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Evaluation of smell and taste in patients with Wegener's granulomatosis

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Abstract Although a reduced olfactory/gustatory function affects patients in all parts of life, this problem has not received much attention in Wegener's granulomatosis (WG). The aim of this study was to assess the smell/taste function of WG patients. Demographic data of 16 WG patients (9 males, 7 females) were obtained. They all subjectively assessed their taste/smell function on visual analogue scale. Olfactory/gustatory functions of the patients were tested with 'Sniffin' Sticks and 'Taste' strips, respectively. The results were then compared with those from sex and age-matched control group ($n = 16$) and normative data. WG patients subjectively assessed their olfactory ($p = 0.03$) and gustatory ($p = 0.02$) function to be lower than control group. All the olfactory scores (odour identification, odour discrimination and threshold) in both genders were significantly below the scores in the control group. WG patients were hyposmic. For taste (total taste score, as well as scores for the qualities sweet, sour, salty and bitter), WG patients did not significantly differ from controls and were normogeusic. However, the gustatory scores showed the tendency of reduction as compared to the control group. In conclusion, WG patients truly suffer from olfactory/taste dysfunction, but this is worse with olfaction. It is, therefore, imperative that physicians should make their patients to be aware of these sensory dysfunctions and educate them on methods to cope with it for better quality of life.

Keywords Taste · Smell · Wegener's granulomatosis

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Introduction

Wegener's granulomatosis (WG) is an autoimmune multisystemic disorder which is characterised by vasculitis of small and medium size vessels and necrotising granulomatous inflammation [1, 2]. It is part of a large group of vasculitis syndrome known by their associated circulating antineutrophil cytoplasmic antibody (ANCA) and an increased tendency to develop thromboembolism [3, 4]. Although any organ in the body may be affected by the disease, it commonly affects upper respiratory tracts (nose, paranasal sinuses and trachea), lower respiratory tracts (lungs) and kidneys. When both lungs and kidneys are affected, it is usually referred to as "classic" or "generalised" WG [1, 5, 6]. However, when the clinical findings are isolated to the upper respiratory tract or the lungs, it is referred to as "limited" WG and the later type occurs in approximately one-fourth of cases [5, 6].

The clinical presentation of the disease depends on the affected organs. More than 80% cases of WG have clinical manifestations involving the head and neck region [7]. This may clinically present as chronic rhinorrhea, epistaxis, nasal ulceration, hearing loss, eye redness, discharge or impairment of vision, oral mucosa ulcer, loosening of teeth and difficulty with breathing [1, 3, 8, 9]. Optic, abducens, and facial nerves have been reportedly affected by WG [10]. The chorda tympani from facial nerve mediate taste in the anterior two-third of the tongue, while the nervus intermedius gives secretory and vasomotor fibres to the mucous membrane of the nose and mouth [11, 12]. It is therefore expected that in cases of WG, taste may be affected. Although the affection of olfactory nerve by WG has never been reported in the literature, chronic rhinosinusitis, nasal ulceration, crusts, scars, granulomatous inflammation and altered nasal mucus due to WG may cause olfactory dysfunction. Impairment in the sense of smell (olfaction) has been shown to cause problems, such as impairment in the detection of smoke in fire [13], ability to identify spoilt food, cooking of good food, reduce appetite and change in mood [14]. Some of these patients lose weight because of the distorted olfactory function while some gain weight because they add more sweeteners like sugar to increase taste sensation hence consuming more calories [15]. Hence, dysfunctions in smell and taste have very important implications on health, this may be life threatening and could also lead to reduction in the quality of life. It is, therefore, the objective of this study to find out if patients with WG truly have impairment of taste and smell function so as to adequately inform them and give advice on how to overcome the deficits.

Patients and methods

Patients

There were 16 patients with confirmed diagnosis of WG that participated in the study. The confirmation of WG disease in these patients was by biopsy for histology which showed chronic granulomatous inflammation and vasculitis. There was also identification of high titre levels of circulating ANCA in the blood sample of the patients. All patients gave written informed consent. The study protocol was approved by the Ethics Committee of the Faculty of Medicine at the Technical University of Munich (Number: 1677/06, Amendment 1). There were 16 healthy volunteers without evidence of WG, rhinologic or renal symptoms in the control group. The participants in the two groups were matched for age and sex.

