Effectiveness of preventive treatment on approximal caries progression in posterior primary and permanent teeth: a review

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ABSTRACT. Aim A literature review to assess the effectiveness of preventive treatment on approximal caries progression in posterior teeth is presented. Methods Retrospective and prospective studies conducted on primary and permanent teeth published in the literature were identified and reviewed. Results The assessment of the reviewed studies showed that they were inconclusive regarding the primary teeth. The studies reviewed showed that different preventive measures, especially fluoride varnish, fluoride solution and fluoridated toothpaste, had a significant effect on the retardation of the progression of approximal lesions in permanent teeth. However, the survival time of approximal caries at the non-restorative stage after application of a preventive treatment, the frequency of application of a preventive measure, the most effective preventive measure, the suitable interval of taking radiographs to evaluate the progression of a lesion and the health and economic benefits cannot be determined from the reviewed studies. Conclusion It was concluded that further studies are needed to evaluate the effectiveness of various preventive measures on approximal caries progression.

Keywords: Approximal caries, Preventive treatment, Children, Adolescents

Introduction

The slow progression rate of approximal caries [Shwartz et al., 1984; Mejare et al., 1999; Hintze et al., 1999; Gustafsson et al., 2000], the limited life period of restorations [Paterson, 1984; Qvist et al., 1986] and the concern about saving tooth substance are the main factors which contributed to the use of remineralizing rather than restorative measures to monitor approximal enamel and dentine lesions. Thus, investigators have tested different preventive measures to control the progression of these lesions. It would be beneficial, therefore, to know the effectiveness of these measures on the progression of approximal caries. Accordingly, the purpose of this paper was to review the literature on the effectiveness of various preventive modalities on approximal caries progression in primary and permanent teeth.

Literature review

Definition of approximal caries. In the reviewed studies approximal caries was defined as a radiolucent area that could not be related to normal anatomy or hypoplasia detected on posterior bitewing radiographs.

Diagnosis of approximal caries. In all reviewed studies the diagnosis of approximal lesions was carried out using posterior bitewing radiographs. Three studies [Zickert et al., 1982; Grondahl et al., 1984; Gisselsson et al., 1994] did not report the technique of taking radiographs, while the remaining investigations used a standardised method. The sets of radiographs were examined simultaneously in four studies [Grondahl et al., 1984; Modeer et al., 1984; Bruun et al., 1985; Gisselsson et al., 1994], while the others did not mention the way of recording radiographic findings. The investigations were carried...
out in five studies by two examiners [Zickert et al., 1982; Groeneveld, 1985; Axelsson et al., 1987a; Axelsson et al., 1987b; Petersson et al., 1991], in one by five [Ogaard et al., 1994], in another the number of examiners was not reported [Grondahl et al., 1984] and in the remaining studies one examiner evaluated the radiographs. In five studies the examiners trained themselves on the diagnosis of approximal caries prior to the beginning of the investigation [Axelsson et al., 1987a; Bjarnason and Finnbogason, 1991; Petersson et al., 1991; Peyron et al., 1992; Ogaard et al., 1994]. In all studies radiographs were read under optimal light conditions. In six studies [Craig et al., 1981; Modeer et al., 1984; Petersson et al., 1991; Bjarnason and Finnbogason, 1991; Peyron et al., 1992; Twetman and Petersson, 1999] a magnification device was used to examine the radiographs. Two studies [Murray and Majid, 1978; Powell et al., 1981] did not use such a device, while the remaining studies did not indicate the method of examining the radiographs.

Approximal caries was recorded in both enamel and dentine. Regarding the progression stages of approximal enamel lesions, nine studies [Powell et al., 1981; Grondahl et al., 1984; Modeer et al., 1984; Axelsson et al., 1987a; Petersson et al., 1991; Peyron et al., 1992; Gisselsson et al., 1994; Ogaard et al., 1994; Twetman and Petersson, 1999] divided the enamel into outer and inner halves. Two studies [Murray and Majid, 1978; Zickert et al., 1982] recorded lesions in equal or greater than one half in the enamel. One study [Axelsson et al., 1987b] divided the enamel into the outer one fourth and the inner as greater than one fourth. One study [Craig et al., 1981] did not divide the enamel at all and three studies [Bruun et al., 1985; Groeneveld, 1985; Bjarnason and Finnbogason, 1991] recorded lesions in the enamel and that reached to the dentine-enamel junction (DEJ) separately.

