

The Use of Sodium Chloride Powder Sachets May Not Increase the Risk of Microplastic Emissions in Nasal Irrigation Fluids: A Preliminary Study

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Background and Objectives: Microplastics, which originate from the breakdown of larger plastic fragments or are intentionally produced for industrial applications, pose significant human and ecological risks through inhalation, ingestion, and dermal contact. Our study examined the release of microplastics during the preparation of homemade saline solutions, specifically when tearing open powder packets and mixing the powder with water.

Methods: We used commercially available polypropylene nasal irrigation bottles from the Korean market and collected six samples of nasal irrigation fluids. The samples were categorized into two groups: the control group comprised three samples, without sodium chloride powder, while the powder-added group consisted of three experimental samples, where a sachet of sodium chloride powder was mixed into the water to achieve a 0.9% sodium chloride concentration. The preparation involved cooling boiled water before mixing in the powder sachet. A Raman XploRA Plus confocal microscope was used for the detection and analysis of microplastics.

Results: We observed 17, 56, and 26 microplastic particles in the control group samples, with a mean of 33.00 ± 20.42 , and 7, 6, and 34 microplastic particles in the powder-added group, with a mean of 15.66 ± 15.88 . There was no significant difference in microplastic content between the groups. Analysis revealed that the control samples contained 66 fragments (67%) and 33 fibers (33%), while the powder-added samples contained 45 fragments (96%) and two fibers (4%). We identified three types of polymers: polypropylene (control: 96, powder-added: 41), polyethylene (control: 2, powder-added: 3), and polyethylene terephthalate (control: 1, powder-added: 3).

Conclusion: Our findings indicate that adding sodium chloride powder to nasal irrigation fluids does not significantly alter microplastic release, highlighting the importance of considering potential microplastic pollution from common medical devices.

Keywords: Nasal irrigation; Irrigation bottle; Sodium chloride powder; Microplastics; Raman analysis.

INTRODUCTION

Microplastics, which are plastic particles smaller than 5 mm, originate from the degradation of larger plastic items or are intentionally produced for diverse industrial applications [1]. These particles are ubiquitous in various environments, both natural and anthropogenic, such as soils, oceans, food sources, and the atmosphere [2-4]. Studies indicate that microplastics can enter the human body via inhalation, ingestion, and

dermal contact, posing significant threats to human health and ecosystems [5].

The nasal cavity functions as the primary defense against pathogens entering the respiratory tract, acting effectively as a natural filter. There is strong support for the effectiveness of nasal irrigation in maintaining nasal cavity health [6]. This procedure, which involves flushing the nasal passages with a saline solution, helps remove mucus and prevent bacterial growth. It is recommended for managing various nasal conditions [6]. Nasal irrigation is especially advocated as a primary treatment for chronic rhinosinusitis, aiding in the reduction of antibiotic use [6]. Furthermore, following endoscopic sinus surgery, nasal irrigation promotes healing in the nasal and sinus cavities and reduces the reliance on extensive medication [6].

Previous preliminary studies have indicated that the fluids used for nasal irrigation may contain microplastics, which

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could originate from the irrigation bottle itself [7]. Nasal irrigation typically involves a saline solution prepared by mixing sodium chloride powder with water. The recommended method involves using water that has been boiled and then cooled, to which a sachet of nasal irrigation powder is added to create a 0.9% sodium chloride solution. We hypothesize that if the packaging of the nasal irrigation powder contains plastic components, microplastics could be released into the solution when the packaging is opened and the powder is mixed into the water. Our current research aims to explore the potential release of microplastics during the preparation of these homemade saline solutions, with a specific focus on the actions of opening the powder packets and combining the powder with water.

METHODS

Commercially available nasal irrigation bottles made of polypropylene (PP) were purchased from the Korean market. We collected six samples of nasal irrigation fluids, which were divided into two groups: three samples constituted the control group, which did not contain sodium chloride powder, and three samples comprised the experimental group, where a sachet of sodium chloride powder was added to the water to achieve a 0.9% sodium chloride concentration (Supplementary Fig. 1 in the online-only Data Supplement). Following the instructor's guidelines, the fluids were prepared by boiling water, allowing it to cool, and then dissolving one sachet of nasal irrigation powder in the water.

