



# Comparison of the Healing Effect of Nasal Saline Irrigation with Triamcinolone Acetonide Versus Nasal Saline Irrigation alone in COVID-19 Related Olfactory Dysfunction: A Randomized Controlled Study

Erkan Yildiz<sup>1</sup> · Selcen Koca Yildiz<sup>2</sup> · Selçuk Kuzu<sup>3</sup> · Çağlar Günebakan<sup>3</sup> ·  
Abdulkadir Bucak<sup>3</sup> · Orhan Kemal Kahveci<sup>3</sup>

Received: 3 June 2021 / Accepted: 4 July 2021  
© Association of Otolaryngologists of India 2021

**Abstract** There is no routinely determined treatment for olfactory dysfunction because of COVID-19. Saline irrigation and nasal corticosteroid treatments are safe and inexpensive methods, and have low side effects. In our study, we argue that saline nasal irrigation and topical corticosteroid treatment can be used in the treatment of patients with olfactory loss in all areas of rhinology. A total of 150 patients who admitted to our clinic with other symptoms or with only acute odor loss, diagnosed with COVID-19 with RT-PCR were divided into 3 equal groups. Fifty patients in Group 1 were not given any extra treatments. The other 50 patients in Group 2 were given saline irrigation for treatment; and the 50 people in Group 3 were given both saline irrigation and nasal steroid spray for treatment. The “Subjective Olfactory Capability (SOC)” was used for olfactory function evaluation of patients. Self-Rating Olfactory Score (SROS), and Olfactory Dysfunction Duration (ODD) were recorded on the 1st, 15th and 30th days. SROS of the group receiving Nasal Saline + Triamcinolone Acetonide treatment on the 30th day was significantly higher than in other groups ( $p^{-1-3} = 0.018$ ,  $p^{2-3} = 0.033$ ). Also, the ODD was significantly reduced in this group compared to other groups ( $p^{-1-3} = 0.022$ ,  $p^{2-3} = 0.028$ ). Topical triamcinolone treatment was found to be successful in the treatment of olfactory dysfunction due to COVID-19. Nasal

steroids, which are both inexpensive and have low side effect profiles, can be used safely in the treatment of patients with olfactory losses.

**Keywords** COVID 19 · Olfactory disorders · Steroid therapy · Olfactory test

## Introduction

The new Coronavirus (COVID-19) is a serious infectious disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus, which started in Hubei Province of China in 2019, and caused a pandemic all over the world in 2020 [1]. The disease begins with symptoms such as fever, weakness, sore throat, cough, joint pains, diarrhea, loss of smell and taste, leading to respiratory failure and death with lung involvement. COVID-19 caused serious disruptions in healthcare systems all over the world. Approximately 90.000.000 new cases and 2.000.000 deaths were reported as of January 2021. For this reason, efforts to develop new vaccines and drugs to treat COVID-19 are continuing very quickly. It was found that acute odor loss in COVID-19 can be an important symptom for the diagnosis of COVID-19. It was also determined that Angiotensin-Converting Enzyme-2 (ACE-2) and Transmembrane Serine Protease-2 (TMPRSS2) receptors were present in the bronchial and respiratory epithelium, as well as in the olfactory epithelium with viral involvement in the disease. The disease also causes nasal inflammation, mucosal edema, and reduced airflow in olfactory cleft in the acute phase, like a classic upper respiratory tract disease. Loss of odor related to COVID-19 is often not a symptom that patients care about firstly; and therefore, it is difficult to document and

✉ Erkan Yildiz  
dr.erkanyildiz@hotmail.com

<sup>1</sup> Department of Otorhinolaryngology, Afyonkarahisar Şuhut State Hospital, 03800 Şuhut/Afyonkarahisar, Turkey

<sup>2</sup> Afyonkarahisar, Turkey

<sup>3</sup> Department of Otorhinolaryngology, Healty Science University Hospital, Afyonkarahisar, Turkey

monitor these patients because patients without additional complaints are admitted to hospital later. Also, infection risks of patients and home quarantines prevent odor tests [2]. Although olfactory disorder is considered harmless for patients, a significant relation was found in many studies between odor loss and 5 years of mortality increase [3]. Infection is estimated to directly damage the olfactory cleft in viral olfactory dysfunction. In wider biopsy studies related to olfactory epithelial, atypical findings such as metaplasia or neuroma formation were detected [4]. Increases were detected in bulb signals in imaging studies performed with Magnetic Resonance Imaging (MRI) in Post-Viral Olfactory Dysfunction (PVOD) because of COVID-19 [5].

