Probing around teeth
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SUMMARY AND CONCLUSIONS

CHAPTER 9
As stated in the introduction, a proper diagnosis is a prerequisite in order to be able to deliver optimal treatment. During the last century the periodontal probe has evolved into an effective instrument for periodontal examination. The research in this thesis was carried out to improve our understanding concerning several aspects of the use of a periodontal probe in gingivitis, treated and un-treated periodontitis. The general aim was to investigate the influence of the design of the probe itself on accuracy and reproducibility in periodontal probing as well as the effect of probing pressure on the assessment of the attachment level.

**Periodontal examination; gingivitis**

During the last decades many studies have been published on various aspects of periodontal probing. The histological position of the probe tip in the sulcus or pocket, proved to be influenced by two main variables i.e. degree of inflammation and probing pressure. In gingivitis however, the pressure used when probing the marginal periodontal tissues appeared less important than the method of stimulating bleeding of the marginal periodontal tissues (bleeding on probing to the bottom of the pocket vs. bleeding on marginal probing). In gingivitis the apical termination of the junctional epithelium is still at the CEJ and the inflammatory infiltrate is mainly restricted to the coronal portion of the gingival tissues. Therefore in order to attain bleeding after probing in gingivitis, the probing technique is a critical factor. It was suggested in the literature that the Eastman Interdental Bleeding (EIB) index was able to identify more approximal inflammation than the bleeding on marginal probing (BOMP) index. In CHAPTER 2 the two methods of provoking bleeding of the marginal gingiva were tested for the validity of this suggestion. For this study 43 subjects were selected based on having established moderate gingivitis without interdental recession of the gingival tissues. Plaque was scored on all approximal sites after which the BOMP index was assessed in 2 contra-lateral quadrants and the EIB index in the opposing quadrants in a split-mouth design. The results showed for the BOMP index a score of 84% and for the EIB a score of 87% bleeding. The significant correlation between plaque and gingival bleeding for the BOMP index (0.55) was higher than for the EIB index (0.44). In a subsequent experiment, the 2 methods were tested in an experimental gingivitis model involving 25 subjects, in which at random in one quadrant the development of gingivitis was prevented by daily flossing. At baseline, both indexes were assessed at all approximal sites. In the experimental gingivitis quadrant,
the BOMP index increased to 69% and the EIB index to 73%. Both indices showed a significant correlation with plaque; 0.60 and 0.64 respectively. In the quadrant with flossing as intervention, the BOMP index increased to 38% and the EIB index to 30%. In conclusion, the suggestion in the literature that the EIB is able to identify more inflammation could not be confirmed according to the present results. It appears that the ability of the BOMP index and the EIB index to assess the level gingival inflammation is comparable.

**CEJ detection: Accuracy of detection**

In order to determine the amount of loss of attachment as well as further breakdown, it is essential to be able to measure the distance between the CEJ and the most coronal connective tissue attachment level. Determination of the CEJ is therefore the first step in achieving an accurate probing attachment level measurement. The CEJ is often positioned subgingivally and difficulties are experienced in the accurate clinical assessment of this anatomical landmark. Therefore choosing the probe with the best properties in determining the correct position of the CEJ is the first step in achieving a correct diagnosis. It was hypothesized that with changing the shape of the tip of the probe the tactility would improve and the validity of the assessment of the CEJ would increase. In this respect the Vivacare TPS beveled-ball was proposed in the literature as the superior probe. In CHAPTER 3 Vivacare TPS beveled-ball probe was tested against the Merritt-B probe and ball-ended CPITN probe in terms of the accuracy and precision with which the CEJ could be assessed in both deciduous and permanent teeth. In an ‘in vitro’ model, consisting of 70 extracted permanent and 30 deciduous human teeth mounted in plaster with an artificial gingiva made of silicone rubber, with each probe duplicate CEJ assessments were carried out at six sites per tooth by 4 examiners. Upon completion of the measurements the distance between the CEJ and the artificial gingival margin was determined using a stereomicroscope. Results indicate that on average the Vivacare TPS estimated the CEJ 0.19mm coronal of its microscopically assessed position. The Merrit-B assessed the CEJ 0.05 mm apical and the CPITN probe 0.11mm coronally of its actual position. In deciduous teeth again the Vivacare TPS probe and the CPITN estimated the CEJ coronal of the true position (0.35 and 0.63mm resp.) whereas the Merrit-B placed it apically (0.02mm). In both permanent and deciduous teeth only the measurements performed with the Merrit-B were on average not significantly different from the microscopic assessment. In
conclusion, based on the results, increasing the tactility of the probe by changing the shape of the tip did not produce a more valid estimation of the location of the CEJ. The use of the Meritt-B probe offered the most accurate assessment of the location of the CEJ in both permanent and deciduous teeth. It can be speculated that, due the irregular enamel surface texture close to the CEJ, the increased tactility of the TPS probe and the CPITN probe may have been suggestive to assess the irregular surface texture to be the CEJ.

