Relationships between alveolar bone levels measured at surgery, estimated by transgingival probing and clinical attachment level measurements

M. J. Ursell
Department of Periodontology and Preventive Dentistry, U.M.D.S., Guy's and St. Thomas's Hospitals, London, England

Ursell MJ: Relationships between alveolar bone levels measured at surgery, estimated by transgingival probing and clinical attachment level measurements. J Clin Periodontol 1989; 16: 81–86.

Abstract. Alveolar bone level measurements obtained by transgingival probing were compared with alveolar bone levels measured during surgery at 178 sites in 9 patients. Probing depth measurements using constant loads of 30 g and 60 g were also compared with bone levels measured at surgery at the above sites. The effects of inflammation, location of the site on the tooth surface and tooth type were also investigated. Transgingival probing was unaffected by these factors and proved to be an accurate method of measuring alveolar bone levels ($r = 0.975$). Probing depth measurements were affected by the presence of inflammation, assessed by the bleeding response to probing, and variation in probing load. The effect of inflammation was to reduce the mean distance between the probe tip and the alveolar bone from 2.4 mm to 1.9 mm. None of the relationships between the measurements were significantly affected by the location of the site on the tooth surface, or by tooth type.

Key words: clinical measurements; transgingival probing.

Accepted for publication 1 March 1988

To date, techniques of non-surgical clinical measurements of alveolar bone levels have received little attention. Goadby (1928), Hirschfeld (1953), Easley (1967) and Tibbetts (1969) described bone sounding techniques, but their work did not involve measurements or comparisons with surgical measurements of alveolar bone levels. Greenberg, Laster & Listgarten (1976) compared vertical bone sounding measurements, which they called transgingival probing, with bone levels measured at surgery on the buccal surfaces of 106 teeth, and found close agreement between the two methods of measurement. Probing clinical attachment level measurements have been compared with bone level measurements by Suomi et al. (1968), who showed a wide degree of variability in the relationship.

However, Renvert et al. (1981) found a good correlation between clinical attachment level measurements and probing bone levels when bone levels were measured during surgery at 62 sites with intra-bony defects.

The primary aim of the present study was to investigate the relationship between measurements of alveolar bone levels obtained by transgingival probing and at surgery on a wide range of tooth types and sites with varying degrees of inflammation. The secondary aim was to investigate the relationships between the above measurements and clinical attachment level measurements using probing loads of 30 g and 60 g, at the same sites.

Material and Methods

Subjects and sites

9 periodontal patients aged 20–59 years, 2 male and 7 female, participated in this study. All had received oral hygiene instruction, scaling and root planing prior to the study. 178 sites were studied, the number of sites per subject ranged from 10–27. 59 sites were situated on incisor and canine teeth, 70 sites on premolar teeth and 49 sites on molar teeth. Measurements were made at 6 sites on incisor, canine and premolar teeth, and at 8 sites on molar teeth, in order to obtain more information about furcation areas. The 8 sites on lower molar teeth were mesial and distal on each of the roots on the buccal and lingual surfaces. The 8 sites on the upper molar teeth were (a) mesial and distal on the buccal surfaces of the buccal roots; (b) palatal interproximal surfaces of the buccal roots; (c) mesial and distal surfaces of the palatal root.

Procedure

A hard cold cure acrylic overlay was constructed for each patient, and a hemi-cylindrical locating groove for the probe was placed at each site. This design was evolved to minimize any frictional binding whilst providing the maximum guidance for the probe.

The load sensitive probe used (Vine Valley research) was fitted with a custom made tip, which was of identical dimension to the University of Michigan "O" probe, having the same degree of taper and a terminal diameter of 0.35 mm. Markings were at 3–10 mms at 1 mm intervals, and at 13, 14 and 15 mm.

