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Prevalence of horizontal attachment loss in extracted teeth

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Abstract

Objective: Probing attachment level provides useful information on patterns of destruction of the periodontium. It is difficult to detect complex attachment loss in clinics. The purpose of this study was to estimate prevalence of vertical and horizontal attachment loss in extracted teeth.

Material and Methods: We collected 10,212 extracted teeth from 130 dentists in Japan. After staining of periodontal membrane with erythrosine, linear loss of vertical and horizontal attachment was measured using a digital caliper.

Results: Mean vertical attachment loss varied from 5.3 to 8.6 mm. Incisors had severe attachment loss at mesial sites. Specific local attachment loss at palatal sites was observed in maxillary premolars and molars as well as in mandibular canines and premolars. Horizontal attachment loss was observed in 23% of the teeth. Frequency of horizontal attachment loss of ⩾2.1 mm was 6.4%.

Conclusion: Severe attachment loss was observed on the palatal side of maxillary premolars. More than 1/3 of the maxillary first molars showed horizontal attachment loss. It may be impossible to debride 6.4% of teeth in cases of severe periodontitis because horizontal attachment loss may be deeper than the curette blade length.

Key words: dentition, permanent; epidemiological study; extracted tooth; horizontal attachment loss; periodontal attachment loss; periodontal ligament

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Determination of a realistic prognosis and treatment plan for periodontally involved dentitions requires accurate assessment of the factors influencing each tooth. Periodontal attachment level is the most frequently used variable in monitoring longitudinal studies of periodontal disease. However, reproducibility of clinical measurements is affected by several factors, including periodontal pocket depth (Deas et al. 1991), tooth type (molar versus non-molar) (Goodson et al. 1982) and location of the measured site (buccal versus lingual/palatal) (Halazonetis et al. 1989). Awareness of root morphology and the condition of the periodontal tissues is also essential for reliable periodontal pocket probing.

Due to improvements in debridement tools and increases in the number of options for scaling and root planing, the applicability of these procedures has been widened. Mechanical therapy is effective for the majority of patients with mild-to-moderate chronic periodontitis (Greenstein 2000). Better understanding of the anatomy of periodontal destruction is needed for effective debridement of root surfaces.

There have been several studies of the distribution of vertical attachment loss (Ånerud et al. 1983, Baelum et al. 1988, Okamoto et al. 1988, Papapanou et al. 1988, Yoneyama et al. 1988). Their findings have been applied to subgingival debridement of root surface deposits. However, there have been few studies of prevalence of patterns of horizontal periodontal destruction. The purpose of the present study was to estimate patterns of periodontal destruction based on vertical and horizontal attachment loss in extracted teeth.

Material and Methods

A total of 21,364 extracted teeth were collected from 130 dentists in Japan, and 10,212 of these teeth satisfied the criteria for assessment of periodontal attachment after staining. Acceptable teeth had an intact cemento-enamel junction (CEJ), i.e. teeth were excluded if they showed evidence of caries, restorations, extraction damage beyond the CEJ, or absence of periodontal ligament. The teeth were identified based on crown and root morphology.

The staining procedure described by Waerhaug (1975) was performed, but erythrosine solution (trace®, Lorvic Co., St. Louis, MO, USA) was used instead of crystal violet. The teeth were immersed in the dye at room temperature for 5 min, then washed in running water for 10 to 15 min and air-dried. Plaque and calculus were removed after staining to expose the cemento-enamel junction and facilitate assessment (Klock et al. 1993).

Root length was measured using a digital caliper (Mitsutoyo, Tokyo, Japan) and a dissecting microscope (SMZ-1B, Nikon Co., Kawasaki, Japan). The vertical attachment level was measured from the most coronal level of the stained periodontal membrane on the long axis of the root to the most apical point of the root. Vertical linear loss of attachment was defined as the difference between the root length and the vertical attachment level.

Six to eight linear measurements, to the nearest 0.1 mm, were recorded per tooth (Fig. 1). Linear loss of attachment was based on the mean of two measurements. The ratio of attachment loss to root length was divided into 4 categories: 0–25, 25–50, 50–75, and 75-100 percentile. Then, a line connecting the means was drawn. Mean and standard deviation of attachment loss was calculated for each root surface (buccal, mesial, palatal/lingual, and distal) and differences were assessed using Tukey's method.