Subjective assessment

All the participants had initial subjective rating of their appetite and ability to perceive smell and taste on visual analogue scale and the score ranged from 0 to 100 for each of the variables (where 0 meant complete loss of appetite and no perception of smell or taste while 100 meant excellent appetite and excellent perception of smell or taste). A score of 0–20 is very poor, 30–40 is poor, 50–60 is good, 70–80 is very good and 90–100 is excellent. Thereafter, all the participants in both the test and control groups had both olfaction and taste tests carried out on them.

Olfaction or smell testing

Olfaction or smell testing was carried out using the "Sniffin' Sticks". The "Sniffin' Stick" test battery is a validated test recommended by the "Working Group Olfaction and Gustation" of the German Society for Otorhinolaryngology, Head and Neck Surgery for the evaluation of nasal performance [16–18]. It comprises tests for odour identification (ID), odour discrimination (DIS) and odour threshold (THR). Odours were presented in felt-tip pens. The cap was removed and the tip of the pen was positioned approximately 2 cm in front of the patient's nostrils for 3 s. Reports have shown that THR can reflect more on the function of the peripheral olfactory system than tests of odour ID and DIS. ID and DIS required cognitive performance like verbal communication, memory and attention [19, 20].

Odour identification testing (ID)

Sixteen pens already impregnated with 16 familiar different odours were placed close to the nostrils of each patient at different times. The patients were then asked to choose the substance from four different items in a forced-choice procedure that best fits the presented odour (4-alternative forced choices). The number of corrected choice by the patients was then recorded. The minimum point that could be scored by a patient was zero and the maximum score was 16.

Odour discrimination testing (DIS)

The kit contained 48 pens which were arranged in 16 triplets. In each triplet, two of the pens contained the same odour while the third contained another odour. The patient's nose was presented with these three pens and he or she was expected to discriminate and identify the pen with the different odour (3-alternative forced choice). When the patient correctly identified the pen with a different odour, he or she was given a point score and when he or she got it wrong, he or she scored zero. The process was repeated for

the 16 triplets' pens. The minimum point that could be scored by a patient was 0 and the maximum score was 16.

Threshold testing (THR)

The kit contained 48 pens which were arranged in 16 triplets. In each triplet, two of the pens were without odour while the third stick had been impregnated with *n*-butanol solution. However, the 16 pens with odour were impregnated with different concentration of *n*-butanol. The patient's nose was first presented with triplet pens in an increasing fashion from the lowest to the highest concentration of *n*-butanol and then asked to identify the pen with *n*-butanol odour. After the correct recognition of the pen with *n*-butanol odour in a triplet, the triplet pens were then shuffled and represented in a randomised fashion. If he or she was able to correctly recognise the odorised pen in a triplet the second time, a reversal of the staircase was started until he or she could no longer identify the pen which contained the n-butanol. The THR is the mean of the last 4 of 7 staircase reversals. Thus, the value of THR could be 1–16.

Each of these 3 different tests allowed for a maximum score of 16 points and together, a total maximum score of 48 points. The sum of the score or points from THR, ID and DIS is referred to as TDI. THR and DIS tests were carried out when patients' eyes were closed to avoid any visual identification of the pens that contained the odorant. Together, the three tests took approximately 30 min on each participant.

Normative value

To differentiate between normosmic (normal olfactory function) and hyposmic (reduced olfactory function) patients, Hummel et al. [18] defined the values of tenth percentile for 16–35 years old subjects. Thus, a TDI score of 30.5 for women and 29.5 for men, a THR score of 6.5 for women and 6.0 for men, a DIS score of 10 for either women or men and, an ID score of 11 for either women or men were taken as normal values. Scores below these points would be regarded as hyposmia based on Hummel et al. [18].