The distance between the base of the overlay, which was shaped to a right angle to facilitate accurate measurement, and the gingival margin was measured and recorded. Probing depths were then recorded, initially with a load of 30 g, and the bleeding response to probing was recorded after a 60-s interval. The bleeding response was classified as nil, discrete or profuse. When blood did not flow laterally along the gingival crevice, the response was classified as discrete: when blood did flow laterally along the crevice, the response was classified as profuse (Sidi & Ashley 1984).

At this stage, local anaesthesia was administered, and the probing depths were recorded with a load of 60 g. The load sensitive circuit was then switched off, and with finger pressure applied in the line of the probe tip the probe was advanced through the tissues until bone was felt, and the measurement was recorded. The load required was not quantified, but was well in excess of the 100 g maximum load capacity of the machine. The previously scheduled periodontal surgery followed, and as soon as the bone and root surfaces could be clearly seen, the distance between the base of the onlay and the bone was measured, and a record made when an intrabony defect greater than 1 mm in depth was present.

All procedures and measurements, which were recorded to the nearest millimetre, were carried out by the same operator in the same dental chair, thus ensuring consistent illumination, both background and direct, and operator position. Following the fabrication of onlays, the reproducibility of all measurements except surgical measurements of bone height was assessed.

The data in this study were normally distributed and had arithmetic intervals except for bleeding scores; in all cases parametric statistical testing was used.

Results

There was a statistically significant difference of 0.52 ± 1.21 mms ($p<0.001$) between probing depths measured using loads of 30 g and 60 g (Table 1). The differences between transgingival and surgical measurements of alveolar bone height were not statistically significant. When all sites are considered, the correlation with bone levels measured at surgery was similar when probing loads of 30 g ($r=0.87$) and 60 g ($r=0.90$) are considered. There was a higher degree of correlation when transgingival and surgical measurements of bone levels were compared at all sites ($r=0.98$).

The scattergrams in Fig. 1 illustrate the increasing degree of correlation when probing at 30 g, 60 g and transgingival probing are compared with bone levels measured at surgery, the number of outlying points progressively reducing with the increasing probing load.

When the probing depths using loads of 30 g and 60 g are analysed according to the bleeding response (Fig. 2), a greater diversity in the scattergrams and correlation coefficients can be seen, ($r=0.80$ for non bleeding at 30 g compared with 0.95 when bleeding was present). The distribution of the scattergrams can be seen to be less diverse when bleeding is present. The relationship between transgingival probing and surgical measurements of bone levels is unaffected by the presence or absence of bleeding.

Comparisons between the mean distances from the probe tip to the alveolar bone according to the degree of inflammation are shown in Fig. 3. The difference between probing at 30 g and 60 g is maintained when no bleeding or discrete bleeding is present. However, when profuse bleeding is present, the

Table 1. Means, standard deviations and ranges of probing depths at 30 g and 60 g together with transgingival measurements of bone levels (TBL) and surgical measurements of bone levels (SBL) (mm) and correlation coefficients with surgical measurements, all sites ($n=178$)

	Probing depth			Bone level		
	30 g	60 g	difference (60 g–30 g)	TBL	SBL	difference (SBL − TBL)
mean	6.53	7.05	0.52*	8.61	8.73	0.12
SD	3.73	3.74	1.21	3.99	4.11	0.92
range	1.0 to 15.0	1.0 to 16.0	−2.0 to 7.0	2.0 to 18.0	2.0 to 18.0	−2.0 to 6.5
Pearson's r with SBL	0.870	0.904		0.975	–	

* Significant difference, $p<0.001$, Student's paired 't' test.

