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Prevalence of Proximal Caries in Adults and Children at Bristol Dental Hospital and South Bristol Community Hospital

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Abstract:

Introduction: Despite lack of data regarding proximal dental caries lesions, they may account for a substantial (>50%) proportion of all reported caries in some populations. Detection of proximal caries relies on clinical and radiographic examination. This study aimed to investigate the prevalence of proximal caries in posterior teeth in adults and children treated at Bristol Dental Hospital (BDH) and South Bristol Community Hospital (SBCH) in 2013.

Method: Radiographs were examined and statistical analyses determined the distribution and average number of decayed proximal surfaces between 4 sample groups (BDH Adult, BDH Child, SBCH Adult, and SBCH Child).

Results: Of the 178 subjects, 41.6% were free from proximal caries. Those with caries each had, on average, 3 carious proximal surfaces. There was a clear difference in the proportion of caries-free subjects between the 4 groups, which was lowest in the BDH Child group where 90% possessed at least one untreated decayed proximal surface. This may be explained by the fact that many of patients in this group are referred for multiple extractions of carious teeth.

Conclusions: Posterior teeth are not uniformly affected by caries. Fewer proximal surfaces are restored than occlusal lesions possibly due to implementation of preventive treatment modalities.

Keywords: Prevalence Proximal Caries Adults Children

Introduction

Dental caries is a dynamic disease process caused by bacterial fermentation of dietary sugars and subsequent demineralization of susceptible dental hard tissues.[1] A recent Global Burden of Disease study stated the average worldwide prevalence of untreated caries in permanent teeth as 35% for all ages with a 38% rise in years living with the disease between 1990 and 2010.[2] Proximal caries refers to demineralization of the mesial and distal surfaces of posterior teeth. Despite a lack of data regarding proximal lesions specifically, mesial and distal caries may account for a substantial (>50%) proportion of all reported caries in some populations.[3]

Apart from bitewing radiographs, which are generally counted as gold standard for detection of proximal caries, many adjunctive diagnostic tools have been introduced in the recent years.[4,5] It is important to note that the true (clinical) size of carious lesions is more advanced than what is depicted on the radiographs.[6,7] This is because that at least 30% demineralization should have occurred before caries lesion can be visualised radiographically.[8,9]

Many studies have documented caries prevalence and progression, the majority being longitudinal studies utilizing data collected between 1985 and 1994.[10-12] There is a scarcity of current data from the UK on the prevalence of proximal caries in adults and children. It is generally assumed that primary teeth are more susceptible to proximal caries than permanent teeth owing to broader contact areas and thinner enamel and dentine.[13,14] Furthermore, it has been found that 36.4% of children had proximal caries in the deciduous dentition while only 5% had proximal caries affecting permanent teeth. [10] European studies have reported a continued decrease in caries prevalence, especially in young adults.[15,16] Data from surveys conducted at 10 year intervals from 1973 to 2003 found a marked decrease in the prevalence of proximal surfaces that were decayed and filled in the 20-50 years old age range.[17] Interestingly, the proportion of surfaces that were carious but unrestored increased, possibly indicative of a shift towards preventative treatment modalities.

It is reported that most proximal lesions present as non-cavitated with an intact superficial enamel layer overlying the lesion when viewed in histological section.[18] This has led toward techniques more conservative of tooth tissue, aiming to re-mineralize the lesion and/or halt progression.

Preventive treatment including topical fluoride applications, oral hygiene instruction and dietary advice potentially aid the re-mineralization process and there is a greater arrest rate of proximal lesions where two or more preventive measures are administered. A recent systematic review reported positive results for different proximal sealing techniques in managing non-cavitated proximal lesions in primary and permanent teeth.[19] It has also been proposed that micro-invasive techniques (resin infiltration) may provide the best long- term cost-effectiveness in the treatment of early dentinal proximal lesions.[18]

It has been observed that the mesial surface of the first permanent molar had higher levels of caries than the distal surface of the second primary molar.[12] Such findings may help to focus preventative advice to protect surfaces that are theoretically most at risk.[20] Nevertheless, a study into caries prevalence at an individual level asserts proximal lesions affecting both enamel and dentine inevitably progress over time when remineralisation strategies were the only intervention.[12] The rate of proximal caries progression is difficult to ascertain and is influenced by patient and/or clinician interventions, and different scoring criteria have also resulted in wide variation in cited estimates of progression rate in posterior primary teeth.[21] Nonetheless, evidence has demonstrated that lesions advance more rapidly in deciduous teeth than permanent teeth and furthermore, a higher caries index has been linked to an accelerated demineralization of proximal outer enamel surface lesions in both primary molars and first permanent molars.[22]

There is a strong positive correlation between levels of deprivation and levels of disease.[23] Oral health inequalities continue to present a significant challenge to dental public health, predominantly due to socio-economic disparities between different regions of the UK,[24,25] mainly as a result of public policy.[26] Moreover, the majority of caries are often attributed to a disproportionately small percentage of a given population.[11]

There is currently no available data regarding prevalence of proximal dental caries in different dental care settings in the UK. This data can help use the limited available resources more efficiently, e.g. by targeting patients who are most in need.

