Periotest values and occlusion

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Abstract:

Numerous experiments have been carried out in order to identify occlusal trauma as an etiologic factor in the pathogenesis of periodontopathies. With Periotest (http://www.periotest.de/) an instrument is available to quantify occlusal overstressing. In 905 teeth and 43 patients with periodontitis the Periotest values were determined without occlusal contact and under maximum habitual occlusion. Clinical parameters like probing depth, recession, papillary bleeding index, bone resorption and qualitative such as tipped tooth, filling, abrasion facets in the occlusal areas and eccentric abrasion facets were evaluated. Bone resorption was determined based on intraoral radiographs. Multiple linear regression calculations between standard Periotest values (Periotest value without tooth contact) or Periotest value differences (the difference between Periotest values under maximum habitual occlusion and without occlusal contact) as dependent variables and the quantitative parameters as independent variables resulted in determination coefficients of 61% for the Periotest value without occlusal contact and 40 % for the Periotest value difference. The influence of bone resorption clearly dominated over all other quantitative parameters.

Occlusal parameters as tipped teeth, restorations and abrasion facets were explored in teeth without bone resorption and without pathological pockets. Significantly higher Periotest values and significantly more negative Periotest value differences in tipped teeth were interpreted as a possible source of occlusal trauma. Less negative Periotest value differences in teeth with eccentric abrasion facets indicate reduced intercuspidation. Abrasion facets in the occlusal areas tend to cause higher stressing. Restorations had no effect on Periotest values and Periotest value differences.

Zusammenfassung:

Bei 43 Patienten mit marginaler Parodontitis wurden an 905 Zähnen die Periotestwerte ohne Okklusion und in maximaler Interkuspidation ermittelt. An klinischen Befunden wurden die quantitativ meßbaren Parameter Tiefe der Sulcustaschen, Rezession, Papillenblutungsindex, Knochenabbau und die qualitativen Merkmale Kippung, Füllung, Schliffflächen im Okklusionsfeld und exzentrische Schliffflächen erhoben. Der Knochenabbau wurde durch Ausmessen von Mundfilmen bestimmt. Multiple lineare Regressionsrechnungen zwischen Periotestwert ohne Okklusion und Differenz der Periotestwerte in maximaler Interkuspidation und ohne Okklusion als abhängigen Variablen und den quantitativen Parametern als unabhängige Variablen ergab Koeffizienten der Determination von 61 % für den Periotestwert ohne Okklusion und 40 % für die Periotestwertdifferenz. Der Einfluß des Knochenabbaus dominierte deutlich gegenüber dem Einfluß der übrigen quantitativen Parameter. Der Einfluß der traumatischen Parameter Kippung, Füllung und Schliffflächen auf die Regression zwischen Periotestwertdifferenzen und Knochenabbau wird dargestellt. Signifikant höhere Periotestwertdifferenzen bei Zahnkippungen bringen ein okklusales Trauma zum Ausdruck. Schliffflächen im Okklusionsfeld haben traumatische Bedeutung. Exzentrische Schliffflächen wirken ebenfalls traumatisierend bei parodontal progredient geschädigten Zähnen. Okklusionsstörungen können bei bestehender marginaler Parodontitis zu verstärktem Knochenabbau führen.

Clinical relevance

The Periotest procedure even in a dentition with initial periodontal disease gives clear, quantitative data about the occlusally traumatising factors: tipping of teeth, eccentric abrasion facets and to a certain extent abrasion facets in the occlusal areas.

Introduction

In the beginning of this century, Karolyi [1] reported the correlation between bruxism and periodontal disease. Since then, numerous experiments have been carried out in order to identify occlusal trauma as an etiologic factor in the pathogenesis of periodontopathies. In 1928, Orban described resorption processes on the side of stressed teeth subjected to pressure [2]. Bhaskar and Orban demonstrated in their animal experiments using monkeys, that traumatised teeth did not display any increased pocket formation, but evaded an occlusal trauma by osseous absorption [3]. Waerhaug found increased pocket formation from intrusion only under extreme mechanical stress condition [4]. The uppermost epithelial cuff prevented further epithelial down growth.

