Association between overweight/obesity and increased risk of periodontitis


Abstract

Objective: To investigate periodontitis as a co-morbidity of overweight/obesity in an age-matched sample of periodontitis cases or periodontally healthy controls.

Methods: Participants were periodontally assessed using whole mouth clinical periodontal measures. Multivariable conditional logistic regression was used to calculate the odds ratio for diagnosis of periodontitis when body mass index (kg/m²), overweight (BMI 25–29.99 kg/m², or obese BMI ≥ 30 kg/m²) were the explanatory variables. A receiver operating characteristic (ROC) curve was generated of all possible BMI (kg/m²) cut-off points discriminating individuals for diagnosis of periodontitis.

Results: The study comprised 286 participants. BMI showed a dose–response association with increased odds (1.12 per increase of 1 kg/m², 95% CI 1.05–1.20, p = 0.001) of being a case compared to a control independent of gender, ethnicity, smoking status and dental plaque level. Similarly overweight/obese were independently associated with increased odds of diagnosis of periodontitis for overweight (OR = 2.56, 95% CI 1.21–5.40, p = 0.014) and for obese (OR = 3.11, 95% CI 1.05–6.48, p = 0.015) compared to normal weight individuals. The ROC curve analysis confirmed diagnosis of periodontitis was 1.6 times more likely in an individual with the BMI ≥ 24.32 kg/m².

Conclusions: Overweight/obese individuals are more likely to suffer from periodontitis compared to normal weight individuals in this case–control sample.

Obesity is a highly prevalent condition worldwide especially in developed countries (WHO 2006). It is a metabolic condition occurring due to an energy imbalance (intake > consumption), which subsequently leads to an increase in adipose tissue deposits (Bray 2007). As adipocytes exert a number of endocrine functions, increased adiposity is associated with a state of low-grade inflammation and insulin resistance (Bray 2004, Gimeno & Klaman 2005). Periodontitis is a chronic inflammatory disease driven by bacterial pathogens and is one of the most common oral infections worldwide (WHO 2004). The host response to periodontal pathogens represents a crucial determinant of the individual’s susceptibility to periodontitis. Several pro-inflammatory molecules and processes implicated in the pathogenesis of periodontitis, including cytokines (e.g. Interleukin-IL-6), chemokines and T-cell function, could be altered by obesity (Falagas & Kompoti 2006). An altered (delayed and sustained) inflammatory state, such as that found both in animal experimental conditions (Amar et al. 2007) and in obese individuals, could predispose individuals to increased periodontal tissue...
Materials and Methods

Study design

This study was designed as a case-control analysis of age-matched participants enrolled in a larger clinical study recruiting cases and controls based on the presence or absence of periodontitis as confirmed by full-mouth periodontal examination. The exposure of body mass index (BMI) was calculated during data analysis based upon cross-sectional epidemiological data collection and/or re-analysis of existing health survey databases (Chaffee & Weston 2010, Suvan et al. 2011). These studies have been valuable in generating the hypothesis of association, however fall short of using robust and consistent methods to diagnose periodontitis (pragmatic screening and heterogeneous case definitions) which may lead to biased results. The aim of this study was to ascertain the odds of having periodontitis if an individual is overweight or obese. The null hypothesis was of no association between overweight/obesity and diagnosis of periodontitis (case definition proposed for studies of risk factors for periodontitis (Tonetti & Claffey 2005) in an age-matched sample of adults).

Study participants

The overall clinical study sample consisted of 471 individuals recruited from the UCLH NHS Trust (UCLH Eastman Dental Hospital) new patient clinics between June 2006 and December 2010. Periodontitis cases were recruited from referrals to the Unit of Periodontology whilst periodontally healthy controls from other units within UCLH Eastman Dental Hospital. All participants (cases and controls) were ≥18 years old, had a minimum of 20 natural teeth and were otherwise systemically healthy (no active infectious diseases such as hepatitis, HIV or TB, or uncontrolled metabolic diseases including diabetes, kidney, liver or cardiovascular diseases assessed by the examining clinician and medical history). Exclusion criteria comprised pregnancy, chronic use of non-steroidal anti-inflammatory drugs; antibiotics use within 3 months of study visit and past periodontal therapy. Cases were included if they presented with the presence of one or more sites with PPD ≥5 mm or radiographic evidence of bone loss ≥20% of the root length. Controls were included if they had no evidence of periodontitis (absence of sites with PPD ≥5 mm).