The aim of this retrospective study was to investigate the prevalence of proximal caries (by tooth and tooth surface) in posterior teeth in adults and children treated at Bristol Dental Hospital (BDH) and South Bristol Community Hospital (SBCH) in 2013, by examining suitable posterior radiographs (both digital and plain film).

Materials and Methods

Bristol Dental Hospital: The majority of patients seen at Bristol Dental Hospital are referred by General Dental Practitioners for either treatment planning or specialist treatment. Patients that attended consultant-led assessment appointments on the Adult Dental Health and Child Dental Health clinics in January 2013 were identified from archived outpatient activity data. This centre is regarded as a secondary healthcare setting. Clinic codes were provided by the patient administration staff. Patients with suitable radiographs were sourced through the radiology department's internal referrals list. Plain film radiographs were viewed by two examiners (4th year undergraduate dental students) using a lightbox and hand magnifier, if required.

South Bristol Community Hospital:

The South Bristol Community Hospital (SBCH) opened in 2012 as a key part of a vast regeneration programme which aims to improve access to services in this deprived area. It provides a community dental service for local residents requiring routine dental treatment and is regarded as a Primary Care setting.[27] Although local referrals are accepted, the majority of patients are self-referred. Patients that attended both staff and student clinics at SBCH in 2013 were identified using the diary tool on the Software of Excellence programme (a Henry Schein® company). Digital radiographs were viewed by two 4th year undergraduate dental students using DBSWIN software (Dürr Dental).

Subject eligibility criteria:

- Subjects aged under 18 when the radiograph was taken were classified as children.
- Subjects must possess radiographs displaying the proximal surfaces from the mesial of the first premolar/ first deciduous molar to the distal of the second permanent molar in all quadrants. Horizontal bitewing radiographs were radiographs of choice although vertical bitewings and posterior long-cone periapicals were accepted.
- Radiographs must be of sufficient quality (grade 1/ grade 2 which are diagnostically acceptable).
- Radiographs must have been taken during 2013.

Data analysis methods: Subjects were randomly assigned an identification number against which their data was inputted onto a spreadsheet (Microsoft Excel) to ensure anonymity. Baseline data for each subject were inputted to the Statistical Package for the Social Sciences (SPSS) 21.0 software (IBM, 2012). The data included: gender, age when radiograph was taken (years), type of radiograph, sample group (BDH Adult, BDH Child, SBCH Adult, and SBCH Child).

For every tooth that is usually visible on a bitewing radiograph (4, 5, 6, 7, D and E in each quadrant) the presence/absence of each mesial, distal and occlusal surface was recorded and, if present, the caries status (carious/sound) and restorative status (restored/unrestored). Surfaces were recorded as non-carious if frank caries could not be identified. Absent teeth/ surfaces not visible radiographically were omitted from the analysis. The baseline data for each sample group were compared to check that each group was representative of the general population.

Data collected was used to calculate the overall caries status for each subject and the number of surfaces affected in those with decay. The proportions of carious proximal and carious occlusal surfaces were also compared. Chi-squared tests were used to analyse caries status between groups, while Kruskal-Wallis tests were used to compare the median and variance of the number of carious surfaces in each group. Further statistical analysis compared the percentage of surfaces present that were healthy, carious or restored between different tooth surfaces. Box-plots were used to visualise the differences in median and variance and Kruskal-Wallis or Mann-Whitney U tests used to analyse the distribution. The radiographs of five subjects were assessed by two examiners (H.I. and K.G.) and a Kappa test was used to check inter-examiner agreement.

Results

The sample consisted of 178 subjects ranging between the ages of four and 74 years (median = 21 years). SBCH and BDH have been equally represented and a proportionate number of adults to children included at each site (Table 1). There are similar demographics in each sample group (Table 2) so the results are not confounded by differences in the baseline variables. The majority (86%) of radiographs assessed were bitewings.

In total, 68% of subjects had at least one decayed surface, and a higher proportion of subjects (58.4%) had proximal caries compared to occlusal caries (48.9%). Subjects that were not free from caries had an average of four carious surfaces. The median number of three proximal surfaces affected is generally higher than two occlusal surfaces and there is also a wider range of results for proximal caries, with 25% having more than five carious surfaces.

There was strong evidence ($p<0.001$) that the proportion of subjects with caries was different between the four sample groups. The BDH Child group in particular had much higher levels of caries (90%) than the other groups (Table 2). It is clear that there is a difference in proximal caries status – with 90% of children at BDH possessing at least one decayed proximal surface while the other groups are very similar, with around half of subjects suffering from proximal caries. In contrast, there is much more variation in the proportion with occlusal caries, ranging from 75% in the BDH Child group to only 24.5% in the BDH Adult cohort.

