Bleeding on probing as it relates to probing pressure and gingival health

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Abstract. The present study was designed to determine the threshold pressure value to be applied in provoking bleeding on probing (BOP) in clinically healthy gingival units. 12 female dental hygiene students volunteered for the study. They were selected on the basis of excellent oral hygiene standards, absence of probing depths >3 mm and absence of caries or dental restorations on smooth and proximal tooth surfaces. Applying a probing force of 0.25, 0.5, 0.75 and 1.0 N in one of the 4 jaw quadrants, respectively, on 2 different occasions with an interval of 10 days, bleeding on probing was assessed. Oral hygiene and gingival conditions were determined using the criteria of the plaque control record and the gingival index. On the basis of the BOP values, obtained using the lowest probing force (0.25 N), the subjects were divided into 2 groups: group 1 ("minimal BOP" value) consisted of 6 subjects yielding practically no bleeding (mean BOP= 0.9%) at both examinations, while the subjects of group 2 ("low BOP" value) had slightly higher BOP% (mean BOP=13.4%). Both groups showed significant increase in mean BOP% with increasing probing force (0.9%–36.1% in group 1 and 13.4%–47.0% in group 2). Regression analysis revealed an almost linear correlation and a high correlation coefficient between BOP% and probing force. The comparison of the regression lines of the 2 groups showed almost identical slope inclination. However, slight differences in slope inclination were found for different sites: approximal sites clearly yielded steeper regression lines than buccal/oral sites. The results of the study demonstrated that the BOP test using uncontrolled forces may result in a proportion of false positive readings and that a strong possibility exists for the traumatization of clinically healthy gingival tissues if a probing force exceeding 0.25N is applied.

Key words: bleeding on probing; clinical trials; gingival health; probing force.

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Inflammatory periodontal disease is clinically characterized by various symptoms, including swelling and accentuated redness of the gingiva, and an increased tendency for bleeding (Schour & Massler 1947, Mühlemann & Mazor 1958, Löe & Silness 1963). These symptoms have led to the development of clinical indices which have been adopted in clinical trials as well as in daily practice. Especially the symptom of bleeding on probing (BOP) has been used in the creation of clinical indices for the assessment of periodontal health or disease (Löe & Silness 1963, Mühlemann & Son 1971, Ainamo & Bay 1975, Saxer et al. 1977). The assessment of presence or absence of BOP appears to fulfill the requirements for an ideal clinical parameter to verify presence or absence of inflammatory processes in the periodontium (Greenstein 1984), namely objectivity, reproducibility and easy clinical management.

Several studies have revealed correlations beteen BOP and histopathology (Greenstein et al. 1981, Polson et al. 1981, Davenport et al. 1982, Thilo et al. 1986, Brecx et al. 1987), clinical (Löe & Silness 1963, Mühlemann & Son 1971, Meitner et al. 1979) and microbiological (e.g., Slots et al. 1979, Armitage et al. 1982) changes associated with periodontal diseases. More recent clinical trials have attempted to define the diagnostic value of BOP (e.g., Badersten et al. 1985, Lang et al. 1986, Claffey & Shanley 1986, Lang et al. 1991). Using different sets of data, sensitivity, specificity and predictability of BOP for periodontal stability or disease progression were calculated. Generally, BOP showed a modest sensitivity and specificity and rather low positive but high negative predictive values. One reason for the discrepancy between the low positive and high negative predictive values may be that a high number of false positive scorings are generated during probing. In other words, the provoked bleeding by probing could in several instances be the effect of mechanical trauma to healthy sites. To eliminate the variability in the assessments, standardized probing pressures have been advocated to be used when determining BOP (Van der Velden & De Vries 1978, Robinson & Vitek 1979, Polson et al. 1980). However, so far the appropriate probing pressure to be applied to minimize false positives and, hence, to distinguish between health and disease in the gingival tissues has not been determined as yet.

