Prevalence of Tooth Wear in Adults

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Purpose: The aim of this study was to investigate data on the prevalence of tooth wear in adults and assess possible correlations using a systematic review.
Materials and Methods: A search of the literature, using PubMed and the Cochrane Library, from January 1980 to July 2007 was made using keywords "tooth + wear"; "dental + attrition + prevalence"; "dental + wear + prevalence"; "erosion + prevalence"; and "abrasion + prevalence." References were independently screened for inclusion and exclusion by two investigators and Cohen Kappa was used as the measure of agreement. Data were collected and converted into the Smith and Knight Tooth Wear Index. ***Results:*** One hundred eighty-six references were initially selected and subjected to the systematic review procedure; 13 survived the inclusion procedure. Four articles were suitable for regression analysis at tooth level (R^2 = .593) and 3 at subject level (R^2 = .736), using "age and age squared" and "age squared" as variables, respectively. Six studies reported males having significantly more tooth wear than females. ***Conclusion:*** The predicted percentage of adults presenting with severe tooth wear increases from 3% at the age of 20 years to 17% at the age of 70 years. Increasing levels of tooth wear are significantly associated with age. *Int J Prosthodont 2009;22:35–42*

There has been an increasing interest in tooth wear in dental literature. While there is a decline in the prevalence of caries in industrialized countries, some authors describe a general trend of increasing tooth wear, acid erosion in particular, amongst the young.[1,2] There are abundant data on the prevalence of tooth wear in children and adolescents, but data on adults are scattered. Anecdotal clinical experience suggests tooth wear in adults is common, but little evidence exists on the natural course of the condition. The irreversible and multifactorial aspects of wear of the teeth make it one of the most difficult dental problems to manage, and early diagnosis of pathological forms of wear is therefore important.

Many authors use the terms "tooth wear" and "erosion" interchangeably. Strictly, the definitions relate to different causes, tooth wear being recognized as the overarching term including erosion, abrasion, and attrition.[3] However, the emphasis by some researchers seems to target the term "erosion" rather than "abrasion" or "attrition." Despite the terminology being widely accepted, the clinical appearance and interpretation of the types of tooth wear vary among clinicians.[4]

Several indices used to describe the severity of tooth wear have been outlined in the literature. Indices grade tooth wear by recording surfaces, teeth, or the whole mouth.[5–7] One of the most commonly used indices was

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developed by Smith and Knight[7] and has been adapted by many researchers.[8,9] This index is easy to use and is not biased in the etiology.

The prevalence of tooth wear in adults has been investigated by several studies, but clear data to describe general trends are lacking, partly because of the problems mentioned above. Based on the literature published since 1980, there is little evidence to suggest what the levels of tooth wear are in adults. The aim of this study was to investigate data on the prevalence of tooth wear in adults and assess possible correlations using a systematic review.

Material and Methods

Search, Inclusion, and Exclusion

Published literature from January 1980 to July 2007 was searched using PubMed and the Cochrane Library and different sets of keywords: *(1)* "tooth + wear"; *(2)* "dental + attrition + prevalence"; *(3)* "dental + wear + prevalence"; and *(4)* "(erosion + prevalence) and (abrasion + prevalence)." All titles and abstracts were read and any non-English publications, reviews, case-reports, historical and forensic studies, in vitro and in situ studies (on nonhuman tooth material), and articles not describing prevalence were excluded. In the case of doubt or if an abstract was not available, the full article was examined. Articles that appeared to be the same, following the four separate search strategies, or separate articles from the same study were eliminated. Studies on subjects less than 18 years of age and on specific groups, such as alcoholics, were excluded.

References were independently screened for inclusion and exclusion by two investigators (NHJC and AVTS) and Cohen Kappa (κ) was used as the measure of agreement. Disagreement was resolved after discussion and, when necessary, a third investigator (CMK) acted as the mediator. From the remaining references, the full-text articles were read. In addition, the reference lists of the included articles were hand-searched using the same criteria. Appropriate references were cross-matched with the original list of references and those not already included were added.