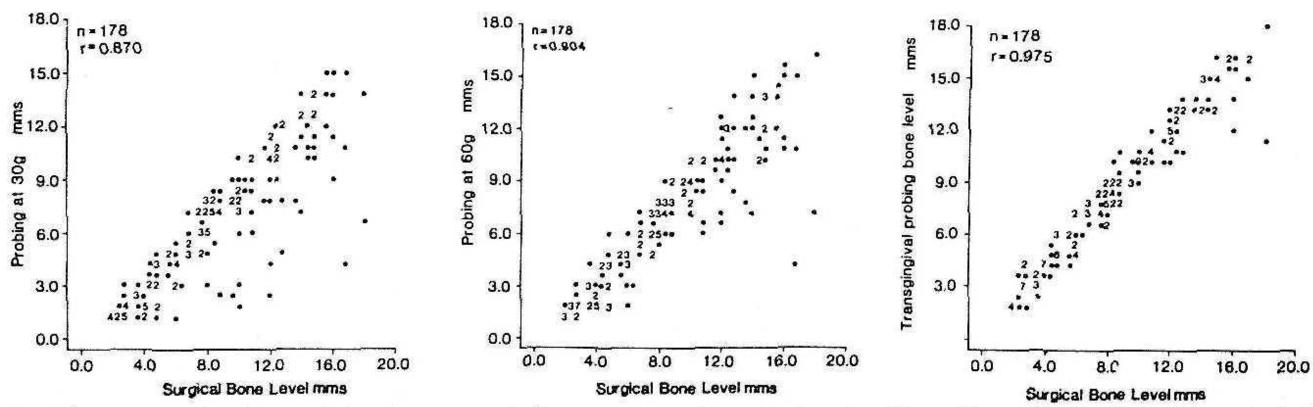

Fig. 1. Scattergrams showing correlations between surgical measurements of bone levels and probing at 30 g, probing at 60 g and transgingival probing measurements of bone levels for all sites.