In 1961 Mühlemann and Herzog induced an artificial occluso-articular impairment with changeable inlays. A phase of acute increase in mobility was followed by a period of gradual adaptation [5].

From animal experiments and observations in humans, Glickman found no formation of periodontal pockets after occlusal overloading [6], but an alteration of the pathway of gingival inflammation into the underlaying periodontal tissues [7] as well as angular or craterlike bony defects [8-10]. He concluded, that occlusal traumatism had a co-destructive effect on the periodontium when it occurred in association with an already-existing gingivitis [9,11-14]. In healthy gingiva a healing process was initiated after periodontal cleft expansion and osteoclastic adaptation [15]. Svanberg and Lindhe investigated the effects of occlusal traumas on beagles. They found hypermobility through osteoclastic activity and increased radiotranslucency [16]. In cases of non-inflamed gingivae there was an adaptation to the new occlusion; in contrast, inflammatory symptoms were more evident in cases of already existing periodontitis [17]. Incomplete vertical fractures and increased probing depth could be ascertained on the stressed teeth [18].

Polson's experiments with squirrel monkeys and beagle dogs led to similar results [19-22]. Despite increased clinical mobility, gingivitis could not be induced; however, the medullary spaces of the alveolar bone were enlarged. A regeneration after discontinuation of the artificial occlusal trauma could only be observed when concurrently existing inflammatory symptoms were eliminated [22-25].

Rateitschak could reduce tooth mobility by grinding in but the inflammatory symptoms remained unchanged [26]. According to his opinion, an occlusal trauma does not cause either gingivitis or periodontitis with pocket formation. However, it can hasten the progress of an already existing disease. Renggli and Mühlemann drew similar conclusions [27]. Waerhaug and Hansen [28] stated that a pocket was not a result of the traumatic occlusion but of subgingival plaque formation. Stahl [29], Stallard [30], Ericson and Lindhe [31], Bratschko [32] and Mühlbradt [33] also reported that occlusal trauma as a co-destructive factor does not initiate periodontal impairment; it only has an aggravating effect when other inflammatory factors (e.g. gingivitis) are present. Shefter and McFall [34], Perrier and Polson [35], Meitner [36], Comar et al [37] and Kemper et al [38] found no correlation between occlusal traumas and increased pocket formation.

In 1972-1984 the Periotest® device was developed by Schulte et al. to gain objective data of periodontal function and to avoid clinical tooth mobility testing [39]. The Periotest value doesn't reflect simply tooth mobility but is dependent on the visco-elastic characteristics of the periodontium [40]. One of the advantages is, that this device is hand-held and does not require any fixation during measurement. The measuring principle is based on the deceleration of a rod which taps against the tooth at a constant speed [41]. The greater the degree of periodontal disease, the longer the time required for deceleration. The Periotest measurement without occlusal contact to the antagonistic tooth gives information about the unstressed periodontium of an individual tooth or about the implant bed of a single implant [42]. In contrast, the Periotest measurement carried out under maximum habitual occlusion gives information about the occlusal loading situation [43].

The aim of this study was to investigate the correlations between Periotest values both without and in occlusion and clinical and radiological findings. This was performed in a group of patients with periodontal disease. All of these patients attended a private dental practice. The results were compared with the results of similar investigations carried out in our Dental School. Furthermore the influence of occlusal factors on Periotest values under maximum habitual occlusion was examined.

Materials and methods

Forty-three patients aged between 19 and 63 years and with 905 teeth were investigated. Intraoral radiographs (Kodak Ektaspeed and a Siemens Heliodent, long tube, 70 kV) were taken using the standard Updegrave paralleling technique [44-46] with the RINN XCP film holder system. Bone resorption was determined by evaluation of radiographs according to Fig 1. The total root length L_0 is the distance from the cementoenamel junction to the apex. The intra-alveolar root length L_1 is the distance between alveolar crest and apex. Very translucent septa were regarded as destroyed up to the point at which the bone was opaque again [47]. The percentage of bone resorption (BR) was calculated using the following equation:

$$BR = 100 \times (L_0 - L_1)/L_0 .$$

Probing depths were recorded at four sites per tooth using a P-WHO probe and the 4 individual values totalled. Recessions of the attached gingivae were measured similarly from the cemento-enamel junction, either vestibularly or orally, according to extension. The papillary bleeding index [48] was recorded using the P-WHO probe in the right upper jaw and left lower jaw on the oral side, in the left upper jaw and right lower jaw on the vestibular side.

