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ORIGINAL ARTICLE

Halitosis in Oral and Maxillofacial Surgery Patients - a Pilot Study

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SUMMARY

Background: **Halitosis is a relatively inhomogeneous pathology with an extremely high prevalence in the population. Potential risk factors for bad breath include bacterial decomposition of organic material as well as numerous general and systemic diseases. The aim of the present study was to analyze whether certain subgroups of oral and maxillofacial surgery patients have a higher risk of halitosis. Further the impact of halitosis on the patient's quality of life was ascertained.**
Methods: **A total of 127 oral and maxillofacial patients aged between 19 and 86 years were enrolled in this study. On account of their underlining disease, patients were divided into five different investigation groups. The dental examination comprised tongue coating, periodontal screening index (PSI), gingival index (GI), PI (plaque index), DMF-T values as well as non-stimulated saliva flow rates. Halitosis was monitored both organoleptically according to Rosenberg and instrumentally by means of a Halimeter®, which records the volatile sulfur compounds (VSC values in ppm). Patients were further asked to fill out questionnaires regarding their medical history and oral hygiene, oral health (OHIP-14), and quality of life (BDI-II).**
Results: **Halitosis values, which were recorded by a Halimeter® correlated with the objective Rosenberg golden standard method. Furthermore, halitosis values correlated with elevated PSI, GI, and DMF-T values as well as the degree of tongue coating. Patients with oral cancer showed significantly higher VSC values compared to all other groups. No difference in VSC values could be found between all other patient groups.**
Conclusions: **The Halimeter® could be validated as a suitable method for determining halitosis in oral and maxillofacial patients. The significantly increased halitosis values in cancer patients as opposed to all other patient groups suggests the potential of halitosis VSC values as a potential screening method. The development of non-invasive breath tests for diagnosis could be subject of future research.**
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KEY WORDS

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INTRODUCTION

Due to its high prevalence in the population, halitosis has great social impact since it can sustainably influence interpersonal relationships [1]. Approximately 25% of the western industrialized population temporarily suffer

from bad breath and 6% are permanently haunted by oral malodor. The social stigmatization which goes along with this clinical picture is notoriously strong [2]. With a prevalence of 21%, men have a three-fold higher life time risk of contracting halitosis than women with 9%. Elevated age further goes along with bad breath [3]. In literature, several synonyms are suggested for the description of halitosis e.g., „foetor ex ore", „bad breath", and „oral malodor". While foetor ex ore describes bad breath which originates from the oral cavity itself, halitosis also includes malodor of other sources e.g., the gastrointestinal tract. Bacterial decomposition leads to the production of volatile sulfur compounds (VSC) which represent major components of bad breath [1,4-8]. Those sulfur-containing compounds are hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), and dimethyl sulfide ($[CH_3]_2S$) [9]. Substances such as indole, skatole, cadaverine, putrescine, and short-chain fatty acids are further noted [10].

Lesions within the oral cavity e.g., a coated tongue, periodontitis, carious lesions, and insufficient oral hygiene are considered to be the most relevant sources of bad breath. However, diabetes mellitus, reflux, tonsil stones, liver, or kidney failure as well as the intake of medication are also described [2,5,8].

Recent literature suggests an interconnection of specific volatile organic compounds (VOCs) and different cancer types such as lung, breast, rectum, ovarian, prostate, and bladder cancer [11]. Due to their distinct pattern of VOCs, trained dogs are able to discriminate melanoma lesions from healthy skin, only by scent [12]. Further, associations between bad breath and different types of head, neck and respiratory cancers are discussed, making the development of devices for the diagnosis of different types of diseases a matter of current research [13-15].

While ongoing research is promising and Halimeters® are still frequently used, the organoleptic diagnosis, which was established by Rosenberg et al., is still considered to be the gold standard investigation technique [7,16,17].

Since halitosis is known to be a precursor of a large number of pathological findings of intraoral or systemic nature [2,6], the aim of the present study was to screen patients hospitalized in the Department for Oral and Maxillofacial Surgery by means of subjective and objective halitosis testing systems to evaluate if there were any differences between the diseases. A comprehensive intraoral examination was conducted in order to rule out other possible intraoral causes.

