

Quantifying plaque during orthodontic treatment: A systematic review

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ABSTRACT

Objective: To evaluate the literature on different methods of scoring plaque in patients with fixed orthodontic appliances.

Materials and Methods: A systematic electronic and hand search using MEDLINE and PubMed was conducted.

Results: Most orthodontic trials have used the original Silness and Loe plaque index. Indices vary in several potentially important aspects. Only two papers have reported reproducibility of methods of plaque scoring in orthodontic patients.

Conclusion: Some plaque indices are inappropriate for orthodontic patients. Newer digital planimetric methods are promising if more complex. There is a need to further assess the reproducibility and practicability of the advocated methods. (*Angle Orthod.* 2012;82:748–753.)

KEY WORDS: Fixed appliance; Plaque scoring; Systematic review

INTRODUCTION

Dental plaque is a highly complex organization in a biofilm form and is considered the main causative factor in dental caries and periodontal disease. Orthodontic treatment with fixed appliances is a risk factor for plaque accumulation.¹ Assessment of dental plaque is therefore essential in evaluation of the oral hygiene of individual patients undergoing fixed appliance treatment and in clinical studies measuring plaque.

One approach to scoring plaque is planimetric plaque analysis, which expresses the plaque area as a percentage of the tooth surface covered with plaque.² However, the most common basis for plaque scoring is the use of a numeric categorical scale (ie, an index). Several such indices have been developed over the years, most notably those advocated by Silness and Loe,³ O'Leary,⁴ and Quigley and Hein,⁵ and its modification, the Turesky index.⁶ These

subjective visual evaluations are generally based on plaque extent and thickness near the gingival margin and coronal extension of plaque. They were designed to reflect the typical pattern of progression of plaque accumulation.

However, with fixed orthodontic appliances in place, the pattern of plaque accumulation is significantly affected by the presence of bonded attachments and archwires⁷; the suitability of these indices for bracketed orthodontic patients must therefore be questioned (Figure 1). In relation to the occurrence and severity of gingivitis and periodontal disease, traditional indices may still be appropriate when orthodontic appliances are in place, but with regard to enamel decalcification, these indices are unlikely to satisfactorily reflect the pattern of plaque accumulation. The aim of this paper was to review the literature on methods of quantifying plaque accumulation for patients wearing fixed appliances.

MATERIALS AND METHODS

A PRISMA (Preferred Reporting Items for Reporting Systematic reviews and Meta-Analyses) protocol was followed to report this systematic review.^{8,9} The search was confined to articles in the English language. An electronic search using MEDLINE and PubMed was conducted using the following free-text terms: orthodontics, orthodontic (preventive, corrective, and interceptive), orthodontic brackets, dental plaque, and dental plaque index.

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Figure 1. Disclosed plaque on a bracketed tooth showing distribution predominantly behind the archwire.

In addition, a hand search was carried out from 1980 to 2011 in *American Journal of Orthodontics and Dentofacial Orthopedics*; *The Angle Orthodontist*; *European Journal of Orthodontics* and *Journal of Orthodontics*. The studies that were sought were clinical trials of patients receiving fixed orthodontic treatment wherein the plaque accumulation was quantified. Exclusion criteria included studies where other aspects of dental plaque were examined (eg, where orthodontic ligatures were examined with scanning electron microscopy) and studies in which plaque was subjected to microbial analysis. The method of plaque scoring in each study was scrutinized for evidence of its merits and deficiencies and was assessed for any data related to reproducibility of the method.

RESULTS

The electronic and hand search initially identified a total of 115 abstracts. These were screened for eligibility, and 53 were accepted as potentially meeting the inclusion criteria. Independent examination by two reviewers produced 40 articles that met the criteria.

Table 1 contains the number of papers that were excluded with the reasons. Table 2 presents the method of plaque quantification used for the included papers.

DISCUSSION

Table 2 shows that a significant majority of trials involving patients wearing fixed orthodontic appliances^{10–31} have used the plaque index originally described by Silness and L  e. This index is a

Table 1. Number of and Reasons for Rejected Papers

Number of Papers Rejected	Reason for Rejection of the Paper
4	No plaque quantification
3	Interproximal plaque scoring only
3	Study of a single tooth
2	Orthognathic surgery
1	Cleft lip and palate

Table 2. Studies of Plaque Accumulation in Patients Wearing Fixed Orthodontic Appliances