Only teeth with antagonistic contact were selected for Periotest measurements. Tooth contact under maximum habitual occlusion was checked by a occlusion testing foil (Shimstock, 8 μm, Hanel-GmbH, Nürtingen B-W, Germany). The first Periotest measurement was performed without antagonistic contact under standard conditions according to the instructions given by the manufacturer and at website http://www. periotest.de/beschreibung.htm. Subsequently, if the first measurement had been carried out in the maxillary jaw the same tooth was measured again under maximum habitual occlusion. Between these two measurements the handpiece was not moved. The values with (PTC) and without tooth contact (PTV) yielded the Periotest value difference (DIFF). Since PTC is less than PTV this Periotest value difference is negative. The guidelines for the Periotest measurements given by the manufacturer (Ing. Peter Gulden, Medizintechnik, Bensheim, Germany) were followed [49].

Abrasion facets were diagnosed either intraorally or on a plaster model. Abrasion facets with antagonistic contact in habitual occlusion and in eccentric occlusion were differentiated [50] (ICD-No. 521.10 + 521.18).

Statistical analysis

The determination, correlation and regression coefficients were calculated with a standard spreadsheet program (1 2 3 Version 3D from Lotus Development Inc.). Checking of the regression coefficients against 0 and the checking of the regression linearity were carried out according to Sachs [51]. Multiple and single linear regressions were calculated with the percentages of bone resorption (BR), probing depth (PD), recession (REC) and papillary bleeding index (PBI) as independent variables and the Periotest value (PTV) without occlusal contact as well as the Periotest value difference (DIFF) as dependent variables (response). The difference between two average values was tested with Student's t-test.

Results

Table 1 shows the determination, correlation and regression coefficients of Periotest values *without* occlusal contact. At 61%, the multiple quadratic correlation is slightly higher than the single correlation with bone resorption only (60%). The linear regression line of the Periotest values depending on bone resorption is to be seen in Fig 2 together with the individual measurement values. The linear coefficient of determination of probing depth is clearly lower at 31%. On the other hand, the influences of recession (10%) and papillary bleeding (PBI) (4%) are negligible.

Table 2 shows the determination, correlation and regression coefficients with the *Periotest value difference* as dependent variable. For the Periotest value difference, the multiple coefficient of determination (40%) is only slightly higher than the single coefficient of determination r^2 for bone resorption only (39%). The linear regression line of the Periotest value differences depending on bone resorption are shown in Fig 3 together with the individual measurement values. The influence of probing depth (39%) is again much lower, while recessions (12%) and PBI (3%) only show an insignificant influence.

The following results were found by examining teeth without bone loss and without pathological pockets.

Periotest value differences of *tipped* teeth with an average of -16.5 are more negative than that of untipped teeth with -7.5 as is shown in Table 3 and Fig 4. Simultaneously the Periotest values without occlusal contact of tipped teeth (16.5) are higher than that of untipped teeth with 5.3.

Filled teeth have at -6.8 less negative Periotest value differences than unfilled teeth with -8.1, even this difference is not significant. The Periotest values without occlusal contact are equal.

Teeth with *abrasion facets in the occlusal areas* show with -8.5 more negative Periotest value differences than teeth without abrasion facets (-6.9). However, this difference is not significant. The average Periotest value difference of teeth with *eccentric abrasion facets* at -2.7 is significantly less negative than that of other teeth with -8.3. The Periotest values without occlusal contact of teeth which show abrasion facets are slightly reduced (2.3; 5.8 and 3.5; 5.6), but this difference is not significant.