Dentinal approximal caries was recorded in ten studies [Murray and Majid, 1978; Craig et al., 1981; Grondahl et al., 1984; Modeer et al., 1984; Groeneveld, 1985; Axelsson et al., 1987a; Axelsson et al., 1987b; Petersson et al., 1991; Peyron et al., 1992; Gisselsson et al., 1994] by dividing the dentine into outer and inner halves, in one study [Bjarnason and Finnbogason, 1991] dentinal caries was when the lesion passed the DEJ, in one study [Twetman and Petersson, 1999] in the outer half of the dentine and in another [Zickert et al., 1982] into the dentine and more than half the thickness of the dentine. Finally, three studies did not divide dentine into areas at all.

Type of studies. Longitudinal studies published in the English literature are included in this review. A major difficulty in carrying out a longitudinal study is to retain adequate numbers in the follow-up. In the reviewed studies, 57-100% of subjects were retained in the follow-up period. Eight of the studies were retrospective [Murray and Majid, 1978; Powell et al., 1981; Grondahl et al., 1984; Groeneveld, 1985; Axelsson et al., 1987a; Bjarnason and Finnbogason, 1991; Peyron et al., 1992; Ogaard et al., 1994], while the others prospective.

Retrospective studies are dependent on the availability of accurate records. The diagnostic threshold at which restorative treatment of approximal caries was indicated may vary from study to study. Hence, it is difficult to make direct comparisons between the various studies on the true effectiveness of preventive methods on approximal caries progression. Finally, of the reviewed studies, seven used a test and a control group [Zickert et al., 1982; Modeer et al., 1984; Groeneveld, 1985; Peyron et al., 1992; Gisselsson et al., 1994; Ogaard et al., 1994; Twetman and Petersson, 1999] and one study the half mouth technique [Murray and Majid, 1978]. Two studies followed up the same subjects [Craig et al., 1981; Grondahl et al., 1984] and the remaining investigated the effectiveness of various preventive measures on the progression of approximal caries between different groups.

Results

Four studies [Murray and Majid, 1978; Craig et al., 1981; Peyron et al., 1992; Gisselsson et al., 1994] were conducted on posterior primary teeth, while one [Groeneveld, 1985] did not report whether primary and/or permanent posterior teeth were included in the sample. The other studies were carried out on posterior permanent teeth. In all reviewed reports the criteria used to evaluate the effectiveness of a preventive measure on the approximal caries were progression, regression or arrest of the lesion. The results are presented separately for the primary and permanent teeth as follows.

Primary teeth. Table 1 shows the results and other relevant information of the reviewed studies concerning primary teeth. One study using fluoride varnish [Peyron et al., 1992] and the other that used chlorhexidine gel [Gisselsson et al., 1994] showed a significant effect on the progression of approximal lesions, while a third [Murray and Majid, 1978], using fluoride varnish, did not find such a significant effect. The fourth report [Craig et al., 1981] gave results in percentages and found retardation of the progression of approximal enamel lesions.
Permanent teeth. Tables 2 and 3 present the results and other relevant information of the reviewed studies on the effectiveness of preventive measures and the differences of the effectiveness between preventive measures on the progression of approximal caries respectively. The results, concerning fluoride, showed that different fluoride modalities, such as fluoride varnishes, solutions and toothpastes, had a significant effect on the progression of proximal caries. Regarding chlorhexidine gel and oral hygiene instructions, the effectiveness on the progression of approximal caries cannot be clearly established from an assessment of the reviewed studies.
## Table 3 - Studies of the effectiveness of different preventive measures on the progression of approximal caries in permanent teeth.