The purpose of the present study was therefore to determine the threshold

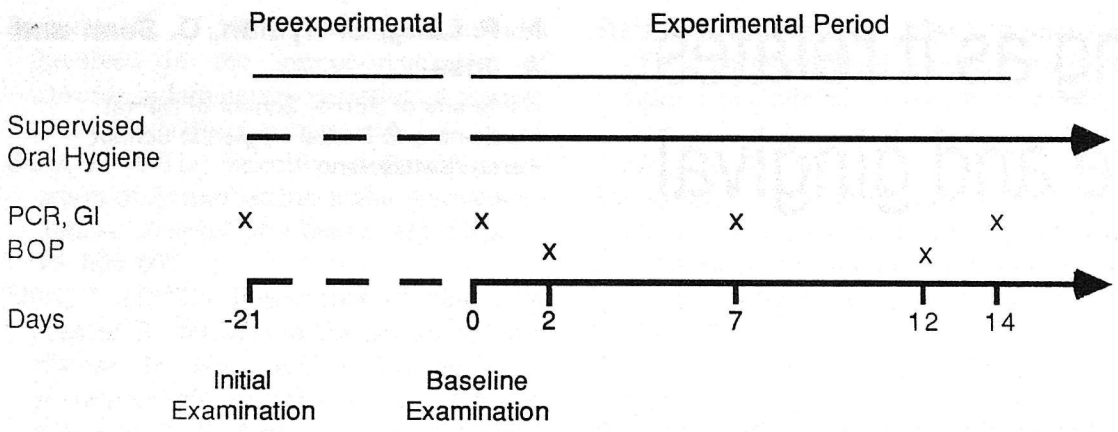

Fig. 1. Outline of the study. PCR = plaque control record. GI = gingival index. BOP = bleeding on probing.

pressure to be applied in provoking bleeding on probing in clinically healthy gingival units.

Material and Methods

12 female students, aged 20–27 years (*x*: 22.7 years), from the Dental Hygienist School of Berne, Switzerland volunteered for this study and signed consent forms to participate. They were selected on the basis of excellent oral hygiene standards, absence of increased probing depths (>3 mm) and absence of any carious lesions or dental restorations on smooth and approximal tooth surfaces.

Following an inital examination (day −21; Fig. 1) which included an evaluation of oral hygiene standards and gingival conditions, the students entered a 3-week pre-experimental period of daily supervized oral hygiene practices after the removal of any plaque and/or calculus. The supervision of oral hygiene continued then throughout the study. At the termination of the pre-experimental period, the subjects were re-examined (baseline: day 0). At the initial, the baseline and subsequent examinations (days 7 and 14), oral hygiene standard was assessed using the plaque control record (PCR; O'Leary et al. 1972). The gingival condition was assessed using the criteria of the gingival index system (GI; Löe & Silness 1963).

On days 2 and 12 (Fig. 1), Bleeding and Probing (BOP) to the depth of the clinical sulcus was evaluated using different probing forces which were controlled by an electronic pressure sensitive probe with a point diameter of 0.4 mm (Vineland Mfg. Comp.). Since the periodontal probes used in the present study were standardized in size and dimensions, only the probing force varied in order to test different probing pressures. The reason for assessing BOP on different days (days 2 and 12) than the PCR and GI (days 0, 7 and 14) was to avoid traumatic effects on the gingiva by these clinical scorings.

The forces used to assess BOP were 0.25, 0.5, 0.75 and 1.0 N for the 4 quadrants of each dentition, respectively. In each individual, the quadrants were randomly assigned to one of the standardized probing forces. The same probing forces were applied at both the first (day 2) and the second (day 12) assessments of BOP.

All clinical parameters, i.e., PCR, GI and BOP were assessed at the mid-buccal and mid-oral surfaces and, for the approximal surfaces, at the buccal aspect of the mesial and distal contact areas of all teeth excluding third molars. BOP was calculated as the percentage number of bleeding gingival units out of the 28 units per score quadrant.

Data analysis

For each individual, the jaw quadrant with the lowest applied probing force (i.e., 0.25 N) was used as a basis for comparison. BOP values for each probing force were computed for each quadrant and each type of tooth surface (buccal, oral, approximal), respectively. Linear regression and correlation analysis were performed using BOP and probing force as determinants (Chilton 1967).

Results

The individual mean plaque % for all subjects was 13.8% at the start of the pre-experimental phase and remained low (PCR 3.6–15.1%(throughout the study. The individual mean GI score for all subjects was 0.17 at the start of the pre-experimental phase and decreased significantly during the course of the study to extremely low values (GI = 0.02–0.10). In other words, all participants showed almost complete absence of clinical signs of gingival inflammation at any of the observation periods.

