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The Relationship between both Partial and Complete Denture Wearers and the Presence of Oral Malodour and the Effect of Denture Cleansers on the Oral Microbiota

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Abstract

Oral malodour may be considered a substantial concern for a sizeable percentage of the general population and as such it is important for clinicians to identify the causes of oral malodour, to treat the problem effectively.

Aim: The aim of the present study was therefore to review the published literature on the presence and perception of oral malodour (halitosis) in patients wearing both removable partial or complete dentures and the effect of denture cleansers on the oral microbiota.

Materials & Methods: A comprehensive electronic search of databases such as PUBMED, Cochrane, Google Scholar, EmBase and Web of Science was performed up to February 2016.

Results: 55 potentially relevant reports were identified with six studies included in the review. Of the six included papers, only one study was randomised, and five studies were either non-randomised controlled clinical trials or, quasi randomised trials. The results from these studies would suggest that there was an indirect association between the presence and perception of oral malodour in both RPD and complete denture wearing patients.

Conclusions: The strength of evidence was however insufficient to draw any definitive conclusions on a potential correlation of oral malodour in patients with RPDs.

Keywords: Oral malodour; Denture wearers; Oral microbiota; Denture cleansers; Review

Abbreviations: RPDs: Removable Partial Dentures; RCT: Randomised Clinical Trials VSCs: Volatile Sulfur Compounds; LPS: Lipopolysaccharide; OT: Organoleptic Testing; SRD: Slow-Releasing Dosage; CHX: Coating of Chlorhexidine; PI: Plaque Index; PE: Periogard; CE: Cepacol; CT: Corega Tabs; MI: Medical Interporous; P: Polident; DW: distilled water; DD: Degu Dent; DR: Gingival Recession; TM: Tooth Mobility; PD: Probing Depth; GI: Gingival Index; CI: Calculus Index

Introduction

Halitosis is a generic term to describe an odour that is "definitely not pleasant, deriving from the breath of an individual." Synonyms of halitosis frequently encountered in the published literature include fetor ex ore, fetor oris and stomatodysodia [1]. Several published studies have suggested that at least 30% to 50% of the public suffer from halitosis [2-3] although a recent consensus review reported that the condition may be underestimated in dental practice [4]. Oral malodour may therefore be considered a substantial concern for a sizeable percentage of the population and as such it is of the utmost importance to identify both the causes and pre-disposing factors of oral malodour to effectively treat the problem. Clinically, oral malodour may be caused by periodontal disease, inadequate oral hygiene, tongue debris, deep caries, inadequately fitted restorations, endodontic lesions and limited salivary flow [5].

Due to the highly subjective nature of oral malodour, it has been established that there are numerous objective methods for assessing halitosis. There are three main objective methods of

assessing halitosis: 1) gas chromatography, 2) halimetry (sulphide monitoring) and 3) organoleptic (hedonic) measurements. The differentiation and quantification of VSCs has been considered possible via Gas Chromatography. The clinical measurement of VSCs is also plausible through a portable Gas Chromatography device. One of the advantages of a portable device was that it used air in lieu of a special carrier gas, the portable device was also sensitive to three sulphides as well as being cost-effective [6]. One important shortcoming of the portable device was that it was incapable of determining the non-VSC source of halitosis. Other methods used to assess halitosis such as the BANA test, salivary incubation test, ammonia monitoring, quantifying beta-galactosidase activity, polymerase chain reaction and the ninhydrin method have been reported in the literature but according to van den Brook et al. [7] these methods are reported to be relatively obsolete. There are, however, limited data regarding the relationship between both partial and complete denture wearers and the presence of oral malodour and the effect of denture cleansers on the oral microbiota. Considering the increased interest in oral malodour in both dentate and edentate patients the present study will attempt to provide an overview on the presence and perception of oral malodour in patients wearing both removable and complete dentures.

Materials & Methods

Aim of the study

The research question and aim of the present review was to evaluate and/or compare the presence of oral malodour and its perception in patients with removable partial or complete dentures and the effect of denture cleansers on the oral microbiota.

