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Is toothwear associated with oral health related quality of life in adults in the UK?

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Objectives: Toothwear may impact on an individual's everyday life, yet there is little research investigating the association between toothwear and oral health related quality of life (OHRQoL). The aim of the present study was to investigate the association between toothwear and OHRQoL in adults in the United Kingdom. ***Basic research design:*** This study involved secondary analysis of data from 5187 participants with toothwear in the Adult Dental Health Survey conducted in 2009. Toothwear was assessed using Smith and Knight criteria and the Basic Erosive Wear Index and classified as mild, moderate and severe. ***Main outcome measures:*** Correlation analyses were carried out between OHIP-14 total scores and toothwear type. Regression analyses investigated the association between toothwear and OHRQoL adjusting for demographic variables. ***Results:*** There was a significant association between toothwear and OHRQoL, with more severe toothwear associated with greater oral health impact on daily life. The association between erosive toothwear and OHRQoL was significant for moderate and severe severities only. The adjusted linear regression model identified that toothwear accounted for 0.02% of the variance in total OHIP-14 scores. Females, younger individuals and less deprived individuals showed a greater association between toothwear and OHRQoL. ***Conclusions:*** In this general population sample, there was a small significant association between toothwear and OHRQoL impacts. However, the association was only significant for more severe categories of toothwear.

Keywords: *Toothwear, quality of life, adult, public health dentistry*
Mesh Terms: *"Tooth wear"; "Health Related Quality of Life"*

Introduction

Toothwear can be defined as 'the loss of tooth substance by means other than caries or dental trauma' (Yule and Barclay, 2015). It may be the result of mechanical wear between teeth or between a tooth and another object (e.g. a smoking pipe). Alternatively, toothwear may be the result of chemical "erosion" resulting from food or stomach acid. Data from epidemiological surveys suggest that toothwear is increasing in prevalence (Kreulen *et al.*, 2010; The Health and Social Care Information Centre, 2011). Yet, most published literature on toothwear and its management adopts the mechanistic perspective of the biomedical model of health (Slade, 1997; Locker and Allen, 2007; Sischo and Broder, 2011). Most of the available literature, for example, concerns the prevention of toothwear and rehabilitation following toothwear, whereby rehabilitation aims to rebuild the shape of teeth for aesthetic and gnathologic purposes (Chander and Rees, 2010; Kaidonis, 2012; Yule and Barclay, 2015; Yim, 2017). This therefore focusses on clinically defined need with little focus on the patient perspective or any potential quality of life improvement.

There have been several attempts to reorient the delivery of healthcare into a more person-centred process based on the needs of the individual, particularly with changes introduced following the WHO reclassification of health (WHO QoL Group, 1995). Health related quality of life is an invaluable concept in health research and the delivery of healthcare (Robinson, 2016). It can be argued that further investigation of the patient experience of toothwear is essential to improve our understanding of the impact of toothwear on those affected (WHO QoL Group, 1995; Sischo and Broder, 2011). Yet, to date, the literature lacks any formal investigation of the relationship between types of toothwear and quality of life.

There have been 11 previous studies investigating the relationship between toothwear and oral health-related quality of life (OHRQoL) (Al-Omiri *et al.*, 2006; Ahlner-Elmqvist *et al.*, 2009; Vargas-Ferreira *et al.*, 2011; Papagianni *et al.*, 2013; Rodriguez *et al.*, 2013; Abanto *et al.*, 2014; Tampubolon, 2015; Andrade *et al.*, 2016; Brignardello-Petersen, 2017). The majority of these are cohort or cross-sectional studies, with conflicting results on the association between toothwear and OHRQoL. Three studied the association in children (Vargas-Ferreira *et al.*, 2011; Abanto *et al.*, 2014; Andrade *et al.*, 2016). One report was an opinion piece only (Brignardello-Petersen, 2017). Most of the remaining studies used generic OHRQoL measures rather than those specific to oral health conditions. Furthermore, previous studies have used varying [clinical] measures for toothwear, meaning little consistency in approach, and none have specifically assessed the influence of different types of toothwear. Additionally, most previous studies have used sampling techniques that focus on specific populations (intentionally or otherwise). Thus, there are few studies investigating the association between toothwear and OHRQoL using general population samples.

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Few previous studies have provided any detail on statistical power, and similarly, little detail on the sample's demographic characteristics have been given. Yet, we know from other oral health conditions that demographic factors such as socioeconomic position, age and gender can have an important impact on (oral health) quality of life (Guyatt and Cook, 1994; Rebelo *et al.*, 2016).

The aim of the present study, therefore, was to examine the association between different types of toothwear and OHRQoL in a general population sample; namely the UK Adult Dental Health Survey [2] which is a representative sample of [6469] people across England, Northern Ireland and Wales. A further aim was to examine whether key demographic factors (age, gender, socioeconomic status) influenced the relationship between toothwear and OHRQoL.