Attachment loss in the horizontal direction was assessed by measuring the distance between the tangent of the most convex point at the coronal side and the tangent of the most concave point of the stained periodontal membrane (Fig. 2).

Three examiners performed the measurements. Independent duplicate measurements were performed, without access to the recordings of the first assessments. Agreement between examiners within 0.5 mm of root length and attachment level ranged from 79.9% to 82.3% and 75.7% to 79.7%, respectively.

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) at Okayama University Computer Center.

Results

Number of teeth examined, mean root length and mean vertical attachment loss for each tooth type are shown in Table 1. Mean root length varied from 11.4 mm for mandibular central incisors and maxillary third molars to 15.8 mm for maxillary canines. Maxillary and mandibular canines showed more severe attachment loss than any other tooth type. Increased values were also found for the first and second maxillary molars, as well as the first mandibular premolars. Percentage of vertical attachment loss was highest for maxillary first molars (63–64%), and was lowest for mandibular third molars (45–48%). The mandibular canines were the only tooth type with statistically significant differences in mean root length and vertical attachment loss between right and left.

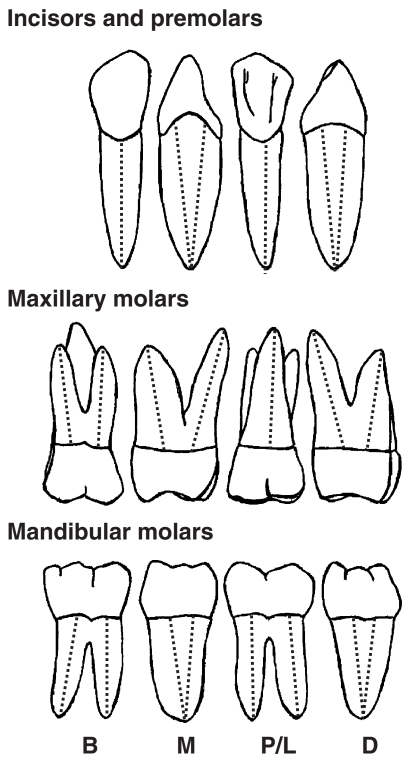

Fig. 1. Tooth surfaces showing sites of linear measurements of vertical attachment loss (B = buccal, M = mesial, P = palatal, L = lingual, D = distal). Each line extends from a root apex to a bisector or trisection point of the curricular circumference from each surface view.

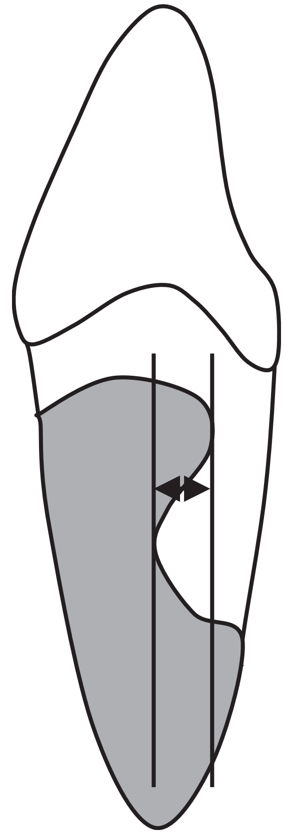

Fig. 2. Tooth with complex loss of attachment showing how to measure with a digital caliper. The vertical lines were drawn as visualization aids.

Table 1. Number of teeth, mean root length, and mean vertical attachment loss for each tooth type