MATERIALS AND METHODS

After approval by the ethics committee of Rhineland-Palatinate, Mainz, Germany (No. 837.348.15 (10116)), 127 patients of the Department of Oral and Maxillofacial Surgery, were enrolled in this study. All patients gave oral and written consent to participate in this study. Depending on their underlining diseases, the patients were assigned to one of five subgroups: Group 1 = malignant tumors (n = 44; 34.6%), Group 2 = inflammation (n = 24; 19.7%), Group 3 = oral mucosa abnormalities (n = 21; 16.5%), Group 4 = trauma/dysgnathia (n = 23, 18.1%), and Group 5 = odontogenic lesions (n = 14; 11%). All patients were investigated within the scope of ambulatory recall appointments, with the exception of the malignant tumor patients who were screened either within their post-operative recall appointments or on the day prior to surgery. All patients received an oral examination which included the periodontal screening index (PSI) with codes from 0 - 4 depending on the pocket depth, calculus and bleeding on probing; Plaque Index (PI) with values from 0 = no plaque to 3 = abundance of soft matter; Gingival Index (GI) which scores the degree of gingival inflammation on a scale from 0 = normal gingiva to 3 = severe inflammation; DMF-T index, which asseses the number of decayed, missing, and filled teeth, as well as tongue coating according to Miyazaki [7,18]. Additionally, stimulated and unstimulated saliva flow were analyzed using the spitting-method established by Navazesh [19, 20]. Halitosis was evaluated organoleptically according to Rosenberg. Each participant's breath was assessed by the same standardized examiner from a distance of 10 cm. The degree of odor was subsequently rated on a scale from 0 (no noticeable odor) to 5 (extreme foul odor) [24,25]. Instrumental evaluation of halitosis was conducted by means of a Halimeter® (Interscan ANSYCO, GmbH), which records the volatile sulfur compounds (VSC values in ppm). Mean values were then ranked from 0 - 2 (< 100 ppm = 0, no halitosis; 100 - 150 ppm = 1, mild halitosis; > 150 ppm = 2, severe halitosis). Furthermore, participants were asked to fill out questionnaires regarding their oral, general, and mental health. The OHIP-G14 questionnaire is an abbreviated version of the oral health impact profile in German language, comprising 14 questions about the oral health associated quality of life [21,22]. The BDI-II questionnaire allows an assessment of mental health based on each participant's self-perception regarding their general well-being [23]. A third questionnaire addressed oral hygiene habits as well as the degree of personally experienced halitosis.

Statistical analysis

The collected data was statistically analyzed using IBM SPSS 22.0 for Windows XP (IBM SPSS Statistics for Windows; IBM Corp, Armonk, NY, USA). A significance level of 0.05 was set. All p-values are two-sided. For solely metric data correlation, the coefficient r according to Pearson-Bravais was used whereas Spearman-Rho was used for the Kendall-Tau-tests performed to analyze correlations between ordinal or ordinal and metric data. Linear regression analysis was used for expressing correlations between measured VSC values and clinical data. Subgroups were compared by means of Kruskal-Wallis-Test.

Table 1. Overview of the intraoral parameters (PSI, GI, PI, and DMF-T-values) as well as the halitosis values (organoleptic and VSC) in the different investigation groups.

Group	1 Malignant tumors	2 Inflammation	3 Oral mucosal abnormalities	4 Trauma/dysgnathia	5 Odontogenic lesions
n	44	24	21	23	14
Female/Male	17/27	12/13	16/5	11/12	7/7
Organoleptic (Rosenberg: 0 - 5)	1.4	1.2	1.2	0.8	1.2
VSC (ppm)	111.6	85.1	69.7	69.4	69.7
PSI (0 - 4)	2.2	1.59	2.38	2	2.1
PI (0 - 3)	0.99	0.69	0.61	0.82	1.22
GI (0 - 3)	0.92	4.7	5.9	5.4	1.3
DMF-T	18.34	14.5	17.95	21.7	22.5

RESULTS

From February 2016 to March 2017, 127 patients of the Department of Oral- and Maxillofacial Surgery participated in this study. Patients' mean age was 56.7 years with a distribution of 49.6% (n = 63) female and 50.4% (n = 64) male. The collective was further subdivided according to underlying diseases into: Group 1 = malignant tumors (n = 44; 34.6%), Group 2 = inflammation (n = 24; 19.7%), Group 3 = oral mucosa abnormalities (n = 21; 16.5%), Group 4 = trauma/dysgnathia (n = 23; 18.1%), and Group 5 = odontogenic lesions (n = 14; 11%) (Table 1).