The two research questions were: (i) Is there an association between different types of toothwear and OHRQoL? And (ii) Is this association influenced by demographic factors?

Materials and Methods

The target population was adults (16 years and older) living in the UK. The sample population was individuals who were recruited to the Adult Dental Health Survey 2009 (ADHS).

The ADHS 2009 was a national survey that used randomised cluster sampling to provide a representative sample of the UK population. Various methods were used to reduce recruitment bias (The Health and Social Care Information Centre, 2011). 13,400 households were enrolled in the survey. From these households, 13,509 adults were invited to participate with 11,380 taking part (84% response rate). Sixty-one per cent (6469) of individuals were eligible for clinical assessment.

The sample size for this secondary analysis was determined by the data available from the ADHS. Of the 6469 individuals recruited for clinical assessment, 1282 were excluded because they lacked toothwear and/or OHRQoL data. The final sample for this study was therefore 5187. Data were available for 5175 individuals in the "any toothwear" (ATW) group and 433 who had erosive toothwear (ETW).

The ADHS 2009 assessed toothwear using two different assessment tools (Table 1). "Any anterior toothwear" (ATW) recorded all types of toothwear with the modified Smith and Knight criteria (Millward *et al.*, 1994). "Erosive toothwear" (ETW) was recorded using the Basic Erosive Wear Examination (BEWE)(Bartlett *et al.*, 2008). All tooth surfaces (buccal, incisal and lingual) were included in these assessments. Post-hoc assessments of inter-examiner variability were conducted as part of the ADHS 2009.

OHRQoL was assessed via the Oral Health Impact Profile-short form (OHIP-14). Total OHIP-14 scores.

The first research question was addressed using Spearman's rho to for correlations between ATW, ETW and OHRQoL.

The second question was addressed using an adjusted linear regression model with ATW and ETW scores as the independent variables. Age, gender and Index of Multiple Deprivation (IMD) were added into the regression models. The total OHIP-14 score was the dependent variable.

Power calculations were carried out using G*Power 3.1.9.2 (Universität Kiel, Germany) with a specified alpha error of 0.05. The required power was 0.80. All other statistical tests and data processing was undertaken using IBM® SPSS® version 23 (International Business Machines Corp.).

Results

Of the sample, 51.7% were female, 58.6% were 35-64 years of age, 18.8% were 16-34 years of age and 22.5% 65 years or older. In England, Wales and Northern Ireland, 7.2, 9.0% and 5.4% of the sample respectively were in the most deprived decile (Table 2).

Mean IMD varied between 3.8% and 5% from the source population for England, Wales and Northern Ireland. Age and gender were normally distributed, however, there were proportionately fewer individuals older than 70 or younger than 30 years of age.

Research question 1: Is there an association between different types of toothwear and OHRQoL?

There was a significant positive correlation between ATW and total OHIP-14 score ($r=0.059$, $p<0.05$) but no significant relationship between ETW and total OHIP-14 score ($r=-0.081$, $p=0.091$). Post-hoc power tests for ATW-OHRQoL and ETW-OHRQoL returned a power (1-ß err prob) of 1.00 and 0.99 respectively.

Research Question 2: Is the association between toothwear and OHRQoL influenced by socio-demographics?

The regression analysis found that the two toothwear variables accounted for less than 1% of the variance in OHIP-14 scores. The incorporation of the demographic variables age, gender and IMD decile resulted in greater variance in OHIP-14 scores attributable to ATW and ETW: 0.02% for ATW and ETW ($F=14.15$, $p<0.05$). Gender, age, and deprivation were all influenced the regression model ($p<0.05$), accounting for between 1.2% (age) and 7.0% (gender) of variation in OHIP-14 scores.

As can be seen in Table 3, the standardised estimates for ATW were significant and positive, but only for the severe wear category. For ETW, the estimates were significant and negative, but only for moderate and severe erosive toothwear.

The post-hoc power test for ATW returned a power (1-ß err prob) of 1.00 and is thus interpreted to achieve the desired statistical power (within the limits of this post-hoc test), whilst that for ETW was 0.52, indicating it did not achieve sufficient power.