Case definition and age matching

This subset study sample was selected from the overall based upon the European Federation of Periodontology (EFP) case definition of periodontitis for epidemiological studies of risk factors. A “periodontitis case” was defined when “proximal attachment loss of ≥3 mm in ≥2 non-adjacent teeth” was identified (Tonetti & Claffey 2005). Based on presence/absence of this criterion a case or a control population were identified. Furthermore, as ageing represents an important risk factor for periodontal tissue loss (Grossi et al. 1994), 143 age-matched pairs (one to one based on year of birth) were identified for analysis.

Sample size calculation

Sample Size Tables for Clinical Studies software were used to calculate the sample size for this study (Machin et al. 2008). A sample of 274 individuals (137 participants per group) would have 90% power to detect a clinically relevant odds ratio of 2.0 for presence of periodontitis in obese compared to normal weight individuals, assuming a prevalence of obesity in the general population of 23.8% and using a 0.05 two-sided significance level (DOH UK 2006).

Data collection

Data collection methods were the same for all study participants. All visits were carried out in the same setting and measurements were performed by one of the three calibrated study examiners. Prior to the initiation of the study, an examiner repeatability exercise was undertaken to confirm adequate intra-examiner repeatability using 10 non-study patients suffering from moderate to severe periodontitis (duplicate measurements with another patient or waiting a time period of 30 min between). Following this, a calibration exercise was carried out on 10 patients per examiner to confirm inter-examiner agreement (measured by one examiner then alternate examiner on the same day). The data were analysed to confirm intra-examiner repeatability and inter-examiner calibration at a pre-determined success criteria level of agreement within ±2 mm for CAL in a minimum 98% of sites measured. All examiners reached levels above the 98% agreement threshold for repeatability and calibration.

At the study visit, following informed consent, the study examiner obtained the participant’s medical history update, oral examination, a lifestyle questionnaire (exercise, diet, oral hygiene practice, etc.), demographic data (age, gender, smoking history and ethnicity) and body weight and height for calculation of BMI. Height and weight were measured by a trained dental nurse using a wall-mounted height measure and mechanical scales (BMI was calculated as kg/m² during data processing).

Periodontal health or disease status was based upon recording of whole mouth probing pocket depths and clinical recession. Dental plaque levels and gingival bleeding on probing scores were assessed dichotomously as plaque or bleeding being present or absent (O’Leary et al.
1972, Ainamo & Bay 1975). All clinical parameters were assessed at six sites per tooth for all teeth present in the mouth.

**Statistical analysis**

SPSS 20.0 (IBM Corp 2011) statistical software package and Stata 10.0 (StatCorp) were used for data analyses. Data for all participants were combined in SPSS 20.0 and the database was checked for accuracy and consistency. The data were then imported into Stata 10.0.

Following completion of descriptive statistics, statistical significance was set at a p-value of <0.05. Continuous, normally distributed variables were reported as means and standard deviations (SD). Categorical variables were summarized as percentages. Comparisons of all continuous and categorical data between groups (cases and controls) were analyzed with paired t-tests and conditional logistic regression, respectively, to check for statistically significant differences between the groups. As the next step, univariable conditional logistic regression analyses were carried out to investigate the relationship of BMI and gender, ethnicity, smoking status and full-mouth plaque score with periodontal diagnosis (being a case or control). Those factors found to be statistically significant at the 10% level were then included in the final multivariable models as potential predictors of being a case.

