

Clinical Periodontal Diagnosis: Probing Pocket Depth, Vertical Attachment Level and Bleeding on Probing

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Periodontal pocketing, attachment loss, bone loss, and subgingival inflammation are among the clinical signs of periodontitis. Periodontal pockets and subgingival inflammation give evidence of actual periodontal infection, whereas attachment loss and bone loss are symptoms of former periodontitis that has caused tissue destruction in the past. Several clinical or radiographic methods are used to score periodontal pockets, attachment loss, bone loss, and subgingival inflammation and to assess the degree of periodontal destruction. Assessment of the different diagnostic parameters at the same site at different points in time provides information on progression of the disease or the results of local treatment.

For judgment and interpretation of the different periodontal parameters it has to be kept in mind that parameters, which are used to evaluate periodontal pockets, attachment loss, bone loss, and subgingival inflammation are diagnostic tests. These tests attempt to assess an anatomic or pathologic reality by using as simple, practicable, and least invasive a method as possible. However, tests often fail to reflect reality perfectly. Further, diagnostic tests exhibit measurement errors that have to be considered for interpretation.

Test methods, diagnostic tests, and parameters can be judged according to intra-individual as well as inter-individual reproducibility and validity. Inter-individual reproducibility describes to what extent the results of a test are influenced by the examiner. Intra-individual reproducibility represents the safety with which a repeated measurement by the same examiner will provide identical results.

Validity (accuracy) describes how sufficiently a test or examination method represents the anatomical or pathological reality that is to be assessed.

Landmarks

The gingival crevice and the periodontal pocket respectively extend apical from the gingival margin to the most coronal extension of the epithelial attachment (American Academy of Periodontology, 2001). A precise determination of these structures is only provided by histometric means. The measurement of probing pocket depths (PPD) is a clinical diagnostic test to assess the coronal extension or the depths of the periodontal pocket respectively. In this test a periodontal probe is inserted into the periodontal pocket with defined force (0.2–0.3 N) in apical direction parallel to the tooth axis between gingiva and tooth surface until probing pressure and tissue resistance are in balance. The probing pocket depth is read out in relation to the gingival margin using the markings of the periodontal probe (Figs. 1 to 5). Periodontal and probing pocket depth may be influenced by changes at the bottom of the pocket and at the gingival margin. The excision of the whole gingiva coronally of the epithelial attachment, e.g. by gingivectomy, will result in a periodontal pocket and probing depth near 0 mm. However, this is achieved at the expense of loss of gingiva and severe recession (Fig. 3).

Elimination of gingival inflammation with a remission of the subepithelial infiltrate and substitution of inflammatory cells by fibroblasts and collagen



Fig. 1 Measurement of probing pocket depth (PPD) and vertical attachment level (PAL-V) using a simple manual probe (PCPUNC15) at the distobuccal site of a left first maxillary premolar.

would result in an increase of tissue pressure at the bottom of the pocket. This increased tissue pressure would increase tissue resistance against probing pressure and thus result in probing depth reduction (clinical attachment gain) (Figs. 4 and 5). If only PPD is assessed the influence of both mechanisms (recession/clinical attachment gain) cannot be distinguished. However, if instead of the quite variable landmark 'gingival margin' a relatively stable landmark as the cemento-enamel junction (CEJ), restoration margins, or a reference splint are chosen the changes of measurements are primarily influenced by changes at the bottom of the pocket (measurement of clinical attachment levels) (Figs. 1 to 5).