Discussion

The aim of this study was to investigate the relationship between OHRQoL and toothwear in the UK population as a secondary analysis of data from the ADHS 2009. Within the limits of this investigation, there appears to be a relationship between ATW and total OHIP-14 scores. This is small but significant, with a positive correlation, which is maintained in a linear regression model

Table 1. Variables selected from the Adult Dental Health Survey 2009

Concept	*Variables*	*Coding (ADHS 2009)*	*Recoding (present study)*
Toothwear	"Any toothwear" (ATW)	1 - "Sound – no wear exposing dentine"	1 – "No toothwear"
		2 - "Loss of enamel – just exposing dentine"	2 – "Mild toothwear"
		3 - "Loss of enamel exposing dentine on >1/3 of surface"	3 – "Moderate toothwear"
		4 - "Complete loss of enamel/pulp exposure/exposure sec. dentine"	4 – "Severe toothwear"
		5 - "Fractured tooth"	4 – "Severe toothwear"
	"Erosive toothwear" (ETW)	1 - "Sound – no wear"	1 - "no erosive wear"
		2 - "Loss of enamel"	2 - "mild erosive wear"
		3 - "Distinct defect, hard tissue loss >50% of surface area"	3 - "moderate erosive wear"
		4 - Hard tissue loss >50% of surface area"	4 - "severe erosive wear"
Gender	-	Male / Female	Male / Female
Age	Age group	16-24	16-24
		25-34	25-34
		34-44	34-44
		45-54	45-54
		55-64	55-64
		65-74	65-74
		75-84	75-84
		85+	85+
Deprivation	Index of Multiple Deprivation (IMD)	Grouped by decile for England, Wales and Northern Ireland	Grouped by decile for England, Wales and Northern Ireland

adjusted for age, gender and deprivation. There was not a significant relationship between ETW and total OHIP-14 scores in bivariate analysis. However, the regression model suggests that there may be a relationship between moderate and severe erosive toothwear and total OHIP-14 scores. These findings suggest potential differences in the relationship between types of toothwear and oral health impacts in daily life. Although it is important to note that, as the ADHS includes only cross-sectional data, it is not possible to make any inference of causality.

Regression analysis using an adjusted model accounting for age, gender and IMD decile suggests that the relationship between ATW and OHRQoL was significant for severe toothwear only. The confidence interval at this point does not cross zero but is wide (0.76-6.60) suggesting a wide variation in OHIP-14 total scores within each group. Data should, therefore, be interpreted with caution. Given that statistical power was achieved, this may be an indication that either mild and moderate ATW did not have a significant relationship with OHRQoL, or that the measure used (total OHIP-14 score) was not sufficiently sensitive to differences in OHRQoL associated with ATW. The latter has been suggested in a previous study (Li and Bernabé, 2016).

Many different oral health conditions can impact on OHRQoL, with the OHIP-14 having been validated to assess the impacts of several oral conditions such as periodontal disease and tooth loss. Published literature report varying impacts of oral health conditions, such as periodontal disease, on OHIP-14 total scores (Allen and McMillan, 1999; Araújo *et al.*, 2010; Bernabé and Marcenes, 2010). Due to variations in methods, it is not possible to compare the difference in impact between oral health conditions on OHIP-14 total scores directly, however, these results suggest that tooth loss and periodontal disease may have greater impacts than tooth wear.

As indicated by previous studies, toothwear may result in functional limitations in addition to changing the appearance of teeth. It may, in some cases, also result in pain (Al-Omiri *et al.*, 2006; Bartlett *et al.*, 2013; Papagianni *et al.*, 2013; Brignardello-Petersen, 2017). The risk of pain may be increased if the severity of wear increases. Furthermore, functional limitations or changes in appearance may become more noticeable with greater severity. This may explain the differences found with different severities of ATW. It is not clear how and in what way individuals perceive these differences and in turn, how they translate into self-reported impacts on oral health-related quality of life. Further exploration of this is warranted. Recommendations from Guyatt and Cook (1994) suggest that qualitative interviews to explore the dimensions of quality of life influenced by different severities of toothwear may be appropriate. In addition, a more in-depth understanding of when, how and in what way individuals perceive toothwear symptoms and any change in toothwear (the 'tipping point') would be recommended.

There was a small significant relationship between moderate and severe ETW and total OHIP-14 score, but in the opposite direction to that for ATW. This was not significant for mild ETW. Given the wide confidence intervals for moderate and severe ETW data should be interpreted with caution. These findings may indicate wide individual variability in the relationship between ETW and

Table 2: Characteristics of the study sample (n=5187)

	%
Gender	
Male	48.3
Female	51.6
Age (Years)	
16-24	6.6
25-34	12.2
35-44	19.2
45-54	19.5
55-64	19.9
65-74	14.1
75-84	7.2
85+	1.3
IMD Decile	
1 least deprived	7.1
2	7.1
3	8.3
4	8.3
5	11.3
6	11.6
7	11.1
8	11.1
9	11.6
10 most deprived	12.5

Table 3: Regression analysis for severity of "any" and "erosive toothwear" predicting OHIP-14 scores.