Organoleptically measured halitosis could be detected in 8.7% of all patients, with the highest values present in Group 1 and lowest in Group 4. In 68.2% of Group 1, a very mild to mild odor could be observed, whereas 20.45% were diagnosed with no halitosis and 11.4% with a moderate to strong degree of halitosis. Thus 45.45% of all patients with Rosenberg scores of 3 and 4 (= moderate and strong odor) were part of the malignant tumor group. Instrumental examination by means of a Halimeter® showed the presence of halitosis (> 100 ppm) in 19.7% overall. In Group 1 a total of 36.46% were diagnosed with halitosis, followed by Group 3 with 14.3% and Group 2 with 12.0%. Only 8.7% in Group 4 and 7.1% in Group 5 showed a VSC concentration above 100 ppm. With regard to statistical analysis VSC concentrations in Group 1 (mean value = 104 ppm) were significantly higher compared to all other groups ($p < 0.001$). As opposed to Group 1 there was no significant difference between the remaining groups ($p = 0.698$) (Figure 1). Comparing both, organoleptic evaluation of halitosis according to Rosenberg and instrumental measurement of VSC values by means of a Halimeter®, a significant correlation between elevated VSC values and organoleptic ratings could be detected ($r = 0.549$; $p > 0.001$). For the assessment of the periodontal situation, PSI, GI, and PI values were measured (Figure 2). Elevated PSI values (Kendall-tau; $p = 0.006$) as well as GI (Kendall-tau; $p = 0.003$) correlated significantly with the presence of organoleptically measured halitosis. High PI values were further associated with augmented halitosis values; however, this was not significant ($p = 0.26$). Furthermore, the degree of tongue coating ($r = 0.294$; $p < 0.001$) correlated significantly with organoleptically measured halitosis. Significant differences with regard to stimulated ($p = 0.019$) and unstimulated saliva flow rate ($p = 0.024$) could be found between the investigated groups. Comparing all collectives, the highest values of stimulated saliva flow occurred in Group 1 (malignant tumors) (M = 2.06 mL/min; SD = 1.71), followed by Group 2 (inflammation) (M = 1.50 mL/min; SD = 0.97), and Group 3 (oral mucosa abnormalities) (M = 1.27 mL/min; SD = 0.94). Lowest values were surveyed in Group 5 (odontogenic lesions) (M = 0.99 mL/min; SD = 0.81) and Group 4 (trauma/dysgnathia) (M = 0.97 mL/min; SD = 0.97). Regarding unstimulated saliva flow Group 2 showed the highest mean value of 0.75 mL/min (SD = 0.71) and Group 5 the lowest with a mean rate of 0.314 mL/min (SD = 0.37). However, the degree of saliva flow both unstimulated and stimulated had no significant influence on halitosis values whatsoever. Likewise, inverse correlations could be found between DMF-T values and self-perceived halitosis (Spearman-Rho; $r = -0.239$; $p = 0.001$). Cigarette consumption had no significant impact on halitosis, since differences between smokers and non-smokers could not be observed on VSC concentrations. Regarding the psychological questionnaires, both OHIP-G14 and BDI-II scores could not be associated with elevated halitosis values. With regard to self-perceived halitosis, 32.28% of all subjects stated to be affected by halitosis with again the highest occurrence in Group 1 (12.60%) (Figure 3).