Fig. 2 shows the mean BOP percentage at days 2 and 12 for each subject, when a probing force of 0.25 N was applied. The patients were ranked from 1 to 12 and divided into 2 groups according to the individual mean BOP % using this probing force. The 6 patients (no 1–6) with the lowest BOP % formed group 1 (*minimal BOP*), and the remaining 6 patients (no 7–12) constituted group 2 (*low BOP*). Group 1 yielded a minimal mean BOP of 0.9% at 0.25 N, while group 2 exhibited a somewhat higher but still low mean BOP of 13.4%.

In Fig. 3, the mean GI scores of days 0, 7, 14 are presented for each subject, again ranked according to their mean BOP % at 0.25 N. Both groups yielded a mean GI score of 0.06.

The mean % of surfaces exhibiting plaque in each subject during the experi-

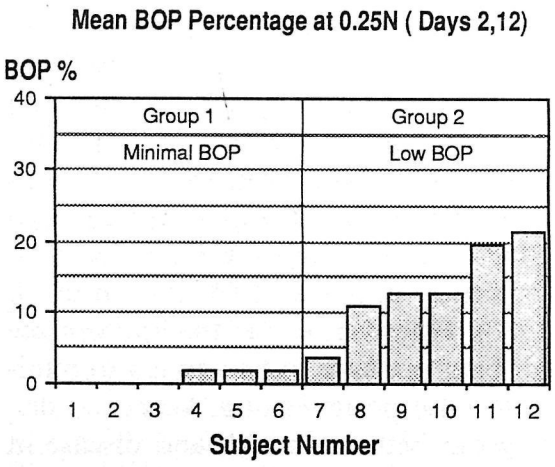

Fig. 2. Individual mean BOP % of days 2 and 12 using a probing force of 0.25 N. According to this BOP %, 2 subject groups were formed.

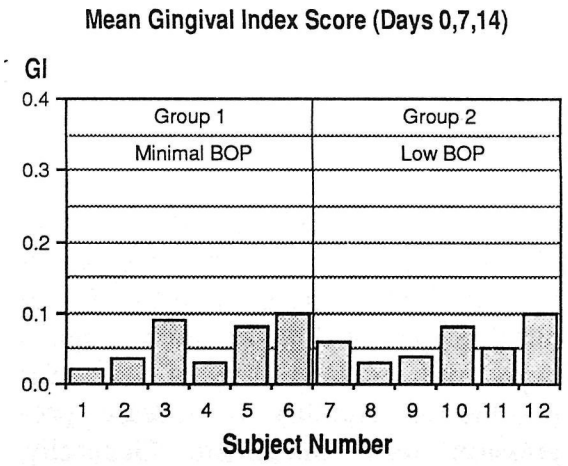

Fig. 3. Individual mean GI scores of days 0, 7, 14. Same ranking of subjects as in Fig. 2.

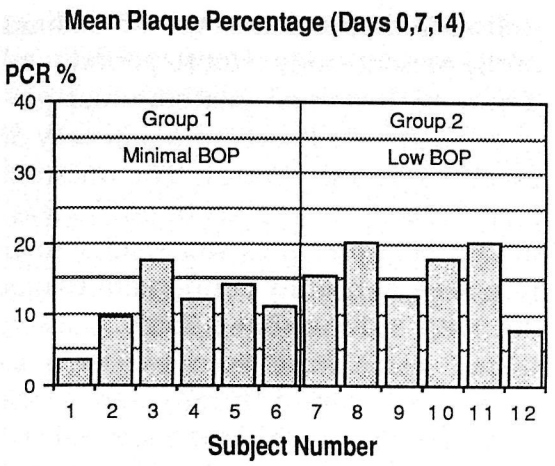

Fig. 4. Individual mean PCR of days 0, 7, 14. Same ranking of subjects as in Fig. 2.