Author	Year	Method
Feliu JL	1982	Silness and L��e
Busschop et al.	1985	Silness and L��e
Sinclair et al.	1987	Silness and L��e
Huber et al.	1987	Silness and L��e
Polson et al.	1988	Silness and L��e
Boyd & Robertson	1989	Silness and L��e
Brightman et al.	1991	Silness and L��e
Davies et al.	1991	Silness and L��e
Jackson SA	1991	Silness and L��e
Alexander SA	1991	Silness and L��e
Morrow et al.	1992	Silness and L��e
Dubey et al.	1993	Silness and L��e
Burch et al.	1994	Silness and L��e
Anderson et al.	1997	Silness and L��e
Lees & Rock	2000	Silness and L��e
Laher et al.	2003	Silness and L��e
Smiech-Slomkowska & Jablonska-Zrobek	2007	Silness and L��e
Ristic et al.	2007	Silness and L��e
Pandis et al.	2008	Silness and L��e
Sharma et al.	2008	Silness and L��e
de Souza et al.	2008	Silness and L��e
Paschos et al.	2008	Silness and L��e
Williams et al.	1991	Modified Silness and L��e
Clerehugh et al.	1998	Modified Silness and L��e
Thienpont et al.	2001	Modified Silness and L��e
Costa et al.	2007	Modified Silness and L��e
Wilcoxon et al.	1991	O'Leary
Naranjo et al.	2006	O'Leary
��gaard	2006	O'Leary
Trimpeeneers et al.	1997	Quigley and Hein
Wenderoth et al.	1999	Quigley and Hein
Rafe et al.	2006	Quigley and Hein
Aloufi et al.	2010	Quigley and Hein
Kilicoglu et al.	1997	Bonded Bracket Plaque Index (BBPI)
Burden et al.	2004	Bonded Bracket Plaque Index (BBPI)
Turkkahraman et al.	2005	Bonded Bracket Plaque Index (BBPI)
Aloufi et al.	2010	Bonded Bracket Index (BBI)
Heintze et al.	1998	Ortho-Plaque Index (OPI)
Williams et al.	1991	Percentage plaque coverage
Klukowska et al.	2011	Digital image analysis estimation of percentage plaque coverage

categorical scale. Code 0 is given when there is no plaque accumulation, code 1 when plaque can be removed from the gingival third, code 2 when there is visible plaque, and code 3 when there is a heavy accumulation of plaque. This index has the merits of simplicity and wide usage throughout dentistry. However, with only four categories, it has relatively poor discrimination. It reflects the common pattern of progression of plaque accumulation in the absence of an orthodontic bracket, so it is inherently less appropriate for the categorization of plaque on bracketed teeth.

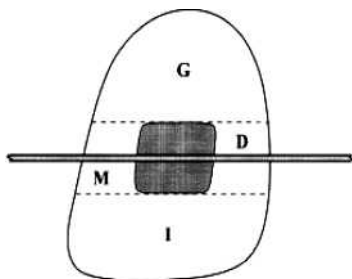


Figure 2. Diagram showing modification of the Silness and Loe index as described by Williams. The tooth is divided into mesial (M), distal (D), gingival (G), and incisal (I) regions for plaque measurement.

Williams et al.³² addressed the shortcomings of the Silness and Loe index for bracketed teeth by modifying it to take into account the pattern of plaque accumulation in orthodontic patients. In this index, the tooth is divided into medial, distal, gingival, and incisal regions in relation to the bracket (Figure 2). Plaque is then scored in each area based on the four codes used in the original Silness and Loe index, and values summed to obtain a total score, which can therefore range between 0 and 16 for each tooth. This index was also used by Clerehugh et al.,³³ Costa et al.,³⁴ and Thienpont et al.³⁵ in studies of patients with fixed orthodontic appliances. This index acknowledges the usual effects of orthodontic appliances on plaque distribution and has much greater categorical discrimination than the Silness and Loe index. These advantages must be viewed as substantial and as justifying discontinuation of the unmodified Silness and Loe index in orthodontic patients.

A few studies have used the O'Leary⁴ index in orthodontic patients. This index scores plaque separately on mesial, midpoint, and distal aspects of both facial and lingual surfaces for each tooth. All visible plaque is scored, even if slight, and plaque scores are expressed as a percentage of the total number of potential sites. Naranjo et al.,³⁶ Wilcoxon et al.,³⁷ and Øgaard et al.³⁸ used this index. This index has a maximum score of 3 on a given tooth surface and therefore is less discriminatory than the Silness and Loe index or its modification already described. The appropriateness for orthodontic patients of the divisions of the tooth surface into three vertical sections may also be considered less appropriate for bracketed teeth than the modification advocated by Williams et al.³² (Figure 2).

The Quigley and Hein⁵ plaque index and its modification as the Turesky Index⁶ measure the progressive coronal extension of plaque covering the tooth surface and are scored as in Table 3. These indices again fail to reflect the typical pattern of progressive plaque accumulation in the presence of an orthodontic bracket. If, for example, there is a line of

Table 3. The Quigley and Hein Index

0	No plaque
1	Flecks of plaque at gingival margin
2	Definite line of plaque at gingival margin
3	Gingival third of the surface is covered with plaque
4	Two thirds of the surface is covered with plaque
5	More than two thirds of the surface is covered with plaque

plaque behind the archwire, but no other plaque on the tooth, what score should be allocated?