Gustatory or taste test

This test was carried out with a filter paper taste strips impregnated in four different concentrations of sweet, sour, salty, and bitter taste making up to a total of 16 strips. The concentration is as indicated for sweet taste (0.05, 0.1, 0.2, 0.4 g/ml sucrose), sour taste (0.05, 0.09, 0.165, 0.3 g/ml citric acid), salty taste (0.016, 0.04, 0.1, 0.25 g/ml sodium chloride) and bitter taste (0.0004, 0.0009, 0.0024, 0.006 g/ml quinine hydrochloride) [21]. Each taste strip has two surfaces and each surface was placed differently on the two sides of the dorsal surface of the anterior aspect of the tongue during testing at approximately 1.5 cm from the tip of the tongue. After placing one of these taste strips on the tongue, patients had to identify the taste stimuli and answer in a forced-choice procedure (answers included "sweet", "sour", "salty" and "bitter"). Patients were instructed to keep their tongue protruded during the process of testing. If the patient could not identify the taste presented, he or she scored zero point but if he or she could correctly identify the taste, he or she scored one point. For all the different concentrations of the taste stimuli, the maximum point that could be scored based on presentation of stimuli to one side of the tongue was 16 points, to both sides of the tongue was 32 points. The test on each patient took about 20 min.

Normative value

In terms of the definition of hypogeusia, the tenth percentile from subjects aged between 18 and 40 years was used to separate normogeusic from hypogeusic subjects using bilateral taste strip testing of the tongue [22]. The score of 19 or higher for women and a score of 17 or higher for men (range 0–32) would be regarded as normogeusic based on Landis et al. [22].

Statistical analysis

The data collected were coded, edited, and the statistical analysis was performed using SPSS software (version 16.0, SPSS Inc., Chicago, IL, USA). Data were presented as mean ± standard deviation. To compare patients with normative data, one and two sample *t* tests were used. For subgroup comparisons, the Mann–Whitney and when appropriate, the two sample *t* test were used. To evaluate relations between different measurements, the χ^2 test or the Spearman was used and the Pearson correlation coefficient was calculated. All statistical comparisons were made using a two-sided 0.05 level of significance.

Results

Patient cohort

Sixteen patients with WG were investigated. There were 9 (56.25%) males (ages ranged from 44 to 76 years, mean age of 61 years ± 9.1) and 7 (43.75%) females (ages ranged from 25 to 70 years, mean age of 54.4 years ± 15.6). Only 5 (31.25%) WG patients had renal involvement showing generalised disease. One WG patient had associated skin and skeletal problems. The duration of the disease ranged

from 0.5 to 22 years, with mean duration of 7.9 years ± 6.9. The last period of the disease exacerbation to the time of the study ranged from 0.5 to 60 months, with mean of 12.1 ± 15.7 months. Septal perforation was in 10 (62.5%) patients and 8 (50%) patients had previous history of sinonasal surgeries of which 75% had associated septoplasty. All patients had nasal endoscopy to confirm no crust within the nasal cavities before testing. The medications received by the patients included low dose cortisone ($n = 13$), methotrexate ($n = 4$), azamedac ($n = 1$), cotrimoxazole ($n = 4$), mycophenolate ($n = 2$), cyclophosphamide ($n = 4$), azathioprine ($n = 3$), aspirin 100 mg ($n = 2$) and ACE inhibitors ($n = 2$). There was no history of smoking and alcohol consumption in any of them. None of the patients had relevant co-morbidities influencing taste and smell, such as hyperactivity or hypoactivity of the thyroid gland, diabetes, or neurological disorders. The body mass index (BMI) for the male patients ranged from 18.8 to 36.4 m^2/kg, with mean BMI of 27.5 ± 6.0 m^2/kg, while that of female patients ranged from 22.6 to 37.9 m^2/kg, with mean BMI of 30.0 ± 5.7 m^2/kg.

For the control group, there were 9 males (ages ranged from 42 to 74 years, mean age of 56.8 ± 10.2 years) and 7 females (ages ranged from 26 to 66 years, mean age of 51.3 ± 14.2 years). The body mass index (BMI) for the male controls ranged from 24.8 to 35.2 m^2/kg, with mean BMI of 28.2 ± 4.2 m^2/kg, while that of female controls ranged from 22.7 to 28.3 m^2/kg, with mean BMI of 26.0 ± 2.9 m^2/kg.