There is strong evidence to suggest that the sample groups are significantly different when comparing number of "total surfaces affected if caries present" ($N=121$, $p < 0.001$) and number of "proximal surfaces affected if caries present" ($N=104$, $p < 0.01$). There was not sufficient evidence for a difference between the sample groups in terms of "occlusal surfaces affected in caries present" ($N = 87$, $p = 0.5$). Subsequently, a pairwise analysis was done to see if BDH Child was the only group responsible for the small p values or if there is evidence that the medians are also different in each of the other sample groups. The pairwise analysis for Total Surfaces affected (Table 3) shows that there is strong evidence that no sample group has the same median as any other except the SBCH Child and BDH Adult groups. This is important as without this analysis it could not be confirmed that the one particular sample group is not skewing the data and causing the other analyses to give misleading results. However, the pairwise analysis for Proximal Surfaces affected (Table 4) shows that only the BDH Child group has strong evidence to support difference between the sample groups. This leads us to question whether this group is an anomaly and if, therefore, children do not have more proximal caries than adults.

There is strong evidence to suggest that sample groups are significantly different in terms of the % Healthy ($N=72$, $p<0.01$), % Caries ($N = 72$, $p < 0.001$) and % Restored ($N = 72$, $p < 0.05$). There is a smaller proportion of healthy primary molars than healthy permanent teeth (Figure 1), with the second primary molars having the lowest average but the first primary molars having the widest range. This same trend is observed with an even greater distinction between the more carious primary teeth and the less decayed permanent dentition (Figure 2). In contrast, the proportion of teeth that are restored exhibits a very different pattern (Figure 3). Despite the second premolar having the highest median, the permanent molars, especially the second permanent molar, display a considerably higher range.

Proximal surfaces tend to be healthier than occlusal surfaces (Figure 4). Although the level of caries is very similar in both surface types (Figure 5), there are many more restored occlusal surfaces (Figure 6). These findings are confirmed by the median and Mann-Whitney U tests which give small p values for the percentage of healthy (N=72, p <0.001) and restored surfaces (N=72, p <0.01) but larger p values for the percentage of carious surfaces (N=72, p = 0.2).

The kappa test used to check inter-examiner agreement gave very strong evidence to reject the null hypothesis “there is no agreement between the two examiners” for the five subjects assessed by both examiners. In fact, the Kappa value of 0.924 indicates very good agreement which will reduce bias in the results and increase confidence in the analysis.

Discussion

The percentage of subjects free from proximal caries in this study was approximately 42%. Overall a greater proportion of patients with untreated proximal caries than occlusal caries were identified, contradicting previous studies.[28,29] A greater number of occlusal surfaces were restored suggesting that historically, there was a higher ratio of occlusal to proximal caries. This trend would appear to be changing, possibly due to improvements in oral health and preventive measures targeted at occlusal surfaces e.g. fissure sealants. Additionally, the sole use of radiographic imaging has arguably resulted in an under- reporting of occlusal caries as it is well understood that bitewings cannot clearly depict early occlusal lesions.

The BDH child group differed greatly in proximal caries experience than the other groups. The most likely explanation for this finding hinges on the fact that BDH is a secondary referral centre; majority of children are seen because they have greater care needs and cannot be treated in general dental practice, often due to multiple carious lesions.

Research has shown that primary and permanent teeth are not uniformly affected within individuals with the disease,[3] and this is supported by the results of this study. It is thus surprising that there is little difference in proximal caries between the SBCH adult and child groups. This may be explained by the idea that older tooth surfaces are more likely to develop caries than newer surfaces.[20] Theories to explain this finding range from the composition of mature enamel being more susceptible to caries and/or less receptive of fluoride[30] to morphological differences in the teeth.[31] The older and therefore more vulnerable teeth in the SBCH adult group may be offset by the more caries-prone primary molars in the SBCH child group.

The key strengths of this study are sample size (which is reflected in the low p-values), randomisation of subjects and the equal representation of the 4 sample groups. Furthermore, the high level of inter-examiner agreement supports the reliability of the results. Many of the published reports on proximal caries prevalence were conducted outside of the UK with results predating the 21st century. The findings of this study provide some insight into the current prevalence at a local level, although findings should be substantiated with thorough investigations into the subjects' histories and socio-economic backgrounds in order to draw any valid conclusions.

The main limitation of the study lies in the recording of caries, simply recorded as present or absent. Although this permitted quicker data collection no insight is provided on the stage of caries progression. Many classification systems exist yet the 'Modified International Caries Detection and Assessment System' introduced in 2005[32] provides clinicians with a concise framework to classify both cavitated and non-cavitated lesions based on the stage of progression through enamel and dentine. With such a classification future research could include prospective follow up studies of the same subjects and the treatment interventions, if any, that have been implemented.