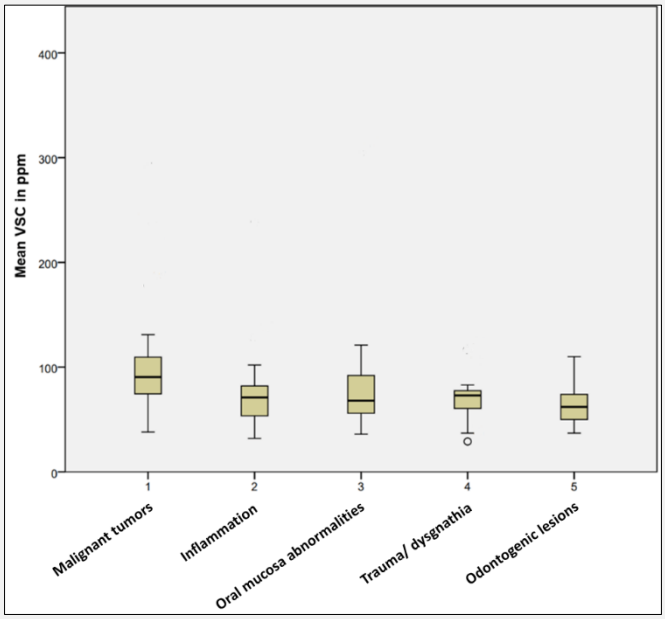

Figure 1. Mean volatile sulfur compounds (VSC) halitosis values (ppm) in the five investigation groups.

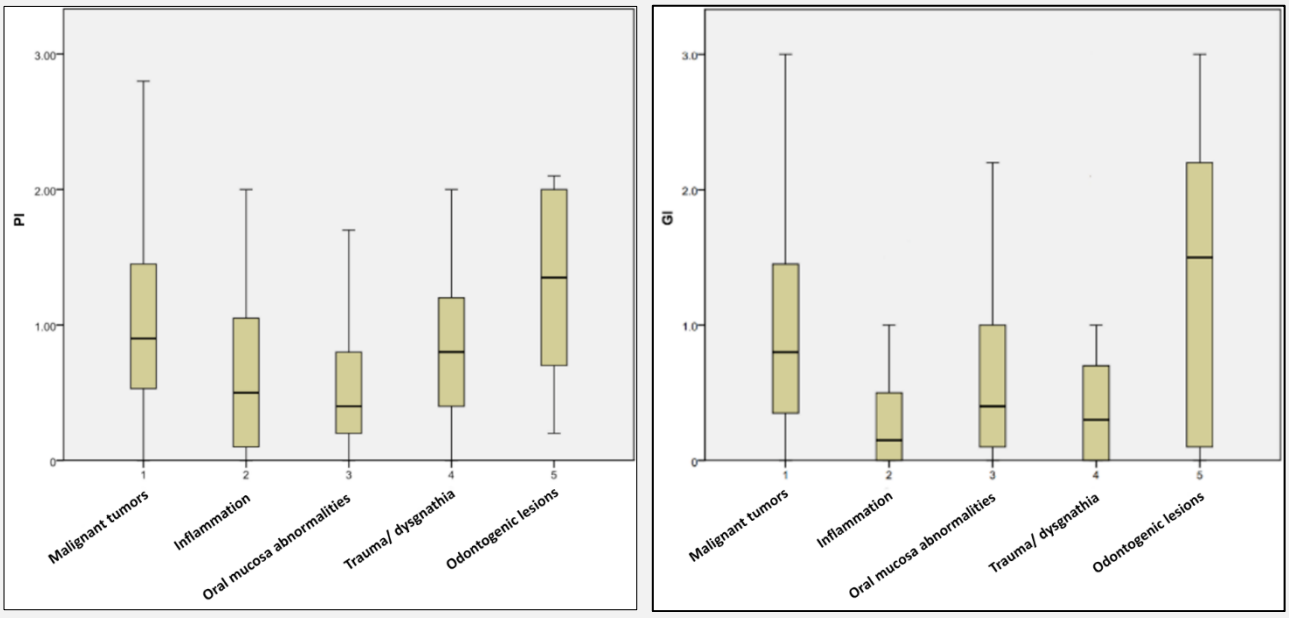

Figure 2. Overview of the periodontal parameters PI (Plaque Index) and GI (Gingival Index) in the five different investigation groups.