Search strategy: Five search engines namely: PubMed, Cochrane, Google Scholar, EmBase, Web of Science were utilised to identify any relevant studies. The key words utilised for both a single search and for the combined search consisted of the following terms: oral malodour, oral malodor, fetid oris, partial denture, removable partial denture, complete denture, denture wearers. Using the individual search engines, the terms 'OR' and 'AND' were initially selected as a search query with the above terms which was followed by a subsequent combined search of key words (malodour and removable partial and complete dentures) utilising the 'AND' search function. A final search strategy that used all five search engines highlighted relevant articles for the review.

Inclusion/exclusion criteria: The inclusion criteria included the following: randomised clinical trials (RCT), quasi randomised clinical trials and controlled clinical trials which were blinded and with allocation criteria, were included. Interventional studies related to adhesive materials and cleansing of dentures correlated to oral malodour, together with longitudinal studies examining oral malodour in partially dentate and edentulous patients as well as cross-sectional studies investigating oral malodour in both categories of patients were also included. There were no restrictions on the number of subjects in the included studies due to the scarcity of suitable published studies. Only studies that were published in the English language were included. Studies that included published reviews such as systematic or Cochrane reviews together with proceedings from Workshops, meeting abstracts and opinion papers, in vitro studies and case reports were not included in the review. Published studies not published in the English language were also excluded.

Data collection and analysis: A review of the abstracts and titles was performed by one of the reviewers (IP) who then obtained copies of all the relevant studies where available. Two reviewers (IP and RM.) subsequently sought to determine the eligibility of the papers and data extraction. Any differences as to the inclusion or exclusion of articles were resolved following discussion between the two reviewers, further arbitration regarding whether a paper should be included was referred to a third Reviewer (DGG).

Results

Results from the initial literature search up to 28th February 2016, comprised of 56780 articles. 56677 articles were duplicated and removed. One hundred and three articles remained after eliminating the duplicates. After a second electronic search, fifty-five articles remained for consideration. After this screening, titles and key words were evaluated and thirty-five articles were excluded. Finally, twenty articles were fully read, and six included in the final review (Figure 1).

Excluded studies and reasons for their exclusions

Prior to the final resolution of studies to be included in the review, two of the Authors (IP and RM) independently assessed the suitability of these studies based on the inclusion/exclusion criteria. Following the initial phase of the study it was evident that one paper originally considered relevant to the present study was published as a poster abstract, and despite efforts to obtain a published paper it appeared that the article has not been published. It was agreed with a third Reviewer (DGG) that this article should not be considered for inclusion in the review. Fourteen studies were excluded from the present review as follows: 1) Abstract only [7], 2) RCT or case control trials not meeting the inclusion criteria [2], 3) Lack of detail relating to the type of dentures included in the trial or where subjects wearing dentures were excluded from the trial [2], 4) Pilot study/trial [1], 5) Insufficient numbers of recruited subjects [1], and 6) Published in the Chinese language; no English translation available [1] (Table 1).

Characteristics of included studies: Six studies were included in the results section of this present review [8-13]. Three of these studies were conducted in Brazil [10,12,13], one study was conducted in Croatia [9], one study in Israel [8] and one study in Turkey [11] (Table 1). None of the six included studies were commercially funded.