Subjective assessment of smell and taste of WG patients

On a visual analogue scale (VAS) from 0 to 100, WG patients rated their subjective olfactory function to be from 0 to 100, with mean of 65.7 ± 36.8 and their gustatory function to be from 0 to 100, with mean of 67.2 ± 30.0. The comparison of the subjective assessment in WG patients with those participants in the control group (smell: mean of 83.8 ± 10.4; taste: mean of 83.5 ± 10.4 as well as median) can be seen in Fig. 1. There was a significant difference in subjective assessment of olfaction ($p = 0.03$) and taste ($p = 0.02$) between the two groups. In addition, WG patients rated their appetite to be 52–100, with mean of 90.5 ± 13.4 and median of 97. On a scale from 0 (none) to 100 (high), patients rated the frequency of parosmia as 6.8 ± 17.1 (range 0–66, median 0), phantosmia as 0.5 ± 2.0 (range 0–8, median 0), desire to add more sweetener like sugar to meals as 11 ± 20.5 (range 0–70, median 0), desire to use more salt as 5.0 ± 7.0 (range 0–20, median 0), preference for fatty meals as 22.5 ± 31.0 (range 0–95, median 7.5), preference for bitter meals as 10.6 ± 25.3 (range 0–100, median 0) and reduction in saliva as 4.6 ± 9.5 (range 0–27, median 0).

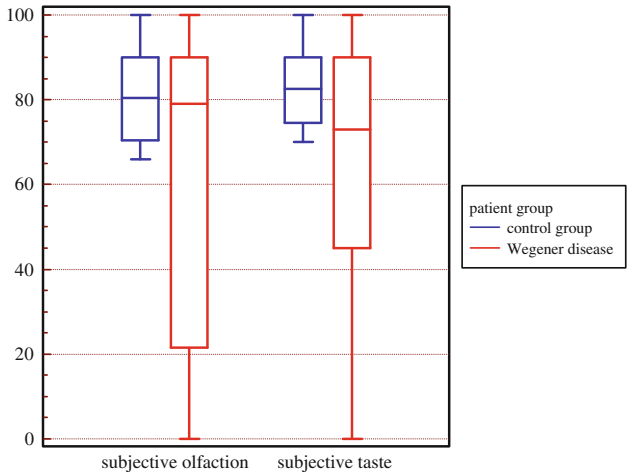

Fig. 1 Comparison of subjective olfaction and taste between WG patients and control group

Table 1 Comparison of olfactory and taste function (right side of tongue) between WG patients and control group

Variable	Wegener disease	Control group	p	Percentage difference
Age	58.1 ± 12.4	54.1 ± 12.8	0.38	
Identification	10.3 ± 4.8	13.6 ± 1.4	0.013	24.3 ± 11.3
Discrimination	8.3 ± 3.6	13.1 ± 2.2	0.0001	36.6 ± 15.8
Threshold	4.2 ± 3.1	7.4 ± 1.9	0.001	43.2 ± 31.9
TDI	22.9 ± 10.2	32.7 ± 4.6	0.009	29.9 ± 13.3
Sweet	3.0 ± 1.0	3.3 ± 0.8	0.37	9.1 ± 6.1
Sour	2.0 ± 1.3	2.5 ± 1.0	0.27	20.0 ± 12.0
Salty	2.6 ± 1.0	3.2 ± 0.7	0.10	18.8 ± 9.4
Bitter	2.2 ± 1.3	2.6 ± 1.1	0.35	15.4 ± 7.7
Total	10.0 ± 3.0	11.7 ± 2.8	0.10	14.5 ± 1.7
Subjective olfaction	65.7 ± 36.8	83.8 ± 10.4	0.03	26.5 ± 34.4
Subjective taste	67.2 ± 30.0	83.5 ± 10.4	0.02	24.6 ± 37.5

Olfactory or smell test of WG patients compared with normative data (10th percentile) and control group

All the olfactory scores (ID, DIS, THR and TDI) in both males and females with WG (Table 1) were below the scores of the 10th percentile for 16 to 35-year-old subjects defined by Hummel et al. [18], thus demonstrated that the patients were hyposmic.