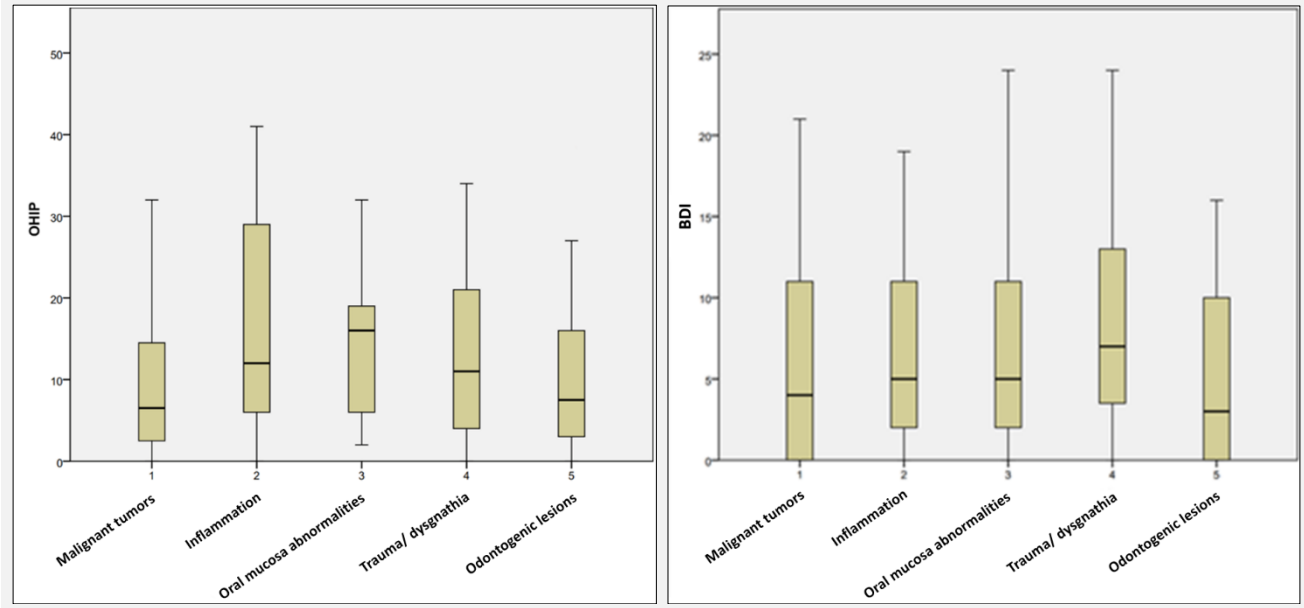

Figure 3. Results of the psychological questionnaires (OHIP and BDI) in the different investigation groups.

DISCUSSION

In literature foetor ex ore is described as bad breath specifically originating from the oral cavity, while halitosis is classified as oral malodor associated with a plethora of underlying systemic diseases. Since the etiology of bad breath is multifactorial, the discrimination between both foetor ex ore and halitosis is clinically challenging. The present study examined the degree of halitosis in systemically healthy patients hospitalized for primarily intraoral pathologies such as trauma, malignant tumors, intraoral inflammation and odontogenic foci to see if there were any quantitative differences. When comparing the different subgroups, patients with malignant tumors (Group 1) showed significantly higher VSC-concentrations ($p < 0.001$) and organoleptically measured halitosis values as opposed to all other groups. This observation is interesting since it suggests a correlation between oral cancer and halitosis. However, the limitation of this study is that cancer patients were either investigated prior to surgery or during the recall appointments which are part of post-operative care. Interestingly, both groups showed highly increased VSC-concentrations. The elevated halitosis values of patients prior to surgery go along with the study of Bouza et al. who found an alternate composition of exhaled breath and oral cavity VOCs in patients with oral cancer by means of gas chromatography, investigating biomarkers for non-invasive cancer diagnostic [39]. The fact that the recall patients showed equally elevated levels of oral malodor might be explained by accompanying morbidities such as radiation caries, xerostomia, and individual lifestyle (smoking, elevated alcohol consumption). In contrast to Group 1, no significant difference with respect to measured halitosis levels between the remaining groups could be established ($p = 0.698$) implying that oral inflammation, oral mucosa abnormalities, trauma/dysgnathia, and odontogenic lesions seem to contribute in an equal way to VSC values. The mean values of group 2 to 5 were comparable with ratings observed in a control group of patients without halitosis by Ye et al. (75.00 ppm ± 60.62) [38]. This conclusion needs to be put into perspective since other alterations in the oral cavity might blur potential differences between the analyzed diseases. Previous studies demonstrated that tongue coating can be considered a main factor for halitosis since its rough surface texture provides an ideal environment for sulfur producing bacteria [29,30]. The present study confirmed a significant correlation between tongue coating and organoleptic perception of halitosis ($r = 0.254$, $p = 0.001$), but no significant association with measured VSC concentrations. Oral microbiota and their contribution to volatile compounds, such as VSC values are described as main factors for intraoral halitosis [29] and might be of importance with periodontal diseases [9]. PSI (Kendall-tau; $p = 0.006$) and GI (Kendall-tau; $p = 0.003$) were significantly associated with elevated levels of halitosis in the present study. A high saliva flow rate might eliminate some of the compounds being responsible for halitosis. Significant