	Number of teeth		Root length (mm)*		Attachment loss (mm)*	
	right	left	right	left	right	left
Maxilla						
Central incisor	394	373	12.2 (1.7)	12.1 (1.6)	6.1 (2.1)	5.9 (2.1)
Lateral incisor	420	404	12.7 (1.5)	12.7 (1.5)	6.6 (2.2)	6.6 (2.2)
Canine	274	263	15.8 (2.1)	15.8 (2.2)	8.0 (3.0)	7.9 (2.9)
First premolar	337	354	12.5 (1.6)	12.4 (1.8)	6.4 (2.1)	6.3 (2.1)
Second premolar	287	298	13.6 (1.7)	13.4 (1.7)	6.6 (2.2)	6.7 (2.2)
First molar	283	271	12.1 (1.3)	12.1 (1.3)	7.7 (2.2)	7.6 (2.1)
Second molar	352	313	12.0 (1.4)	12.1 (1.5)	7.2 (1.9)	6.9 (1.9)
Third molar	243	248	11.4 (1.8)	11.6 (1.7)	5.9 (2.1)	5.9 (2.1)
Mandible						
Central incisor	686	588	11.4 (1.2)	11.4 (1.2)	6.7 (1.7)	6.6 (1.7)
Lateral incisor	558	530	12.6 (1.2)	12.5 (1.4)	6.9 (1.8)	6.8 (1.9)
Canine	293	319	14.7 (1.7)	14.7 (1.7)	8.6 (2.4)	8.0 (2.4)†
First premolar	294	254	13.6 (1.4)	13.6 (1.5)	7.1 (2.1)	6.8 (2.2)
Second premolar	241	221	13.8 (1.7)	13.8 (1.7)	6.6 (2.2)	6.8 (2.1)
First molar	165	157	12.7 (1.3)	12.6 (1.3)	6.9 (2.1)	6.8 (2.2)
Second molar	251	254	12.8 (1.4)	12.8 (1.4)	6.4 (2.0)	6.4 (2.2)
Third molar	153	134	11.7 (1.5)	11.8 (1.5)	5.3 (2.0)	5.6 (2.1)

*Mean (SD).
†Statistically significant difference between right and left ($p < 0.01$, *t*-test).

The patterns of vertical attachment loss in the maxilla and mandible are shown in Figs 3 and 4, respectively. In addition, mean values of vertical attachment loss are summarized in Table 2. Palatal sites in the maxillary premolars and molars as well as in mandibular canines and premolars exhibited more pronounced vertical attachment loss than any other tooth surface ($p < 0.001$, Tukey's method). The mesial surface exhibited the most severe attachment loss in maxillary and mandibular incisors ($p < 0.001$, Tukey's method). Buccal surfaces had less severe attachment loss than any other tooth surface in mandibular second molars ($p < 0.001$, Tukey's method).

Horizontal attachment loss was observed in 22.6% of the teeth examined (Fig. 5). Frequency of horizontal attachment loss was highest in the maxillary first premolars (35.9%), followed by mandibular third molars (31.4%) and mandibular second molars (29.5%). The mean (standard deviation) and mode length of horizontal attachment loss were 1.9 mm (2.2 mm) and 0.6–1.0 mm, respectively (Fig. 5). The percentages of teeth with horizontal attachment loss greater than 1.6, 2.1 and 3.1 mm were 8.5%, 6.4%, and 4.0%, respectively (Fig. 5).

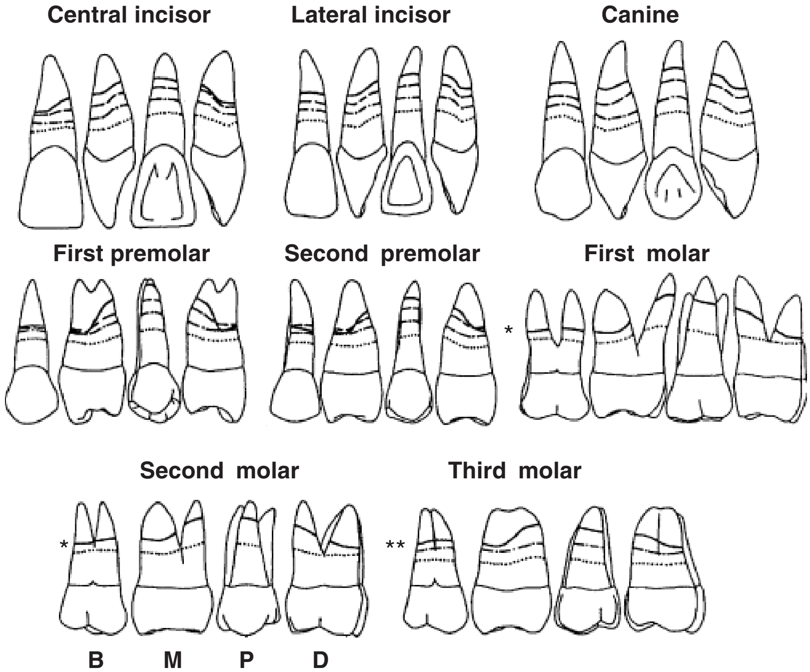

Fig. 3. Distribution of vertical attachment loss in maxillary teeth (B = buccal, M = mesial, P = palatal, D = distal). ··········, 0–25 percentile; —·—·—·, 25–50 percentile; — — — —, 50–75 percentile; ————, 75–100 percentile; *————, 25–100 percentile; **————, 50–100 percentile.