In addition, these scores (ID, DIS, THR and TDI) were significantly lower than those of the sex- and age-matched participants in control group (Table 1; Fig. 2). Looking at the percentage (%) difference between WG patients and control group, THR was much more affected and reduced than DIS and ID (Table 1).

There was no significant difference in the olfactory function between patients with and without generalised disease

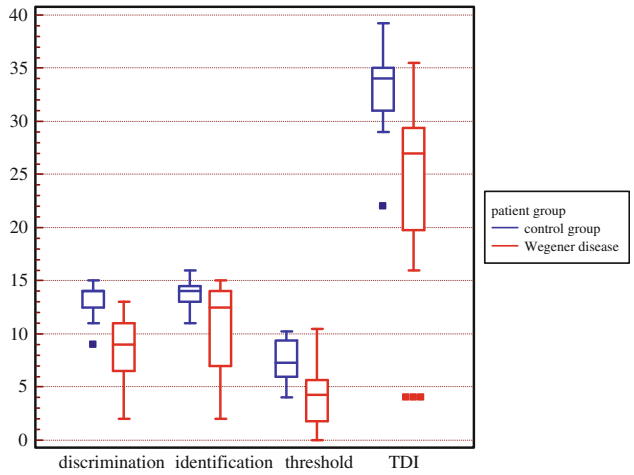

Fig. 2 Comparison of olfactory function between Wegener disease patients and control group

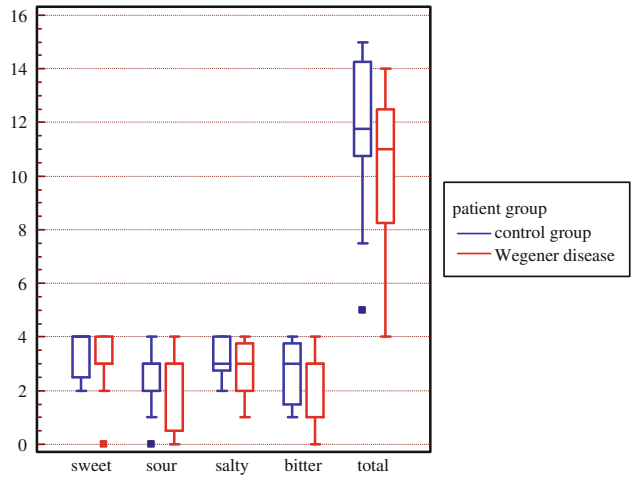

Fig. 3 Comparison of taste function between Wegener disease patients and control group

[ID ($p = 0.91$); DIS ($p = 0.09$); THR ($p = 0.73$); TDI ($p = 0.34$)]. There was no correlation between olfactory function and duration of the WG [ID ($p = 0.18$, $r = 0.35$); DIS ($p = 0.18$, $r = 0.35$); THR ($p = 0.10$, $r = 0.42$); and TDI ($p = 0.10$, $r = 0.42$)]. There was also no correlation between olfactory function and duration of last exacerbation of the disease [ID ($p = 0.17$, $r = 0.35$); DIS ($p = 0.69$, $r = 0.10$); THR ($p = 0.58$, $r = 0.39$); and TDI ($p = 0.36$, $r = 0.24$)]. However, there was a significant correlation between subjective assessed olfactory function and the scores of "Sniffin' sticks" test in ID ($p = 0.0001$, $r = 0.83$) and TDI ($p = 0.0039$, $r = 0.68$) tests, but not in THR ($p = 0.13$, $r = 0.39$) and DIS ($p = 0.056$, $r = 0.48$) tests. There was no significant difference in the olfactory function of WG patients who had septal perforation and those without septal perforation [ID ($p = 0.59$); DIS ($p = 0.43$); THR ($p = 0.55$); TDI ($p = 0.92$)]. There was also no significant difference in olfactory function of WG patients who had nasal surgeries and those without nasal surgeries [ID ($p = 0.22$); DIS ($p = 0.95$); THR ($p = 0.62$); TDI ($p = 0.92$)].