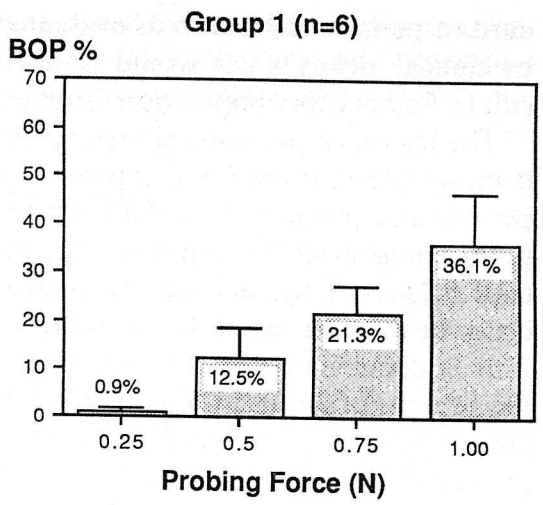

Fig. 6. Mean BOP % for group 1 (*minimal BOP*) applying the 4 different probing forces.

Discussion

The participants of the present study were selected on the basis of their history of immaculate plaque control and excellent gingival and periodontal health. These extraordinary conditions were reflected in very low plaque and gingival indices at the start of the study which were even further improved throughout. In addition, the absence of caries cavities and fillings also documented an unusual state of dental health.

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mental period are depicted in Fig. 4. The 2 groups had a mean PCR of 11.3% and 15.6%, respectively. (No statistically significant difference: $t = 1.57$ at 10 dF).

The mean BOP % for all 12 subjects for the different standardized probing forces used are depicted in Fig. 5. Clearly, an almost linear increase from 7.1% to 41.5% was noted with increasing probing force applied. The differences of the mean % of bleeding units between each of the different probing forces applied were statistically significant ($p < 0.01$). In Figs. 6 and 7, the corresponding mean BOP percentages are presented separately for each of the two subgroups (groups 1, 2). Almost identical linear relationships were observed in both groups between the mean BOP % and the probing forces. It should be noted, however, that the regression line was at a lower level for group 1 (0.9%–36.1%) (Fig. 6) compared to group 2 (13.4%–47.0%) (Fig. 7). The variation of the mean BOP % for each of the different probing forces applied was of a similar magnitude in both groups. In the group with "minimal BOP" response at 0.25 N (group 1), practically no sites bled on probing using this probing force (Fig. 6).

Figs. 8 and 9 present the regression analyses of the mean BOP % and the probing forces applied at all sites and at the different tooth surfaces in groups 1 and 2, respectively. Generally, high correlation coefficients were found in group 1, while group 2 yielded somewhat lower but still highly significant correlation coefficients between mean BOP % and the different probing forces. Also, different intercept values with the x-axis were found for groups 1 and 2, confirming the difference in mean BOP % at 0.25 N between the 2 groups. On the other hand, the inclination of the regression line slopes were very similar for all and also for the individual tooth sites when comparing the two subject groups, while the inclination of the slopes were somewhat different when comparing different tooth surfaces (i.e., approximal with buccal/oral) within the same subject group.

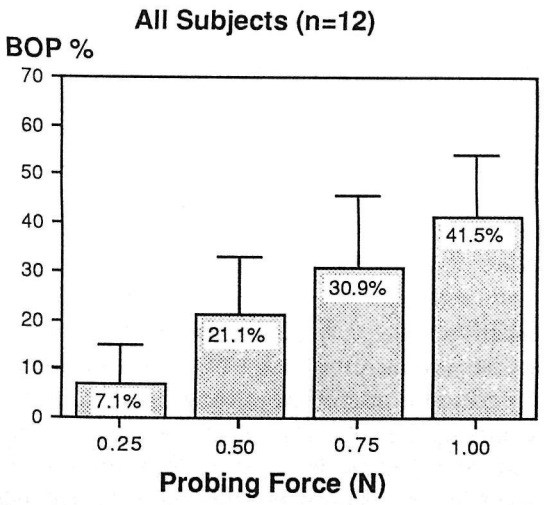

Fig. 5. Mean BOP % for all subjects applying the 4 different probing forces.