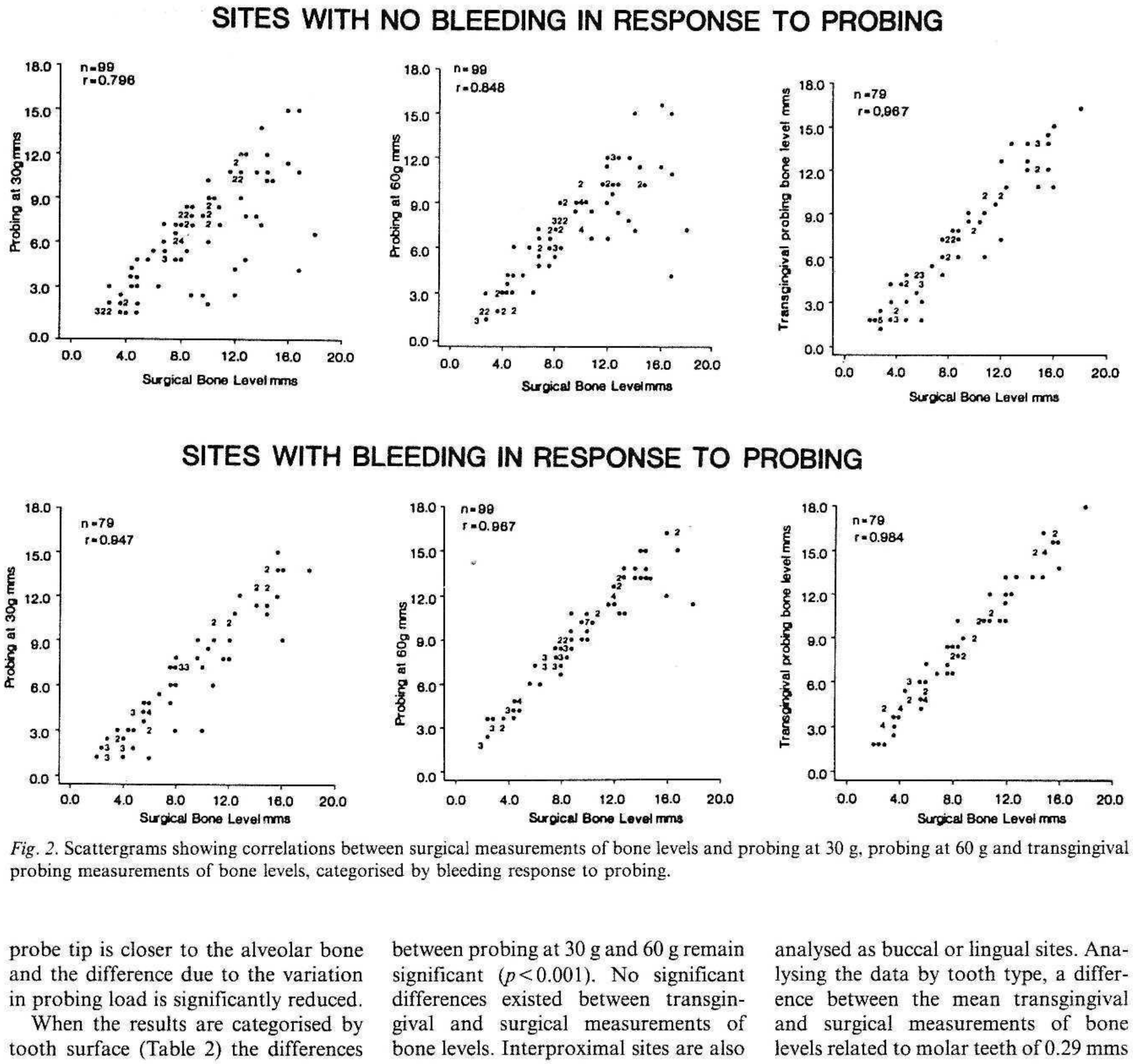

Fig. 2. Scattergrams showing correlations between surgical measurements of bone levels and probing at 30 g, probing at 60 g and transgingival probing measurements of bone levels, categorised by bleeding response to probing.

probe tip is closer to the alveolar bone and the difference due to the variation in probing load is significantly reduced.

When the results are categorised by tooth surface (Table 2) the differences between probing at 30 g and 60 g remain significant ($p<0.001$). No significant differences existed between transgingival and surgical measurements of bone levels. Interproximal sites are also analysed as buccal or lingual sites. Analysing the data by tooth type, a difference between the mean transgingival and surgical measurements of bone levels related to molar teeth of 0.29 mms

Table 2. Means, standard deviations and ranges of probing depths at 30 g and 60 g together with transgingival measurements of bone levels (TBL) and surgical measurements of bone levels (SBL) (mm), and correlation coefficients with surgical measurements, categorised by site

		Probing depth			Bone level		
Sites		30 g	60 g	difference (60 g–30 g)	TBL	SBL	difference (SBL − TBL)
buccal ($n=89$)	mean	6.15	6.74	0.60*	8.28	8.46	0.17
	SD	3.58	3.58	1.20	4.00	4.20	0.99
	range	1.00–15.00	1.00–15.00	−1–7.0	2.00–16.50	2.00–18.00	−2–6.5
Pearson's r with SBL		0.84	0.86		0.97	–	
lingual ($n=89$)	mean	6.91	7.35	0.44*	8.94	9.01	0.07
	SD	3.85	3.88	1.21	3.97	4.02	0.84
	range	1.00–15.00	1.00–16.00	−2–5.0	3.00–18.00	3.00–18.00	−1.5–4.0
Pearson's r with SBL		0.90	0.94		0.98	–	
interprox. ($n=109$)	mean	6.54	7.02	0.47*	8.73	8.84	0.11
	SD	3.65	3.67	1.13	4.00	4.10	0.89
	range	1.00–15.00	2.00–16.00	−1–6.0	2.00–18.00	2.00–18.00	−2–4.0
Pearson's r with SBL		0.87	0.90		0.98	–	

* Significant differences, $p<0.001$, the Student paired 't' test.