Multivariable conditional logistic regression, accounting for the age matching, was used to estimate the odds ratio for diagnosis of periodontitis when either BMI as a continuous variable (kg/m²) or BMI expressed as a categorical variable based upon WHO categories (BMI expressed as a categorical variable – normal 18.5–24.99 kg/m², overweight BMI 25–29.99 kg/m², obese BMI ≥30 kg/m²) with periodontal diagnosis (being a case or control). The main finding of this analysis would have an area under the curve of 0.62, suggesting that it was reasonable to use this approach to discriminate between those individuals with and without periodontitis (Fig. 1). The cutpoint of 24.32 (related to BMI) produced the optimal sensitivity of 61.54% and specificity of 61.89% were correctly assigned overall with a likelihood ratio (LR) of 1.6 (meaning the disease is 1.6 times more likely in an individual with the BMI ≥ 24.32).

**Results**

The study sample consisted of 286 individuals (143 case/control pairs) ranging in age from 25 to 66 years. Statistically significant differences in gender, ethnicity and distribution of former smokers were noted (Table 1). Furthermore, cases tended to exhibit greater values of BMI and there were more overweight/obese individuals than controls. All periodontal clinical variables recorded in the sample resulted in statistically significantly higher average values for cases compared to controls (Table 1). Univariable analysis showed all covariates to be statistically significant at the 10% level. Therefore, all were included in the multivariable conditional regression models (Tables 2 and 3). Multivariable conditional logistic regression with BMI as a continuous variable (kg/m²) demonstrated that BMI had a dose-response association with an increased risk of being a case compared to a control, with an odds ratio of 1.12 per increase in 1 kg/m² (95% CI 1.045–1.197, p = 0.001), after adjusting for the other covariates in the model (Table 2). Gender, ethnicity and smoking were also statistically significant predictors of periodontitis diagnosis, whilst dental plaque scores were not.

Multivariable conditional logistic regression with BMI considered in three categories demonstrated that the overweight category and the obese category were associated with increased odds of diagnosis of periodontitis when compared to the normal category (Table 3). The estimated odds ratio for having periodontitis if an individual was overweight was 2.56 (95% CI 1.210–5.400, p = 0.014). The odds ratio for a diagnosis of periodontitis for obesity was: 3.11 (95% CI 1.056–6.48, p = 0.015). As in the continuous analysis (Table 2) gender, ethnicity and smoking were statistically significant predictors of periodontitis diagnosis in this categorical analysis.

The ROC analyses had an area under the curve of 0.62, suggesting that it was reasonable to use this approach to discriminate between those individuals with and without periodontitis (Fig. 1). The cutpoint of 24.32 (related to BMI) produced the optimal sensitivity of 61.54% and specificity of 61.89% were correctly assigned overall with a likelihood ratio (LR) of 1.6 (meaning the disease is 1.6 times more likely in an individual with the BMI ≥ 24.32).

**Discussion**

The main finding of this analysis was a positive strong association between body mass index (continuous and categorical definitions) and diagnosis of periodontitis in an age-matched case–control study, and this association was independent of gender, ethnicity, smoking status and dental plaque levels.

These results were obtained in a sample representative of the UK population BMI distribution with a prevalence (49.0%) of overweight/obese (BMI ≥ 25) that is similar to that for the English population (50%) at the time of study recruitment. It was slightly less representative, however,
Covariates were simultaneously adjusted for all variables. Bold denotes statistically significant result at \( p < 0.05 \) in direction of increased risk. N/A refers to not applicable.