<table>
<thead>
<tr>
<th>Investigator(s) and Year</th>
<th>Sample Size</th>
<th>Age (yrs)</th>
<th>Duration (yrs)</th>
<th>Method of placing preventive measures</th>
<th>Frequency of application</th>
<th>Preventive measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powell et al. (1981)</td>
<td>307</td>
<td>12-14</td>
<td>4</td>
<td>n.a.</td>
<td>Home use Home use</td>
<td>No F dentifrice Dentifrice with 0.4% SnF₂ 10% SnF₂ solution 10% SnF₂ solution &amp; SnF₂ dentifrice</td>
<td>Significant retardation in the progression of enamel and dentine lesions with 10%SnF₂ solution and 0.4% SnF₂ dentifrice</td>
</tr>
<tr>
<td>Brum et al. (1985)</td>
<td>251</td>
<td>9-12</td>
<td>3</td>
<td>Home use Brush Twice/year Fortnightly</td>
<td>Fluoride varnish Fluoride rinses</td>
<td>No significant difference in the progression of enamel proximal caries</td>
<td></td>
</tr>
<tr>
<td>Axelsson et al. (1987a)</td>
<td>252</td>
<td>13-14</td>
<td>3</td>
<td>n.a. Home use Supervised Home use Supervised Home use n.r.</td>
<td>Twice/day Weekly Twice/day 0.2% NaF dentifrice and 0.05% NaF solution 0.2% NaF dentifrice 0.05% NaF solution 0.2% NaF dentifrice and 0.7% F varnish</td>
<td>Significantly lower mean value score in the progression of enamel lesions in the group treated with dentifrice and varnish</td>
<td></td>
</tr>
<tr>
<td>Axelsson et al. (1987b)</td>
<td>187</td>
<td>13</td>
<td>2.5</td>
<td>n.r.</td>
<td>4 times at baseline and every 6 months 4 times at baseline and every 6 months Every 6 months</td>
<td>Chlorhexidine gel Oral instructions Regular prevention</td>
<td>No significant difference in the progression of enamel and dentine caries among the groups</td>
</tr>
<tr>
<td>Petersson et al. (1991)</td>
<td>146</td>
<td>11</td>
<td>3</td>
<td>n.r.</td>
<td>3 times/week/once a year Every 6 months</td>
<td>Fluoride varnish Fluoride varnish</td>
<td>Significant lower mean value score in the progression of enamel and dentine caries in the group treated 3 times/week/once a year</td>
</tr>
<tr>
<td>Bjarnason and Finnbogason (1991)</td>
<td>315</td>
<td>11-12</td>
<td>3</td>
<td>n.a.</td>
<td>Tooth brushing</td>
<td>250 ppm F dentifrice 1,000 ppm F dentifrice</td>
<td>No significant difference in the progression of enamel lesions between the groups</td>
</tr>
</tbody>
</table>

n.a. = not applicable  
n.r. = not reported

**Discussion**

The reviewed studies investigated the effectiveness of different preventive measures on approximal caries progression in primary and permanent posterior teeth. Bitewing radiographs were used to diagnose and evaluate the progression of approximal caries. Although it is generally accepted that bitewing radiographs are an invaluable aid in the diagnosis of approximal caries, some intra- and inter-examiner variability is inevitable [Murray and Shaw, 1975; Grondahl, 1979; Mileman et al., 1982; Pliskin et al., 1984; Machiulskiene et al., 1999; Nyvad et al., 1999]. Nevertheless, as clinicians are dependent on this diagnostic tool, the use of good quality standardized radiographs, well defined diagnostic criteria and calibrated examiners reduces the possibility of errors.
and variations in the process of diagnosing and evaluating the progression of approximal caries [Grondahl, 1979; Pliskin et al., 1984]. Of the reviewed studies, five did not perform a reproducibility test [Zickert et al., 1982; Grondahl et al., 1984; Bruun et al., 1985; Groeneveld, 1985; Ogaard et al., 1994], while the rest of them reported acceptable to high reproducibility in diagnosing approximal caries. It should be pointed out, however, that it is not easy to achieve good examiner reliability, particularly in the assessment of initial enamel lesions. Of those studies that conducted a reproducibility test, three reported the results of a reliability coefficient [Murray and Majid, 1978; Axelsson et al., 1987b; Bjarason and Finnbogason, 1991], five gave the percentage agreement [Powell et al., 1981; Modeer et al., 1984; Axelsson et al., 1987a; Peyron et al., 1992; Twetman and Petersson, 1999] and the others did not report the statistical method.

The reviewed studies differ from each other in the ages of the patients studied, preventive measures used and the criteria of recording proximal caries radiographically. The results of the investigations on primary teeth are, therefore, inconclusive and further research is necessary to evaluate the effectiveness of various preventive measures on approximal caries progression. Despite the differences between the studies conducted on permanent teeth, the results showed that different fluoride modes, such as fluoride varnishes, solutions and toothpastes, had a significant effect on the progression of approximal caries. To make these results clinically more meaningful the following issues should be taken into consideration.