Data Extraction

Papers were blinded of source information and only the sections "Materials and Methods" and "Results" (including tables and figures) were made available. The articles were jointly scrutinized by four investigators (NHJC, AVTS, DWB, and JMR) and data were extracted according to the headings shown in Tables 1 and 2. If the content of the data of a study was not clear to the investigators, the specific item was not recorded. Data from studies using indices other than the Smith and Knight[7] index were recalculated and if possible, converted to the Tooth Wear Index (TWI) (Table 2).

Statistics

Frequencies, percentage distributions, and age cohorts were recalculated or redefined if necessary. To quantify the relationship between the explanatory variables and the prevalence of tooth wear, linear regression models were used. These models estimate the change of the TWI corresponding to the change in a certain explanatory variable, for example gender or age. By including not only age but also "age squared" in these models, nonlinear relationships between age and the TWI could also be estimated. Preliminary analysis showed that regression was not possible for the variables "gender," "number of teeth," "tooth number," and "tooth surface," as there were insufficient data. Consequently, analysis was performed for "age" and the dependent variable "percentage of population presenting with tooth wear." According to Harrell, there is a limit to the number of variables in a model for regression analysis that is dependent on the number of data points.[10] Therefore, three regression models were tested: the first with only "age," the second "age and age squared," and the third only "age squared." The model with the highest adjusted R^2 was chosen (best fit). To correct for heteroscedasticity induced by differences in sample size at different ages, age groups were weighted with $\sqrt{N}$. Statistical analyses were done with SPSS 14.0.

Results

Search, Inclusion, and Exclusion

Figure 1 shows the number of references obtained by the four sets of keywords using PubMed. Interobserver agreements were rated "moderate" to "very good" ($\kappa \geq 0.78$). The Cochrane Library did not add any additional references. From a total of 1,953 references, 186 were initially selected based on the abstracts and titles. Of these, 90 were found in more than one search, leaving 96 separate papers, 74 of which were excluded because they targeted subjects less than 18 years of age or specific groups. From the 22 articles included for full-text assessment, 2 reported on the same population. The first[11] was on subjects older than 18 years, the second[12] up to 24 years. The latter did not provide additional data and was excluded. From the remaining 21 papers, 2 were thesis supplements[13,14] published in articles already included in the selection procedure and were excluded. An additonal 6 studies were excluded as the full text article did not include data on preva-