Attachment loss may occur and will then be measured in a vertical direction (vertical probing attachment level: PAL-V or clinical attachment level: CAL-V). However, the stability of the landmarks CEJ or restoration margin is relative. Caries or erosion may change the location of, or destroy the CEJ. The location of restoration margins may be altered after the replacement of old restorations by new ones. With each newly performed restoration the reference for attachment level 'moves' slowly apically and reduces attachment loss artificially. This is a problem particularly in long-term follow-

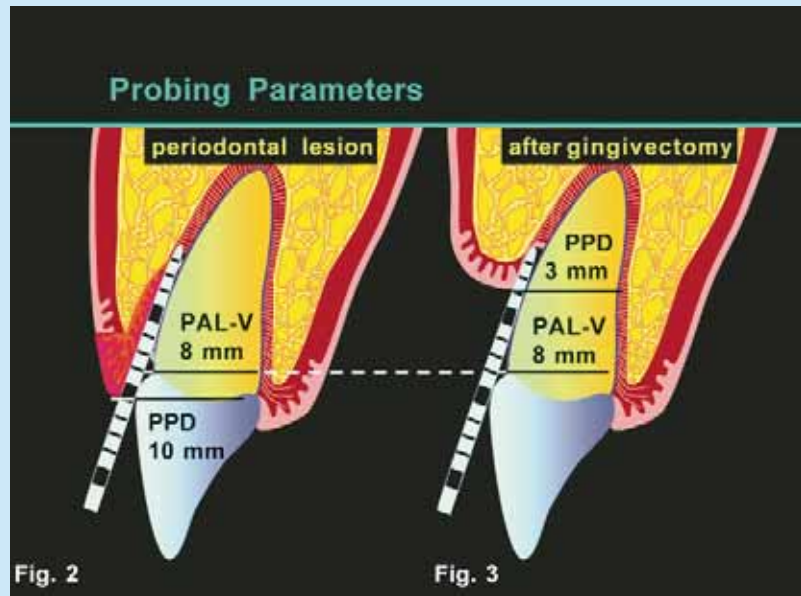


Fig. 2 Measurement of probing pocket depth (PPD) and vertical attachment level (PAL-V) at a periodontal lesion with attachment loss and bone loss.

Fig. 3 Measurement of probing pocket depth (PPD) and vertical attachment level (PAL-V) after gingivectomy and ostectomy. PPD is reduced dramatically while PAL-V remains.

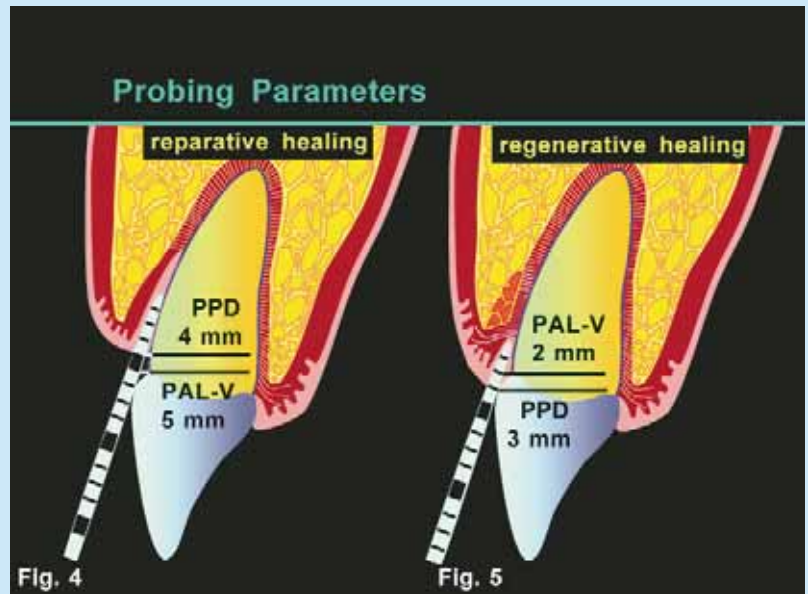
ups covering 5 years or more. This problem cannot be overcome by the use of splints as reference for PAL-V measurements because the fit of these splints is likely to deteriorate with tooth movements or new restorations.

