST-treatment: Right Ear	Symptomatic improvement (1–10)
M	29	/	/	C	A	A	A	7
M	53	/	/	B	C	A	A	10
M	64	Type 2 Diabetes	Metformin	B	A	A	A	9
F	65	Rheumatoid Arthritis, Hypertension	Hydroxychloroquine, Enalapril	C	C	A	A	9
F	65	Type 2 Diabetes	Metformin	B	A	A	A	10
M	68	Multiple Sclerosis	/	C	A	A	A	8
F	70	/	/	C	C	A	A	10
F	85	Hypertension, Hypercholesterolemia	Irbesartan, Atorvastatin, Cardioaspirin	B	B	A	A	10

Legend:
F = Female
M = Male
Tg = Tympanogram

normalization of the tympanometric curve (type A) in all patients, indicating a recovery of Eustachian tube function. All patients reported improvement in symptoms related to rhinogenic deafness, with subjective scores ranging from 7 to 10 (median: 9.5). Patients with more complex comorbidities, such as rheumatoid arthritis and diabetes, still showed significant improvement. No adverse effects were reported during or at the end of the thermal treatment cycle.

Discussion

The results of this study highlight the usefulness of sulfurous thermal treatments in the management of rhinogenic deafness associated with chronic rhinosinusitis, nasal polyposis, and seasonal respiratory allergies. It is particularly relevant that patients with comorbidities, such as metabolic or autoimmune disorders, still experienced significant symptom improvement, suggesting that thermal treatments can be well-tolerated even in the presence of complex clinical conditions.

The therapeutic properties of sulfurous waters are well-documented in the scientific literature (Fioravanti et al. 2011, 2017, 2024; Viegas et al. 2019; Munteanu et al. 2021), and the results observed in this study confirm their beneficial effects in treating otolaryngological conditions. The content of hydrogen sulfide in these waters provides anti-inflammatory and mucolytic properties (Wallace et al. 2015). This compound is capable of reducing local inflammation of the respiratory mucosa and improving mucociliary clearance, facilitating the removal of excess secretions and restoring Eustachian tube patency (Viegas et al. 2019; Carubbi et al. 2019). The combined effect of sulfur aerosol and bilateral tubaric insufflations proved particularly effective in reducing mucus accumulation in the middle ear, contributing to the normalization of pressure and tubal function. Another important aspect is the anti-allergic effect of sulfurous waters (Silva et al. 2020; Viegas et al. 2024), which was crucial for patients with seasonal respiratory allergies. Hydrogen sulfide has been shown to inhibit the release of inflammatory mediators, such as histamine (Joly et al. 1998; Antoniadou et al. 2023), thereby reducing the allergic inflammatory response. Finally, it is useful to underscore that no patient reported adverse effects during or after the treatment, confirming the safety of sulfur-based thermal treatments. This is particularly important for patients with comorbidities, who may be at greater risk of complications from therapeutic interventions.

This study has several limitations. First, the sample size is limited to only eight subjects, which reduces the generalizability of the results. Additionally, the absence of a control group makes it difficult to accurately determine the efficacy

of thermal treatments compared to other standard therapies. Finally, no long-term follow-up was included, meaning the duration of the improvement over time could not be assessed. Future studies with larger sample sizes, appropriate controls, and extended monitoring could provide more robust data on the efficacy and duration of the benefits of thermal treatments with sulfurous waters.

Conclusions

In conclusion, this study suggests that thermal treatments with sulfurous waters represent a useful and safe therapeutic option for rhinogenic deafness caused by chronic rhinosinusitis. The therapy led to significant improvements in tubal function and quality of life for the patients, with potential benefits both in terms of reducing inflammation and alleviating associated symptoms. The results collected here suggest that such treatments should be considered as part of an integrated approach to managing these health conditions. However, further studies with larger sample sizes and long-term follow-up will be necessary to confirm the duration of the benefits achieved and to compare this therapy with other therapeutic approaches currently in use.

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Declarations

Ethics approval All participants provided informed consent to participate in the study, which was conducted as part of routine clinical care and did not involve the administration of any experimental therapy. Data were fully anonymized in compliance with EU privacy regulations. The study was designed and conducted in full adherence to the principles of the Declaration of Helsinki. Formal ethics committee approval was not required, as the research consisted solely of a series of case reports (Regional Decree: 1104–29/09/2014: "Disposizione concernenti il Comitato Etico Regionale (CER) Regione Marche").

Competing interests Bruno Borioni, Geniale Mariani, and Marcello Moscoloni serve as physicians at Frasassi Thermal Springs ("Terme di Frasassi - S. Vittore," AN, Italy). Michele Antonelli acts as an external scientific consultant for the institution. The Administrative Director of Terme di Frasassi had no role in the collection, management, or publication of data related to this work.

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