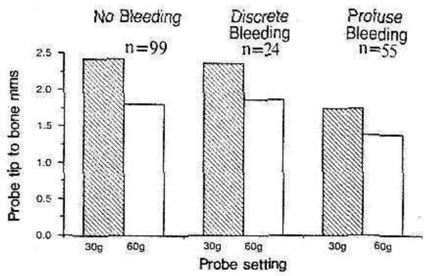

Fig. 3. Bar chart showing mean distances between probe tip and alveolar bone level.

Table 3. Means, standard deviations and ranges of probing depths at 30 g and 60 g together with transgingival measurements of bone levels (TBL) and surgical measurements of bone levels (SBL) (mm), and correlation coefficients with surgical measurements, categorised by tooth type

Tooth		Probing depth			Bone level		
type		30 g	60 g	Diff	TBL	SBL	Diff
anterior ($n=59$)	mean	5.91	6.41	0.50*	8.24	8.33	0.09
	SD	3.87	3.90	1.32	4.37	4.29	0.70
	range	1–14	1–15	−1–5.0	2–16	1–17	−2–2.0
Pearson's r with SBL		0.820	0.885		0.987	–	
Premolar ($n=70$)	mean	6.49	7.08	0.59**	8.48	8.50	0.02
	SD	3.70	3.71	1.34	3.72	3.82	0.81
	range	1–15	1.5–15.5	−1–7.0	2–16	2–16	−1–4.0
Pearson's r with SBL		0.907	0.936		0.977	–	
Molar ($n=49$)	mean	7.33	7.78	0.45**	9.26	9.55	0.29
	SD	3.51	3.50	0.82	3.87	4.26	1.23
	range	1–15	1–16	−2–2.0	2–18	2–18	−1.5–6.5
Parson's r		0.887	0.895		0.959	–	

* $p<0.01$.
** $p<0.001$.

was found (Table 3). This compares with 0.09 mms for incisor and canine teeth and 0.02 for premolar teeth. The difference of 0.29 was not statistically significant. The correlation coefficients between transgingival and surgical measurements of bone levels were similar for different tooth types, as were those between attachment levels and bone levels measured at surgery. Fig. 4 illustrates the reduction in the correlations between surgical bone levels and probing at 30 g, 60 g and transgingival probing when intrabony defects were present. Transgingival probing was found to be the most accurate estimator of alveolar bone levels when compared