Validity

Clinical measurements of probing pocket depths as well as clinical assessments of vertical probing attachment loss using periodontal probes are diagnostic tests that often fail to represent exactly the anatomical or pathological reality, which can only be assessed precisely by histological or histometric methods (gold standard). If an epithelial and subepithelial infiltrate is present the periodontal probe will penetrate the apical epithelium and will stop just coronally of the intact fibers of the connective tissue attachment (Spray et al, 1978). Thus, the probe tip is located 0.25–0.4 mm apical to the termination of the junctional epithelium or the bottom of the pocket, respectively (Listgarten, 1980). Some authors report a penetration of the probe tip up to 1.25 mm apical of the coronal fibers of the connective tissue attachment for a probing force of 0.3 N and a Gingival Index of 3 (Robinson and Vittek, 1979) (Fig. 2).

Fig. 4 Measurement of probing pocket depth (PPD) and vertical attachment level (PAL-V) after reparative healing. A long junctional epithelium has developed, and the inflammatory infiltrate is replaced by fibroblasts and collagen. PPD and PAL-V are reduced by recession on one hand and higher tissue resistance against probing on the other hand (clinical attachment gain).

Fig. 5 Measurement of probing pocket depth (PPD) and vertical attachment level (PAL-V) after regenerative healing. New connective tissue attachment and new bone have formed. PPD and PAL-V are reduced by recession on one hand and higher tissue resistance against probing on the other hand (clinical attachment gain).



Under healthy periodontal conditions the probe tip stops approximately 0.4 mm coronal of the termination of the junctional epithelium (Armitage et al, 1977, Listgarten, 1980). After elimination of the subepithelial infiltrate by consequent removal of supragingival and subgingival bacterial deposits the inflammatory cells are substituted by fibroblasts and collagen which leads to an increase of tissue pressure. This increased tissue pressure will resist probing pressure to a higher extent than inflamed tissue whether a long epithelial attachment (reparative healing) (Fig. 4) or a new connective tissue attachment (regenerative healing) (Fig. 5) is established. Under healthy conditions using the same probing force a periodontal probe will penetrate less far apically between tooth surface and gingiva than in cases of inflammation. This will result in PPD reduction and clinical attachment gain. Thus, the type of therapeutic outcome – reparation or regeneration – may not be determined and distinguished by clinical means (Fig. 4, 5) (Caton and Greenstein, 1994).

The penetration depth of a periodontal probe is influenced by additional factors. On one hand the coronal position (PPD, PAL-V) of the probe tip corresponds to gingival tissue pressure, while on the other it is related to probing force. It has been

shown that there is a correlation between probing pressure and assessed PPD and PAL-V, respectively (van der Velden, 1979). Similarly, for subjects with healthy gingiva and treated periodontitis, there was a correlation between the frequency of BOP and probing force. Even if inflammation is absent due to injury the conclusion was that for probing forces of more than 0.25 N there exists a high risk to provoke BOP thereby resulting in a false positive result of the diagnostic test BOP as indicator for subgingival inflammation (Lang et al, 1991). Hence, probing forces of 0.2–0.3 N are recommended for the assessment of PPD and PAL-V (Lang et al, 1991; Karayiannis et al, 1992). Additional factors influencing the penetration of the probe under otherwise constant conditions are the diameter of the probe tip, probe angulation, and subgingival calculus on which the probe may get stuck before reaching the bottom of the pocket.

Sensitivity and Specificity

In a periodontal pocket with a subepithelial infiltrate there is a fragile pocket epithelium and a dense subepithelial system of dilated brittle arterioles, capillaries, and venules. Careful probing of

Table 1 Properties of diagnostic tests and their definition

		Disease			
		present	absent		
Diagnostic test	positive	true positive (a)	false positive (b)	positive predictive value:	$\frac{a}{a + b}$
	negative	false negative (c)	true negative (d)	negative predictive value:	$\frac{c}{c + d}$
		sensitivity:	specificity:		
		$\frac{a}{a + c}$	$\frac{d}{b + d}$		

such a pocket using a periodontal probe and a probing force of approximately 0.2 N will result in injury of the vessels of the subepithelial plexus. There will be bleeding into the pocket which will lead to bleeding at the gingival margin for at least 30 seconds after probing. Thus, bleeding on probing (BOP) may be interpreted as a diagnostic test for the existence of a subepithelial infiltrate and periodontal inflammation. However, if the probing force chosen is too low, there is a risk of not provoking a bleeding despite the presence of subgingival inflammation because the probe fails to penetrate deep enough into the pocket, thereby producing a false negative test. The use of too much force for probing may cause injury to healthy tissue resulting in a bleeding despite the absence of a subgingival inflammation thereby producing a false positive test (Lang et al, 1991).