Olfactory dysfunction is a common disorder affecting more than 20% of general population. Among its causes, there are traumas, viral diseases or idiopathic causes. Post-Viral Olfactory Dysfunction (PVOD) is the most common form of it, and is seen in approximately 40% of population [5], impairing the quality of life in many patients, and leading to increased morbidity rates. Spontaneous regression is very small in the majority of patients with olfactory dysfunction, and often a treatment modality is required. For this reason, many new treatments were identified in the past, including pharmacology agents, such as oral and nasal steroids, Platelet-Rich Plasma (PRP), Vitamin A, Ginkgo Biloba, zinc sulfate, alpha lipoic acid, minocycline, theophylline, and minocycline [6]. However, despite all these agents, the treatment of olfactory dysfunction is still quite limited. Topical steroid nasal irrigation and olfactory training are the best treatments proven so far [7, 8]. Nasal saline irrigation treatment can be used very successfully with high volume in chronic sinusitis [9]. Many studies were conducted on olfactory dysfunction in COVID-19. However, no successful treatments were performed so far in Post-Viral Olfactory Dysfunction (PVOD) because of COVID-19 [10]. Based on the literature data, we argue that nasal steroid and nasal saline irrigation treatment can be successful in the treatment of PVOD.

## Materials and Methods

The study included 150 patients admitted to our hospital between November 2020 and January 2021. The study was planned as a single-center randomized-controlled study. A total of 150 patients admitting to our clinic with other symptoms or with only acute odor loss, diagnosed with COVID-19 were divided into 3 equal groups (Group 1, 2, 3). The 50 patients in Group 1 were not given any extra treatment. Saline irrigation was applied for treatment to 50 people in Group 2 (hypertonic solution/10 cc to each nose, twice a day/1 month); and 50 people in Group 3 were

given both saline irrigation (hypertonic solution/10 cc per nose, twice a day/1 month) and nasal steroid spray 2\*2 puffs/each nose/Triamcinolone Acetonide 0.055%). The diagnosis of COVID-19 of patients was confirmed with the RT-PCR Test. The study was approved by the Ethics Committee of Afyonkarahisar University of Health Sciences, and was conducted in line with the Principles of Helsinki Declaration. Informed Consent Forms were received from all patients.

The evaluation of patients was done with a wide-scope questionnaire that contained the characteristics of odor loss and other clinical findings. Evaluations were made on days 1, 15, and 30 with face-to-face interviews on the first day, and with a telephone survey on the other days. Routine objective olfaction tests (e.g., Sniffin' Sticks Test, UPSIT, and CCRC) could not be used to reduce infection of COVID-19 and because patients were in quarantine. The "Subjective Olfactory Capability (SOC)" Method was used to evaluate the self-reported olfactory function and olfaction-related quality of life for evaluations [11, 12]. SOC was used face-to-face on the day that patients had COVID-19-related odor loss, and evaluations were repeated on the 15th and 30th days of treatment. Olfactory functions were evaluated by using drinks with sharp smells (e.g., lemonade, coffee), nutrients (lemon, garlic), spices (mint, black pepper, thyme), and some cleaning agents (soap, bleach, menthol) to evaluate the odor separation of patients. The olfactory function was evaluated with self-scoring method. All patients were asked to evaluate olfactory function by giving a score of 1–10 (0 = no odor at all, and 10 = full odor) [12]. A form was created to include additional diseases, age and gender of patients in addition to the odor functions. The Self-rating olfactory scores and olfactory dysfunction severity scores collected on days 1, 15, and 30 were recorded.

## Exclusion Criteria

Patients under the age of 18 and older than 65, those who had neurological and psychological diseases, those who had previous history of head traumas, and those who had metabolic diseases.