### Table 1. Characteristics of study sample and univariable analysis (matched for age) \( n = 286 \)

<table>
<thead>
<tr>
<th>Covariate (categorical)</th>
<th>Control ( n (%) )</th>
<th>Case ( n (%) )</th>
<th>Odds ratio (CI)</th>
<th>( p )-value</th>
<th>Total ( n (%) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (ref)</td>
<td>143 (50.0)</td>
<td>143 (50.0)</td>
<td>1</td>
<td>&lt;0.005</td>
<td>286 (100)</td>
</tr>
<tr>
<td>Female</td>
<td>94 (48.3)</td>
<td>45 (31.5)</td>
<td>1</td>
<td>0.073</td>
<td>139 (49.9)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White (ref)</td>
<td>108 (75.5)</td>
<td>108 (75.5)</td>
<td>1</td>
<td>0.008</td>
<td>196 (61.5)</td>
</tr>
<tr>
<td>Asian</td>
<td>21 (14.7)</td>
<td>25 (17.5)</td>
<td>1.85 (0.93, 3.66)</td>
<td>0.078</td>
<td>46 (16.1)</td>
</tr>
<tr>
<td>Other</td>
<td>14 (9.8)</td>
<td>43 (30.1)</td>
<td>4.56 (2.20, 9.43)</td>
<td>&lt;0.001</td>
<td>57 (19.9)</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never smoker (ref)</td>
<td>94 (60.5)</td>
<td>79 (55.2)</td>
<td>1</td>
<td>0.179</td>
<td>173 (59.2)</td>
</tr>
<tr>
<td>Smoker</td>
<td>22 (15.4)</td>
<td>27 (18.9)</td>
<td>1.56 (0.81, 3.03)</td>
<td>0.185</td>
<td>49 (17.1)</td>
</tr>
<tr>
<td>Former</td>
<td>27 (18.9)</td>
<td>37 (25.9)</td>
<td>1.78 (0.95, 3.36)</td>
<td>&lt;0.001</td>
<td>64 (22.4)</td>
</tr>
<tr>
<td>BMI 3 Categories</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (ref)</td>
<td>96 (67.1)</td>
<td>62 (43.4)</td>
<td>1</td>
<td>0.045</td>
<td>158 (55.2)</td>
</tr>
<tr>
<td>Overweight</td>
<td>31 (21.7)</td>
<td>52 (36.4)</td>
<td>2.68 (1.44, 4.97)</td>
<td>0.002</td>
<td>83 (29.0)</td>
</tr>
<tr>
<td>Obese</td>
<td>16 (11.2)</td>
<td>29 (20.3)</td>
<td>2.72 (1.27, 5.84)</td>
<td>0.010</td>
<td>45 (15.7)</td>
</tr>
<tr>
<td>BMI 2 Categories</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (ref)</td>
<td>96 (67.1)</td>
<td>62 (43.4)</td>
<td>1</td>
<td>0.007</td>
<td>158 (55.2)</td>
</tr>
<tr>
<td>Overweight/obese</td>
<td>47 (32.9)</td>
<td>81 (56.6)</td>
<td>2.70 (1.61, 4.50)</td>
<td>&lt;0.001</td>
<td>128 (44.8)</td>
</tr>
</tbody>
</table>

### Covariate (continuous) | Control mean (SD) | Case mean (SD) | Mean diff control–case (CI) | \( p \)-value | Total mean (SD) |
<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>37.88 (8.98)</td>
<td>37.88 (8.98)</td>
<td>-2.27 (-3.42, -1.12)</td>
<td>&lt;0.001</td>
<td>25.38 (5.24)</td>
</tr>
<tr>
<td>BMI (continuous)</td>
<td>24.24 (4.22)</td>
<td>26.52 (5.89)</td>
<td>2.27 (1.44, 4.97)</td>
<td>0.002</td>
<td>23.92 (25.2)</td>
</tr>
<tr>
<td>Number of teeth</td>
<td>28.51 (2.31)</td>
<td>27.90 (2.93)</td>
<td>0.60 (0.01, 1.18)</td>
<td>&lt;0.001</td>
<td>28.20 (2.66)</td>
</tr>
<tr>
<td>Full-mouth plaque score (percentage)</td>
<td>52.36 (21.05)</td>
<td>45.49 (25.73)</td>
<td>6.86 (1.25, 12.47)</td>
<td>0.017</td>
<td>48.92 (23.92)</td>
</tr>
<tr>
<td>Full-mouth bleeding score (%)</td>
<td>20.61 (13.79)</td>
<td>25.79 (25.69)</td>
<td>-32.17 (27.54, 56.81)</td>
<td>&lt;0.001</td>
<td>36.70 (26.14)</td>
</tr>
<tr>
<td>Periodontal probing depth (mm)</td>
<td>1.99 (0.27)</td>
<td>3.80 (1.07)</td>
<td>-1.80 (-1.98, -1.60)</td>
<td>&lt;0.001</td>
<td>2.89 (1.19)</td>
</tr>
<tr>
<td>Percentage of sites PPD&gt;4 mm (%)</td>
<td>0.20 (0.68)</td>
<td>0.77 (3.49)</td>
<td>-0.57 (-0.57, -0.45)</td>
<td>&lt;0.001</td>
<td>0.59 (0.57, 0.71)</td>
</tr>
<tr>
<td>Clinical attachment level (CAL)</td>
<td>2.00 (0.33)</td>
<td>4.22 (1.19)</td>
<td>-2.21 (-2.42, -2.01)</td>
<td>&lt;0.001</td>
<td>3.11 (1.41)</td>
</tr>
</tbody>
</table>