Gustatory or taste test of WG patients compared with normative data (10th percentile) and control group

The total taste score for men and women with WG were not below the scores of the 10th percentile for 18 to 40-year-old subjects defined by Landis et al. [22], thus demonstrating that the patients are normogeusic.

In addition, there were no significant differences between the scores of total taste, sweet, sour, salty and bitter in WG patients and those of the sex and age-matched participants in control group (Table 1). However, WG patients showed the tendency to have lower scores in total taste and in the qualities of sweet, sour, salty and bitter sensation (Table 1; Fig. 3). Looking at the percentage difference between WG patients and control group, sour, salty and bitter function were assumed to be affected the most (Table 1).

There was no significant difference in the total taste score between patients with and without generalised disease ($p = 0.09$). There was no correlation between duration of disease and total taste score ($p = 0.75$, $r = 0.08$). There was also no correlation between total taste score and duration of last exacerbation of the disease ($p = 0.78$, $r = 0.07$). There was also no correlation between subjective assessed taste function and the results of the taste strip test [salty ($p = 0.82$, $r = 0.06$); sour ($p = 0.61$, 0.14); bitter ($p = 0.36$, $r = 0.25$) and sweet ($p = 0.37$, $r = 0.25$)].

Discussion

This present study clearly showed that WG patients were hyposmic with reduced olfactory function in odour identification, odour discrimination, and odour threshold compared to the sex and age-matched healthy control group. Although the WG patients were normogeusic, they showed tendency to develop reduced gustatory functions in total taste and taste qualities of sour, salty and bitter sensation more than the participants in the control group.

Subjective assessment of olfaction and taste results showed that the patients were aware of their diminished chemosensory functions. However, they subjectively rated the loss of smell and taste to be similar. Taste sensation consists of the qualities sweet, sour, salty, and bitter. It has been shown that all odours in food are smelled especially through the retronasal passage and 80% of the food information is smelled [23]. Patients are often unaware of this fact and think that they have taste disorder when they actually suffer from an olfactory disorder.

Surprisingly in this study, WG patients rated their subjective appetite as very good. Looking at the BMI of the WG patients, they showed, on the average, overweight. Olfactory dysfunction has influence on dietary behaviour of an individual. Weight gain has been reported in some patients suffering from a distorted olfactory function because they usually add a lot of sugar/sweeteners to their meal [15], use more salt, garlic and spices [24] to compensate for the loss of olfaction by increasing taste or trigeminal chemosensory sensation, thus increasing the risk of developing overweight, high blood pressure or diabetes. In the subjective assessment by WG patients in this study, they preferred to eat more fatty, sweet, and bitter meals. On the other hand, some patients suffering from a reduced olfactory function have been shown to develop weight loss due to loss of appetite. They have no pleasure for food because they do not enjoy meals. Cooking and differentiating spoilt or burnt food from good food is really a problem with them [14]. They are socially isolated and easily develop mood changes, unable to smell themselves (hygiene), fire and gas which might be life threatening [13, 14]. Therefore, WG patients must be informed and aware of their reduced olfaction for improved quality of life and safety. Quality of life might be improved using small amounts of additional flavours [25, 26] or glutamate [27, 28], which has to be investigated in future.

Although a reduced olfactory and gustatory function affects patients in all parts of life, this problem has not received much attention in WG patients. To the best of our knowledge, there were only two published prospective studies in which taste and smell have been investigated in WG patients. Göktas et al. [29] tested smell and taste in nine WG patients with "Sniffin' Sticks" and "taste strips". They did not include control group, thus compared the individual test result (TDI) of the patients with normative data from Hummel et al. [18]. They identified one WG patient to be anosmic, four to be hyposmic and four to be normosmic. Laudien et al. [30] also investigated olfaction in WG patients, but only tested their odour identification and reported lower odour ID score in 18% of the patients. However, this present study clearly demonstrated that ID, DIS, THR and TDI scores were significantly lower in WG patients as compared to sex and age-matched participants in the control group and that the WG patients were hyposmic. In this present study, all the subtest results of "Sniffin' Sticks" test battery were significantly diminished as compared to the scores in control group and normative data of Hummel et al. [18]. However, THR was affected the most. Although THR was mostly affected, the diminished scores of ID significantly correlated to the subjective assessment of smell in WG patients thereby identifying the measurement of ID as a useful tool.