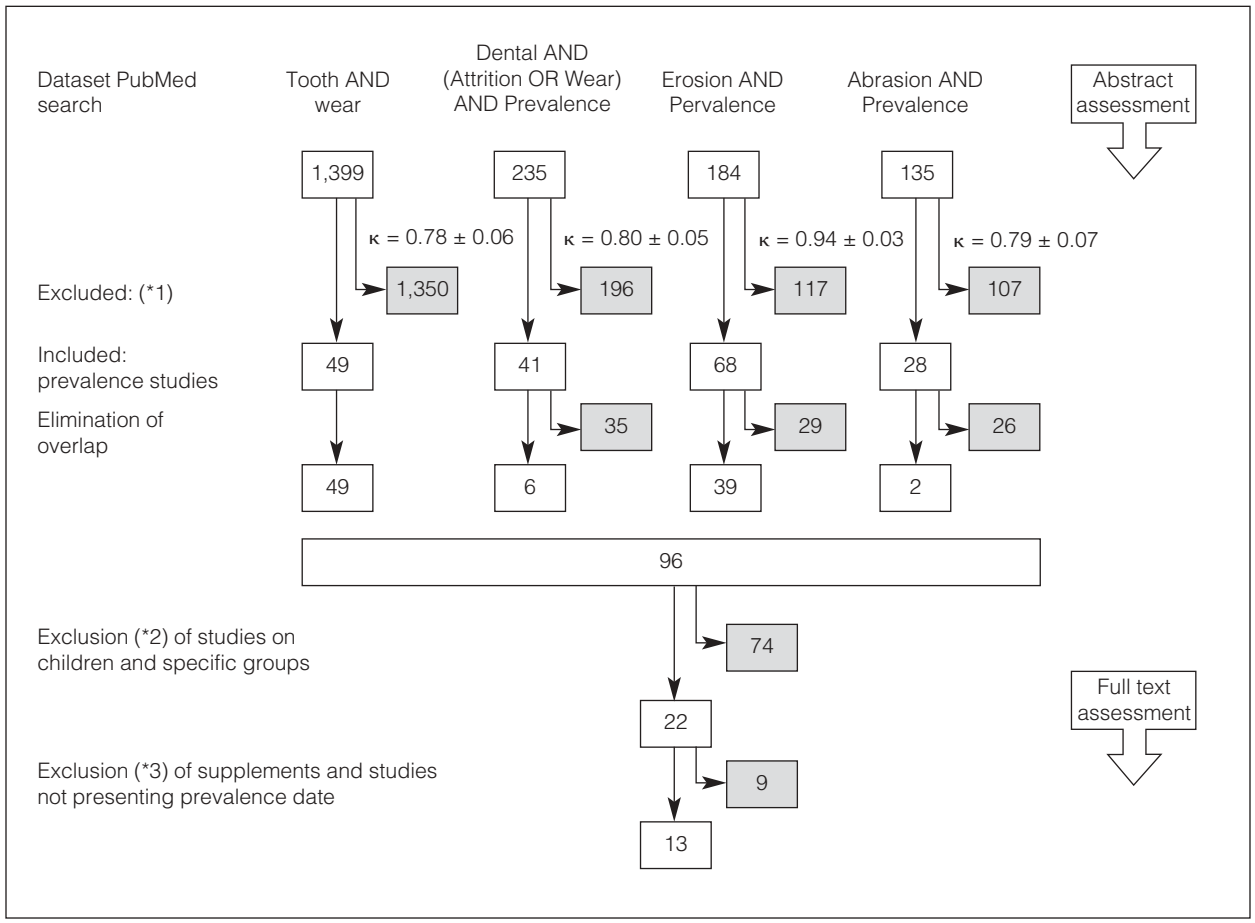

Fig 1 Flowchart describing the results of each step in the selection procedure.

lence.[15–20] Cross-checking the reference lists did not reveal any other articles.

The details and data from the remaining 13 studies[21–32] are summarized in Tables 1 and 2. Two, however, contained incomplete data.[26,28] The missing data were sourced from previously published work, allowing analysis to be completed.[33,34]

Data Extraction

Eight studies reported wear on all tooth surfaces, one on the occlusal surface only, one on both the occlusal and cervical surfaces, and three on only cervical surfaces. One study reported only the data from erosion and another focused on anterior teeth (Table 1). Study populations were obtained from 10 countries. Seven studies were randomized population-based samples and six were convenient samples. The number of subjects was reported in all studies and the number of teeth reported in eight.

Six studies presented data at the subject level, five at the tooth level, and two on both (Table 2). The Smith and Knight[7] TWI was used in two studies and modifications of the index in six. One study[23] using this TWI converted data into pathological thresholds based on expected wear for different age groups and, since these data could not be compared to other studies, they were excluded from further analysis. Eight studies split the populations into age groups and presented wear as a mean for each group.

From the 13 papers it was only possible to compare wear on the occlusal and cervical surfaces. The overall percentages of extensive wear (TWI scores 3 and 4) at tooth level varied from 1.4% to 5.7% for occlusal and 3.9% to 24% for cervical wear. Subject level was reported by eight studies with a total of 4,593 subjects (range: 148 to 1,007 subjects per study). The seven studies reporting at the tooth level included 171,472 teeth in 9,476 subjects (range: 527 to 3,817 subjects per study). The most severely affected teeth were molars (three studies)[6,27,30] and the most commonly affected teeth were incisors (three studies)[6,21,30] and molars (one study).[27] Six studies reported higher prevalence of tooth wear in males than females (Table 2). Two studies reported no significant difference and five did not analyze this variable.