**Tine shape and probing pocket depth**

It is apparent from the existing literature that probe penetration, assuming that forces are controlled, depends on the degree of inflammation in the adjacent soft tissue, probe tine diameter and also tine shape. The resistance offered by the periodontal tissues when probing, will increase as the dimensions of the probe tine increases. First the influence of the shape of the probe tine on the probing pocket depth was investigated for a tapered, parallel and ball-ended WHO tine at two probing pressure levels. For this purpose 12 patients, treated for moderate to severe periodontitis, were selected (CHAPTER 4). All three tine shapes, each with a diameter of 0.5 mm at the tip, were mounted in hinged handles exerting a constant probing force (Brodonic®). The handles were adjusted to either 0.25 N (1270 kPa) or 0.5 N (2550 kPa). Using all 6 possible tine/force combinations in 3 sessions, in each session, one tine/force combination was used in the 2 contra-lateral quadrants, and another tine/force combination in the 2 opposing quadrants. The measurements in the same quadrants could therefore be used for comparisons within the same site. Differences (mean per patient) between probing depth measurements show that the WHO tine yields deeper recordings than the parallel/sided and tapered tines, both at 1270 kPa and 2550 kPa. It was concluded that, in addition to probing force, the tine shape of a periodontal probe is of significant influence on the recorded probing pocket depth.

However it can be questioned which probe tine is best in determining the actual attachment level. In order to provide data to establish which tine shape is best in assessing the most coronal connective tissue level, the probe penetration in relation to the microscopically assessed attachment level was assessed of sites with untreated periodontal disease using 4 probing pressures (CHAPTER 5). Since in untreated periodontal disease the resistance offered to the probe tip is limited, 4 relatively low probing pressures were used to reach the intended level of attachment (510 kPa, 760 kPa, 1020 kPa...
and 1270 kPa). In 22 patients, scheduled for partial or full mouth tooth extraction, 135 teeth were selected. At mesial and distal sites of the teeth reference marks were prepared using a diamond fissure burr. The three probe tines (tapered, parallel and ball-ended WHO tine shape) all with a diameter at the tip of 0.5 mm, were mounted in a modified Florida Probe® handpiece. The tine shapes were distributed at random over the sites. At each site increasing probing pressures were used. After extraction, the teeth were cleaned and stained for connective tissue attachment. The distance between the reference mark and the attachment level was determined using a stereomicroscope. The clinical results showed that the parallel and ball-ended tine compared to the microscopic assessment reached, on average, more apical at all force levels. With increasing forces, the parallel tine stopped 0.96 to 1.38 mm and the ball-ended tine 0.73 to 1.06 mm beyond of the microscopically assessed attachment level. The tapered tine did not deviate significantly from the microscopic values at the pressures of 760 kPa, 1020 kPa and 1270 kPa. It was concluded that for the optimal assessment of the attachment level in inflamed periodontal conditions, a tapered probe with a probing pressure of 1270 kPa (tip diameter of 0.5 mm and probing force 0.25 N), may be best suitable.