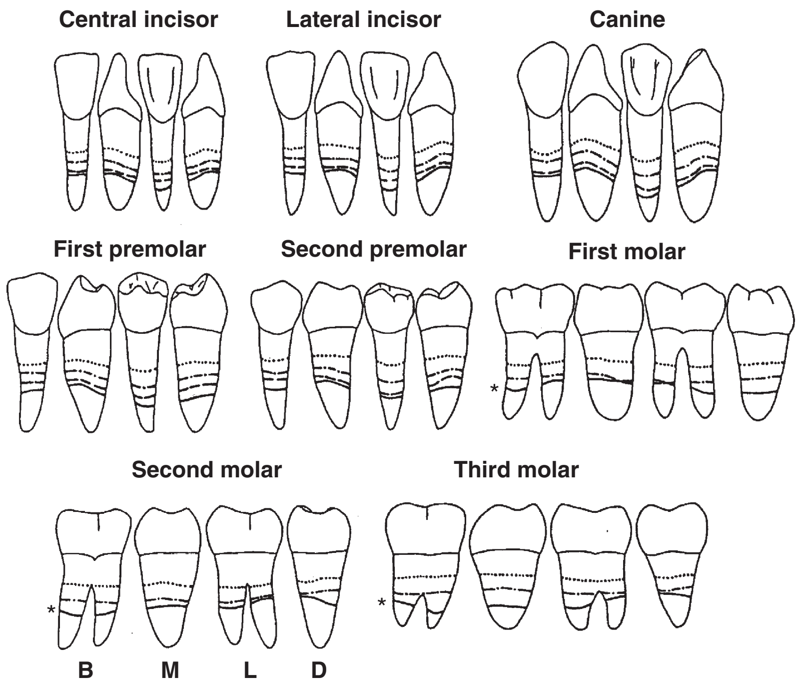

Fig. 4. Distribution of vertical attachment loss in mandibular teeth (B = buccal, M = mesial, L = lingual, D = distal). ··········, 0–25 percentile; —·—·—·, 25–50 percentile; — — — —, 50–75 percentile; ————, 75–100 percentile; *————, 50–100 percentile.

Discussion

In the present epidemiological study, we evaluated the three-dimensional shape of the bottom of the periodontal pocket from the periodontal membrane remaining on extracted teeth, and analyzed the prevalence of vertical and horizontal attachment loss for each tooth type. Exact knowledge about the morphology of the bottom of the periodontal pocket can be of use in precise adaptation of instruments such as periodontal probes and scalers.

Stained extracted teeth are very well suited to evaluation of loss of attachment (Waerhaug 1975). Measurements from extracted teeth are almost identical to those obtained from histologic sections, and are more precise than clinical measurements because a periodontal probe penetrates to the connective tissue attachment of highly inflamed gingiva (Saglie et al. 1975, Powell and Garnick 1978). This approach is also superior to clinical studies using techniques such as periodontal pocket probing and X-rays, because all aspects of the tooth are examined (Waerhaug 1978).

Little is known about distribution of horizontal attachment loss (Carranza & Camargo 2002). Periodontal pockets are classified according to the number of surfaces involved, as follows: simple (1 tooth surface), compound (2 or more tooth surfaces), and complex (Carranza & Camargo 2002). Complex pockets