Table 1 Sample Characteristics and Relevant Wear Measurement Specifications of the Included Studies

Reference	Country where study was done	Subject selection	No. of subjects	% female	No. of teeth	No. of age groups (min–max)	Surfaces assessed	Wear index used	No. of levels	Reproducibility: Intraobserver agreement	Reproducibility: Interobserver agreement (no. of observers)	Remarks
Xhonga and Valdmanis[30]	United States	UDC	527	—	16,863	1 (14–88)	Cervical	Depth of lesion	4	—	Not presented (2)	2 Clinics, 1 examiner each
Hugoson et al[11]	Sweden	RPB	585	52	13,209	7 (20–0+)	Occlusal	Modified TWI	4	—	ICC 0.88–0.99 (7)	
Salonen et al[22]	Sweden	RPB	751	51	—	7 (20–80+)	All	Own classification	3	—	(1)	
Lussi et al[6]	Switzerland	RPB	391	—	—	2 (26–30, 46–50)	All	Modified after Linkosalo and Markkanen (1985)	Facial: 4 Others: 3	—	$\kappa = 0.80–1.00$ (2)	Erosive lesions only
Donachie and Walls[23]	United Kingdom	RPB	586	—	—	4 (45–75+)	All	TWI	5	$\kappa = 0.84$	(1)	
Smith and Robb[24]	United Kingdom	RDP	1007	56	—	6 (< 25 to > 65)	All	TWI	5	—	(1)	Subjects with ≥ 12 scorable teeth only
Milosovic and Lo[25]	Malaysia (Borneo)	CS	148	57	3,641	1 (14–77)	All	Modified TWI	4	$\kappa = 0.63 –0.78$	(1)	
Nunn et al[26]	United Kingdom	RPB	3817	54	45,720*	1 (16–75)	All	Modified TWI	4	—	$\kappa = 0.44–0.96$ * (75) *	Anterior teeth only
Akgül et al[31]	Turkey	UDC	428	57	—	4 (> 20)	Cervical	Lesion present / not present	2	—	— (—)	Buccally unrestored teeth only
Borcic et al[32]	Croatia	RDP	1002	—	18,555	6 (10–65)	Cervical	TWI cervical	5	—	(1)	
Taiwo et al[27]	Nigeria	RPB	690	42	19,280	1 (> 65)	All	Modified after Eccles (1982)	4	—	71%	Elderly only
Bernhardt et al[28]	Germany	RPB	2707	53	54,204	8 (20–59)	Occlusal Cervical	Modified TWI Cervical: yes /no lesion	4 2	$\kappa = 0.68–0.91$	$\kappa = 0.53 - 0.74$ (8)	Subjects with ≥ 4 teeth only
Rafeek et al[29]	Trinidad and Tobago	CS	155	67	1,755	4 (16–65+)	All	Modified TWI	4	—	— (—)	

— No information / not described.
* Data found in reference and/or supportive paper.
TWI = Tooth Wear Index according to Smith and Knight (1984); RPB = random population based; RDP = random from dental practices; CS = convenience sample; UDC = university dental clinic (patients).

Table 2 Description of Outcomes of the Included Studies

Study	Outcome at subject/tooth level	Total wear/group: own classification	Conversion from originally used index into TWI		% TWI at subject level	% TWI at tooth level	Most severely affected tooth	Most commonly affected tooth	Most commonly affected surface	Overall % extensive wear (TWI of 3 or 4)	Tooth wear more in males (level of significance)	Remarks
Xhonga and Valdmanis[30]	Tooth	No erosion	0	0	NA	57.4	Mandibular molars	Anterior teeth	—	24	Not analyzed	Cervical only
		Minor erosion	1	1 / 2		18.7						
		Moderate erosion ≤ 3 mm	2	3		1.6						
		Severe erosion > 3 mm	3	4		22.3						