Trimpeners et al.,³⁹ Wenderoth et al.,⁴⁰ and Rafe⁴¹ used the Quigley and Hein index in studies of orthodontic patients. Wenderoth et al. were studying the effectiveness of fluoride-releasing sealant in reducing decalcification during orthodontic treatment. The index they used clearly was not well suited to that purpose because it is based on a distribution of plaque that is more relevant to gingivitis than to decalcification when a bracket is in situ.

The Bonded Bracket Plaque Index (BBPI) was advocated by Kilicoglu et al.⁴² and has been used in three studies.⁴²⁻⁴⁴ Plaque is scored as in Table 4. This index aims to take account of the effect of an orthodontic bracket on plaque distribution. However, it can be seen that some codes in this index are ambiguous or perhaps illogical to apply. Although it refers to an orthodontic bracket, the categories put emphasis on spread toward and contact with the gingiva. This emphasis is perhaps appropriate in the study by Turkkahraman et al.,⁴⁴ who used the index to compare the periodontal condition using two ligation methods. However, it is less suited to studies of the relationship between plaque and decalcification.

A study by Aloufi et al.⁴⁵ used the Quigley-Hein index to compare groups, but an index they named the Bonded Bracket Index (BBI) was also advocated. Category definitions in the BBI are very similar to those in the BBPI, but no category can be used to describe an absence of plaque, and the highest grade of accumulation is reached at a lower area of coverage. The BBI can therefore be considered less discriminatory than the BBPI.

Table 4. The Bonded Bracket Plaque Index (BBPI) (After Kilicoglu et al.)

0	No microbial plaque on the bracket or the tooth surface
1	Microbial plaque only on the bracket
2	Microbial plaque on the bracket and tooth surface, but not spreading toward the gingiva
3	Microbial plaque on the bracket and tooth surface, spreading toward the papilla
4	Microbial plaque on the bracket and tooth surface, part of the gingiva is covered with plaque
5	Microbial plaque on the bracket and tooth surface, gingiva is totally covered with plaque

The Ortho-Plaque Index (OPI) was described by Heintze et al.⁴⁶ Each bracketed tooth has three sites for measuring plaque: (I) cervical to the bracket toward the gingiva, (II) the region of the “shadow” of the archwire and mesial and distal to the bracket, and (III) coronal to the bracket. This zoning of the tooth is very similar to zoning for the modified Silness and Løe index and similarly has much to recommend its use in orthodontic patients, because the gingival zone is appropriate for studies of gingivitis and the middle zone reflects the tendency for plaque to accumulate behind an archwire. This index does not appear to have been used by other authors, possibly because of its relative complexity of calculation when compared, for example, with the modified Silness and Løe index.

The methods so far discussed are all categorical indices that are entirely dependent on visual estimation. The other potential approach is actual measurement of the percentage area covered by plaque using digital image analysis of photographs. Smith et al.⁴⁷ were among the first of several to report such a method. The advantages of a photograph are that it can be assessed at leisure, is a permanent record, and can be viewed on multiple occasions, enabling assessment of reproducibility, which was found to be excellent in this study. However, this study was not carried out on patients with orthodontic appliances in place. Williams et al.³² had previously used standardized photographic views of disclosed teeth to measure the percentage area of plaque coverage in fixed appliance patients. They compared these results with those obtained using their modification of the Silness and Løe index and concluded that either method could be of value in studies involving fixed appliances, the choice depending on factors of convenience, methodologic considerations, and cost.

It is interesting to note that percentage area measurement of plaque has been used in only one subsequent study—that by Klukowska et al.⁴⁸ The relative lack of orthodontic studies using this method is probably related to the longer time required—even though direct digital measurement and computation are now used—and the greater technical complexity of the method.

It should be noted that area measurement is not completely immune from an element of subjective judgment and other potential sources of error. These potential errors are probably small in relation to those associated with visual estimation for a categorical index, but they are nevertheless a factor. Klukowska et al.⁴⁸ used an expert analyst to adapt and apply the pixel color discrimination method of Smith et al. They reported very high reproducibility of the “masking” protocol for identifying tooth boundaries. One potentially powerful refinement of area measurement is a

separate analysis for different regions of the labial tooth surface, which Klukowska et al.⁴⁸ reported and which confirmed the high levels of plaque accumulation behind an archwire.

CONCLUSIONS

- Most orthodontic trials have used the original Silness and Løe plaque index. A few more recent studies have used indices specifically designed to score plaque in patients wearing fixed appliances; these are inherently more appropriate if a categorical index is used. The modified Silness and Løe index may be considered the most valid and discriminatory.
- Only two papers have reported the reproducibility of measurements of plaque coverage in orthodontic patients. Digital photographs of disclosed teeth greatly facilitate such analysis.
- Direct digital measurement of percentage plaque coverage is more complex but is likely to prove more valid and more reproducible than categorical indices.

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