Blinding of BDH and SBCH subjects was not performed which could introduce an element of bias to the reporting of caries. This study based caries diagnosis on largely bitewing radiography of which the films were only referred/taken by qualified clinicians at BDH. It was deemed unfeasible to source radiographs of BDH adult patients under the care of dental students. The vast majority of films were taken on the adult clinic and could not be traced to the radiology department's records. Patients with complex medical and/or dental histories are generally seen by consultants. There may be significant differences in caries prevalence between patients seen by staff and those seen by students which may have skewed the results.

Few subjects in the primary dentition were included in the study due to the difficulty in obtaining suitable radiographs. The issue of compliance with radiography in young children in the future may be overcome through use of other diagnostic means. An *in vitro* study[33] proposes that the diagnostic validity of laser fluorescent imaging (DIAGNOdent™) may be superior to that of conventional radiography, in primary molars at least.

In conclusion, this study has shown that there has been a shift in caries trends since the publication of previous literature. It has also demonstrated at a local level that children treated at BDH are most in need of resources aimed at preventing and managing proximal lesions. The data corroborates ideas that teeth differ in susceptibility to caries. However, there is still scope for research into the best management strategies to address proximal caries.

Conflicts of Interest:

The authors have no conflicts of interest.

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Table 1: Frequency distribution of gender, age and type of radiographs among the sample groups

Variable		Number	%
Sample Group	**BDH Child**	40	22.5
	BDH Adult	49	27.5
	SBCH Child	43	24.2
	SBCH Adult	46	25.8
Hospital	**BDH**	89	50
	SBCH	89	50
Gender	**Female**	88	49.4
	Male	90	50.6
Adult/Child	**Adult**	95	53.4
	Child	83	46.6
Type of Radiograph	**Bitewing**	153	86
	Periapical	3	1.7
	Vertical Bitewing	22	12.4

Table 2: Frequency distribution of gender, type of radiographs, total caries status, proximal caries status and occlusal caries status among 4 sample groups

Variable		Sample Group							
		BDH Child		BDH Adult		SBCH Child		SBCH Adult	
		Number	%	Number	%	Number	%	Number	%
Gender	Female	18	45	24	49	21	48.8	25	54.3
	Male	22	55	25	51	22	51.2	21	45.7
Type of Radiograph	Bitewing	40	100	27	55.1	43	100	43	93.5
	Periapical							3	6.5
	Vertical Bitewing			22	44.9				
Total Caries Status	Caries Free	4	10	25	51	12	27.9	16	34.8
	Caries Present	36	90	24	49	31	72.1	30	65.2
Proximal Caries Status	Caries Free	4	10	25	51	20	46.5	25	54.3
	Caries Present	36	90	24	49	23	53.5	21	45.7
Occlusal Caries Status	Caries Free	10	25	37	75.5	17	59.5	27	58.7
	Caries Present	30	75	12	24.5	26	60.5	19	41.3

Table 3: Pairwise comparison between each Sample group of the median number of carious surfaces in subjects who are not free from caries

Sample 1 - Sample 2	Test Statistic	Significance	Adjusted Significance
SBCH Adult - BDH Child	16.061	0.000	0.000
BDH Adult - BDH Child	7.545	0.006	0.036
SBCH Adult - SBCH Child	7.408	0.006	0.039
SBCH Adult - BDH Adult	7.002	0.008	0.049
SBCH Child - BDH Child	6.895	0.009	0.052
SBCH Child - BDH Adult	0.014	0.906	1.000

Table 4: Pairwise comparison between each Sample group of the median number of carious surfaces in subjects who are not free from proximal caries

Sample 1 – Sample 2	Test Statistic	Significance	Adjusted Significance
SBCH Child - BDH Child	11.929	0.001	0.003
SBCH Adult - BDH Child	8.525	0.004	0.021
BDH Adult - BDH Child	6.465	0.011	0.066
SBCH Adult - BDH Adult	1.969	0.008	0.963
SBCH Child - BDH Adult	0.537	0.464	1.000
SBCH Adult - SBCH Child	0.091	0.763	1.000

Figure 1: Boxplot of the percentages of surfaces that are Healthy for each Tooth Type

Figure 2: Boxplot of the percentages of surfaces that are Carious for each Tooth Type

Figure 3: Boxplot of the percentages of surfaces that are Restored for each Tooth Type

Figure 4: Stem and Leaf diagram of the percentages of surfaces that are Healthy for each Surface Type

Figure 5: Stem and Leaf diagram of the percentages of surfaces that are Carious for each Surface Type

Figure 6: Stem and Leaf diagram of the percentages of surfaces that are Restored for each Surface Type