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Evaluation of a New Furcation Stent as a Fixed Reference Point for Class II Furcation Measurements

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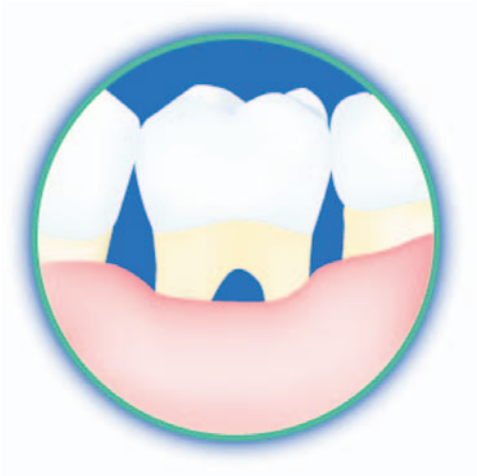

Abstract

Aim: To date probing of the furcation using sounding has been one of the reliable methods to assess horizontal component of furcation in multirooted teeth. A more precise and reliable measurement of this horizontal component of furcation involves using a fixed reference point providing stability and reproducibility of measurements. A custom stent is used to provide a fixed reference point and can be used pre- and post-surgically without re-entry. Therefore, the purposes of this study were to (1) assess the reliability of furcation measurements by direct probing (without stent) and with the use of a newly designed furcation stent and (2) to assess the furcation measurements in relation to gingival margin position pre- and post-operatively.

Methods and Materials: Forty-three chronic periodontitis patients with buccal grade II furcation involvement in maxillary or mandibular molars were included. The furcation involvement was measured by direct probing using a UNC-15 calibrated probe with and without using a custom stent. The furcation involvement and gingival margin position were measured pre- and post-surgically.

Results: There was a significant reduction in plaque (PI) and gingival inflammation (GI) during the study period. The reduction in plaque index and gingival index was observed from 1.75 ± 0.35 to 0.92 ± 0.30, 1.88 ± 0.35 to 0.98 ± 0.29, respectively. Complete agreement was found between the first and the second measurement for about 74% of sites without the custom stent, whereas 86% of the sites measured using the stent had complete agreement. The differences never exceeded 1 mm for any of the sites. There was significant ($t = 2.49$; $p<0.05$) difference observed at complete agreement level ('0' difference).

Conclusion: It may be concluded the clinical attachment level-H of the furcation involvement using a PCP UNC-15 probe and a custom designed stent provides reproducible information about the furcation depth in multirooted teeth.

Clinical Significance: Use of a simple modified furcation stent has shown greater reproducibility of furcal depth measurements than direct probing without the stent. The furcation stent definitely addresses the problems of existing methods of horizontal furcal depth measurements reported in the literature. The major advantages of the newly designed stent are the simple construction and non-invasive application which translates to wide practical applications.

Keywords: Furcation involvement, horizontal measurement, furcation stent, fixed reference point, reproducibility

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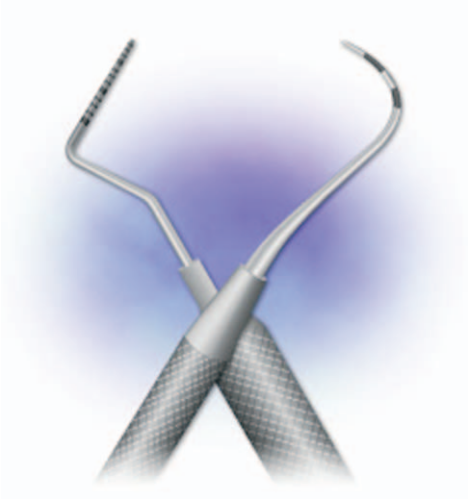
Introduction

In spite of continuous and vast developments in the field of periodontics few developments have focused on furcation measurement, though it is one of the common problems in the management of periodontal patients. A reliable method of obtaining reproducible measurements of furcation is still lacking, especially in the horizontal direction. To date, probing of the furcation using sounding has been one of the reliable methods to assess the horizontal component of furcation,[1] but producing a stable and reproducible reference point has remained a problem.