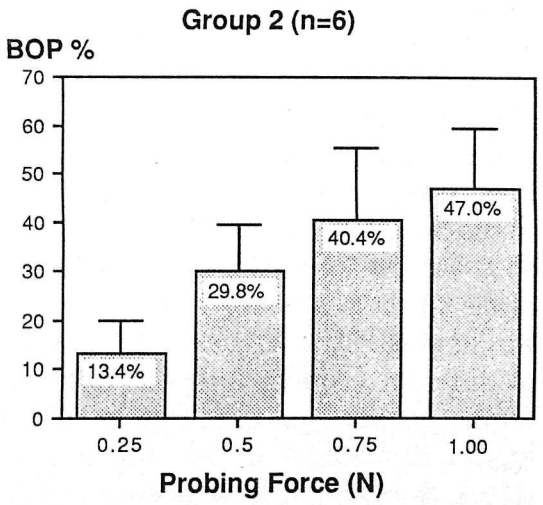

Fig. 7. Mean BOP % for group 2 (*low BOP*) applying the 4 different probing forces.

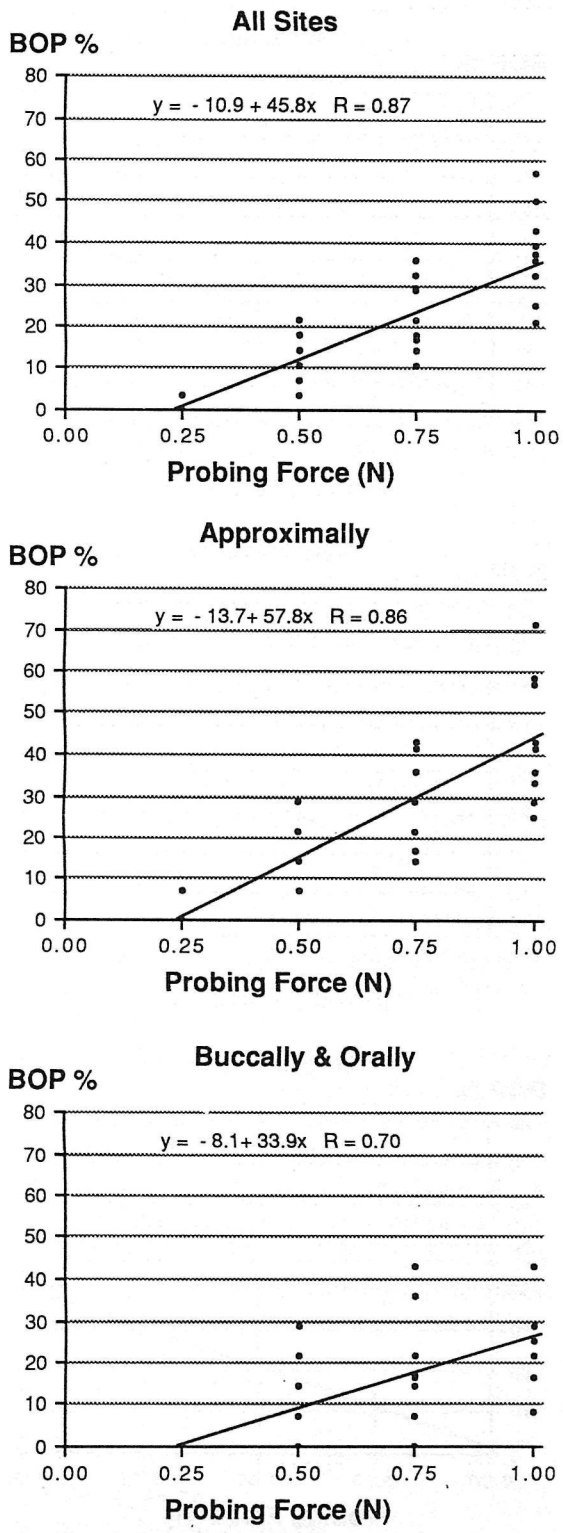

Fig. 8. Regression analyses (group 1) of the mean BOP % and the varying probing forces applied for all sites, and the approximal and buccal/oral sites respectively.

healthy gingival units, a minimal inflammatory infiltrate may be identified histologically adjacent to the junctional epithelium (e.g., Brecx et al. 1987). However, the parameter *bleeding on probing* (BOP) to the bottom of the gingival sulcus or pocket has been introduced into *clinical* diagnostics and hence, it should preferably be compared with other clinical, rather than histologic parameters in the diagnosis of health or disease. In this respect, the young dental hygienists volunteering for the present study certainly reflected a subject population of such a high standard of periodontal health as evaluated by clinical means which would be difficult to find in other population samples.