Table 2. Mean vertical attachment loss by tooth type and surface

	Buccal	Mesial	Palatal/lingual	Distal
Maxilla				
Central incisor	4.24 (2.55)[a]	6.96 (2.85)	6.74 (2.64)	6.52 (2.46)
		NS	NS	
Lateral incisor	5.04 (2.71)	6.97 (2.56)	6.65 (2.71)	6.98 (2.56)
			NS	
Canine	7.14 (3.20)	7.77 (3.53)	8.47 (3.59)	8.18 (3.33)
			NS	
First premolar	5.09 (2.60)	5.95 (2.54)	8.31 (3.29)	6.42 (2.66)
Second premolar	5.62 (2.83)	6.29 (2.61)	8.07 (3.08)	6.76 (2.75)
First molar	6.11 (2.90)	8.57 (2.82)	9.80 (3.79)	7.27 (2.84)
Second molar	6.07 (2.75)	7.81 (2.78)	8.57 (3.60)	6.61 (2.40)
Third molar	5.61 (2.68)	6.24 (2.87)	6.85 (3.69)	5.46 (2.60)
		NS		
Mandible				
Central incisor	5.70 (2.28)	6.94 (1.95)	6.77 (2.08)	6.81 (1.91)
			NS	
			NS	
Lateral incisor	5.57 (2.44)	7.23 (2.13)	7.13 (2.29)	6.92 (2.09)
		NS		
Canine	6.75 (3.07)	8.56 (3.02)	9.24 (3.01)	8.31 (3.01)
			NS	
First premolar	6.07 (2.69)	6.48 (2.50)	8.12 (2.74)	7.31 (2.62)
Second premolar	6.18 (2.78)	6.37 (2.61)	7.57 (2.78)	6.85 (2.61)
	NS			
First molar	6.70 (2.76)	6.18 (3.47)	7.51 (2.85)	7.02 (3.58)
	NS			
		NS		
			NS	
Second molar	7.08 (3.07)	6.45 (3.59)	6.48 (2.79) 5.64	4.71 (3.15)
		NS		
Third molar	5.55 (2.88)	5.77 (3.32)	5.67 (2.65)	4.71 (2.50)
	NS			
		NS		
		NS		

*Mean (SD).
Statistically significant differences were observed between all pairs of tooth surfaces in each tooth type ($p<0.05$, Tukey's method), except for pairs indicated by ''NS.''

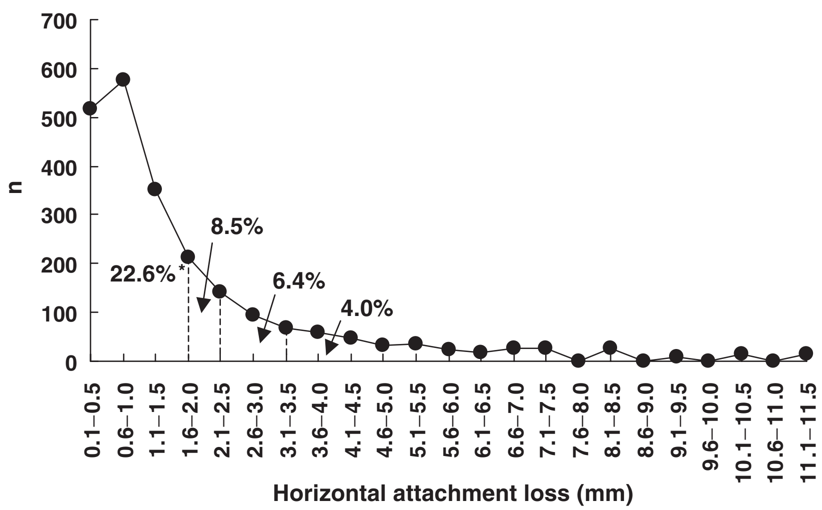

Fig. 5. Distribution of horizontal attachment loss. *Percentage of horizontal attachment loss of $\geqslant$0.1 mm was 22.6% in all extracted teeth examined.

have a spiral shape; they originate on 1 tooth surface, and twist around the tooth to involve 1 or more additional surfaces; and the only communication with the gingival margin is at the surface where the pocket originates.

Horizontal attachment loss was observed in 22.6% of the teeth examined in the present study. The presence of this loss would not be detected in clinical measurement/assessment. The frequency of horizontal attachment loss of $\geqslant$2.1 mm was 6.4%. The length of curette blades ranges from 2.5 to 4.5 mm and assuming that the curette blade reaches $<$2 mm horizontally, about 6.4% of teeth will not be properly debrided. Even if debridement of root surfaces is effective and performed carefully, about 6% of teeth with periodontal disease may not be restored to good condition.

Distribution of vertical attachment loss varied according to tooth type and tooth surface. Palatal sites exhibited statistically significant loss in maxillary premolars and molars as well as in mandibular canines and premolars. These results are inconsistent with those of a clinical descriptive study on probing attachment level in Japan (Okamoto et al. 1988, Yoneyama et al. 1988). In that study, interproximal surfaces were found to have lost more periodontal tissue support than buccal or lingual surfaces. This disagreement may be due to differences in severity of periodontitis. Mean attachment level was $<$5 mm in the previous study, and was $>$5 mm in the present study. This explanation is supported by results of a clinical prospective study (Halazonetis et al. 1989). Attachment loss at sites with attachment level of $\geqslant$6 mm is independent of tooth type and surface; however, attachment loss is more frequent at proximal surfaces for sites with attachment levels of $<$6 mm.