Assessment of regeneration techniques in the treatment of furcation defects are done by re-entry,[2] clinical parameters,[3] using a combination of clinical and advanced radiographic aids (such as CADIA and Digital Subtraction Radiography).[4,5] Most of these methods have their own shortcomings. Re-entry surgery to enter the furcation is associated with morbidity and is ethically questionable.[6]

Although linear measurements are readily translated into the clinical environment, they may truly not represent the volumetric changes that occur at the defect after regeneration. A method to detect volume change of the periodontal defect after the treatment involves the use of impression material such as polysiloxane.[1] The trimming of the impression material to correspond to the entire volume of the furcation is somewhat subjective. In addition, the impression material is



prone to distortion or tearing when it is removed from the furcation.[6] Conventional radiographs for the interpretation of furcation areas is reported to be limited for a reliable and predictable assessment of alveolar bone status.[7] CADIA has its own limitations; due to the anatomy of furcations, the alveolar bone is projected onto the root and periodontal ligament structures. Therefore, the detection of subtle changes in density by means of CADIA might be hampered against a background with more structured noise than at interdental crestal sites.[8]

Thus, the quest for non-invasive methods to assess regeneration continues and usually the studies depend on horizontal probing of furcation to assess the extent of furcation involvement and amount of regeneration post surgically. Most

studies have either used a curved Naber's probe,[9] a flexible TPS probe,[10] or a flexible disc probe[3] for horizontal probing to assess regeneration in the furcation region.

The flexible TPS probe seems to be unsuitable for the accurate assessment of degree of furcation involvement.[10] While using Naber's and TPS probes, accurate horizontal readings could not be evaluated due to the curved geometry of the probe involved.[11] The Florida probe is not designed to measure furcation involvement. The diagnostic characteristics of Naber's probe is clear, however, the ability to use it for a prognosis and to determine mm increments of change is limited due to its color coding in 3 mm intervals.

Another important factor in assessing bone regeneration in the furcation using linear measurements is to produce a stable and reproducible reference point, which still remains an elusive goal.

Various reference points used for furcation measurement include:

- Use of a second periodontal probe held against the furcation
- PVC stops positioned on the root surface concavities
- The tangent to the root surface adjacent to the scored furcation
- The gingival margin
- The initial fluting of the furcation entrance
- Orthodontic bands

The use of existing reference points to measure horizontal furcation involvement has several drawbacks. A second periodontal probe may be held against the furcation and directed against the long axis of the tooth. The intersection of the two probes will indicate the depth of the horizontal component of the defect.[6] Holding the reference probe at exactly the same point and the point of inserting the probe is not easily reproducible while holding two probes at a point in the posterior area is also cumbersome. The horizontal measurement (H) is also difficult to record because of the gingival heights and the depth of vestibule. Failure to position the probe accounts for the low-N value and the inability to accomplish horizontal measurements limits its usefulness regardless of its reproducibility.[12]

PVC stops can also be positioned on root surface concavities to serve as reference for the measurements, but in this case the coronal position of the gingiva in some cases may obstruct the visual control.[1] Use of a tangent as a reference might provide a lower reliability of the measurements of the distolingual furcations due to the impossibility of direct vision and difficulties probing this remote location.[5] The use of the gingival margin as the reference point is also not a reliable measurement of regeneration, as with the gingival recession of approximately 0.5 mm for the treatment groups; the fixed reference point at the six month re-measurement may have been more apical than the initial measurements. With a more apical position of the probe tip, the location of the tip within the furcation area may not have been the same as the initial measurements.[3] Use of initial fluting of the furcation entrance has also been used as the reference point from which vertical and horizontal measurements were made; while this was done to standardize the reference point, the presence of the soft tissue covering the furcal fluting prevents a categorical statement of the reference point equivalence for all measurements at a given furcation.[13]

Another study described the extensions mounted on the stents designed in such a way to be used as the reference point for both the vertical and the horizontal measurements of the furcation defects. Though, this omitted the need to manufacture separate stents for the vertical and horizontal measurements, it was realized the readings of the horizontal measurement from the edge of the stent may not represent accurate millimeters due to the geometry involved when using a curved probe. A change in the horizontal defect depth of 1 mm at the tip of the curved probe may be reflected by a smaller change than 1 mm at the edge of the stent.[11]

To monitor standard periodontal therapy, the estimation of the furcation degrees seems to be sufficient, but to evaluate the clinical success of complex therapeutic techniques it seems advisable to perform more precise measurements of horizontal probing attachment level of furcation along with the vertical component.[5]

Thus, to record more precise and reliable measurement of horizontal component of furcation, a fixed reference point is needed, which is free

of the above mentioned drawbacks in terms of detection, stability, and reproducibility. In order to overcome these problems a customized stent is required which will provide a fixed reference point for the measurement of the horizontal component of the furcation which could be used pre- and post-surgically without re-entry.

Therefore, the objectives of this study were:

- To assess the reliability of furcation measurements by direct probing (without stent) and with the use of a newly designed furcation stent.
- To assess the furcation measurements in relation to gingival margin position pre- and post-operatively.