Covariates were simultaneously adjusted for all variables. Bold denotes statistically significant result at \( p < 0.10 \) in direction of increased risk. BMI, Body Mass Index, FMPS, Full-mouth plaque score.

classed as overweight and 17.0% classed as obese compared to estimates for the English population of 26.2% and 23.8% for overweight and obese, respectively (DOH UK 2006).

Published systematic reviews have identified two other case-control studies of the association between periodontitis and obesity (Buhlin et al. 2003, Alabdulkarim et al. 2005). Buhlin and co-workers reported an association between overweight/obesity and periodontitis in a sample of 50 periodontitis cases and 46 periodontally healthy controls. They reported an odds ratio of 4.54 (95% CI 1.588–13.00) which is higher than that found in this study (OR 2.76 95% CI 1.487–5.127) (Buhlin et al. 2003). This could be due to a difference in sample size or differences in covariates included in analyses. A study of 200 obese compared to 200 non-obese participants demonstrated an odds ratio of 1.86 (95% CI 0.99, 3.51) (Alabdulkarim et al. 2005), which is lower than the odds ratio of 3.11 (95% CI 1.05–6.48) for the same comparison in this study. These differences could be due to the retrospective nature of the Alabdulkarim study and the use of radiographs as the sole means of periodontal assessment. Differences might also be due to other unknown confounding factors.

The study reported here infers a dose–response association between a
common measure of overweight/obesity (BMI) and diagnosis of periodontitis. Both continuous and different categorical definitions of overweight/obesity were strongly associated with diagnosis of periodontitis. Odds ratios were higher than those resulting from a systematic review meta-analysis published in 2011 (Suvan et al. 2011), which showed odds ratios (compared to BMI < 25 Kg/m²) of 1.27 (95% CI 1.06–1.51), 1.81 (95% CI 1.42–2.30) and 2.13 (95% CI 1.40–3.26) for overweight, obese and overweight/obese combined categories respectively. This study found odds ratios of 2.56 (95% CI 1.21–5.40), 3.11 (95% CI 1.05–6.48) and 2.76 (95% CI 1.48–5.12) for the overweight, obese and overweight/obese combined categories, respectively.

When considering the odds ratios of the associated risk of smoking for presence of periodontitis in this study, OR 2.46 (95% CI 1.09–5.56), this is similar to that for overweight (OR 2.56, 95% CI 1.21–5.40), but that for obese is higher (OR 3.11, 95% CI 1.05–6.48) (Table 3).

Exploration by use of the ROC curve of whether a different cutoff point of BMI (than those currently defined by WHO for overweight (BMI 25–29.99 kg/m²) and obesity (BMI ≥ 30 kg/m²)) would be a better predictor of increased risk of periodontitis found that the optimal combination of sensitivity and specificity coincided with the current combined categorization of overweight and obese (BMI ≥25) compared to normal weight individuals (BMI 18.5–24.99 kg/m²). This cutpoint of BMI which resulted in an estimated OR of 2.46, although less than the OR for of 3.11 for obese offers insight of the importance of considering overweight individuals when considering oral health status and investigating the possible mechanisms involved in the association.

