Measuring Periodontal Pocket Depth using Manual and Automated Probe Systems.

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ABSTRACT

Objectives: To assess speed and accuracy of automated periodontal probe (PA-on) in comparison with a manual conventional periodontal probe (Williams) on a cadaveric porcine model.

Methods: Four experienced dental specialists assessed pocket depths on a fresh pig's jaw using manual periodontal probe and automated periodontal probe (PA-on). Eight teeth were chosen as test sites; four maxillary and four mandibular. The participants are dental specialists who are experts in using manual probes. The participants received standardized training to use the automated probe. The measurements were performed on three locations on labial surfaces of the tested teeth. The total time to perform the measurements on eight teeth was recorded. The data were collected and collated onto standardized tables. Statistical analysis was carried out to assess time and pockets depths variability between manual and automated probe.

Results: Measuring periodontal pockets depths took less time when using PA-on rather than Williams. The results also showed that the depths of periodontal pockets were always less when taken by PA-on automated probe. This was statistically significant (P-value = 0.002).

Conclusion: PA-on automated periodontal probe offers an efficient method of detecting periodontal pockets depth in less time and providing more accurate measures. PA-on has an additional advantage of immediate electronic store and analysis of measurements, along with other periodontal health indicators. Further *in vivo* studies are in progress to evaluate the use of the automated probe in clinical practice.

Key words: Automated probe, Manual probe, Periodontal disease, Periodontal pocket.

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Introduction

Periodontitis is a chronic disease affecting the gingival tissues, periodontal ligaments and supporting alveolar bone.(1) Progression of periodontal inflammation leads to loss of supporting connective tissues, alveolar bone and migration of epithelial cell attachment which eventually leads to formation of periodontal pocket. (2) Periodontal probe is one of the basic diagnostic tools being used for the assessment of periodontal conditions.(3) Periodontal probes are used to determine pocket depth, attachment level, amount of gingival recessions, presence of plaque and calculus, and to determine anatomical features of the root.(4)

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Periodontal probing measurements are important not only to periodontists but also to other dental practices such as restorative, endodontic and oral surgery. While the preservation of a healthy periodontal attachment is an important factor in the long-term prognosis of a restored tooth, faulty restoration margins, improper contacts design, and poor contour will eventually lead to periodontal tissues breakdown and loss of attachment due to plaque and calculus accumulation.[5] Periodontal probing is vital in diagnosis and follow-up of implant associated inflammation and bone loss called peri implantitis.[6] Periodontal inflammation and pocket formation is also associated with endodontic infections. Iatrogenic endodontic procedures such as vertical root fractures and perforations may also result in loss of attachment and periodontal pocket formation. It is recommended that periodontal probe should be an integral part of all endodontic tray setups.[7] The accurate reliable and consistent reproducible measurement of pocket depths is the mainstay in the diagnosis, monitoring and treatment of periodontal disease.[8] Accurate measurement depends on many factors. Factors related to operator, where periodontists proved to record more accurate measures in comparison to other dental specialists such as oral surgeons and orthodontists.[9] Other factors are related to pocket itself such as condition of the tissues at the base of the examined pocket.[10] In addition, any elevation in patient discomfort and the inflammatory status of the gingival tissue may affect the accuracy of measurement.[11] The manufacturing of periodontal probes went through generations in order to overcome measurements errors which affect diagnosis and eventually treatment course. The variability of readings depends on the probe tip design, probing pressure, degree of inflammation of the examined tissues and reading and documentation precision.[12] Periodontal probes have been grouped in five generations.[13]