Variable	*B*	*Significance*	*95% confidence interval*	
			Lower bound	*Upper bound*
ATW (Mild)	.981	.473	-1.699	3.661
ATW (Moderate)	1.624	.238	-1.075	4.323
ATW (Severe)	3.675	**.014**	.758	6.591
ETW (Mild)	-.970	**.078**	-2.048	.108
ETW (Moderate)	-1.005	**.026**	-1.891	-.119
ETW (Severe)	-2.473	**.004**	-4.151	-.795

OHRQoL or a lack of sensitivity of OHIP-14 to identify impacts on OHRQoL from ETW. Furthermore, the study does not have sufficient power to detect a difference at this level (i.e. to assess the difference between toothwear severity and total OHIP-14 score), and this finding may, therefore, be at risk of type 2 error.

It is not clear why there was a negative relationship between ETW and total OHIP-14 score. Erosive toothwear may be associated with lower total OHIP-14 scores (i.e. i.e. better OHRQoL). One would have expected a positive relationship due to the likelihood of pain and sensitivity (Abanto *et al.*, 2014), or due to other factors already described (i.e. more severe toothwear would result in a higher impact on OHRQoL). Severe ETW may result in chipping of teeth with marked changes to the appearance of the visible surface of teeth.

The differences in the relationship with OHRQoL for ATW and ETW are interesting and unexpected. Possible explanations may be a relative insensitivity of OHIP-14 to toothwear, or different types of toothwear may have different impacts on OHRQoL, perhaps due to the pattern and appearance of wear. For example, erosive toothwear typically presents as smooth wear lesions on the palatal surfaces (i.e. be less visible to patients), whereas in ATW the wear may be more apparent to patients, with an aesthetic impact. It is not possible to ascertain the cause of this difference from these data, suggesting that qualitative research is necessary to explore individual experiences of toothwear.

The present findings indicate that women may experience more impacts on OHRQoL as a result of toothwear than men. The reasons for this are not clear; toothwear has anecdotally been reported to be more prevalent in females. More recent studies, however, challenge this (Van't Spijker *et al.*, 2009; Cunha-Cruz *et al.*, 2010), and the present study suggests that (in this sample), males and females show a similar prevalence.

Our analysis also found that greater deprivation was associated with less impact from toothwear. Other studies have reported similar findings for other oral conditions (such as caries and periodontal disease), and the mechanisms, in this case, may be similar. Possible mechanisms for this may relate to similar upstream determinants of health which can influence diet, stress and occupational amongst other things (Watt, 2007; Watt *et al.*, 2013). These can influence both the prevalence of a disease in a population, but also the impact of the disease on individuals by changing environmental pressures, access to healthcare, and perceived availability of service.

Finally, older participant experienced less severe OHRQoL impacts than younger groups. Toothwear in older individuals may have progressed more slowly and the effect on OHRQoL may, therefore, be less, given the potential for a slower progression of toothwear in these groups. Toothwear of similar severity in a younger patient may have progressed more rapidly, and thus may have a greater influence on OHRQoL. Furthermore, the changes experienced here may be different than those in older individuals due to differences in perceptions related to oral health between age groups (Masood *et al.*, 2017). Some reports suggest that toothwear may progress more rapidly in younger individuals due to changes in lifestyle, such as diet (Bartlett *et al.*, 2013).

There are several limitations of the present study, which must be considered when interpreting these results. As the data were from an epidemiological study, the findings are only applicable to population settings, rather than individuals. As such, applying findings from the present study at the individual level should, therefore, be avoided (Piantadosi *et al*., 1988; Wakefield and Shaddick, 2006). There was a slight skew towards older age in the sample. This is important to consider when comparing theseresults from to others and when considering the distribution of toothwear. Furthermore, OHIP-14 total scores appear to have a negative skew. Most individuals had little or no

impact on OHRQoL (45% had an OHIP-14 total score of 0). Additionally, this study does not account for other variables that may influence OHRQoL (such as caries and tooth loss). Some variables (e.g. caries) have been investigated previously. Tooth loss may also influence the association between OHRQoL and toothwear. This may require separate investigation to account for number and position of teeth lost within the context of the impact of toothwear on OHRQoL.

Furthermore, OHIP-14 data has been used to indicate OHRQoL as the most suitable measure in the ADHS 2009 dataset. Whilst this measure has been validated in several studies to measure OHRQoL in different populations, these studies largely focus on other oral conditions (Li and Bernabé, 2016), which may have differing impacts on daily functioning and experience. The use of OHIP-14 may fail to identify a relationship between OHRQoL and toothwear when one exists (Li and Bernabé, 2016). Generic OHRQoL measures may lack sensitivity to impacts associated with toothwear (Li and Bernabé, 2016) and thus a condition-specific measure may be useful to investigate this association further.

Conclusions

Despite these limitations, the present study found some support for an association between toothwear and oral health impacts in daily life. At a population level, this association appears small and significant only for moderate and severe toothwear. Further exploration of individual experiences of toothwear is recommended alongside a more detailed examination of the types of impacts toothwear has on quality of life.

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