## Statistical Analyses

SPSS for Windows version 20 (SPSS, Chicago, IL, USA) was used for statistical analyses. Continuous variables were calculated as Mean  $\pm$  Standard Deviation (SD); and categorical variables were calculated as frequency (n) and percentage (%). One-Way ANOVA Test was used to compare the variables among the groups; and  $p < 0.05$  was considered to be statistically significant.

## Results

In terms of gender, there were 30 males (60%), 20 females (40%) in Group 1; Group 2 had 28 males (56%), 22 females (44%); and Group 3 had 26 males (52%), and 24 females (48%). The groups were homogeneous in terms of gender. The mean age was  $38.5 \pm 10.5$  (16–56) in Group 1,  $39.2 \pm 11.3$  (18–61) in Group 2, and  $39.2 \pm 11.3$  (18–61) in Group 3. The groups were homogeneous in terms of age. In terms of additional diseases, Group 1 had hypertension in 4 (8%) patients, Cardiac Disease in 10 (20%) patients, Diabetes Mellitus in 2 (4%) patients, asthma and COPD (Chronical Obstructive Pulmonary Disease) in 3 (6%) patients; Group 2 had hypertension in 8 (16%) patients, Cardiac Disease in 5 (10%) patients, Diabetes Mellitus in 4 (8%) patients, asthma and COPD (Chronical Obstructive Pulmonary Disease) in 1 (2%) patients; Group 3 had hypertension in 6 (12%) patients, Cardiac Disease in 4 (8%) patients, Diabetes Mellitus in 5 (10%) patients, asthma and COPD (Chronical Obstructive Pulmonary Disease) in 5 (10%) patients (Table 1).

Self-Rating Olfactory Score (SROS) was  $3.1 \pm 2.5$  (0–6) before treatment in Group 1,  $4.1 \pm 2.6$  (0–7), on day

15 after treatment, and  $5.2 \pm 2.3$  (0–10) on day 30 after treatment. For Group 2, it was  $2.8 \pm 2.4$  (0–5) before treatment,  $4.8 \pm 3.1$  (1–8) on day 15 after treatment, and  $6.1 \pm 2.2$  (3–10) on day 30 after treatment. For Group 3, it was  $2.7 \pm 3.3$  (0–5) before treatment,  $1 \pm 2.5$  (2–9) on day 15 after treatment, and  $8.5 \pm 3.2$  (5–10) on day 30 day after treatment. When Group 1 and 2 were compared in terms of SROS on day 30, no statistically significant differences were detected ( $p^{1-2} = 0.22$ ). When Group 1 and 3 were compared in terms of SROS on day 30, statistically significant differences were detected ( $p^{-1-3} = 0.018$ ). When Group 2 and 3 were compared in terms of SROS on day 30, statistically significant differences were detected ( $p^{2-3} = 0.033$ ) (Table 2, Fig. 1).

In terms of olfactory dysfunction duration, Group had  $1:15.2 \pm 2.3$  (2–30) days, Group 2:  $12.1 \pm 2.2$  (1–30) days; and Group 3:  $5.6 \pm 3.2$  (1–30) days. When compared in statistical terms, Group 1 and 2 did not have significant differences in terms of duration ( $p^{1-2} = 0.54$ ). When Group 3 was compared with Group 1 and Group 2 in terms of duration, there were statistically significant differences ( $p^{-1-3} = 0.022$ ,  $p^{2-3} = 0.028$ , respectively) (Table 3).

**Table 1** Comparison of the demographic characteristics and clinical finding of the 3 groups

	Group 1 (Untreated) n = 50	Group 2 (Intranasal saline irrigation therapy only) n = 50	Group 3 (Intranasal saline and triamcinolone irrigation treatment) n = 50
Gender			
Male	30 (60%)	28(56%)	26(52%)
Female	20(40%)	22(44%)	24 (48%)
Mean age	$38.5 \pm 10.5$ (16–56)	$39.2 \pm 11.3$ (18–61)	$37.2 \pm 8.4$ (22–57)
Comorbidities			
Hypertension	4 (8%)	8(16%)	6(%12)
Cardiac disease	10 (20%)	5(10%)	4(8%)
Diabetes	2(4%)	4(8%)	5(10%)
Mellitus			
Asthma/COPD	3(6%)	1(2%)	5(%10)
ENT Symptoms accompanying the loss of smell			
Rhinorrhea	41(%82)	45(%90)	36(%72)
Nasal obstruction	35(%70)	42(%84)	40(%80)
Sore throat	48(%96)	36(%72)	32(%64)
Face pain	25(%50)	24(%48)	26(%52)
Postnasal drip	36(%72)	35(%70)	32(%64)
Headache	40(%80)	42(%84)	40(%80)
Ear pain	15(%30)	12(%24)	10(%20)