The first generation includes conventional periodontal probes, which present a handle, a shank and an active part (a round tip) and different types of gradations in millimeters. The accuracy of measurements taken by conventional manual probes is +/-0.82 mm.[14] Williams periodontal probe is an example of conventional probe which is the most used periodontal probe. One major drawback in this type of probes is inconsistent uncontrolled pressure application which leads to over penetration of the probe tip through the thin epithelial attachment in the sulcus floor. This might be painful and causes bleeding on probing.[15] It has been suggested that probe forces between 0.20 and 0.25 N/mm^2 enable accurate diagnostic readings.[16] The second generation of periodontal probes represents pressure-sensitive probes to overcome variability in applied pressure in first generation. But this type of probes still presents a lack of tactile sensitivity. The third generation of periodontal probes includes electronic, computerized probes. These probes are composed of hard component which is the probe tip, and a software component, which receives and analyses the transmitted readings. Transmission takes place through a wired or wireless connection. Automated periodontal probes were developed due to the necessity to use standardized probing forces in periodontal clinical trials. Initially, they were built to deliver a constant probing force which improved the repeatability of probing measurements. Automated probes offer a major advantage of independent practices as they permit a single user concept eliminating errors caused by transfer and documentation of the readings between the operator and the assistant. The fourth generation of periodontal probes includes 3-dimensional probes and the fifth generation presents non-invasive probes, still in the research phase, based on the principle of echography.[17] A recent technology was introduced to visualize periodontal pockets and show attachment loss, by using optical coherence tomography.[18] The aim of the current study is to compare the probing depth measurements and time of recording using either automated periodontal probe PA-on (Orangedental GmbH & Co. KG) which belongs to the third generation, or a manual periodontal probe (Williams probe) which belongs to the first generation on a fresh cadaveric porcine model.

Methods

Four dental practitioners assessed probing pocket depths on a fresh pig's jaw using manual conventional periodontal probe (Williams) and automated periodontal probe (PA-on). Eight teeth were examined, four maxillary and four mandibular. To minimize errors in reading pocket depths, the selected teeth were anterior teeth. Probing readings are more accurate for anterior than for posterior teeth because we have better access, better probe position and improved visibility of anterior area.[19] Errors in posterior teeth reading can also be explained by unconsciously high force application.[20] PA-on probe has a graphic display and a flexible tip with ball shaped fitted tip diameter of which is 0.5 mm. The manual Williams probe is metallic rigid with millimeter scale with 0.5 mm round tip. PA-on provide calibrated measurement with exactly 20 N/mm^2-pressure force. Labial surfaces of the selected teeth were examined at three points: mesial, mid labial and distal. The measured depths for manual and PA-on probing were recorded manually and immediately by a chair side assistant. So, 24 readings were recorded for each examination done by every participant. The probing measuring was performed twice for each type of the examined probes. The clinicians are dental specialists with experience in manual probing measurement. They received standardized training to use PA-on automated probe. The time was recorded separately for each examination using a stop watch. FDI (Federation Dentaire Internationale) two-digit numbering system was used to identify the examined teeth. The measurements were in millimeters and the time measured was seconds. The recorded measurements were organized in tables showing measured pocket depth for three sites (mesial, mid-labial, and distal) on labial surfaces of each tooth for the examined upper and lower anterior eight teeth. Pocket depths were measured twice for both types of probes by each participant. The recorded measurements and time are organized in Tables (I-XVI). The obtained data were registered and submitted to statistical analysis.

Table I : Recorded measurements taken by participant No.1 using manual probe. 1st round.

Tooth Notation	D	B	M
32	1.0	2.5	2.5
31	1.5	1.5	2.5
41	1.5	1.5	1.5
42	1.5	1.5	1.0
22	0.5	1.0	1.0
21	1.5	1.5	1.5
11	1.5	1.5	1.5
12	1.5	0.5	0.5

Total time of examination: 198 seconds.
Measurements in millimeters, FDI two-digit system is used to identify teeth.
M; Mesial, B: Mid-Labial, D: Distal.

Table II: Recorded measurements taken by participant No.1 using manual probe. 2nd round.

Tooth Notation	D	B	M
32	1.0	0.5	0.5
31	1.5	1.5	2.5
41	1.5	1.5	1.5
42	1.5	1.5	0.5
22	0.5	0.5	1.5
21	1.5	1.5	1.5
11	1.5	1.5	1.5
12	1.5	0.5	0.5

Total time of examination: 131 seconds.