Discussion

The Periotest depends on the visco-elastic characteristics of the periodontium [40] and is correlated with the degree of periodontal disease [42,47,49,52]. The Periotest is a quantitative measurement in contrast to clinical tooth mobility testing [39]. With an additional Periotest measurement carried out under maximum habitual occlusion the occlusal loading situation is tested [43,53].

The results show that of various quantitative clinical parameters, bone resorption correlates stronger with both the Periotest values (PTV) and the Periotest value differences (Periotest value under maximum habitual occlusion minus PTV) than do probing depth, recession and papillary bleeding index.

The multiple coefficient of determination for the Periotest value without occlusal contact is at 61% only 1 % higher than the coefficient of the single regression calculation with resorption only (60%). For probing depth (31%), the coefficient of determination is clearly smaller; the recession and papillary bleeding index parameters are still smaller. Therefore the data support the results of earlier investigations [52,54,55], that recession and the degree of gingival inflammation, have no significant influence on tooth mobility. The dependence of the Periotest values on bone resorption (Fig2) is similar to the results found previously [47,56,57].

The Periotest value *differences* found by Schulte and Wagner [58,59] in a healthy dentition range from -2 to -12. The present study revealed in cases of already-existing periodontal disease more negative Periotest value differences as an expression of occlusal overstressing. Sometimes differences of up to -40 were recorded (Fig3) These high values are not found in a healthy dentition.

As Fig 4 shows, restorations of teeth do not influence the Periotest value differences. This corresponds to earlier results with Periotest values without occlusal contact [49]. This diagram illustrates that considerably more negative Periotest value differences are measured in tipped teeth and simultaneous the Periotest values without occlusal contact are greatly increased. The difference to untipped teeth is highly significant. A tipped tooth is therefore related to occlusal trauma. It is still unclear as to whether the misplaced tooth causes this trauma or whether the excess stressing is leading to a change in the position.

Abrasion facets in the occlusal areas tend to cause higher stressing; however, this could not be statistically supported. This leads to the conclusion that the periodontium is able to adapt functionally to the increased load by transformation. This adaptation has also been described by other authors [5,33]. Waerhaug found in dogs that cemental damage, periodontal membrane and alveolar bone will be repaired when the tooth readjusts itself in a new position. The supporting structures seem to be well suited to prevent permanent damage caused by occlusal overload [4].

Influences of abrasion facets are obviously notable in significantly less negative Periotest value differences. Simultaneously, the Periotest values without occlusal contact are somewhat decreased. This means that in our patient group the occlusion of teeth with eccentric abrasion facets is reduced [26], although the test of tooth contact under maximum habitual occlusion was positive.

It can be stated that the Periotest procedure even in a dentition with initial periodontal disease gives clear, quantitative data about the occlusally traumatising factors: tipping of teeth, eccentric abrasion facets and to a certain extent abrasion facets in the occlusal areas.

The Periotest value and the Periotest difference is influenced primarily by bone resorption, less by probing depth. This correlates well with numerous earlier investigations about Periotest value and tooth mobility, especially with those of Maunz [56], Schulte et al. [47] and Steppeler [57] in a different patient group with periodontitis.

For the practical application of the Periotest procedure in a periodontally diseased dentition, the following would be ascertained in addition to the previous, known results [52,53,60]:

- an increased Periotest value without occlusal contact is primarily caused by bone resorption;

- an increased Periotest value difference when compared to normal values is also primarily caused by bone resorption;

- lower Periotest values without occlusal contact, less increased when compared to normal values, with simultaneous high Periotest value differences under maximum habitual occlusion are evidence of the dominant influence of occlusal trauma;

- recessions have no significant influence on the Periotest value difference.