Instrument shape in periodontal treatment

For subgingival debridement it is necessary that the periodontal instruments reach to the bottom of the pathological pocket in order to clean adequately. Since the influence of tine shape on probing was established in both treated and untreated periodontal tissues, it was hypothesized that a slim ultrasonic tip reaches a more apical position when penetrating a periodontal pocket compared to the working tip of a conventional Gracey curette (CHAPTER 6). 20 untreated periodontitis and 15 periodontal maintenance patients were selected, based on the presence of at least one tooth with a site with a pocket of ≥ 5mm in each quadrant. Recordings were made at the 4 approximal sites of the 4 experimental teeth in each patient. First the probing pocket depth was established using a pressure controlled probe with a tapered tip (probing pressure 1530 kPa). Secondly in randomized order the penetration depth was assessed with an EMS PS Ultrasonic Tip and a Gracey curette. Comparing the penetration of the instruments between groups, as related to the probing pocket depth measurements, only in the periodontitis group the ultrasonic tip reached a significantly more apical level. Therefore in untreated periodontitis, the slim ultrasonic tip offers a better chance for an optimal
subgingival debridement in the deeper parts of the pockets compared to traditional curettes. However the deeper penetration of the ultrasonic tip might induce a risk for greater trauma to the coronal connective tissue attachment than the Gracey curette. Based on the literature this appears not to be a major factor in the clinical treatment outcome.

Reproducibility of periodontal probing in maintenance

It seems likely that in clinical research, which is periodontal probe-dependent, the use of pressure controlled probes with the optimal tine shape, probe diameter, standardization of location and direction combined with direct data entry into a computer, might improve the accuracy and reproducibility of the study outcomes. In untreated periodontal patients however, probing errors due to loss of tactility by remaining calculus or overcontouring of restorations remains a disadvantage using a pressure controlled probe. Also a proper assessment of the root anatomy is difficult with these probes. Therefore despite the advantages described on pressure probes, still the conventional periodontal probe is the most frequently used probe in daily periodontal practice. Upon completion of periodontal treatment monitoring the periodontal health status is necessary to establish stability over time. It may be hypothesized that in maintenance care with relatively shallow pockets force controlled probes may perform better than the manual probe. In CHAPTER 7 the manual probe is tested for its reproducibility in probing pocket depth assessment against three commercially available systems with pressure control. In 12 periodontal maintenance patients duplicate measurements were made at day 0 and 1 week later. In each patient four teeth with the deepest pockets were measured at six sites. In total 288 sites were available for comparisons. The Florida Probe® (1590 kPa), the Jonker Probe® (1530 kPa), the Brodontic® probe (2550 kPa) and the manual probe were used in a randomized scheme. Mean probing measurements showed for the Florida Probe® and the Jonker Probe® lower recordings than for the Brodontic® probe and manual probe. The Florida Probe®, the Brodontic® probe and the manual probe showed no differences between the duplicate measurements, except for the Jonker Probe® where the second assessment was deeper. For the Brodontic® probe and the manual probe the correlation coefficients between measurements at day 0 and 1 week were 0.90 and 0.89, respectively, while for the Florida Probe® and the Jonker Probe® they were 0.76 and 0.75, respectively. In
conclusion the Brodontic® probe and the manual probe appear to be reliable tools for reproducible probing pocket depth measurements in periodontal maintenance patients.