differences with regard to stimulated (p = 0.019) and unstimulated saliva flow rate (p = 0.024) could be found between the investigated groups. In Group 2 (Inflammation) the highest unstimulated saliva flow rates were observed, possibly suggesting hypersalivation as reaction to inflammatory processes in the oral cavity. However, neither stimulated nor unstimulated rates correlated significantly with increased halitosis ratings as opposed to Suzuki et al., whose study showed a significant correlation between decreased resting saliva flow and oral malodor [40]. With regard to halitosis occurrence, organoleptically evaluated halitosis could be detected in 8.7%, whereas instrumental examination by means of Halimeter® showed the presence of halitosis (> 100 ppm) in 19.7% of all patients, thus it appears that the instrumental evaluation can be considered more sensitive than the subjective approach performed by a beforehand calibrated examiner. Still, the Halimeter® detects only a quite specific spectrum of odor, primarily recording sulfur compounds (hydrogen sulfide, methyl mercaptan, dimethyl sulfide) and is therefore not able to detect organic compounds such as short chain fatty acids, cadaverines, skatoles, putrescine as well as tinidazole, which are primarily associated with neoplasms [25,28]. When comparing with other studies using instrumental evaluation by means of Halimeter® it must be taken into account, that no uniform reference value has been defined so far. Cutoff values for VSC-concentrations in literature vary from 75 ppm [7,26] to 110 ppm [27]. For the present study values > 100 ppm were rated as perceptible halitosis. There is evidence of quantitative halitosis changes in patients with inflammatory bowel disease [34] or liver disease [35]. For some diseases a distinctive smell has been described such as a sweet acetone-like odor in patients with uncontrolled diabetes mellitus [36] or a fishy ammonia smell accompanying renal failure [28,37]. While each systemic disease is linked to a unique spectrum of odor, the differentiation of foetor ex ore to individual intraoral lesions is not yet defined. This will be the next step for a further study to analyze if there are qualitative changes between the tested diseases. Several studies suggest a psychological component to halitosis perception using questionnaires such as the SCL-90 score, the CMI health questionnaire as well as Hospital Anxiety and Depression Scale (HADS) [31-33]. A high SCL-90 score (Symptom Checklist-90), which assesses the self-perceived psychological stress, correlated significantly with the presence of halitosis [33]. The perception of halitosis seems to be associated with psychological conditions such as depression, anxiety, and sensitivity [32]. In the present study, the psychological assessment by means of OHIP and the DBI-II showed no relationship to halitosis, depression, and oral health-associated quality of life, indicating a seemingly limited validity of those questionnaires for enquiring about halitosis-related mental health issues. Another factor might be that the patients being analyzed had more severe acute problems affecting the quality of life.

CONCLUSION

With several instruments and methods as subject of ongoing research regarding non-invasive diagnosis the Halimeter® is an applicable instrument for evaluating halitosis in oral and maxillofacial patients. Since tumor patients display significantly increased VSC levels, halitosis measurement might be a potential screening method. Further studies need to address differences in tumor sizes and the development regarding the perception of certain volatile compounds that might make breath analysis more specific and suitable for non-invasive tumor diagnosis.

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Declaration of Interest:
The authors declare no conflict of interest.

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