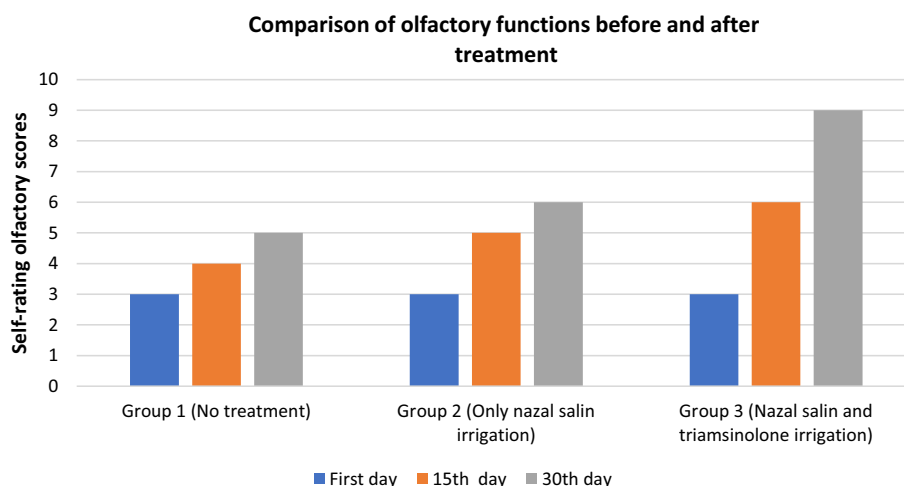
**Table 2** Comparison of olfactory functions (Self-rating olfactory score) before and after treatment

	Before treatment SROS	15th day SROS	30th day SROS	<i>P</i> value
Group 1	3.1 ± 2.5 (0–6)	4.1 ± 2.6 (0–7)	5.2 ± 2.3 (0–10)	
Group 2	2.8 ± 2.4 (0–5)	4.8 ± 3.1 (1–8)	6.1 ± 2.2 (3–10)	$p^{1-2} = 0,22$
Group 3	2.7 ± 3.3 (0–5)	6.1 ± 2.5 (2–9)	8.5 ± 3.2 (5–10)	$p^{-1-3} = \mathbf{0,018}$ $p^{2-3} = \mathbf{0.033}$

*p* values are shown in bold

(All values were calculated as mean ± standard deviation (SD),  $p^{1-2}$  Group 1 vs. Group 2;

$p^{1-3}$  Group 1 vs. Group 3;  $p^{2-3}$  Group 2 vs. Group 3; SROS: Self-rating olfactory score)

**Fig. 1** Comparison of olfactory functions before and after treatment**Table 3** Comparison of olfactory dysfunction duration (days)

	Dysfunction duration	<i>P</i> value
Group 1	15.2 ± 2.3 (2–30)	–
Group 2	12.1 ± 2.2 (1–30)	$p^{1-2} = 0,54$
Group 3	5.6 ± 3.2 (1–30)	$p^{-1-3} = \mathbf{0,022}$ $p^{2-3} = \mathbf{0.028}$

*p* values are shown in bold

(All values were calculated as mean ± standard deviation (SD),  $p^{1-2}$  Group 1 vs. Group 2;

$p^{1-3}$  Group 1 vs. Group 3;  $p^{2-3}$  Group 2 vs. Group 3)

As a result, day 30 SROS (Self-Rating Olfactory Score) of the group that received Nasal Saline + Triamcinolone Acetonide treatment was significantly higher than other groups. Also, olfactory dysfunction duration was significantly reduced compared to other groups.

For this reason, Nasal Saline + Triamcinolone Acetonide treatment is successful in olfactory dysfunction treatment due to COVID-19.