Table III: Recorded measurements taken by participant No.2 using manual probe. 1st round:

Tooth Notation	D	B	M
32	1.0	1.0	1.5
31	1.5	1.5	1.5

41	1.5	1.5	1.5
42	1.5	1.5	1.0
22	0.5	0.5	0.5
21	1.5	1.5	2.0
11	1.0	1.5	1.0
12	0.5	0.5	0.5

Time: 162 seconds.

Table IV: Recorded measurements taken by participant No.2 using manual probe. 2nd round

Tooth Notation	D	B	M
32	1.0	2.0	1.0
31	1.5	1.5	2.0
41	1.5	1.5	1.5
42	1.5	1.5	1.0
22	0.5	0.5	0.5
21	1.0	1.5	1.5
11	1.0	1.5	0.5
12	1.0	0.5	0.5

Time: 140 seconds

Table V: Recorded measurements taken by participant No.3 using manual probe. 1st round

Tooth Notation	D	B	M
32	1.0	0.5	1.5
31	1.5	2.0	2.5
41	0.5	1.5	0.5
42	1.5	1.5	1.0
22	0.5	1.0	0.5
21	1.0	1.5	2.0
11	1.5	1.5	1.5
12	1.5	0.5	0.5

Time: 146 seconds.

Table VI: Recorded measurements taken by participant No.3 using manual probe. 2nd round

Tooth Notation	D	B	M
32	1.0	1.0	0.5
31	1.0	2.0	1.5
41	1.0	2.0	1.5
42	1.0	1.5	0.5
22	0.5	1.0	0.5
21	1.5	1.0	1.5
11	1.5	1.0	1.0
12	1.5	0.5	0.5

Time: 96 seconds

Table VII: Recorded measurements taken by participant No.4 using manual probe. 1st round

Tooth Notation	D	B	M
32	1.0	0.5	2.5
31	1.0	1.5	2.0
41	1.0	1.5	1.5
42	1.5	1.5	1.0
22	0.5	1.5	0.5
21	0.5	1.5	2.5
11	2.0	2.5	1.0
12	1.0	1.0	0.5

Time: 157 seconds

Table VIII: Recorded measurements taken by participant No.4 using manual probe. 2nd round.

Tooth Notation	D	B	M
32	1.5	1.0	1.5
31	2.0	2.0	1.5

41	2.5	2.5	1.5
42	1.5	1.5	1.0
22	0.5	1.0	0.5
21	1.0	1.5	1.5
11	2.0	2.5	1.5
12	1.5	0.5	0.5

Time: 175 seconds

Table IX: Recorded measurements taken by participant No.1 using PA-on. 1st round

Tooth Notation	D	B	M
32	0.8	0.8	2.0
31	1.0	1.7	1.6
41	1.0	1.1	0.9
42	1.0	1.0	1.8
22	0.5	0.5	1.0
21	1.0	0.3	1.4
11	1.6	1.0	0.9
21	1.0	0.5	0.3

Time: 155 seconds

Table X: Recorded measurements taken by participant No.1 using PA-on. 2nd round:

Tooth Notation	D	B	M
32	0.6	0.5	1.0
31	1.0	1.0	1.1
41	0.8	1.0	0.5
42	1.1	1.0	1.0
22	0.2	0.5	1.0
21	1.0	0.4	2.5
11	1.8	1.0	1.0
12	1.0	0.4	0.4

Time: 129 seconds

Table XI: Recorded measurements taken by participant No.2 using PA-on. 1st round

Tooth Notation	D	B	M
32	1.0	1.8	1.8
31	0.9	2.3	2.8
41	1.8	1.8	1.9
42	2.0	1.7	0.9
22	0.8	1.0	1.7
21	1.5	0.9	1.7
11	2.0	2.2	1.0
12	2.3	0.9	0.9