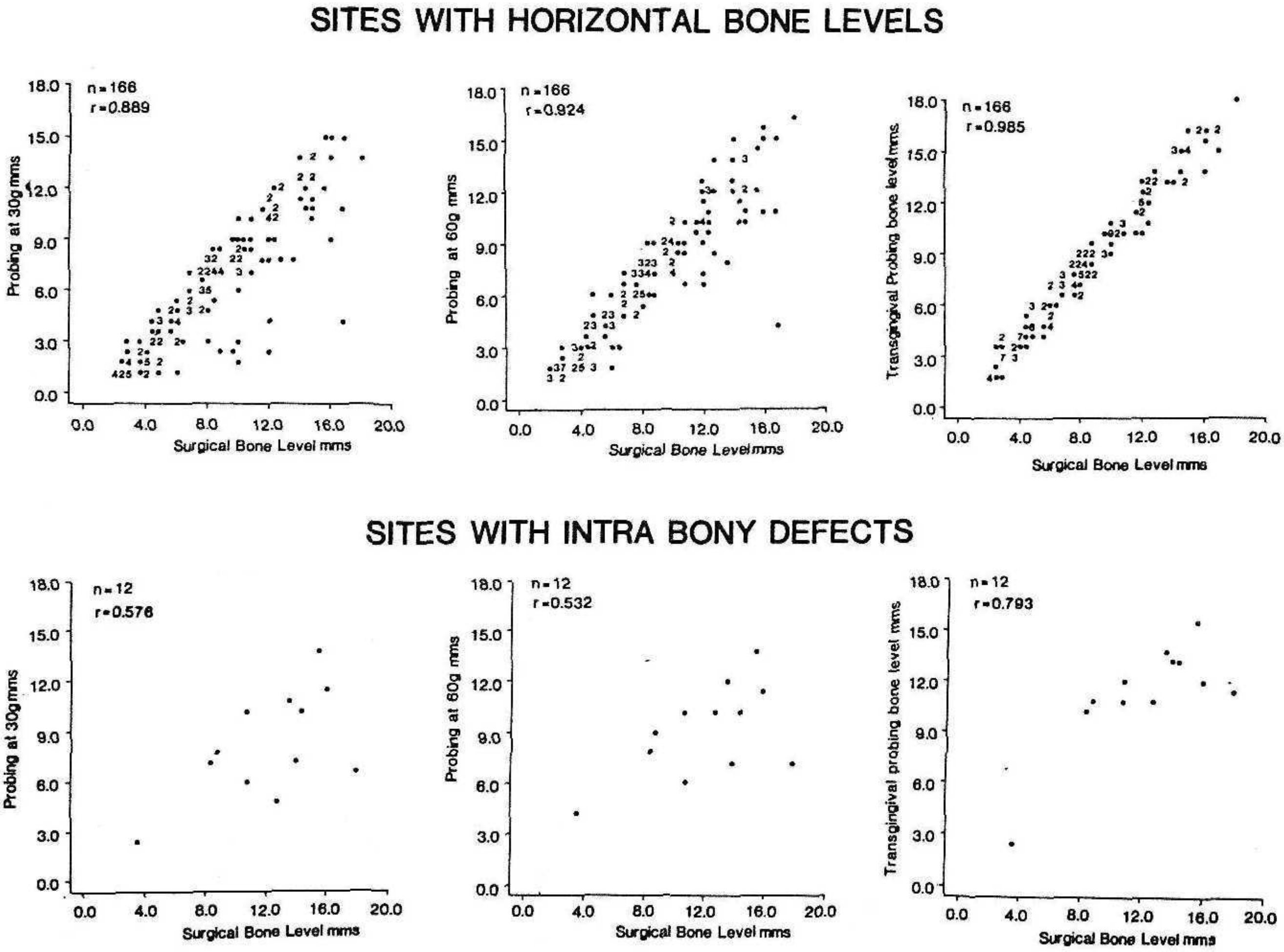

Fig. 4. Scattergrams showing correlations between surgical measurements of bone levels and probing at 30 g, probing at 60 g and transgingival probing measurements of bone levels, categorised by bone morphology.

Table 4. Reproducibility of measurements

	Probing at 30 g				Transgingival probing			
	buccal	(%)	lingual	%	buccal	%	lingual	
concordant	70	(61.9)	58	(53.2)	26	(63.4)	20	(57.1)
±1 mm	35	(31.0)	42	(38.5)	13	(31.7)	12	(34.3)
±2 mm	8	(7.1)	6	(5.5)	2	(4.9)	3	(8.6)
±3 mm	0	(0)	3	(2.8)	0	(0.0)	0	(0)
total	113	(100)	109	(100)	41	(100)	35	(100)

with probing using loads of 30 g and 60 g. However, the very small number of sites where intrabony defects were present suggests that these results should be interpreted with caution. Reproducibility (Table 4) was assessed, and when probing with a load of 30 g is considered, 92.9% of measurements on buccal surfaces and 91.7% of measurements on lingual surfaces were within 1 mm. The corresponding values for transgingival probing were 95.1% and 91.4%.

Discussion

The primary objective of this study was to compare transgingival probing measurements of bone levels with bone levels measured at surgery at a greater number and location of sites than previously investigated. The close agreement between transgingival and surgical measurements of bone height was unaffected by tooth type, location of the site on the tooth surface, inflammation and magnitude of bone loss. A high degree of reproducibility was found, 93.25% of measurements being within 1 mm.

These results are in agreement with those of previous workers (Greenberg et al. 1976, Renvert et al. 1981).