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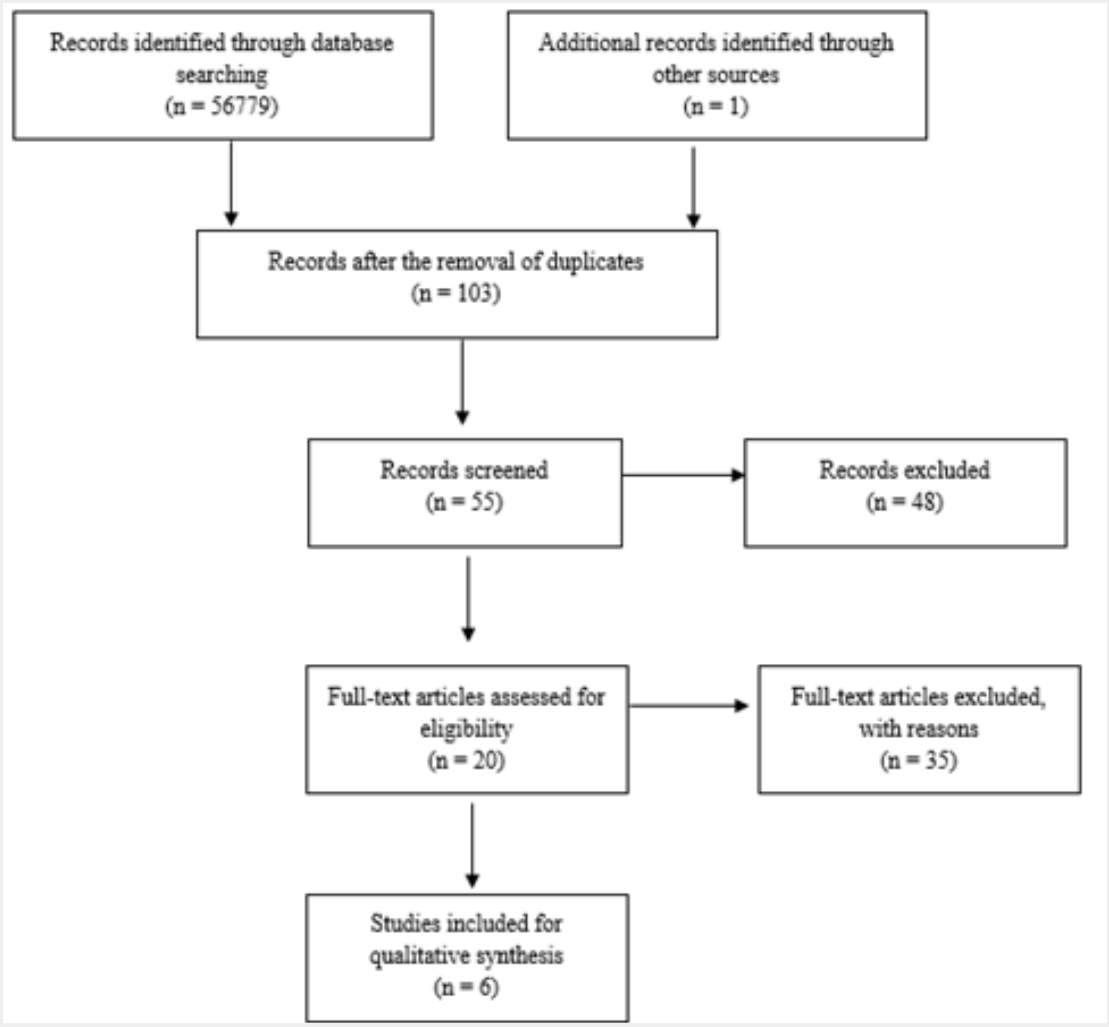

Figure 1: Consort flowchart of the selection mechanism of the included articles.

Table 1: Demographic and participants' characteristics in the included studies.

Investigators	Country and Study Setting	Study Design	Duration	Mean Age of Participants	Age Range of Participants (Years)	Gender Distribution
Zyskind et al. [8]	University of Jerusalem, Israel	Interventional microbiological study in patients with RPDs.	1 week	46	29-67	-
Zlatarić et al. [9]	University of Zagreb, School of Dental Medicine, Croatia	Follow-up study discussing the results, including mouth odour, in patients wearing RPDs.	Not clearly stated	Not stated	38-89	More females
Rocha et al. [10]	Faculty of Dentistry of Aracatuba, Brazil	Longitudinal study assessing MS levels on patients with RPDs.	Not clearly stated (at least 253 days)	48	22-69	More females