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Legends of Figures

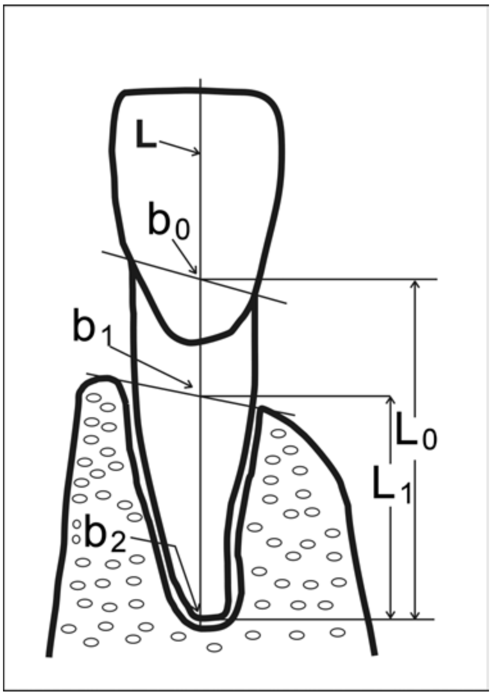

Fig. 1. Schematic illustration of the measurements for the determination of bone resorption.

The mesial and distal cementoenamel junctions are connected by a straight line. Their intersection with the long axis of the tooth (L) is labelled b_0. The intersection of a straight line tangential to the apex perpendicularly to L is labelled b_2. The distance b_0 - b_2 is the total root length labelled L_0. The mesial and distal alveolar crests are joined by a straight line and the intersection with L is labelled b_1. The distance b_1 - b_2 is the intra-alveolar root length L_1.