Renvert et al. (1981) found a mean difference of 0.3 mms when transgingival probing was compared with bone levels measured at surgery, and a correlation of 0.81 between the 2 methods. This compares with a mean difference of 0.12 mm and a correlation of 0.975 in the present study when all 178 sites are considered.

However, the work of Renvert et al. (1981) was restricted to 62 sites related to 33 intrabony defects; when the 12 sites related to intrabony defects in the present study were examined, the correlation between transgingival and surgical measurements of alveolar bone reduced to 0.79. The difference between the mean measurements of intrabony defects is 0.92 mm in the present study, the mean values being 11.38 mm for transgingival probing and 12.29 mm for surgical measurements. In view of the small number of intra bony sites in this category in the present study, caution should be exercised when interpreting these data.

Further work investigating the accuracy of transgingival probing related to intrabony defects of varying morphology, width and depth would be of interest.

The secondary objective was to investigate the relationship between probing with constant loads of 30 and 60 g, and bone levels measured at surgery.

When all sites are considered, a statistically significant difference between the means of probing measurements using loads of 30 g and 60 g of 0.52 mm was found, as previous workers have shown (Van der Velden 1979).

When bleeding on probing was present, the correlations between probing at 30 and 60 g and alveolar bone levels increased. Profuse bleeding had the greater effect on the distance between the probe tip and the bone.

These results are in general agreement with previous work. Thus, Robinson & Vitek (1979), using grossly periodontally involved teeth scheduled for extraction, found a linear relationship between probe tip penetration, gingival index and probing load. A study involving the histological assessment of probe tip penetration and inflammation in artificially induced periodontitis in beagle dogs (Armitage et al. 1977) found increased probe tip penetration when periodontal breakdown was more advanced. The present study confirms that the presence of inflammation results in increased probe tip penetration. In addition, differences in probe tip penetration produced by varying loads are reduced at sites with greater signs of inflammation.

In conclusion: (i) Transgingival probing measurements of crestal bone levels have been shown to give an accurate indication of bone levels measured at surgery; (ii) extrapolation of clinical probing depth measurements to predict alveolar bone levels would be inappropriate, as it has been shown that clinical probing depth measurements are affected by factors which have no effect on bone level measurements; (iii) The value of the information gained from transgingival probing where other diagnostic methods such as clinical probing and radiographs have not yielded a complete picture of bone levels, would seem to outweight the limitations, and suggest that, in these circumstances, consideration should be given to the clinical use of transgingival probing as an adjunct to the diagnostic methods in current use.

Acknowledgement

I am indebted to the staff of the Department of Periodontology and Preventive Dentistry for their support and help, in particular Professor F. P. Ashley, who provided invaluable assistance at all stages of the study.

Zusammenfassung

Die Beziehungen zwischen alveolären, bei chirurgischen Eingriffen festgestellten Knochenniveaus, und Niveaumessungen des alveolären Knochens durch transgingivale Sondierung sowie klinische Messungen des Attachmentniveaus

Durch transgingivale Sondierung erhaltene Messwerte des alveolären Knochenniveaus wurden mit der Höhe der gleichen alveolären Knochenniveaus verglichen, die bei 9 Patienten an 178 Stellen während chirurgischer Eingriffe vermessen wurden. Messungen der Sondierungstiefen, die mit konstantem Sondendruck von 30 g und 60 g vorgenommen waren, wurden auch mit den, anlässlich chirurgischer Eingriffe erhaltenen, Messwerten des Knochenniveaus der gleichen Stellen verglichen. Der Einfluss von Entzündungen, der Lage der Stellen bezüglich der Zahnoberfläche und des Zahntyps wurde ebenfalls untersucht. Die transgingivale Sondierung wurde durch diese Faktoren nicht beeinflusst und es zeigte sich, dass sie eine genaue Methode zur Messung des alveolären Knochenniveaus ($r = 0.975$) ist. Die Messungen der Sondierungstiefe wurden durch das Vorkommen von Entzündungen (festgestellt durch Bluten beim Sondieren) und durch unterschiedlichen Sondierungsdruck beeinflusst. Vorliegende Entzündung reduzierte den Abstand zwischen der Sondenspitze und dem alveolären Knochen von 2.4 auf 1.9 mm. Die Beziehungen zwischen den verschiedenen Messungsarten wurden in keinem Fall durch die Position der Mess-Stelle an der Zahnoberfläche oder durch den Zahntyp beeinflusst.