## Discussion

New Coronavirus Disease (COVID-19) is a serious infectious disease that started in Wuhan, China in December 2019, and spread all over the world in 2020. It was declared to be a pandemic by the World Health Organization (WHO) because of the increasing number of patients. The disease begins with complaints such as fever, cough, sore throat, joint pains, and dyspnea. Olfactory dysfunction (e.g., anosmia, hyposmia) is a new marker which has been reported recently. In most patients, odor loss begins suddenly, and often also leads to taste disorders. It was first

reported in the UK and Iran in the world. British Association of Otorhinolaryngology and American Academy of Otolaryngology—Head and Neck Surgery (AAO-HNS) recommended that symptoms of odor loss added to the list of screening tools for possible COVID-19 infections [13, 14]. Mechanisms such as direct olfactory bulb damage, olfactory epithelial involvement, or neurogenic involvement were mentioned in the olfactory disorder [15]. In a previous study, two key genes (i.e. ACE2 and TMPRSS2) were detected in the human and mice olfactory epithelium [16].

Olfactory dysfunction may occur due to post-infectious traumas or Chronic Rhino-Sinusitis (CRS). Post-Viral Olfactory Dysfunction (PVOD) is the most common among these. Viral factors, such as Epstein-Barr Virus, Rhinovirus, Coronavirus, and Parainfluenza might cause PVOD. The novel coronavirus Severe Acute Respiratory Syndrome ((SARS)-CoV-2) is responsible for temporary or permanent loss of olfaction. It has been shown in recent studies that COVID-19-related olfactory dysfunction is not that different from other PVOD pathophysiologies [10]. These patients complain about hyposmia, dysosmia, parosmia, and mostly anosmia. The number of patients with permanent olfactory losses is much higher than expected. In these patients, evidence-based treatment is not fully clear for the time being. Corticosteroids are used widely for treatment of olfactory losses, and the importance of olfactory training is also remarkable in treatment. In the literature, there is no treatment modality reported for COVID-19-related PVOD so far. However, there are quite a lot of studies in the literature regarding the treatment of classical PVOD. Many of these studies were conducted with systemic steroids. Agents such as prednisolone and methylprednisolone were used in doses ranging from 2 weeks to 1 year in many studies in which systemic steroids were used, and most studies showed significant improvements in TDI scores (Threshold, Discrimination, Identification) [17]. No significant results were reported regarding the addition of Ginkgo Biloba to oral steroid and mometasone spray treatment [18].

In one of the studies of Heilman et al., patients with odor loss were given local and systemic steroids, and although the systemic steroid olfactory corrected the functions, no significant effects were detected in local steroids [19]. In the study of Shu et al., it was shown that topical corticosteroid application with squirting system was more effective than spraying in maintaining olfactory healing with oral corticosteroid treatment [20]. It was reported in a review published in 2019 that the effectiveness of topical steroids was low for olfactory dysfunction, but oral steroids could be used at evidence Level 1 [8]. In an evidence-based review conducted by Hura et al. both

oral and topical steroids were recommended to treat PVOD, but it was also recommended that oral steroids used with caution because of their potential side effects [21]. In Whitcroft et al.'s study, it was reported that systemic steroids could not be used routinely in COVID-19-related olfactory dysfunction, and the use of nasal steroids was still discussed. Also, olfactory training, Vitamin A, zinc sulfate and systemic Omega-3 treatments were recommended as the standard treatment [22]. In our study, significant increases were detected in self-rating olfactory scores in patients who applied topical steroid irrigation with nasal saline compared to the control group. There were also significant decreases in the duration of olfactory dysfunction. Based on this outcome, we believe that topical steroid treatment can be used as a successful treatment modality in COVID-19-related olfactory dysfunction treatment. Also, the significantly low side effects compared to oral steroids constitute a reliable treatment option.

It was shown that nasal saline irrigation was ineffective in many studies conducted on nasal saline irrigation in patients with chronic rhino-sinusitis [23, 24]. In a meta-analysis; however, it was found that hypertonic saline irrigation was more effective in the treatment of chronic rhino-sinusitis compared to isotonic irrigation [25, 26]. In our study, it was found that there were no significant increases in self-rating olfactory scores in patients who did irrigation with nasal saline compared to the control group. Also, significant decreases were not detected in the duration of olfactory dysfunction.