Methods and Materials

Forty-three patients (20 male and 23 female), 28 to 50 years of age under periodontal treatment at the Department of Periodontics, College of Dental Sciences, Davangere, India took part in this study. Patients were suffering from moderate to advanced untreated periodontal disease and had at least one first or second molar remaining in each quadrant according to initial clinical and radiographic examination. The inclusion criteria included periodontal patients with one or two buccal grade II furcation involvement[14] in maxillary or mandibular molars with >5mm midbuccal pockets at the selected sites. The exclusion criteria included the following:

- A history of periodontal therapy during the past six months
- Existence of gingival recession
- A history of known systemic disease
- Smokers
- Pregnant women
- Lactating women

Clinical Examinations

During initial periodontal therapy the furcation involvement of the selected molars in each patient was scored. Gingival inflammation (GI) (Loe and Silness Gingival Index) and plaque (PI) (Silness and Loe Plaque Index) was scored at six sites on every molar.[15] Gingival margin position (GMP) was assessed to the nearest 0.5 mm using a calibrated straight periodontal probe (PCP UNC-15, Hu-Friedy, Chicago, IL, USA) and custom occlusal stent.[16] The horizontal probing attachment level (PAL-H) was assessed to the nearest highest mm in the buccal furcation of selected maxillary and mandibular molars using a custom furcation stent which was a modification of the regular occlusal stent. The direct probing (without stent) of the furcation depth was measured using the gingival margin as the reference point. For a subset of 50 sites of the total sample of 86 sites, both the furcation depth measurements (with and without the stent) were repeated with an interval of one week.[17] The presurgical measurements were performed two weeks prior to periodontal surgery. The post surgical measurements of furcation depth were measured three months after the open flap debridement. The GMP measurements were done two weeks prior to surgery and three months post surgically.

Preparation of the Custom Stent

Two custom stents were fabricated separately for each subject to record GMP and furcation depth at selected sites. The routine stent to record GMP had a groove to facilitate the probe placement midbuccally and GMP was measured from the lower border of the stent to the crest of gingival margin. The furcation stent was prepared with slight modification of the stent used for GMP measurement to facilitate a fixed reference point for furcation depth measurement (Figure 1).

The stent used to record the GMP was extended only up to the occlusal 1/3 of the selected tooth. The furcation stent was prepared using self cure clear resin with the modification in terms of extension of the buccal plate up to the attached

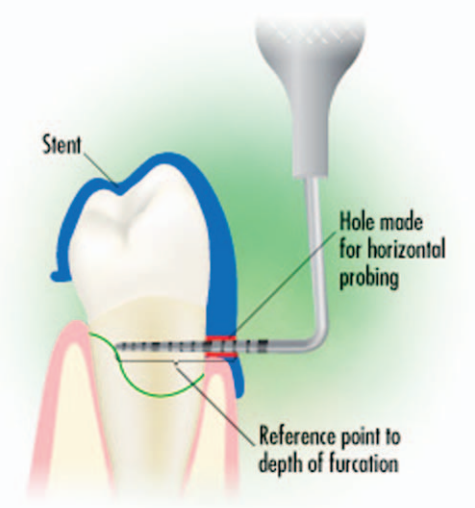


Figure 1. Furcation depth measurement.

gingiva to go beyond the furcal entrance. A hole was made at the buccal extension of the stent approximately coinciding with the furcal entrance to guide the probe penetration in the same direction every time it was inserted for measurements. The outer surface of the hole served as the reference point for the horizontal probing depth.

For furcation involvement, open flap debridement was considered without inverse bevel incision, osseous recontouring, and the flap was undisplaced.

All measurements were performed by one calibrated examiner who was not involved in any aspect of therapy. Prior to initiating the study, the examiner was trained and calibrated in measuring and recording probing pocket depth and clinical attachment levels (CALs). Calibrations of the examiner recording all measurements was accomplished before beginning the study and throughout its duration by randomly selecting eight teeth for remeasurement without access to previous measurement recordings (Figure 2).

Statistical Analysis

The reproducibility of the furcation depth was analyzed by using the students 't' test. The inter group comparisons were made with an unpaired 't' test and intra group comparisons were made with a paired 't' test.