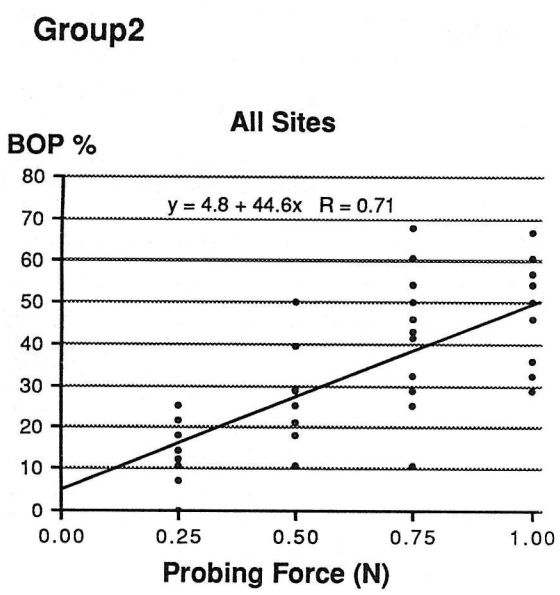

Fig. 9. Regression analyses (group 2) of the mean BOP % and the varying probing forces applied for all sites, and the approximal and buccal/oral sites, respectively.

The results of this clinical experiment demonstrate that the force applied to a periodontal probe with a standardized point diameter of 0.4 mm must not exceed 0.25 N if traumatization of clinically healthy tissues is to be avoided. This is documented by the fact that in the subjects of group 1 ("minimal BOP" group) practically no bleeding could be provoked by this threshold pressure at the two different examinations (days 2 and 12). A few gingival units bled for this pressure in the other subject group (*low BOP* group). Since the mean GI score in both groups was extremely low (0.06), it might be that, on the histological level, the latter group might have differed somewhat from the first.

With increasing probing forces by an increment of 0.25 N, applied for the BOP test, an almost linear increase of bleeding sites with approximately 11% per increment was noted. The increase in group 1 from around 1% to 36% at 1.0 N paralleled the increase in group 2 from around 13% to 47% with almost identical inclination of the regression line slopes. Since the regression lines of both groups yielded similar slopes but different intercepts with the *x*-axis, it seems reasonable to assume that traumatization of healthy gingival tissues is a frequently encountered hazard which in turn may contribute to a number of false positive readings. This may at least in part explain why the specificity as well as the predictive value for disease progression of the BOP test have been shown to be rather modest (Badersten et al. 1985, Lang et al. 1986, Egelberg 1988, Lang et al. 1991).

Another interesting finding of the present study was that around 60% of all gingival units in fact did not bleed even when a probing force of 1.0 N was applied. In this respect, the separate analyses of the different tooth surfaces (Figs. 8, 9) revealed different slope inclinations for approximal and buccal/oral sites, respectively. Approximately 70% of the buccal/oral sites, but only around 50% fo the approximal sites did not bleed when a probing force of 1.0 N was applied. This difference in response to different probing forces at different tooth surfaces may reflect morphological differences of the soft tissues (Hock & Nuki 1971, Wennström et al. 1981) or of the tooth surface anatomy involving different probe inclination.

It should be realized that the findings of the present study refer to periodontal tissues with normal anatomy and gingival health in subjects with a history of excellent plaque control. The question arises, therefore, whether or not increasing probing pressures will yield similar responses in healthy periodontal tissues but with reduced bone height, i.e., in tissues which have been subjected to proper periodontal therapy and which have healed with altered morphology, e.g., the presence of a long junctional epithelium. Before this question is answered, the demand for standardizing probing pressure and choosing the same probing pressure in periodontal tissues with normal or reduced bone height in order to distinguish between health and disease, remains questionable. However, the present study showed that too high probing pressures must be avoided in order to limit the number of false positive readings. Hence, a number of clinical studies which used probing pressures with an obvious traumatic component should be interpreted with care.