Time: 134 seconds

Table XII: Recorded measurements taken by participant No.2 using PA-on. 2nd round:

Tooth Notation	D	B	M
32	1.0	2.9	2.5
31	1.2	2.3	2.4
41	1.9	20.	1.5
42	1.8	1.5	0.5
22	2.1	1.8	2.0
21	2.2	1.2	2.3

11	1.6	2.0	1.0
12	1.0	0.9	0.9

Time: 136 seconds

Table XIII: Recorded measurements taken by participant No.3 using PA-on. 1st round:

Tooth Notation	D	B	M
32	0.5	0.4	0.9
31	0.7	0.8	2.4
41	0.4	0.7	0.7
42	0.7	0.7	0.4
22	0.2	0.5	0.5
21	0.6	0.5	2.0
11	0.6	0.7	0.6
12	0.6	0.1	0.2

Time: 124 seconds

Table XIV: Recorded measurements taken by participant No.3 using PA-on. 2nd round:

Tooth Notation	D	B	M
32	0.4	0.5	1.9
31	0.7	1.0	2.4
41	0.4	0.8	0.8
42	0.7	0.7	0.4
22	0.5	0.6	0.6
21	0.6	0.6	0.2
11	0.9	0.6	0.7
12	0.6	0.1	0.3

Time: 117 seconds

Table XV: Recorded measurements taken by participant No.4 using PA-on.1st round:

Tooth Notation	D	B	M
32	0.9	0.7	1.1
31	1.0	1.5	2.7
41	1.1	1.1	1.0
42	1.0	1.0	1.0
22	0.7	0.8	0.5
21	1.0	1.1	0.9
11	1.4	1.3	1.0
12	1.0	0.4	0.3

Time: 108 seconds

Table XVI: Recorded measurements taken by participant No.4 using PA-on. 2nd round:

Tooth Notation	D	B	M
32	1.0	0.6	1.6
31	1.0	1.1	2.2
41	1.0	1.1	0.9
42	1.0	1.0	0.9
22	0.7	0.5	0.4
21	0.9	1.2	1.0

11	0.9	1.0	0.9
12	1.0	0.3	0.3

Time: 118 seconds

Table XVII: Difference in time of probing between Manual and automatic probing

	Average Time of Manual Probing (Seconds)	Average Time of Electronic Probing (Seconds)	Difference in Time between Manual & Electronic Probing	Percentage of Effect on Time of Probing *
Participant NO.1	164.5	142.0	23.5	+14.2%
Participant No.2	151.0	135.0	16.0	+10.6%
Participant No.3	121.0	120.5	0.5	+0.4%
Participant No.4	166.0	113.0	53.0	+31.9%
Average	14.2%			

*+ Improving Compared to Manual Probing

Table XVIII: The probing depths for all the 4 participants in Manual and automated probing (X-axis). (Y-axis) represents the readings for the 8 examined teeth with 3 sites each (D, B and M).
*Average Manual Probing
**Average Electronic Probing