For microplastic detection, we utilized Raman spectroscopy with an XploRA Plus confocal Raman microscope (Horiba, Longjumeau, France). This equipment features a 532 nm laser and a 1,024×256 pixel-cooled charge-coupled device detector. To minimize laser damage, we reduced the laser power by 10% using an integrated filter and employed gratings with 1,200 grooves/mm. We adjusted the confocal hole to 100 μm and the slit width to 50 μm . System calibration was performed using zero-order correction and alignment with the 520.7 cm^{-1} silicon peak. We captured a mosaic of microscopic dark-field images using an M Plan Semi Apochromat BD objective lens $\times 20/\text{N.A. } 0.45$ (Olympus, Tokyo, Japan), stitching together 29×33 images along the X- and Y-axes. These images were analyzed using the Particlefinder module in LabSpec 6 software to identify bright particles against the dark background. Raman spectra were recorded with an exposure time of 2 seconds per spectrum across the 1,020–3,400 cm^{-1} range. The collected spectra were processed using LabSpec 6 software, which included polynomial baseline correction and exclusion of spectra with high fluorescence. All spectra were analyzed for plastic content using the classical least squares algorithm (Fig. 1). To prevent microplastic contamination, we exclusively used glass materials during the sampling and filtering processes. All procedures were conducted inside a laminar flow box (HSCV-1300; Sinan Science Industry, Gwangju, Gyeonggi-do, Korea) to avoid airborne microplastic contamination. Solutions, including ultrapure water and chemical reagents, were pre-filtered through GF/F grade and metal filters (0.5 μm). All glassware was thoroughly rinsed with filtered

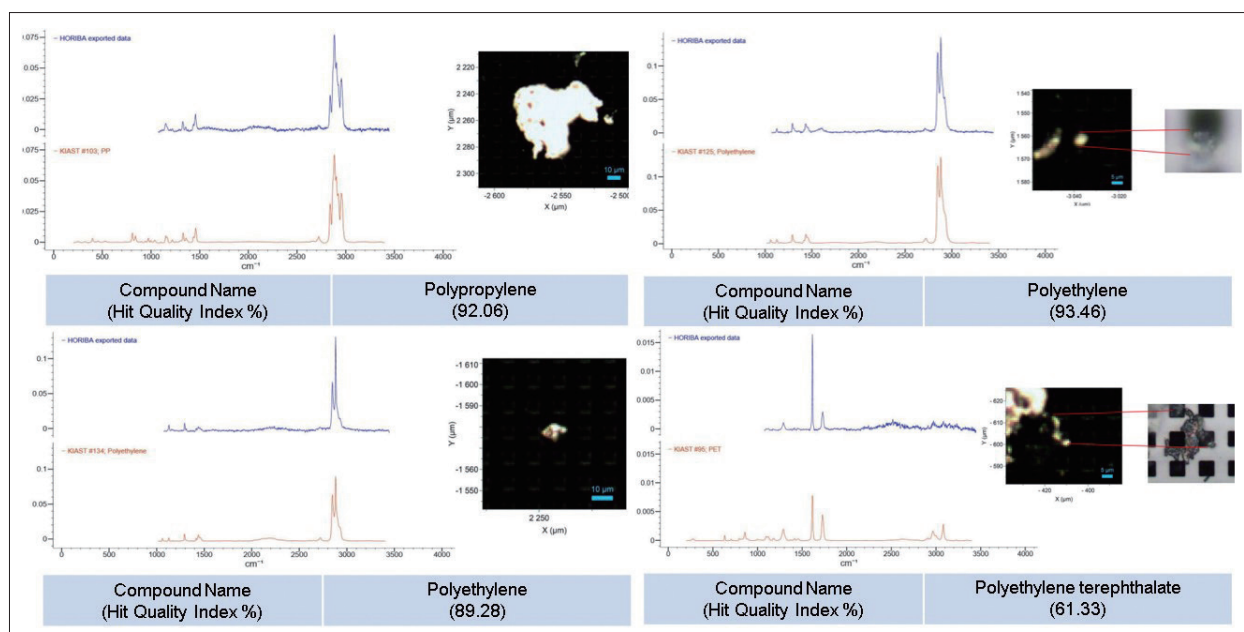


Fig. 1. Examples of microphotographs and results of the Raman analysis of major microplastic types.