The limitations of our study were our inability to perform objective olfactory tests because of COVID-19 infection risk and quarantine periods. Also, the number of patients was relatively small, and the study had a single-centric design.

## Conclusion

So far, there is no treatment employed as the gold standard for the treatment of olfactory dysfunction that occurs due to COVID-19. As common cost-effective treatment agents, topical corticosteroids can be used in most diseases of rhinology, especially in olfactory loss. It was proven in our study that nasal steroids can be used safely and therapeutically for the treatment of the odor loss in Covid-19. Multi-centered studied with wider patient series are required to use steroids more widely in this disease.

**Funding** The authors declared that this study has received no financial support.

## Declarations

**Conflict of interest** No conflict of interest was declared by the authors.

**Ethical Approval** Ethics committee approval was received from Afyonkarahisar Healty Science University Clinical Research Ethic Committee.(05.03.2021–2021/2).

**Informed Consent** Consent was obtained from of the patients.

**Info** The English translation, editing and proofreading procedures of this article were carried out by “Academic Translation Services ([www.tercumeakademik.com](http://www.tercumeakademik.com))”.

## References

- Machhi J, Herskovitz J, Senan AM et al (2020) The natural history, pathobiology, and clinical manifestations of SARS-CoV-2 infections. *J Neuroimmune Pharmacol* 15(3):359–386. <https://doi.org/10.1007/s11481-020-09944-5>
- Moein ST, Hashemian SMR, Mansourafshar B, Khorram-Tousi A, Tabarsi P, Doty RL (2020) Smell dysfunction: a biomarker for COVID-19. *Int Forum Allergy Rhinol* 10(8):944–950. <https://doi.org/10.1002/alar.22587>
- Pinto JM, Wroblewski KE, Kern DW, Schumm LP, McClintock MK (2014) Olfactory dysfunction predicts 5-year mortality in older adults. *PLoS ONE* 9(10):e107541. <https://doi.org/10.1371/journal.pone.0107541>
- Holbrook EH, Rebeiz L, Schwob JE (2016) Office-based olfactory mucosa biopsies. *Int Forum Allergy Rhinol* 6(6):646–653. <https://doi.org/10.1002/alar.21711>
- Galougahi MK, Ghorbani J, Bakhshayeshkaram M, Naeini AS, Haseli S (2020) Olfactory bulb magnetic resonance imaging in SARS-CoV-2-induced anosmia: the first report. *Acad Radiol* 27(6):892–893
- Welge-Lüssen A, Wolfensberger M (2006) Olfactory disorders following upper respiratory tract infections. *Adv Otorhinolaryngol* 63:125–132. <https://doi.org/10.1159/000093758>
- Harless L, Liang J (2016) Pharmacologic treatment for postviral olfactory dysfunction: a systematic review. *Int Forum Allergy Rhinol* 6(7):760–767. <https://doi.org/10.1002/alar.21727>
- Nguyen TP, Patel ZM (2018) Budesonide irrigation with olfactory training improves outcomes compared with olfactory training alone in patients with olfactory loss. *Int Forum Allergy Rhinol* 8(9):977–981. <https://doi.org/10.1002/alar.22140>
- Yan CH, Overdevest JB, Patel ZM (2019) Therapeutic use of steroids in non-chronic rhinosinusitis olfactory dysfunction: a systematic evidence-based review with recommendations. *Int Forum Allergy Rhinol* 9(2):165–176. <https://doi.org/10.1002/alar.22240>
- Chong LY, Head K, Hopkins C et al (2016) Saline irrigation for chronic rhinosinusitis. *Cochrane Database Syst Rev*. <https://doi.org/10.1002/14651858.CD011995.pub2>