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Akaltan & Kaynak [11]	Faculty of Dentistry, University of Ankara, Turkey	Follow-up study observing the results of a specific study design of RPDs on the periodontal health of abutment teeth.	30 months	55	Not stated	More females
Do Amaral et al. [12]	Federal University of Rio Grande do Norte, Department of Dentistry, Brazil	A follow-up study on periodontal indices on patients wearing RPDs.	12 months	45	26-66	More females
Felipucci et al. [13]	Ribeirão Preto Dental School, University of São Paulo, Brazil	Interventional study assessing the effect of cleansers on the metal frame of RPDs.	1,800 min.	-	-	Not stated

Study design and methods: Out of the 6 included studies, three were follow up studies [9,11,12] and three were interventional studies [8,10,13]. In terms of the duration of the included studies, the studies ranged from one week to 30 months in the included studies. The three follow-up studies observed outcomes that lasted from 12 to 30 months.

Characteristics of participants: As far as the study population was concerned, all included studies were conducted in a University Hospital setting. Most of the participants in the included studies were referred to the Department of Prosthodontics (in a University Dental Hospital) by General Dental Practitioners for the provision of removable partial dentures.

All of the participants were provided information on the nature of the study by the study centres. Regarding the inclusion/exclusion criteria, all studies included participants who were partially dentate in either one or both jaws, completely edentulous patients in either the maxilla, mandible or both jaws, healthy volunteers with an absence of any systemic disease that would contraindicate their participation in the study and compliance within each of the included study's objective. The reporting of the age range of the participants in the selected studies varied, for example, four of the included studies reported on the mean age [8-10,12] and four on the age range [8-10,12]; two studies did not mention the age range of the study participants [11,13]. All subjects in the included studies were adults (>18 years old) with an age range between 22 to 89 years. The mean age of participants ranged from 45 to 55 years. The reporting of gender also differed, for example, none of the included studies enrolled equal number of males and females in the experimental design and three other studies were not balanced in gender distribution. For example, four studies were predominantly female [9-12]. Two of the studies did not report on the gender distribution of the participants [8,13] (Table 1).

Outcome measures: The primary outcomes were reported either subjectively and/or objectively in all the included studies. Subjectively, outcomes were reported by using a questionnaire in one follow-up study where the patients were asked to complete the two different parts of questionnaires; the first part of the questionnaire was about age, gender, satisfaction from existing dentures. The second part of the questionnaire in one of the included studies was related to the recording of periodontal indices [9].

Methodological quality of included studies

The methodological quality of the six included studies was assessed in part by a "Risk of bias assessment tool" [14]. Out of the six included studies, four trials had an overall risk assessment of "Unclear risk" [8-10,13]. One of the studies had an overall risk assessment of ''high risk" [12] and one of the studies had an overall risk assessment of ''low risk'' [11] (Table 2).

Table 2: Risk of Bias in the included studies.

Study	Random Sequence Generation	Allocation Concealment	Blinding of Participants and Key Personnel	Blinding of Outcome Assessors	Completeness of Follow-Up	Free of Selective Outcome Reporting	Overall Risk of Bias
Zyskind [8]	?	+	?	?	+	?	?
Zlatarić [9]	?	?	?	?	+	+	?
Rocha [10]	?	?	?	?	+	?	?
Akaltan & Kaynak [11]	+	?	?	?	+	+	+
do Amaral, et al. [12]	-	-	?	-	-	?	-
Felipucci, etal. [13]	-	?	?	?	+	+	?

Key: + Low risk; of bias: - High risk of bias: ? Unclear risk of bias.

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Random sequence generation (Selection bias): Out of the six included studies, three studies mentioned the method used in the trial for generating a random sequence [11-13] with one study considered adequate with a low risk of selection bias [11] whereas in the other two studies there was a high risk of bias [12-13]. In the remaining three studies [8-10], the generation of a random sequence was unclear and therefore it was impossible to judge whether this would lead to a high risk or low risk of selection bias (Table 2).

Allocation concealment (Selection bias): Of the included studies, four studies indicated an unclear risk of selection bias as they failed to report on using concealment of interventions prior to allocation [9-11,13]. In the other two studies, one was considered to have a high risk of bias for allocation concealment [12] and the other study was considered to have a low risk of bias for allocation concealment [8] (Table 2).