Göktas et al. [29] also compared the individual total taste score with normative data from Landis et al. [22] and demonstrated pathological taste strip results in five WG patients (55%) and normal results in three patients (33%). This present study investigated a higher number of WG patients than in the study by Göktas et al. [29]. In addition, in the present study, scores of total taste, as well as the taste qualities of sweet, sour, salty, and bitter sensation were compared with control group. Although the scores from WG patients were within normal values as described by Landis et al. [22], lower scores in WG patients were relatively observed than the scores in the control group.

There are different mechanisms that could explain the distorted olfactory function. The direct effect of WG on olfactory cranial nerve, granulomas around the nerve or olfactory neuritis secondary to vasculitis of the small vessels around it is one mechanism [10]. Another possible cause which had been reported was chronic inflammation of the nasal mucosa which spreads directly to affect the olfactory receptor cells. Assuming that THR reflects the function of the peripheral olfactory system to a higher degree than other olfactory test for example ID or DIS test [19, 20] this would be in line with the result that THR was affected more than ID and DIS in this study. However, ID and DIS tests were significantly reduced as well in our patients even to a lower amount than THR. In addition, renal insufficiency has been shown to alter olfactory function [31–34]. Although 31.25% of the patients in this study had renal involvement by WG (classical WG), there was no significant difference in smell and taste function when compared with those without renal affectation. Surgical operations in the nose have been demonstrated to alter olfactory function [35]. In this study, WG patients with and without past history of sinonasal operation were compared and there were no significant differences in smell and taste sensation. There was also no difference between patients with and without septal perforation. Olfactory receptor cells are located at the roof of nasal cavity or olfactory cleft, middle turbinate and upper nasal septum [36, 37]. Mostly olfactory receptor cells are not affected by septum perforations. However, the nasal air flow can be changed by septum perforations, thus altering the flow of air and odour molecules into the olfactory cleft.

Furthermore, studies have shown that drug-induced taste and olfactory dysfunctions are possible [38] and all the patients in this study were on medication. Unfortunately, the sample size of the patients was too low to compare different sub-groups with different medications. In the literature, taste is reportedly more affected than olfaction by medications. This present study showed taste scores to be lower in WG patients than the control group, but was normogeusic, suggesting no significant effect of medication on taste by WG. Recently, the effects of biologics,

TNF-alpha-inhibitor or methotrexate on taste and smell were investigated in patients suffering from rheumatoid arthritis and no significant differences in smell and taste between users and non-users of these medications were found [39]. The study however showed that low-dose cortisone in rheumatoid arthritis significantly affects THR and TDI, but not ID and DIS. Low-dose cortisone has been shown to probably reduce the peripheral olfactory function. However, high dose cortisone is used to treat olfactory disorders [40]. In this study, majority of the WG patients were treated with low dose cortisone and they had a significant reduction not only in THR score, but also in ID and DIS scores. This showed that the diminished olfactory function in these patients might not have been triggered by the cortisone, but the disease.

The tendency of reduced total taste score as well as a reduction of the scores for the qualities sour, salty, and bitter even though not significant could suggest that WG itself might affect the sense of taste directly. More WG patients must be investigated to answer this question. However, Landis et al. [41] have described that an acquired olfactory impairment is associated with decreased taste function. This can explain that the WG patients are normosmic with the tendency of reduced taste sensation.

In conclusion, WG patients are hyposmic and normogeusic. However, they showed the tendency of a diminished total taste score as well as reduced taste qualities of sour, salty and bitter. It is, therefore, imperative that physicians should make their patients to be aware of these sensory dysfunctions caused by their disease which may be life threatening and thus improve quality of life.

Conflict of interest None.

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