Hugoson et al[11]	Subject and tooth	No / negligible enamel wear Enamel wear & dentin spots Wear ≤ 1/3 crown height Wear > 1/3 crown height	0 1 2 3	0 / 1 1 / 2 2 / 3 / 4 3 / 4	24 # # #	# # # #	–	Mandibular incisors	Occlusal / Incisal	2	Yes ($P < .05$)	Data not convertible into TWI percentage due to unknown overlap in subgroups
Salonen et al[22]	Subject	No wear / enamel Exposure of dentin Extensive dental wear	1 2 3	0 / 1 2 3 / 4	59 36 5	NA	–	–	–	5	Yes ($P < .001$)	
Lussi et al[6]	Subject	No erosion Slight erosion in enamel Severe erosion, dentine involved	0 1 2	0 1 2 / 3 / 4	26 38 36	NA	Mandibular 1st molar	–	Occlusal	–	Not analyzed	Erosive lesions only
Donachie and Walls[23]	Subject	TWI 5-point scale			#	NA	--	Overall: central incisor	Occlusal / Incisal	--	Not analyzed	Data not convertible into TWI percentages only mean TWI scores per tooth
Smith and Robb[24]	Tooth	TWI 5-point scale				3/4: 5.1%	--	--	Occlusal / Incisal	5.1	Yes (not specified)	
Milosovic and Lo[25]	Subject	No wear / enamel Enamel wear only Dentin exposed ≤ 1/3 of surface Dentin exposed > 1/3 of surface	0 1 2 3	0 1 2 3 / 4	0 5.5 53.5 41	NA	--	--	--	--	No difference	
Nunn et al[26]	Tooth	No tooth wear/ only enamel Wear more than in enamel only Extensive exposure of dentin Enamel loss / pulp exposure / sec dentin	0 1 2 3	0 / 1 2 3 4	NA	63 34 3 0	--	--	--	3	Yes (not specified)	Data in text inconsistent with tables
Taiwo et al[27]	Subject & Tooth	No wear Enamel wear only Dentine exposed ≤ 1/3 of surface Dentine exposed > 1/3 of surface	0 1 2 3	0 1 2 3 / 4	7.2 # # #	36.5 30.9 26.9 5.7	Molars	Molar (± 70%)	Occlusal (figures interpreted)	5.7	Not analyzed	Any tooth wear (TWI = 1 to 4) in 92.8%
Bernhardt et al[28]	Tooth	No / negligible enamel wear Enamel wear and dentin spots Wear ≤ 1/3 crown height Wear > 1/3 crown height	0 1 2 3	0 / 1 1 / 2 2 / 3 / 4 3 / 4	NA	30.9 47.1 20.5 1.4	--	--	--	1.4	Yes ($P < .005$)*	Abfraction overall 5,3%
Akgül et al[31]	Subject	No cervical abrasion lesion Cervical abrasion lesion	0 1	0 / 1 2 / 3 / 4	90.9 9.1		–	–	–	–	Yes ($P = .006$)	Cervical only
Borcic et al[32]	Tooth	TWI 5-point scale		 0 1 2 3	NA	73.9 7.1 5.6 3.3 0.6	–	–	–	3.9	Not analyzed	9.5% of teeth was restored or obscured
Rafeek et al[29]	Subject	Wear more than in enamel only Wear more than in enamel only Extensive exposure of dentin Enamel loss / pulp exposure / sec. dentin	0 1 2 3	0 / 1 2 3 4	29 51 16 4		–	–	–	20	No difference	Tooth wear associated with age after combining age groups

TWI = Tooth Wear Index according to Smith and Knight (1984).
# = data presentation insufficient.
— = No information / not described.
* Data found in reference and/or supportive paper.

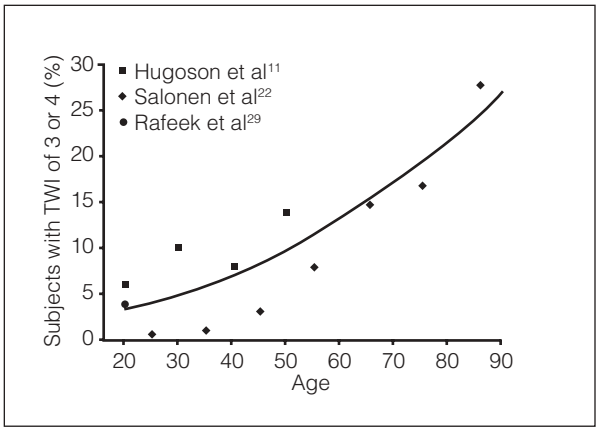

Fig 2 Regression model for subjects with a TWI score of 3 or 4.

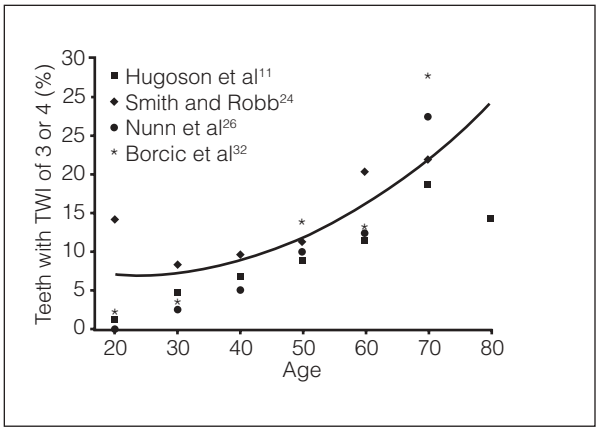

Fig 3 Regression model for teeth with a TWI score of 3 or 4.