Age of the extracted teeth and sex of the subjects were unknown in the present study. Nevertheless, the present findings help elucidate distribution of attachment loss in contemporary populations, and facilitate speculation about the natural history of periodontal disease.

All teeth in the present study presumably exhibited clinical indication for extraction. Although this study was conducted using a large number of samples, the results may not be comparable with those of clinical epidemiological studies.

In conclusion, pronounced attachment loss was observed on the palatal side of maxillary premolars. Horizontal attachment loss was more prevalent for maxillary first molars than for any other tooth type. The fact that horizontal attachment loss was deeper than the length of the curette blade suggests that 6.4% of teeth might not be debrided properly and could be clinically undiagnosed.

References

Ånerud, K. E., Robertson, P. B., Löe, H., Ånerud, Å., Boysen, H. & Patters, M. R. (1983) Periodontal disease in three young adult populations. *Journal of Periodontal Research* **18**, 655–668.

Baelum, V., Fejerskov, O. & Manji, F. (1988) Periodontal disease in adult Kenyans. *Journal of Clinical Periodontology* **15**, 445–452.

Carranza, F. A. & Camargo, P. M. (2002) The periodontal pocket. In *Carranza's Clinical Periodontology*, eds Newman, M. G., Takei, H. H. & Carranza, F. A., 9th edition, pp. 336–353. Philadelphia: W. B. Saunders Co.

Deas, D. E., Pasquali, L. A., Yuan, C. H. & Kornman, K. S. (1991) The relationship between probing attachment loss and computerized radiographic analysis in monitoring progression of periodontitis. *Journal of Periodontology* **62**, 135–141.

Goodson, J. M., Tanner, A. C. R., Haffajee, A. D., Sornberger, G. C. & Socransky, S. S. (1982) Patterns of progression and regression of advanced destructive periodontal disease. *Journal of Clinical Periodontology* **9**, 472–481.

Greenstein, G. (2000) Nonsurgical periodontal therapy in 2000: a literature review. *Journal of American Dental Association* **131**, 1580–1592.

Halazonetis, T. D., Haffajee, A. D. & Socransky, S. S. (1989) Relationship of clinical parameters to attachment loss in subjects with destructive periodontal diseases. *Journal of Clinical Periodontology* **16**, 563–568.

Klock, K. S., Gjerdet, N. R. & Haugejorden, O. (1993) Periodontal attachment loss assessed by linear and area measurements in vitro. *Journal of Clinical Periodontology* **20**, 443–447.

Okamoto, H., Yoneyama, T., Lindhe, J., Haffajee, A. & Socransky, S. (1988) Methods of evaluating periodontal disease data in epidemiological research. *Journal of Clinical Periodontology* **15**, 430–439.

Papapanou, P. N., Wennström, J. L. & Gröndahl, K. (1988) Periodontal status in relation to age and tooth type. A cross-sectional radiographic study. *Journal of Clinical Periodontology* **15**, 469–478.

Powell, B. & Garnick, J. J. (1978) The use of extracted teeth to evaluate clinical measurements of periodontal disease. *Journal of Periodontology* **49**, 621–624.

Saglie, R., Johansen, J. R. & Fløtra, L. (1975) The zone of completely and partially destructed periodontal fibres in pathological pockets. *Journal of Clinical Periodontology* **2**, 198–202.

Waerhaug, J. (1975) A method for evaluation of periodontal problems on extracted teeth. *Journal of Clinical Periodontology* **2**, 160–168.

Waerhaug, J. (1978) Healing of the dento-epithelial junction following subgingival plaque control II: as observed on extracted teeth. *Journal of Periodontology* **49**, 119–134.

Yoneyama, T., Okamoto, H., Lindhe, J., Socransky, S. S. & Haffajee, A. D. (1988) Probing depth, attachment loss and gingival recession. Findings from a clinical examination in Ushiku, Japan. *Journal of Clinical Periodontology* **15**, 581–591.

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