- Imam SA, Lao WP, Reddy P, Nguyen SA, Schlosser RJ (2020) Is SARS-CoV-2 (COVID-19) postviral olfactory dysfunction (PVOD) different from other PVOD? *World J Otorhinolaryngol Head Neck Surg* 6:S26–S32. <https://doi.org/10.1016/j.wjorl.2020.05.004>
- En Wee L, Fu Zi Chan Y, Wei Yang Teo N et al (2020) The role of self-reported olfactory and gustatory dysfunction as a screening criterion for suspected COVID-19. *Eur Arch Oto-Rhino-Laryngology* 277(3):2389–2390. <https://doi.org/10.1007/s00405-020-05999-5>
- Altundag A, Saatci O, Sanli DET et al (2020) The temporal course of COVID-19 anosmia and relation to other clinical symptoms. *Eur Arch Oto-Rhino-Laryngology* 1:3. <https://doi.org/10.1007/s00405-020-06496-5>
- Agyeman AA, Chin KL, Landersdorfer CB, Liew D, Ofori-Asenso R (2020) Smell and taste dysfunction in patients with COVID-19: A systematic review and meta-analysis. *Mayo Clin Proc* 95(8):1621–1631. <https://doi.org/10.1016/j.mayocp.2020.05.030>
- Kaye R, Chang CWD, Kazahaya K, Brereton J, Denny JC 3rd (2020) COVID-19 Anosmia reporting tool: initial findings. *Otolaryngol neck Surg Off J Am Acad Otolaryngol Neck Surg* 163(1):132–134. <https://doi.org/10.1177/0194599820922992>
- Soler ZM, Patel ZM, Turner JH, Holbrook EH (2020) A primer on viral-associated olfactory loss in the era of COVID-19. *Int Forum Allergy Rhinol* 10(7):814–820. <https://doi.org/10.1002/alar.22578>
- Brann D, Tsukahara T, Weinreb C et al (2020) Non-neuronal expression of SARS-CoV-2 entry genes in the olfactory system suggests mechanisms underlying COVID-19-associated anosmia. *Sci Adv* 6(31):5801
- Kim DH, Kim SW, Hwang SH et al (2017) Prognosis of olfactory dysfunction according to etiology and timing of treatment. *Otolaryngol Head Neck Surg (United States)* 156(2):371–377. <https://doi.org/10.1177/0194599816679952>
- Seo BS, Lee HJ, Mo JH, Lee CH, Rhee CS, Kim JW (2009) Treatment of postviral olfactory loss with glucocorticoids, Ginkgo biloba, and mometasone nasal spray. *Arch Otolaryngol Head Neck Surg* 135(10):1000–1004. <https://doi.org/10.1001/archoto.2009.141>
- Heilmann S, Just T, Göktas Ö, Hauswald B, Hüttenbrink KB, Hummel T (2004) Untersuchung der wirksamkeit von systemischen bzw. topischen kortikoiden und vitamin B bei riechstörungen. *Laryngorhinotologie*. 83(11):729–734
- Shu CH, Lee PL, Shiao AS, Chen KT, Lan MY (2012) Topical corticosteroids applied with a squirt system are more effective than a nasal spray for steroid-dependent olfactory impairment. *Laryngoscope* 122(4):747–750. <https://doi.org/10.1002/lary.23212>
- Hura N, Xie DX, Choby GW et al (2020) Treatment of post-viral olfactory dysfunction: an evidence-based review with recommendations. *Int Forum Allergy Rhinol* 10(9):1065–1086
- Whiteroft KL, Hummel T (2020) Olfactory dysfunction in COVID-19: diagnosis and management. *JAMA J Am Med Assoc* 323(24):2512–2514. <https://doi.org/10.1001/jama.2020.8391>
- Liu JJ, Chan GC, Hecht AS, Storm DR, Davis GE (2014) Nasal saline irrigation has no effect on normal olfaction: a prospective randomized trial. *Int Forum Allergy Rhinol* 4(1):39–42. <https://doi.org/10.1002/alar.21235>
- Yousefi J, Madarshahi H, Akhavan A et al (2018) Effect of ESS on olfactory threshold of patients with CRS without nasal polyps. *Int Tinnitus J* 22(1):89–92. <https://doi.org/10.5935/0946-5448.20180015>
- Liu L, Pan M, Li Y, Tan G, Yang Y (2020) Efficacy of nasal irrigation with hypertonic saline on chronic rhinosinusitis: systematic review and meta-analysis. *Braz J Otorhinolaryngol* 86(5):639–646. <https://doi.org/10.1016/j.bjorl.2020.03.008>

**Publisher’s Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.