Table 3 Parameters of the Best Fitting Regression Models for Subject and Tooth Level Analyses

	Estimate	95% CI	*P* value
Subject level*			
Constant	2.08	[-1.80 … 5.96]	.259
Age squared	0.0031	[0.00179 … 0.00441]	.001
Tooth level†			
Constant	4.44	[-0.956 … 9.84]	.102
Age	-0.135	[-0.398 … 0.127]	.297
Age squared	0.00281	[-0.000630 … 0.00570]	.055

*Model significance: $P < .001$; $R^2 = 0.736$.
†Model significance: $P < .001$; $R^2 = 0.593$.

Data Analysis

Subject Level. Three of the eight studies with data at the subject level described the percentage of the study population presenting with a TWI score of 3 or 4, of which two described the results at specific age cohorts (Fig 2). One study[6] could not be analyzed because erosion was only recorded in subjects aged 26 to 30 and 46 to 50 years old. Two studies[25,29] used mean ages with a large range and could not be analyzed further, except for the subjects up to 24 years old in the study by Rafeek et al.[29] Figure 2 shows that three studies were used to construct the regression model with age versus severe wear at levels 3 and 4. Hugoson et al[11] reported on occlusal surfaces but only those aged 20 to 50 years could be used for analysis. Salonen et al[22] and Rafeek et al[29] both reported on all surfaces. Regression analysis showed that the best fit was found in the model using "age squared" (Table 3).

Tooth Level. Four of the seven studies with data at tooth level described the percentage of teeth presenting with a TWI score of 3 or 4 and specified the age cohorts (Fig 3). The other three did not. Regression analysis showed that the best fit was found in the model using "age and age squared" (Table 3).

Discussion

We found relatively few studies on the prevalence of tooth wear conducted on adults, as most data report on children and adolescents. This probably reflects the difficulty of recruiting adults for representative samples on the prevalence of tooth wear. This is discouraging considering the increasing concern that both tooth wear and acid erosion cause clinicians. On the basis of the present data, it is realistic to state that tooth wear is common in adults, although it is not clear whether or not tooth wear is an increasing phenomenon. Longitudinal studies are needed to address this question.

Using too many keywords in electronic searches has the risk of introducing priori exclusion. For instance, a study by Bernhardt et al[28] described the prevalence of wear, but neither title, abstract, nor description of the purpose of the study mentioned the words "prevalence" and/or "wear." On the other hand, the studies by Nunn et al[26] and Bernhardt et al[28] prove that not all data can be found in the original articles and we were fortunate to have access to the missing data from complementary articles. We consider our protocols used to search the literature thorough and comprehensive. After applying the selection criteria, less than 1% of the references originally obtained from PubMed were included, which is in line with the experiences from other systematic reviews.

We explored prevalence studies and considered methodological aspects that might explain variation in results. However, strict guidelines for quality control of prevalence studies are lacking. We found that descriptions of sample constructions (external validity) did not allow any assessment of quality. In terms of internal validity, included studies were restricted to standardized measurements. However, there is no consensus on which index should be used to assess the

severity of tooth wear. The Smith and Knight[7] index was the most common and straightforward for converting other indices. This paper supports the idea of adopting a widely held and used tooth wear index. It is unlikely that a single index will ever be fully adopted by all researchers, but it might be possible to use a skeleton index which can be adaptable to others, both in the collection and presentation of data. In the opinion of the authors and in line with our results, any overarching index must include an assessment of dentin exposure.

Some papers reported tooth wear on the tooth level and others on the subject level, which made comparison more challenging. In converting the original wear scores to TWI scores we dealt with subjective terms, such as "unacceptable level of wear," "severe wear," and "moderate wear." Converting these terms into TWI scores might have encountered some bias, which is why we used scores 3 and 4 as a sign of severe wear. Analyzing lower levels of wear would have made the results more prone to bias due to the clinical difficulties in distinguishing worn from unworn surfaces. Also, higher levels of wear have more clinical relevance for clinicians restoring worn teeth.