**Probing pressure and study outcomes**

In a systematic review on the influence of probing pressure on the probing pocket depth a variety of probe designs, probing pressures and periodontal tissue conditions was found in the literature. Comparison of the different study results proved to be difficult for the substantial amount of variation of the formentioned factors. Therefore, in this study, an attempt was made to calculate a correction factor that compensates for different probing pressures employed in both disease and health when comparing study outcomes. The MEDLINE-PubMed and Cochrane Central Register of controlled trials (CENTRAL) were searched up to June 2008 to identify appropriate studies. The search resulted in 3032 titles and abstracts. In total 5 papers fulfilled the eligibility criteria. These studies provided data with probing pressures ranging from 510 to 9950 kPa. For the evaluation of the results a distribution was made between diseased and healthy/treated sites. The incremental change in probing pocket depth in healthy/treated sites decreased as the pressure increased above 3980 kPa. In diseased sites this phenomenon was already present at pressures above 1000 kPa. At healthy/treated sites a mean increase of probing pocket depth could be calculated of 0.002mm per increase of 10 kPa in probing pressure whereas at diseased sites this value amounted to 0.004mm. The amount of increases of probing pocket depth per 10 kPa probing pressure can be used as correction factors when comparing study outcomes of studies using different probing pressures for assessment of the probing pocket depth. For instance Badersten et al. (1984), when evaluating the effect of non-surgical periodontal therapy, performed their measurements with a probing force of 0.75N with a tip diameter of 0.5 mm which amounts to a probing pressure of 3820 kPa. Results showed twelve months after treatment with hand instruments a mean overall PPD of 3.8 mm. In the study of Kaldahl et al. (1988) a probing force of 0.5 N with a tip diameter of 0.35 mm (5190 kPa) was used when testing the effect of four treatment modalities. The probing pressure used in this study is an increase in probing pressure of 38% compared to Badersten et al. (1984). The mean PPD in sites treated within the non-surgical periodontal therapy modality, was 4.26 mm after 12 months (Kaldahl et al. 1988). In order to be able to compare the probing depth after treatment of the 2 studies, the probing pressure of the Badersten study should be
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adopted to the level that was used in the Kaldahl study with a corresponding mean PPD increase. This can be achieved by using the correction factor of 0.002 mm increase per 10 kPa for healthy/treated sites. Thus the discrepancy of 1370 kPa between the pressures used in the 2 studies times 0.002 is 0.27 mm. So, if in the Badersten study the same probing pressure was used as in the Kaldahl study, the probing depth would have been 4.07 mm. This probing depth value appears to be in closer range of the 4.26 mm as presented by Kaldahl et al. (1988). The study outcome of both studies appears therefore to be in line. Based on the results of this study, it is necessary to use probing pressure as the unit of measure in describing probing if comparison of different study outcomes is to be performed. In this the calculated correction factors may be valid tools to overcome different probing pressures used.

Concluding remarks

The periodontal probe is a multi-purpose tool. It can be used to assess bleeding, pocket depth and attachment level. However all measurements are a reflection of the actual reality and may not represent either the true level of inflammation or the histological dimensions of the pocket. Since the probe is the best we have for clinical diagnosis, this thesis evaluated various aspects of probing periodontal pockets around teeth. What stands out from this research is that probe tine shape and probing pressure are the most important parameters. On average the manual probe with a tapered tine seems to be a suitable instrument for daily practice. A probing pressure of approximately 1270 kPa (tip diameter 0.5 mm and probing force 0.25 N) would suffice in untreated disease to identify the most coronal connective tissue attachment level. However clear under- and overestimations of this attachment level will occur in individual cases. In treated pockets the suggested tip diameter and probing force combination, although reproducible in its probing pocket depth measurements, will lead to a coronal position of the probe tip to the connective tissue level. In some instances, due to the increased tissue tonus of the marginal gingiva after treatment, the resistance offered to the probe tine used (diameter of 0.5 mm) prevents the probe tip from entering the periodontal pocket. It can be speculated that a probe tine with a smaller diameter would facilitate improved access into pockets in treated periodontal tissues.

Despite the limitations of probing there is an abundance of research available in the literature that has supported the value of probing pocket depth measurements in risk management.
The research on probing up to this point in time has focused on the location of the most coronal connective tissue attachment. Nevertheless, it may be questioned whether the ultimate goal should be the ability to diagnose this level both in health and disease for a proper risk assessment in periodontal disease. Apart from specific periodontal regenerative procedures, successful periodontal treatment results in a long junctional epithelium rather than new connective tissue attachment. It has been shown that the barrier function of a long junctional epithelium against plaque is not inferior to that provided by a dentogingival epithelium of normal length. In experimental animal models no difference was observed in the penetration of the inflammatory lesion into the gingival tissues resulting from plaque infection. Therefore the resistance to disease for both types of attachment appears comparable (Magnusson et al. 1983; Beaumont et al. 1984). Supporting this view are the defense mechanisms provided by the junctional epithelium itself. Through relatively quick cell exfoliation and secretion of active antimicrobial substances, a first line of defense is formed against microbial invasion of the tissue (Pöllänen et al. 2003). Up to now it has not been possible to clinically evaluate whether a long junctional epithelial attachment is just as good as a connective tissue attachment. Therefore, further research should be aimed to support the hypothesis considering the most coronal junctional epithelial attachment as the true level of attachment in both healthy and diseased periodontium. For this development of an instrument able to diagnose the location of this attachment level is essential. This instrument could allow in time for a more accurate diagnosis resulting in a more efficient treatment and an improved risk assessment of periodontal disease.