Acknowledgements

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Zusammenfassung

Zusammenhänge zwischen gingivalem Gesundheitszustand, Bluten auf Sondieren und Sondierungskraft

Ziel der vorliegenden Studie war es, den Zusammenhang zwischen Bluten beim Sondieren (BOP) und angewandter Sondierungskraft bei Probanden mit klinisch gesunden parodontalen Verhältnissen zu untersuchen. Als Probanden wurden 12 Schülerinnen der Dentalhygieneschule Bern ausgewählt, die höchstens okklusale Füllungen und keine Sondierungstiefen über 3 mm aufwiesen. Bei allen Probandinnen wurde in zwei Untersuchungen im Abstand von 10 Tagen mit den Kräften 0.25, 0.5, 0.75 und 1.0 N sondiert, wobei jeweils nur eine Kraftgrösse in je einem Quadranten zur Anwendung gelangte. Entzündungszustand und Mundhygiene wurden mittels GI (Löe & Silness 1963) und PCR kontrolliert. Aufgrund der BOP-Werte bei der tiefsten angewandten Kraft (0.25N) wurden die Probandinnen in 2 Gruppen geteilt:

Die 6 Probandinnen von Gruppe 1 ("minimaler" BOP Mittelwert) zeigten in beiden Untersuchungen höchstens an einer Stelle Bluten (x: BOP = 0.9%), während die 6 Probandinnen von Gruppe 2 ("niedriger" BOP Mittelwert) ausgeprägt höhere Blutungswerte (x: BOP = 13.4%) aufwiesen, Beide Gruppen zeigten einen signifikanten Anstieg der BOP-Werte mit steigender Kraftanwendung (von 0.9% auf 36.1% in Gruppe 1 und von 13.4% auf 47.0% in Gruppe 2). Die Auswertung der Daten mittels Regressionsanalyse ergab eine fast lineare Korrelation und hohe Korrelationskoeffizienten zwischen den BOP-%-Werten und der Sondierungskraft. Der Vergleich beider Gruppen ergab eine nahezu identische Steilheit der Regressionsgeraden. Unterschiede waren hingegen hinsichtlich der Lokalisation der untersuchten Stellen festzustellen: Approximale Stellen wiesen einen deutlich steileren Verlauf der Regressionsgeraden auf als bukkale/orale Stellen. Die Resultate dieser Studie bestätigten die Anfälligkeit des BOP-Tests auf falsch positive Untersuchungswerte und die Möglichkeit einer Traumatisierung gesunder Gingivagewebe bei Sondierungskräften > 0.25 N.

Résumé

Saignement au sondage en relation avec pression de sondage et santé gingivale

L'étude présente a été menée afin d'évaluer le seuil de pression requis pour provoquer un saignement au sondage (BoP) au niveau de la gencive cliniquement saine. Douze étudiantes en hygiène dentaire ont été selectionnées pour leur excellente hygiène buccale ainsi que pour l'absence de poches > 3 mm, de caries et d'obturations. Le saignement a été mesuré deux fois à 10 jours d'intervalle en utilisant une pression différente au niveau de chaque quadrant dentaire (0.25, 0.5, 0.75 et 1.0 N). La quantité de plaque et la condition gingivale ont été déterminées en utilisant l'enregistrement du contrôle de plaque et l'indice gingival. En se basant sur les valeurs de BoP obtenues avec la force la plus faible (0.25 N), les hygiènistes dentaires ont été réparties en deux groupes: groupe 1 (valeur BoP minimale) consistant en six sujets n'ayant pratiquement pas de saignement (BoP moyen = 0.9%) lors des deux examens, et groupe 2 (valeur BoP faible) avec peu de saignement (BoP moyen = 13.4%). Les 2 groupes avaient une augmentation significative de BoP lorsque la pression augmentait: de 0.9 à 36.1% pour le groupe 1 et de 13.4 à 47.0% pour le groupe 2. L'analyse de régression a révélé une relation quasi linéaire et un haut coefficient de corrélation entre le % de BoP et la pression au sondage. Les deux lignes de régression avaient des courbes presque identiques. Cependant de faibles différences ont été aperçues quant aux sites différents: les sites interproximaux produisaient des lignes de régression plus raides que les sites vestibulaires et linguaux combinés. Les résultats de la présente étude indiquent que le test de BoP utilisé avec des forces non contrôlées peut s'accompagner de lectures faux-positif. De plus les tissus gingivaux cliniquement sains pourraient être traumatisés lorsqu'une force supérieure à 0.25 N est utilisée.

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