Blinding of participants and key personnel (Performance bias): The blinding of both the participants and key personnel was not reported in any of the included studies. Therefore, it was assumed that the risk of bias was unclear for these studies, with reference to blinding of the participants and key personnel (Table 2).

Blinding of outcome assessors (Detection bias): Out of the six included studies, none of studies indicated a low risk of detection bias with one study considered to have a high risk of bias [12] (Table 2).

Completeness of follow-up (Attrition bias): Five studies out of the six included studies demonstrated a low risk of attrition bias because they reported whether the drop-out patients were included/excluded from the final analysis of the results [8-11,13]. The remaining study was considered to have a high risk of attrition bias [12] (Table 2).

Free of selective outcome reporting (Reporting bias): Three of the included studies indicated a low risk of reporting bias [9, 11,13] with the other three studies considered to have a low risk of reporting bias [8,10,12] (Table 2).

Comparison of statistical methods in the included studies: The statistical methods for the generation and interpretation of the results of the included trials varied significantly between each trial. For example, the studies by do Amaral et al. [12] and Felipucci et al. [13] utilized the Analysis of Variance (ANOVA) test to compare their individual results as well employing the Tukey's test in conjunction with post-hoc ANOVA. A non-parametric student t-test was also used to analyse the levels of *Streptococcus mutans* between measurement and treatment intervals. The study by Zlataric et al. [9], implemented several different statistical tests such as the Kolmogorov-Smirnov test to test the homogeneity of the population as well as the Kruskal-Wallis test which detected the discrepancies between the independent variables and the Wilcoxon test which detected the discrepancies between the dependent variables. The threshold of statistical significance in these studies was $p \leq 0.05$.

Discussion

The correlation between halitosis and periodontal disease has been previously reported in the published literature [15-18] and it was evident from other studies that when the salivary content obtained from individuals with periodontal disease generated malodour more rapidly when compared to the salivary content obtained from periodontally healthy individuals [19-20]. There was also a positive analogy in the levels of air mouth (volatile sulfur compounds [VSCs]) and the number and depth of periodontal pockets [15] an observation subsequently supported by Yaegaki & Sanada [16] where both hydrogen sulphide and methyl mercaptan were observed in higher numbers in patients with periodontal pockets compared to those periodontal pockets in periodontally healthy patients. Other studies have reported that patients with periodontal disease have increased levels of methyl mercaptan/hydrogen sulphide [21]. Morita and Wang [22] also reported an association between periodontal indices including radiographic bone loss and oral malodour (VSCs) in patients with periodontal disease. Ratcliffe & Johnson [17] also discussed the function of VSCs in the pathogenesis of periodontitis, indicated that VSCs created a positive environment for Lipopolysaccharide (LPS) to penetrate the gingival connective tissue(s) due to a direct cytotoxic effect on the epithelial tissues with subsequent impairment of collagen synthesis. Both hydrogen sulphide and methyl mercaptan bind to Type I collagen via the thiol group and it has also been demonstrated that methyl mercaptan may be an alkylating agent enhancing these deleterious effects [22-24].

The association between oral malodour and denture wearers has previously been raised by several investigators [25,26]. The first paper by Verran [25] reported that there were more additional potential microflora harbouring sites in the oral microcosm of denture wearers than those in dentate patients. Furthermore, the denture was also identified as a site for harbouring denture plaque implicating both *Fusobacteria* and *Prevotella* species as well as the role of *Candida albicans* in initiating denture stomatitis and as a contributing factor in oral malodour. According to Verran [25] the composition of the oral biofilm in denture wearers was of a similar pattern to that of dental plaque on the occlusal dental surfaces and included the following bacterial species 1) Gram-positive cocci and rods which were more prevalent, with 2) Gram-negative rods and yeast less prevalent with only a few obligate anaerobes and 3) Candida comprising only 0–0.45% of the population numerically. The second paper by Samnieng et al. [26] compared oral malodour in elderly patients with and without dentures, although the paper did not describe whether the prostheses were full (complete) or partial dentures and as such the study was excluded from the present review. oral malodour (Halitosis) was measured with both Organoleptic Testing (OT) and Oral Chroma together