Limitations of this study are associated with the bias that may occur in the case-control study design. These include the fact that the participants were identified and selected based on whether or not they had the disease (periodontitis in this case) and the exposure (BMI, overweight, obesity) was then investigated within the cases and controls. It is recognized that there may be potential for selection bias due to the recruitment of all individuals from those referred to a dental hospital. Interpretation of results is limited by the lack of knowledge of the onset of periodontitis or the start time of the exposure. This is a common limitation for the case-control study designs but is heightened in this study, because the complexity of the exposure is increased due to the apparent dose–response associated with various levels of overweight and obesity. In addition, variation in the exposure over time increases the complexity of quantifying the exposure. Overweight and obesity are not exposures that have a fixed start date but, rather, weight gain normally occurs gradually. This analysis was based on BMI and BMI categories without analysis of body fat percentage or some other measure of body fat. Increase in fat mass with decrease in lean tissue mass over time with ageing is a normal physiological change in the body (Kotani et al. 1994). Although consistent and statistically significant, the increased odds or magnitude of effect of BMI on the risk of having periodontitis cannot prove a causal relationship between the BMI and the presence of periodontitis. Results from studies demonstrating a temporal sequence of exposure followed by disease are required before firm conclusions can be drawn about causality. Recently published evidence from two longitudinal studies of 40 years reported an association of obesity as well as weight gain with periodontal disease progression (Gorman et al. 2012a,b), but further prospective studies are needed to confirm a temporal associ-
ation between overweight/obesity and periodontitis.

Finally, the results of this study may have been influenced by the relatively small sample size and imbalances between the groups for gender and ethnicity. Strengths of the study include age matching of the sample, which minimized bias that may have been introduced by the complex clinical association of increasing disease and exposure associated with increasing age. Using a widely accepted case definition of periodontitis following full-mouth detailed periodontal assessment adds to the external validity of these findings together with the adjustment for various covariates including dental plaque.

The statistical significance of the positive association between BMI by unit, overweight and obesity (WHO category >25 kg/m²) and the presence of periodontitis is consistent with the hypothesis of an altered inflammatory response associated with obesity as a chronic inflammatory disease. This dysregulated inflammatory response has been proposed to be at the patient level or limited to the site level, that is, the host response to the plaque biofilm within individuals with a BMI at the level of obesity (Genco & Borgnakke 2013).

The validity of BMI as a measurement tool for the study of the association of body composition or obesity with disease or health risks is controversial (Vazquez et al. 2007, Jimenez 2013). In this project, information secured through other measures of body composition including analyses of body fat measurements together with BMI might have provided further insight into the nature of the association, including the association with the severity of disease in the cases. Future studies of the relationship between periodontitis and overweight/obesity should include measures of body fat and preferably, visceral fat in addition to BMI, to continue to evaluate the validity of each body composition measurement for assessing associated health risks.

Conclusions

Obesity was independently associated with the presence of periodontitis as assessed by a full-mouth clinical periodontal assessment. Overweight and obese individuals have an increased risk of having periodontitis compared to those who are within the category of BMI Normal.

Acknowledgements

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StataCorp LP (2011) StataCorp Stata statistical software: release 13. College Station, TX: StataCorp LP.


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### Clinical Relevance

**Scientific rationale for the study:** Epidemiological studies have periodontitis to be associated with overweight and obesity. It is plausible that increasing BMI is associated with the increased risk of having periodontitis.

**Principal findings:** Increasing increments of BMI were associated with a higher risk of the presence of periodontitis. Individuals in Overweight and Obesity categories were also at higher risk of having periodontitis compared to in a normal weight category.

**Practical implications:** People with a body mass index higher than 25 kg/m² may be at increased risk for periodontitis onset.