There were differences in the studies included in the regression analysis, as they assessed different tooth surfaces. For example, Hugoson et al[11] reported data on occlusal surfaces whereas Salonen et al[22] and Rafeek et al[29] reported on all surfaces. The data from these two studies were combined for the analysis of age regression. Unfortunately, Hugoson et al[11] only provided data from the occlusal surfaces so it was not possible to tell what level of wear occurred on the other tooth surfaces. For the purposes of the regression analysis, the data from the three studies was sufficient to predict the relationship with age.

Most early tooth wear indices were developed in an attempt to match treatment need to severity and as such, are biased toward the more severe levels. The Smith and Knight index has 5 levels, from 0 to 4, with wear on enamel denoted by level 1 and early dentin being exposed denoted by level 2. Therefore, the Smith and Knight[7] index is biased toward moderate (level 3) and severe (level 4) levels of tooth wear. The comparison of data between studies was possible at levels 3 and 4 but not possible at those that were less severe. This probably reflects the variability of the scoring system between the different modifications of the Smith and Knight[7] index. From a treatment perspective, the identification of levels 3 and 4 has more clinical significance than the less severe levels.

The difference in the final regression models underlines the importance in data presentation in terms of tooth and subject level. It is known that, apart from age and gender, diet and parafunctional behavior have a role in the etiology of tooth wear. While nearly half of the studies reported males to have significantly more tooth wear than females, not all studies reported on gender in a way that it could be used in the regression analysis, and even less so on diet or parafunctional behavior. Therefore, regression analysis had to be limited to age.

The most interesting finding of this systematic review is that age and tooth wear are correlated to a significant level, with $R^2 = .736$ on the subject level and .593 on the tooth level. The interpretation of these data suggests that tooth wear is a common clinical finding and will increase with age. The degree of association between age and tooth wear on subject level support the results that Milosevic and Lo reported for a small sample ($\rho = 0.60$, $P = .001$).[25]

Conclusion

The predicted percentage of adults presenting with severe tooth wear increases from 3% at age 20 years to 17% at age 70 years. Therefore, there is a tendency to develop more wear with age. It is not possible to state within the limited number of studies analyzed whether this increase reflects greater severity of wear on the same tooth or greater number of teeth involved. To date, there are no longitudinal studies in adults or children that have measured wear progression on the same tooth. The Smith and Knight[7] index is a relatively crude index in that the changes at the tooth level increasing from index 2 to 3 or 3 to 4 represent a significant increase in the severity of tooth wear. For this reason, studies that have shown progression have done so by recording increased wear on all teeth rather than on progression on the same tooth.[6]

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Literature Abstract

Effect of reinforcement on overdenture strain

This in vitro study aimed to evaluate quantitatively the effect of metal reinforcement on overdenture strain around copings and at the midline. A mandibular edentulous model with a 2-mm-thick artificial mucosa and artificial abutment teeth installed bilaterally in the canine position was produced. The coping had a dome-shaped upper surface with a height of 6 mm. The four test designs were: no reinforcement (BS), reinforcement with cobalt-chrome wire (BW), cast metal reinforcement without reinforcement over the coping top (BA), and cast metal reinforcement with reinforcement over the coping top (BB). Bonding between the metal and resin was improved by sandblasting and use of a 4-META adhesive. On the lingual polished surface, strain gauges were attached (3 at the left canine position and 2 at the midline), with the grids oriented mesiodistally. A vertical load of 49 N was applied bilaterally at 6 points on the occlusal surface (first premolar, first molar, and second molar). The strain around the copings was found to be significantly greater with BS than with the other types and significantly less on BB than with the other types. At the midline, the strain on BA and BB was significantly less than on BS and BW. Thus, the authors concluded that among the different kinds of reinforcements evaluated, the cast metal reinforcement that covers both the midline and the coping top significantly reduced strains on the overdenture. They suggested that this simple reinforcement was effective in preventing deformation and fracture of the overdenture. The effect of incorporation of popular attachment systems in this reinforcement design would be valuable information.

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