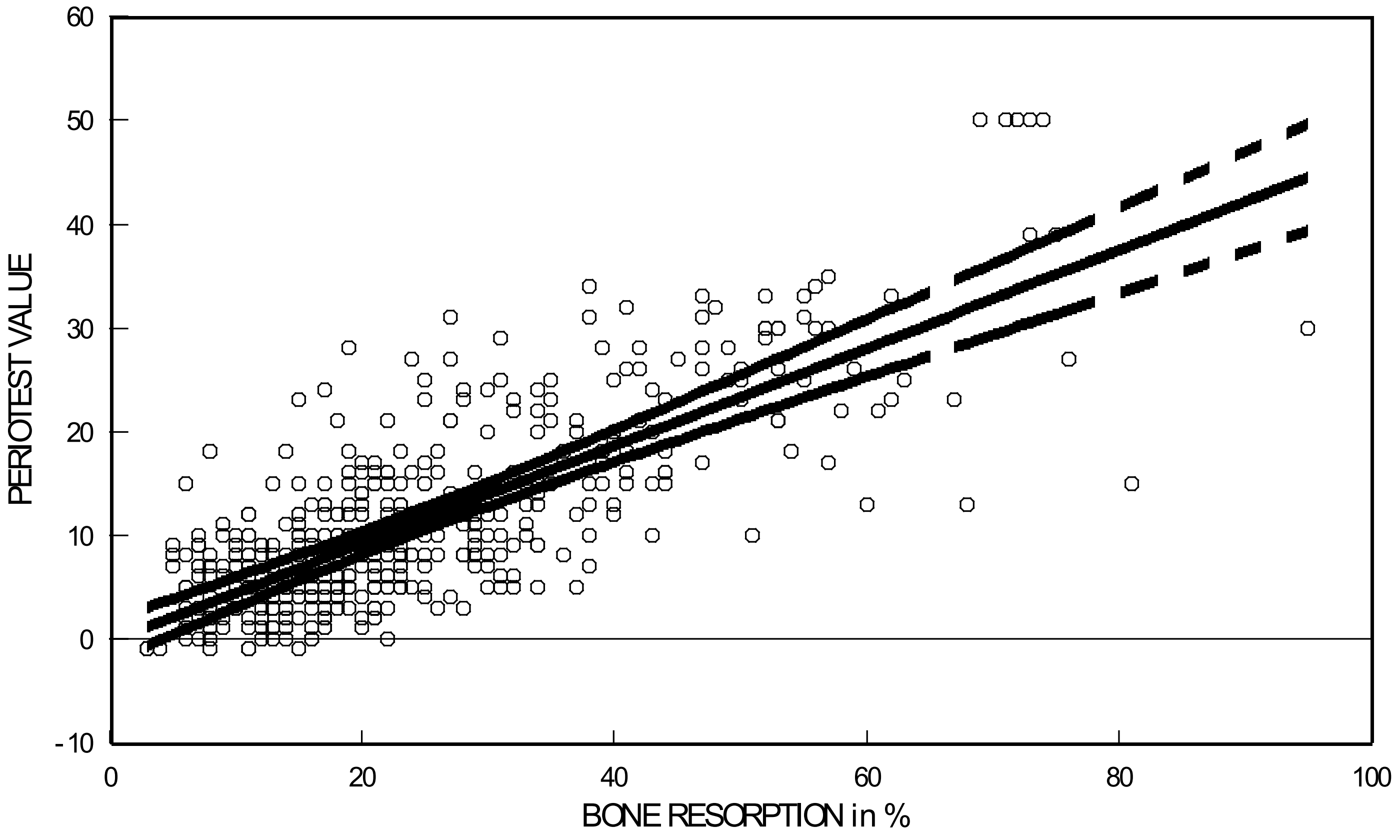

Fig. 2. Dependence of the Periotest values on bone resorption. Linear regression line with confidence borders and the individual measurement values marked by o.