Résumé

Relations entre les niveaux de l'os alvéolaire mesurés lors des interventions chirurgicales ou estimés par sondage transgingival et les mesures cliniques du niveau de l'attache

Les mesures du niveau de l'os alvéolaire obtenues par sondage transgingival ont été comparées aux niveaux de l'os alvéolaire mesurés au cours d'une intervention chirurgicale dans 178 sites chez 9 patients. Les profondeurs de poches mesurées par sondage avec des pressions constantes de 30 g et de 60 g ont également été comparées aux niveaux de l'os alvéolaire mesurés au cours de l'intervention chirurgicale dans les sites ci-dessus. Les effets de l'inflammation, de la position des sites à la surface des dents et du type de dent ont aussi été étudiés. Ces facteurs restaient sans influence sur le sondage transgingival qui s'est révélé être une méthode précise pour mesurer les niveaux de l'os alvéolaire (r= 0.975). La présence d'inflammation, constatée en se basant sur la réaction de saignement lors du sondage, et les variations de la pression employée pour le sondage avaient une influence sur la profondeur mesurée par sondage. L'effet de l'inflammation était de réduire la distance moyenne entre la pointe de la sonde et l'os alvéolaire de 2.4 mm à 1.9 mm. Aucune des relations entre les mesures n'était modifiée par la position du site à la surface de la dent ni par le type de la dent.

References

Armitage, G. D., Svanberg, G. K. & Loe, H. (1977) Microscopic evaluation of connective tissue attachment levels. *Journal of Clinical Periodontology* **4**, 173–190.

Easley, J. R. (1967) Methods of determining alveolar osseous form. *Journal of Periodontology* **38**, 112–118.

Goadby, K. (1928) *Diseases of the gums and oral mucous membranes.* 3rd edition, p. 319. London: Oxford University Press.

Greenberg, J., Laster, L. & Listgarten, M. A. (1976) Transgingival probing as a potential estimator of alveolar bone level. *Journal of Periodontology* **47**, 514–517.

Hirschfeld, L. (1953) A calibrated silver point for periodontal diagnosis and recording. *Journal of Periodontology* **24**, 94–98.

Renvert, S., Badersten, A., Nilveus, R. & Egelberg, J. (1981) Healing after treatment of periodontal intraosseous defects. (1) Comparative study of clinical methods. *Journal of Clinical Periodontology* **47**, 387–399.

Robinson, P. J. & Vitek, R. M. (1979) The relationship between gingival inflammation and resistance to probe tip penetration. *Journal of Periodontal Research* **14**, 239–243.

Sidi, A. D. & Ashley, F. P. (1984) Influence of frequent sugar intakes on experimental gingivitis. *Journal of Periodontology* **55**, 419–423.

Suomi, J. D., Plumbo, J. & Barbano, J. P. (1968) A comparative study of radiographs and pocket measurements in periodontal disease evaluation. *Journal of Periodontology* **39**, 311–315.

Tibbetts, L. S. (1969) Use of diagnostic probes for detection of periodontal disease. *Journal of the American Dental Association* **78**, 549–556.

Van der Velden, U. Probing force and the relationship of the probe tip to the periodontal tissues. *Journal of Clinical Periodontology* **6**, 106–114.

Address:

M. J. Ursell
Department of Periodontology and Preventive Dentistry
Guy's Hospital
London Bridge, SE1 9RT
UK