However, particularly repeated absence of BOP seems to be an indicator of periodontal stability (Lang et al, 1990). The amount of sites that bleed on probing is another method for quantifying the degree of subgingival inflammation (BOP index). The aptitude of a diagnostic test to identify a person or a site truly as diseased is called sensitivity (Table 1). The aptitude to identify a person or a site truly as healthy is called specificity (Table 1). However, even for a diagnostic test with high sensitivity it is difficult to identify or predict a process of low prevalence, e.g. an attachment loss of 2 mm or more in patients under supportive periodontal therapy (SRT) (positive predictive value) (Table 1) (Kaldahl et al, 1996). The exclusion of such a rare occasion using a test of high specificity is more likely to succeed (negative predictive value) (Table 1) (Lang et al, 1990; American

Academy of Periodontology, 2001). Thus, frequent BOP at a site at different examinations during SPT is not a reliable predictor of attachment loss at that site (low positive predictive value: approximately 20–30%). However, repeated absence of BOP points to a low chance of attachment loss at that site (high negative predictive value: approximately 90%) (Lang et al, 1990).

Measurement Error

Factors such as gingival inflammation and probing pressure not only have an impact on whether, and how discrepant the diagnostic tests PPD and PAL-V measurement are from the anatomic reality (validity). Their variability also influences the reproducibility of the assessed parameters. If a measurement or a diagnostic test is performed at the same site in the same manner within too-short a time period to allow a real change at that site (replicate or duplicate measurement) both measurements or tests should produce the same result. If there is a difference between measurement 1 and 2 this difference represents a measurement error. However, the difference of one replicate measurement does not allow a conclusion regarding variability or reproducibility of an assessment method. The evaluation of many replicate measurements at different sites is necessary to calculate an estimate of the measurement error. The mean of the differences of replicate measurements should add up to 0. The standard deviation of this mean (standard deviation of differences of replicate measurements) may be used as measure of the reproducibility of diagnostic tests. The smaller this value the more reproducible, and thus reliable

the test method. Without additional means as reference splints the measurement error of probing parameters lies between 0.5 and 1.0 mm.

If possible, such influencing factors should be kept constant for consecutive measurements. On one hand the same type of probe with standardized dimensions and uniform markings should be used for follow-up PPD and PAL-V measurements. On the other hand clinicians should attempt to keep the probing pressure constant. To fulfill the latter requirement simple pressure controlled probes (second generation probes) and electronic pressure controlled probes (third generation probes) have been developed. Whereas some studies report higher reproducibility for the use of electronic probes (Gibbs et al, 1988; Magnusson et al, 1988 a, b), several other studies have shown that experienced and trained examiners using simple manual periodontal probes (first generation probes) achieve the same reproducibility that is possible with simple or electronic pressure calibrated probes (Wang et al, 1995 a, b; Grossi et al, 1996; Mayfield et al, 1996). However, future applications for electronic probes may arise in the digital practice, in which all documents (radiographs, patient charts, etc.) are digitally processed, with computer-linked electronic probes providing direct transfer of measurements into patient charts – thereby avoiding the error-prone visual read-out and verbal transfer of information to an auxiliary.

Further factors that influence the reproducibility of vertical probing parameters (PPD, PAL-V) are periodontal pocket depth (less reproducibility at deep as compared to shallow pockets), and tooth type (decreasing reproducibility from anterior to posterior teeth) (Mayfield et al, 1996).

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