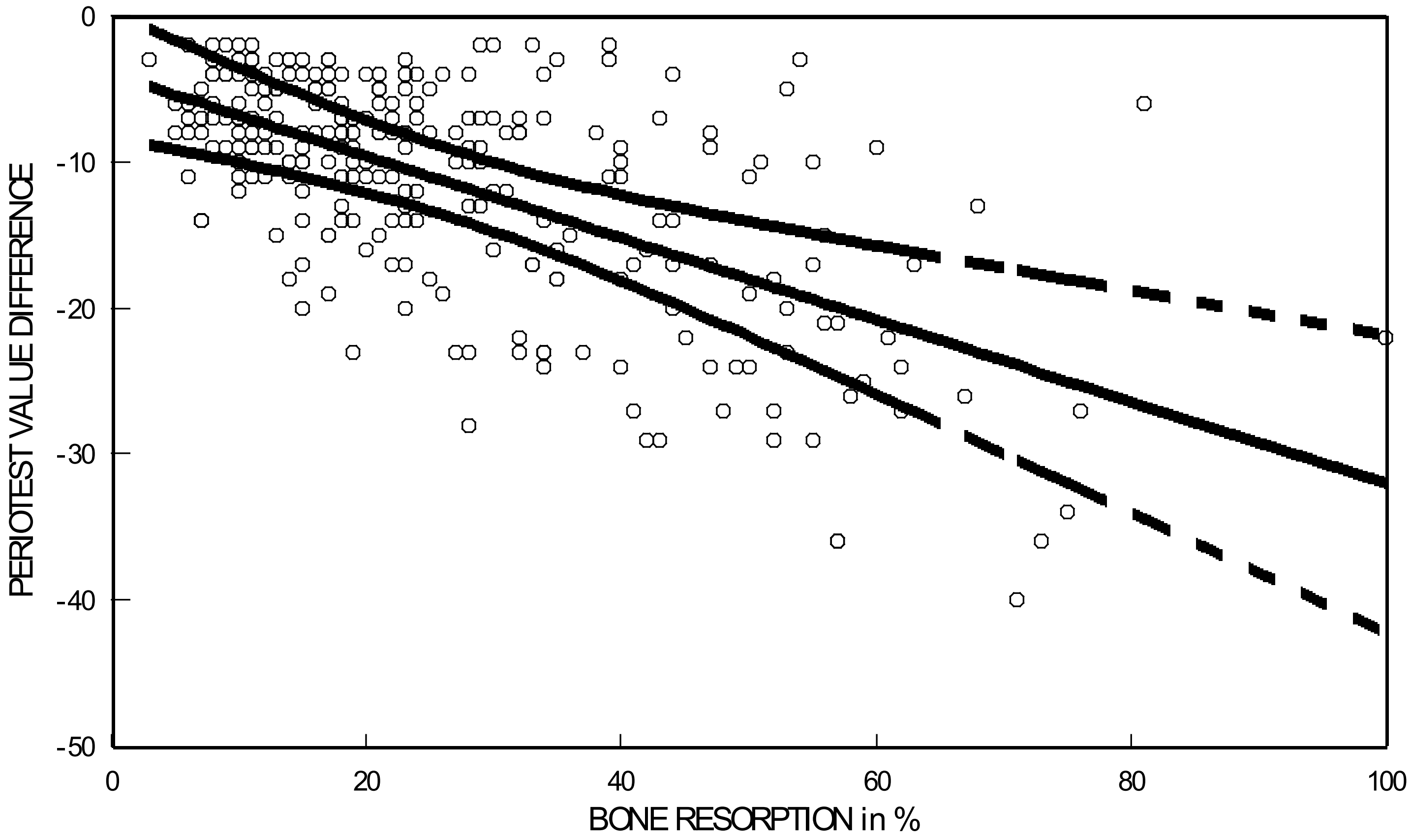

Fig. 3. Dependence of the Periotest value difference on bone resorption, limited to maxillary jaw. Linear regression line with confidence borders and the individual measurement values marked by o.