Reversals and retardation. The first issue is whether the application of fluoride changes preestablished patterns of approximal caries. Of the reviewed studies, only one [Petersson et al., 1991] reported reversal in the enamel and dentine lesions. The higher frequency of reversal of carious surfaces was observed in enamel lesions. The rest of the studies reported retardation in the mean score of progression or the mean number of approximal caries. This finding is clinically meaningful if the time taken for a lesion to progress to a restorative stage is approximately known. However, the duration of the great majority of the reviewed studies was three years and it may not be safe to make a definite conclusion regarding the actual time period a lesion needs to progress to a restorative stage. Besides, only one study [Powell et al., 1981] calculated the median time of progression of initial caries. Thus, it was reported that the projected value of median time for an enamel lesion (equal or less than half of the enamel) was 72 months to progress into dentine. The term median time of progression implies that half of the lesions progress into dentine, while the other half remain at a previous stage. As the projected value of median time may not correspond to the actual one, the survival time of a lesion at a certain stage, after preventive treatment, needs further investigation. Furthermore, studies conducted on the progression of approximal caries reported that the time period a lesion remains at the same stage is extremely variable, not only between individuals, but also between lesions in any individual [Shwartz et al., 1984; Mejare et al., 1999]. To identify the approximal caries which reached the restorative stage, therefore, radiographic examinations at appropriate intervals are required. A suitable interval of taking radiographs, however, cannot be defined from the reviewed studies.

Frequency of preventive applications. Another issue that comes up is the frequency of application of preventive treatment to reverse or retard the progression of approximal caries. The reviewed studies tested different frequencies and preventive measures and the results showed that most of them were clinically effective in retarding the progression of approximal lesions (Table 2). In addition, of the six studies (Table 3) which compared the effectiveness between or among different preventive measures, three [Powell et al., 1981; Axelsson et al., 1987a; Petersson et al., 1991] reported significant differences. It is necessary, therefore, not only to establish the most effective preventive measures but the frequency of application as well.

Health and economic benefit. A third issue is whether a health and economic benefit is derived from the applied preventive treatment. Two of the reviewed studies [Petersson et al., 1991; Gisselsson et al., 1994] performed a simple cost-benefit analysis. The first study [Petersson et al., 1991], examining permanent teeth, estimated the cost to be 30% lower for preventive therapy than restorative treatment. The second study [Gisselsson et al., 1994], conducted on primary teeth, reported a small gain for the preventive treatment based on the total treatment time. The duration of both studies was three years. As mentioned previously, the findings of the reviewed studies showed that the preventive treatment results in retardation of the progression of approximal caries. This retardation implies that a lesion will ultimately develop to a restorative stage.
some time in the future. An interesting question at this point is how long a lesion must remain at a certain stage(s) to give a health and economic benefit. For such a benefit to occur, the period a lesion remains at a non- restorative stage should be at least equal to the life time of a restoration. It has been reported that the median survival time of Class II amalgam restorations in permanent teeth ranges from 10 to 12 years, while for the resin restorations from 6 to 8 years [Mjor et al., 1990; Downer et al., 1999]. Considering the duration of the reviewed studies, it cannot be suggested that the retardation period of the progression of approximal caries corresponds to the life time of the restoration.

In young uncooperative children, however, the retardation of approximal lesions may be beneficial even if the lesion does not remain at the non-restorative stage for as long as the life time of the restoration. In these cases, the retardation of approximal caries progression, after applying preventive treatment, may delay the restoration of the lesion until children become older and more cooperative. The placement of a restoration at older ages is easier and survival time is likely longer than that of a restoration performed at very young ages. It is conceivable that the health and economic benefit of a preventive measure applied to very young ages. It is conceivable that the health and economic benefit of a preventive measure applied to very young ages. It is conceivable that the health and economic benefit of a preventive measure applied to very young ages. It is conceivable that the health and economic benefit of a preventive measure applied to very young ages.

Further caries development. Finally, it is well known that dental caries is an infectious disease. A recent retrospective study [Mejare et al., 2001] found that the risk of developing dental caries on the mesial surface of the first permanent molar, due to the enamel/DEJ lesion of the distal surface of the second primary molar, was fifteen times greater than the risk of the sound surface. It should be pointed out that the children in this study were undergoing an intensive preventive program as well as preventive treatment of approximal caries. It is likely, therefore, that the presence of a retarded lesion increases the risk of developing dental caries in the sound surface of an adjacent tooth.

To summarize, therefore, the results of the reviewed studies showed a retardation in approximal caries progression in posterior permanent teeth by applying preventive treatment with different modes of fluoride on the lesion. However, the survival time of approximal caries at the non-restorative stage after preventive treatment, the frequency of application of the preventive measure(s), the most effective preventive measure(s), the interval of taking radiographs to evaluate the progression of a lesion and the health and economic benefit cannot be determined from an assessment of studies reported in the literature. It is obvious, therefore, that more investigation is necessary.

Conclusion

Based on the results of the reviewed studies, it can be concluded that:

- the effectiveness of a preventive treatment on approximal caries of primary teeth has not been investigated adequately.
- preventive treatment on approximal caries of permanent teeth with different fluoride modes is effective in retarding the progression of a lesion.

However, some issues need further clarification to make this finding clinically more meaningful.

References