ultrapure water before each experiment. During transportation outside the laminar flow hood, samples were covered with aluminum foil. To further minimize contamination risk, nitrile gloves and cotton coats were worn at all times during the experimental procedures. Additionally, three blank samples were prepared in empty glass beakers and subjected to the same procedures as the experimental samples to assess potential contamination during sample pretreatment and analysis.

Descriptive data are presented as the mean value $\pm$ standard deviation. We compared the differences between the two groups using the independent Student t-test. All statistical analyses were conducted using GraphPad Prism Version 8.0 (Graph-Pad Software, Boston, MA, USA).

Table 1. Raman analysis results of nasal irrigation fluids

	Replicates	Number of total microplastics	MP polymer	Range dimensional class (μ m)	Number of microplastics	Number of fibers in microplastics
Control	1°	17	PP	5–10	1	-
				10–20	2	-
				20–50	7	2
				50–100	2	1
				≥ 100	5	2
	2°	56	PP	5–10	3	-
				10–20	7	2
				20–50	22	6
				50–100	14	6
				≥ 100	10	5
	3°	26	PP	5–10	1	-
				10–20	3	-
				20–50	7	3
				50–100	5	3
				≥ 100	7	3
			PE	10–20	2	-
				PET	1	-
			PET	20–50	1	-
				5–10	1	-
				10–20	1	-
Powder-added	1°	7	PP	5–10	1	-
				10–20	1	-
				20–50	1	-
				50–100	2	-
				≥ 100	2	-
			PE	5–10	1	-
				10–20	-	-
				20–50	-	-
			PET	10–20	1	-
				PET	1	-
	2°	6	PP	5–10	2	-
				10–20	1	-
				20–50	1	-
				50–100	1	-
				≥ 100	1	1
			PP	5–10	4	-
				10–20	14	1
				20–50	9	-
			PE	50–100	3	-
				10–20	1	-
	3°	34	PP	≥ 100	1	-
				20–50	2	-
				PET	2	-
			PE	10–20	1	-
				≥ 100	1	-
			PET	20–50	2	-

MP, microplastic; PP, polypropylene; PE, polyethylene; PET, polyethylene terephthalate

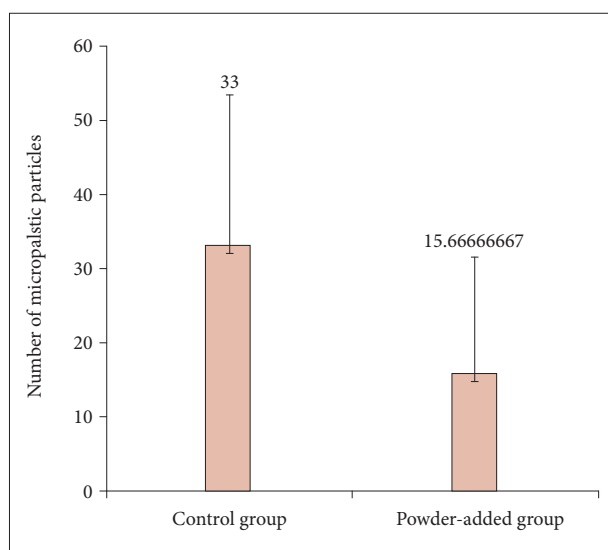


Fig. 2. Number of microplastics detected in the nasal irrigation fluid samples.