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with a questionnaire relating to both systemic factors and oral hygiene habits. An oral examination was included to assess the oral mucosa as well as the thickness of tongue coating, the flow rate and pH of saliva. The results indicated that the coating of the tongue, quality of dentures and wearing dentures overnight were significantly associated with halitosis by Organoleptic Testing. Tongue coating in both dentate and edentate subjects and subjects wearing dentures at the night was associated with Hydrogen Sulphide (H_2S) whereas systemic conditions, medicines intake and quality of dentures in denture wearers were associated with Methyl Mercaptan $(CH_3)_2S$) derived malodour.

One of the problems with the included studies was that they did not examine the tongue coating, oral epithelium, saliva pH or measure oral malodour via Organoleptic Testing or Oral Chroma with only a few studies indicating that their subjects complained of oral malodour. None of the studies examined the biofilm on the RPDs which was unfortunate as this would have provided useful information on the microbiology of the biofilm and any potential association with halitosis. Furthermore, examination of the tongue coating in the studies would have identified the bacterial species and as such would have been a useful diagnostic and assessment tool for patients wearing RPDs with oral malodour. Of the six studies included in the present review only two studies addressed the issue of oral malodour in RPDs directly [9,11] with other studies assessing the effect of denture cleanser materials either on the metal part of the RPDs or on the microflora (particularly *Streptococcus mutans*) [8,10,12,13].

There were also other limitations with undertaking the present review, for there were relatively few relevant studies investigating the microbiological and topographic aspects of oral malodour (halitosis) associated with RPDs. Some of the included studies were either randomised clinical trials or controlled clinical trials with the remainder follow-up studies which were considered pertinent to the present review (Table 1). Nevertheless, a clear risk of bias was identified in some of the studies (Table 2) as well as the limitation of the specific geographical regions involved in these studies which would not be representative of other study populations and therefore one should avoid extrapolating the results from a relatively few included studies to other geographical areas.

Of the six included studies in this review, three were follow up studies [9,11,12] and three were interventional studies [8,10,13]. In terms of the duration of the included studies, the studies ranged from one week to 30 months in the included studies. The three follow-up studies observed outcomes that lasted from 12 to 30 months. In the study by Zlataric et al. [9] there was no correlation between oral malodour, periodontal indices, food impaction and gender which was contradictory to the Yaegaki et al. study [16] where a relationship between the periodontal indices and oral malodour was identified. According to Zlataric et al. [9] only a small proportion (16%) of subjects complained of halitosis which may be due to a lack of awareness of an individual's halitosis particularly in individuals over 60 years as well as poor oral hygiene. Lack of awareness especially in older age group was also a common finding in both dentate patients and patients with RPDs. However, the issue of halitosis was not studied extensively in this study and therefore a definitive correlation or lack of correlation between oral malodour (halitosis) in dentate and RPDs patients was not possible. The study by Akaltan & Kaynak [11] reported on the presence of oral malodour associated with a RPD lingual plate design although food impaction at this site was suggested as a main reason for oral malodour (halitosis). No details, however, about the level of VSCs and microbiological analysis were obtained and as such there was no evidence to suggest a correlation between oral malodour and RPDs although a minor potential association in the perception of oral malodour in both dentate patients and patients with RPDs was suggested.