		Participant No.1		Participant No.2		Participant No. 3		Participant No.4	
		Manual Probing* mm	Electronic Probing** mm	Manual Probing* mm	Electronic Probing** mm	Manual Probing* mm	Electronic Probing** mm	Manual Probing* mm	Electronic Probing** mm
32	D	1.00	0.70	1.00	1.00	1.00	0.45	1.25	0.95
	B	1.50	0.65	1.50	2.35	0.75	0.45	0.75	0.65
	M	1.50	1.50	1.25	2.15	1.00	1.40	2.00	1.35
31	D	1.50	1.00	1.50	1.05	1.25	0.70	1.50	1.00
	B	1.50	1.35	1.50	2.30	2.00	0.90	1.75	1.30
	M	2.50	1.35	1.75	2.60	2.00	2.40	1.75	2.45
41	D	1.50	0.90	1.50	1.85	0.75	0.40	1.75	1.05
	B	1.50	1.05	1.50	1.90	1.75	0.75	2.00	1.10
	M	1.50	0.70	1.50	1.70	1.00	0.75	1.50	0.95
42	D	1.50	1.05	1.50	1.90	1.25	0.70	1.50	1.00
	B	1.50	1.00	1.50	1.60	1.50	0.70	1.50	1.00
	M	0.75	1.40	1.00	0.70	0.75	0.40	1.00	0.95
22	D	0.50	0.35	0.50	1.45	0.50	0.35	0.50	0.70
	B	0.75	0.50	0.50	1.40	1.00	0.55	1.25	0.65
	M	1.00	1.00	0.50	1.85	0.50	0.55	0.50	0.45
21	D	1.50	1.00	1.25	1.85	1.25	0.60	0.75	0.95
	B	1.50	0.35	1.50	1.05	1.25	0.55	1.50	1.15
	M	1.50	1.95	1.75	2.00	1.75	1.10	2.00	0.95
11	D	1.50	1.70	1.00	1.80	1.50	0.75	2.00	1.15
	B	1.50	1.00	1.50	2.10	1.25	0.65	2.50	1.15
	M	1.50	0.95	0.75	1.00	1.25	0.65	1.25	0.95
12	D	1.50	1.00	0.75	1.65	1.50	0.60	1.25	1.00
	B	0.50	0.45	0.50	0.90	0.50	0.10	0.75	0.35
	M	0.50	0.35	0.50	0.90	0.50	0.25	0.50	0.30

Results

There are differences in time of measurement in favor for the automated PA-on probe. Measuring pocket depths always took less time when done by automated probe. Averages time for manual and automated probing are compared for the four participants. Average times are measured in seconds. Differences in recorded times for both types of probes are summarized in table No. 17. Examination speed was always less for the automated probe over the manual. The average reduction in probing time for the four participants was 14.2% in favor for the PA-on automated probe. The results also showed that the manual probe gave higher probing pocket depths compared to the electronic probe. The average readings in millimeter for all participants are summarized in table No.18. Applying On-Way repeated ANOVA test at two levels (Manual and Automated) was done on these data using SPSS v17. The resultant P-value was 0.002 which is statistically significant.

Discussion

In consistence with previous similar study, differences were found between manual PA-on and manual probe in regards to screening time. Regarding time spent with periodontal probing and charting, by using the electronic periodontal probe, a three times decrease of probing time was achieved.[13] In addition, the automated probe provided immediate charting for pocket depths and other variables such as bleeding on probing, pain sensation and loss of attachment.[21] Also as concluded by other researchers, we found higher pocket depth measurements electronic compared to manual probe.[22] The reason might be attributed to the amount of applied forces as it is assumed to be higher for manual probes in comparison to PA-on with fived applied force (0.20-0.25 N/mm^{2}). Previous studies found that electronic periodontal probing offered a useful method for accurately measuring the pocket depths for operators who lack experience. This was because of possible destruction to epithelial attachment in cases of uncontrolled pressure application for manual hand held probes. This might also lead to errors in readings and subsequent faulty diagnosis and treatment.[13] It was assumed by other researchers that the flexibility of the PA-on tip has an advantage of probing tight vertical defects and can better follow the curvature of the root. But the flexibility also carries the disadvantage of reduction of orientation and tactile sensation. The limitation of PA-on design prevents it from measuring deeper pockets more than 11 mm, which make it useless in diagnosing severe periodontal conditions with major loss of attachments and pocket depth.

Conclusion

An automated periodontal probe offers an efficient method of collecting probing pocket depths. PA-on automated probing system saves time in measuring periodontal pockets depths and provides immediate recording and analysis of different indicators of periodontal health condition. More accurate reading of periodontal pocket depth is achieved by PA-on rather than Williams' because of standardized applied probing pressure. Pa-on automated periodontal probe doesn't offer a complete replacement for manual probing but presents an economic advantage by offering single operator practice.

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