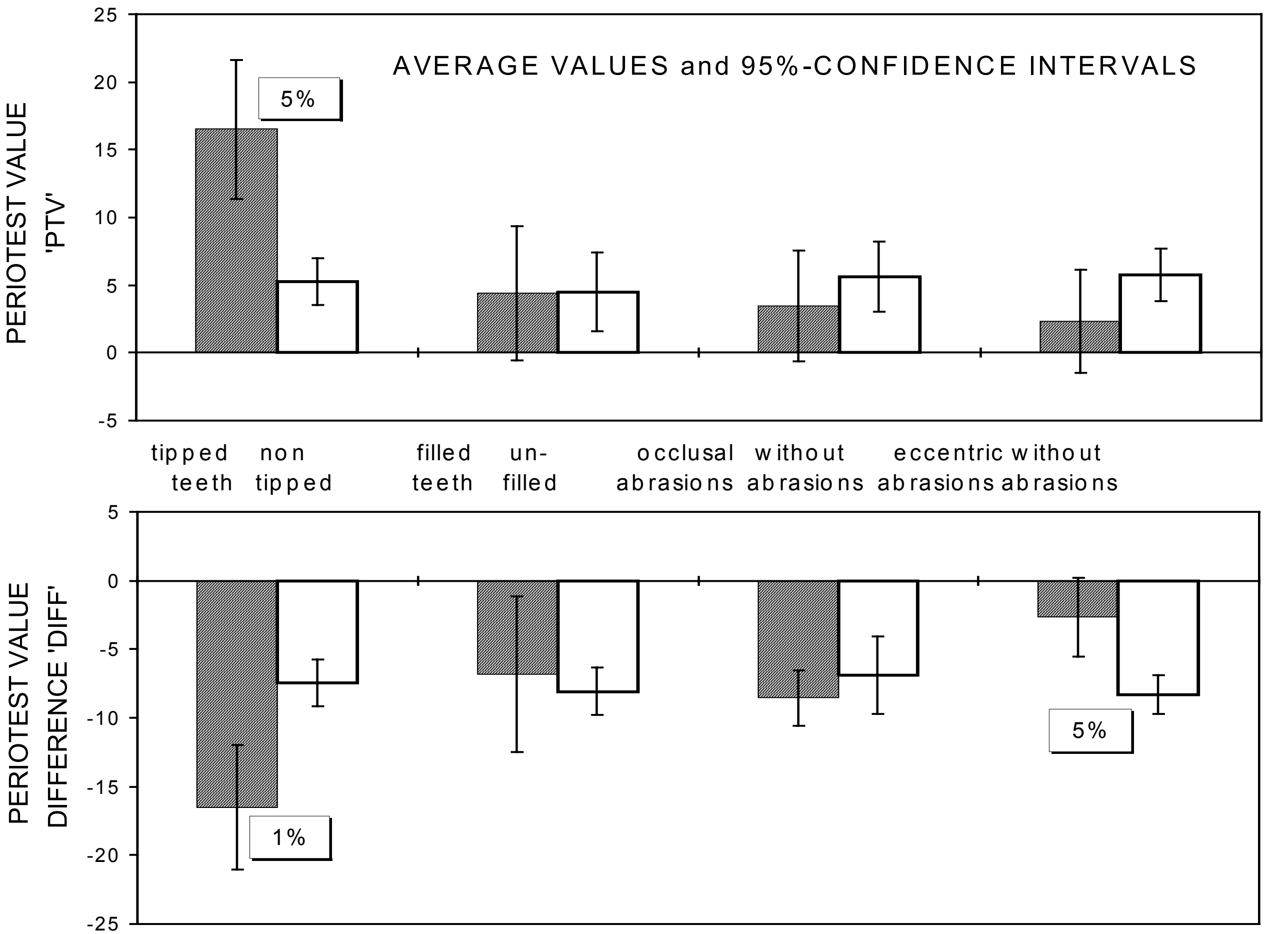

Fig. 4. Dependence of the Periotest value difference on qualitative clinical variables: average values and 95%-confidence-intervals.

Significant results received with Student's paired t-test are marked by ☐ together with level of significance α.

Table 1 Correlation of quantitative clinical variables and Periotest value.

Significant differences from zero are underlined (p=0.05). ± standard error.

PERIOTEST VALUE versus	BONE RESORPTION	SUM OF PROBING DEPTHS	GINGIVAL RECESSION	PAPILLARY BLEEDING INDEX
Coefficient of determination (r^2)	60 %	31 %	10 %	4 %
Coefficient of regression / slope(b)	0.47 ± 0.02	1.25 ± 0.08	2.18 ± 0.29	1.47 ± 0.34
Intercept of regression line (a)	-0.11 ± 5.78	-3.71 ± 7.57	8.57 ± 8.65	8.99 ± 8.96
Number of observations (n)	492	492	492	492
Multiple Coefficient of determination		61 %		

Table 2 Correlation of quantitative clinical variables and Periotest value difference. The Periotest measurement carried out under maximum habitual occlusion and without tooth contact yielded the Periotest value difference (in maxillary jaw only).

Significant differences are underlined (p=0.05). ± standard error.

PERIOTEST VALUE DIFFERENCE versus	BONE RESORPTION	SUM OF PROBING DEPTHS	GINGIVAL RECESSION	PAPILLARY BLEEDING INDEX
Coefficient of determination (r^2)	39 %	19 %	12 %	3 %
Coefficient of regression / slope(*b*)	-0.28 ± 0.02	-0.78 ± 0.10	-2.15 ± 0.36	-1.16 ± 0.38
Intercept of regression line(*a*)	-3.96 ± 6.01	-1.57 ± 6.91	-8.77 ± 7.21	-9.58 ± 7.56
Number of observations (*n*)	261	261	261	261
Multiple Coefficient of determination		40 %		

Table 3 Dependence of qualitative clinical variables and Periotest value without occlusal contact and Periotest value ***difference***. The Periotest measurement carried out under maximum habitual occlusion and without tooth contact yielded the Periotest value difference (in maxillary jaw only). Average values ± confidence intervals. Significant differences (p=0.05) are underlined.

	Periotest value difference	Periotest value without habitual occlusal contact	number of teeth
tipped teeth	-16.5 ± 4.6	16.5 ± 5.1	10
non tipped	-7.5 ± 1.7	5.3 ± 1.7	20
filled teeth	-6.8 ± 5.6	4.4 ± 4.9	5
unfilled teeth	-8.1 ± 1.7	4.5 ± 2.9	16
abrasions in occlusal areas	-8.5 ± 2.0	3.5 ± 4.1	11
without abrasions	-6.9 ± 2.8	5.6 ± 2.6	10
eccentric abrasions	-2.7 ± 2.9	2.3 ± 3.8	3
without abrasions	-8.3 ± 1.4	5.8 ± 1.9	17

Only teeth with antagonistic contact under maximum habitual occlusion, bone resorption less than 3% and Probing depths less than 3 mm were included.