The remainder of the included studies did not directly address the association with oral malodour and denture wearers and assessed the effect of denture cleansing materials either on the metal part of the RPDs or on the microflora (particularly *Streptococcus mutans*) [8,10,12,13]. Although the effects of these dentures' cleansers may have indirectly influenced oral malodour it would be unwise to draw any conclusion that there was a correlation between oral malodour and RPD patients [10,13]. As previously only three out of the six included studies were interventional studies [8,10,13]. The first study by Zyskind et al. [8] involved a slow-releasing dosage (SRD) coating of chlorhexidine (CHX) which was applied on the patients' RPDs to reduce the levels of *Streptococcus mutans* and the total count of bacterial biofilm, the rationale being that the intervention lowered both the Plaque Index (PI) and microbiological load in patients wearing RPDs. The second study by Felipucci et al. [13] compared the effect of six different denture cleansers Periogard (PE), Cepacol (CE), Corega Tabs (CT), Medical Interporous (MI), Polident (PO), 0.05% sodium hypochlorite (NaOCl), and distilled water (DW) control] on the metal surfaces (2 Co-Cr alloys [DeguDent (DD) and VeraPDI (VPDI)]) of the RPDs to determine whether denture cleansers would by reducing the microbial load provide a secondary benefit in reducing the impact of oral malodour (halitosis) in patients wearing complete or partial dentures. No differences in their effect on metal and resin denture surfaces irrespective of the denture cleanser type were reported in this study although the investigators acknowledged the importance of mechanical, chemical cleaning and brushing of the denture after chemical cleaning were effective means of employing satisfactory hygiene and avoiding metal and resin roughness. The third interventional study by Rocha et al. [10] applied CHX in RPDs and demonstrated that the application of CHX decreased the levels of *Streptococcus. mutans* in saliva.

The three other studies included in this present review were follow-up studies and reported on the impact of RPDs on the periodontal tissues including the health of the abutment teeth, microflora, and oral malodour [9,11,12]. The study by Zlataric

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et al. [9] investigated the effect of RPDs on the periodontium of both the abutment and non-abutment teeth in 205 patients and recorded a range of periodontal indices namely: Plaque Index (PI), Calculus Index (CI), Gingival Index (GI), Probing Depth PD), Tooth Mobility (TM) Gingival Recession (GR), and presence of oral malodour. The results of this study indicated that the periodontal variables around abutment teeth were statistically higher than those of non-abutment teeth, although there was no correlation between the periodontal variables, the gender of the patients, food impaction at the denture sites and oral malodour. do Amaral et al. [12] also reported that the levels of biofilm retention with periodontal pathogenic bacteria and subsequent periodontal inflammation increased around the abutment teeth with RPDs design. However, Akaltan & Kaynak [11] emphasized the importance of meticulous oral hygiene in patients with RPDs which would reduce the bacterial load within the plaque biofilm maintaining periodontal health. The importance of well-designed RPD, meticulous oral hygiene and denture care in patients with RPDs has been supported in the published literature [27-29]. Other factors, however, may impact on a patient's perception of oral malodour which can influence the diagnosis of oral malodour for example, the patient's age ≥ 60, their state of systemic health, medication etc., [30].

It was apparent from the evaluation of papers for this review that none of the included studies directly discussed the microbiological aspect(s) of oral malodour in patients with RPDs/complete dentures. Although there is some indirect evidence that would appear to support the notion that the cleaning of RPDs may be beneficial in reducing the bacterial load and subsequently reducing or negating any potential inflammation in the periodontal tissues and have an impact on the micro-organisms responsible for oral malodour, it would be unwise to extrapolate the results from these studies. It was evident when reviewing the published literature there a paucity of suitable studies comparing oral malodour inducing microbiota in complete denture wearers and dentate patients. For example, the study by Felipucci et al. [13] focussed only on one bacterial species namely *Streptococcus mutans* with only a quantitative assessment of the biofilm at different time intervals. Currently it is recognised that there is a complex dental plaque biofilm in both health and disease [31] and as such future studies in this field of research into oral malodour should also recognise the differences in the microbiota in both healthy and periodontally compromised subjects with or without RPDs/Complete dentures and take into consideration the recommendations of Verran when conducting research into the association of oral malodour and denture wearers [25].

Conclusion

The results from the studies included in the present review would suggest that there was some indirect evidence supporting the notion that the cleaning of RPDs may be beneficial in reducing the bacterial load which may indicate an association between the presence and perception of oral malodour in both RPD and complete denture wearing patients. However, the strength of evidence from these studies was insufficient to draw any definitive conclusions on a potential correlation of oral malodour in patients with RPDs.

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