RESULTS

In the blank samples, no microplastic particles were detected, indicating that there was no contamination of microplastics during the analysis procedure. Microplastic particles were quantified in control samples, with counts of 17, 56, and 26 (mean 33.00 ± 20.42), and in the powder-added group, with counts of 7, 6, and 34 (mean 15.66 ± 15.88). No statistically significant difference was observed between the two groups ($p = 0.418$) (Table 1 and Fig. 2). The microplastics were categorized by shape, size, and polymer type (Table 1). In the control group, 66 fragments (67%) and 33 fibers (33%) were identified. In contrast, the powder-added group contained 45 fragments (96%) and two fibers (4%). Three polymer types were detected: PP, polyethylene (PE), and polyethylene terephthalate (PET). The control samples comprised 96 PP, two PE, and one PET particles, whereas the powder-added group contained 41 PP, three PE, and three PET particles. Microplastics predominantly ranged from 10 to 100 μm in size, with those sized between 20 and 50 μm being most common in the control group and those between 10 and 20 μm predominating in the powder-added group.

DISCUSSION

A previous study demonstrated that repeated use of nasal irrigation bottles could lead to the release of microplastics into the irrigation fluids, posing a potential risk of microplastic entry into the human body via the nasal cavity [7]. Building on these findings, the current study evaluated the presence and characteristics of microplastics in nasal irrigation

fluids from both a control group and samples to which a sachet of sodium chloride powder had been added. The average number of microplastics found was 33.00 ± 20.42 in the control group and 15.66 ± 15.88 in the samples with added powder. Contrary to our initial hypothesis, this difference was not statistically significant, indicating that the addition of sodium chloride powder does not increase the risk of microplastic contamination.

The sodium chloride powder was encased in packaging with an aluminum outer layer and a PP vinyl inner layer (Supplementary Fig. 1 in the online-only Data Supplement), while the irrigation bottle was also constructed from PP. This complicates the identification of the precise origin of the detected microplastics. However, the results suggest that the release of microplastics due to the mechanical tearing of PP vinyl is minimal. This supports the idea that there is no significant difference in the generation of microplastics between using normal saline alone and adding sodium chloride powder to the water for nasal irrigation.

This study is the first to explore the impact of adding sachet-based sodium chloride powder on microplastic release during the preparation of nasal irrigation fluid. The results show that the inclusion of this powder does not significantly increase microplastic content. Furthermore, the study underscores the important consideration that the potential release of microplastics from commonly used medical devices should not be overlooked. Considering evidence that suggests microplastics can be absorbed by humans and may have various effects, it is essential to thoroughly examine medical devices made from plastics for potential microplastic release, which calls for additional experimental verification.

In the current study, we detected microplastic particles, including PE and PET, in the main components of the irrigation bottle. Concurrently, microplastics were not found in the blank samples, indicating that there was no contamination from microplastics during the experimental analysis. Consequently, we hypothesize that the irrigation bottle may contain contaminated microplastic particles. The presence of microplastics could be attributed to environmental contamination during the bottle manufacturing process. However, further research is necessary to either confirm our hypothesis or uncover new findings.

There are several limitations to this study. It was confined to using only one type of sodium chloride powder, and the experimental design included just three replicates per group, yielding limited data that restricted the ability to draw robust clinical conclusions. Therefore, the results should be considered preliminary. Further research, incorporating a broader range of samples and increased replication, is crucial to validate these initial findings.

Supplementary Materials

The online-only Data Supplement is available with this article at <https://doi.org/10.18787/jr.2024.00027>.

Availability of Data and Material

Data from this study are available from the corresponding author upon reasonable request. The data are not publicly available.

Conflicts of Interest

Hyun Jin Min who is on the editorial board of the *Journal of Rhinology* was not involved in the editorial evaluation or decision to publish this article. The remaining author has declared no conflicts of interest.

Author Contributions

Conceptualization: Hyun Jin Min. **Data curation:** Kyung Soo Kim, Hyun Jin Min. **Investigation:** Kyung Soo Kim, Hyun Jin Min. **Methodology:** Hyun Jin Min. **Visualization:** Hyun Jin Min. **Writing—original draft:** Kyung Soo Kim, Hyun Jin Min. **Writing—review & editing:** Kyung Soo Kim, Hyun Jin Min.

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