Results

A total of 86 furcation defects were selected from 43 periodontitis patients. Fifty furcation sites were included for reproducibility assessment and 86 sites for pre- and post-operative measurement of furcation depth using the stent and without the stent along with GMP recording using the regular stent. The results of the study are presented in Tables 1 to 3. There was significant reduction in PI and GI during the study period, 1.75±0.35 to 0.92±0.30, 1.88±0.35 to 0.98±0.29, respectively. The difference between the first and second furcation depth measurement for the subset of 50 furcations at various levels using the stent and without a stent are shown in Table 1.

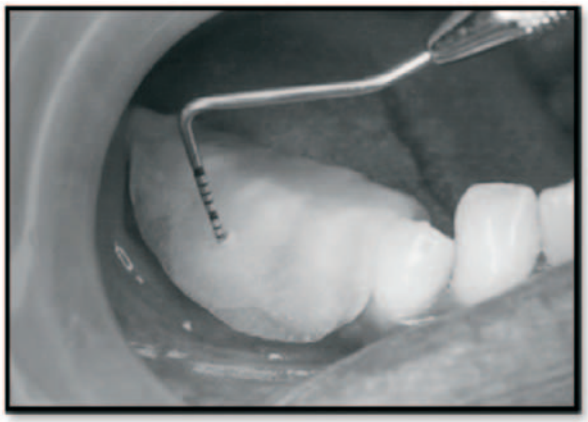


Figure 2. Demonstrates how clinical measurement was taken from stent hole.

There was complete agreement between measurements for 74% of sites measured without a stent compared to 86% of the sites measured using the stent. The differences never exceeded 1 mm. There was a significant difference ($t=2.49$; $p<0.05$) observed at the complete agreement level ('0' difference) between measurements with and without the stent. At -1 mm level, 16% of sites differed for direct probing as compared to 4% with stent furcation depth.

The difference between pre- and post-operative furcation depth was significant using stent and by direct probing ($p<0.001$) (Table 2).

The gingival margin position change was also significant ($p<0.05$). The difference between pre- and post-operative gingival margin position was unchanged in 53% of sites (Table 3).

Discussion

The presence and severity of furcation involvement are generally estimated by measurements of furcation depth. However, in order to determine whether or not progression of periodontitis occurs, the level of attachment must be assessed in relation to fixed reference point at two or more succeeding time points.[18] For clinical furcation measurement, the gingival margin is used as a reference point which may be subject to change in position due to disease progression or postoperatively. Besides the inaccuracies inherent in periodontal probing,[19] a reliable assessment of the attachment level also depends on the stability and distinctness of the structure used as a fixed reference point. For instance, the cemento-enamel junction (CEJ) frequently used as a reference point for periodontal pockets is often difficult to identify.

Table 1. The differences (mm) between the first and second measurements of furcation depths using a stent and without a stent.

Difference (mm) n=50	-3	-2	-1	0	1	2	3	N	$\bar{X} \pm SD$
Furcation depth measurement (without stent)	0	0	8 16%	37 74%	5 10%	0	0	50	- 0.06 ± 0.5115
Furcation depth measurement (with stent)	0	0	2 4%	43 86%	5 10%	0	0	50	+ 0.06 ± 0.373
t = 2.49 and p < .05									

Table 2. Comparison of GMP and horizontal furcation depth measurements post-op (mean ± SD).

Group (n = 86)	Pre-op	Post-op	Difference	Significance	
				t*	P
Without Stent	5.80 ± 1.3	4.71 ± 1.0	1.09 ± 1.0 (13%)	10.1	<0.001
With Stent	8.62 ± 1.5	7.55 ± 1.4	1.07 ± 1.2 (12%)	8.4	<0.001
GMP	4.72 ± 1.1	4.86 ± 1.1	(-) 0.14 ± 0.6 (3%)	2.04	<0.05
*Paired t-test					

Table 3. Comparison between horizontal furcation depth measurements with respect to change in GMP (mean ± SD).

Group n = 86	GMP (Mean Pre-Post Difference)		
	Unchanged (n=53)	Apical Shift (n=22)	Coronal Shift (n=11)
Without Stent	0.94 ± 0.99	1.27 ± 0.77	1.45 ± 1.37
With Stent	1.08 ± 1.31	1.05 ± 0.90	1.09 ± 1.14
Difference*	0.14	0.22	0.36

The significant difference found in this study between using the stent versus no stent for furcal measurements as shown in complete agreement of furcation depth and maximum percentage difference of -1 mm emphasizes the dependability of the stent providing a stable fixed reference point to govern the probe direction and insertion during furcation probing. In the present study the reproducibility of the stent measurements was assessed without any changes in GMP. However, further studies with GMP changes are worth considering.

Inaccuracies in the assessment of pocket depth and CAL changes may also occur if the probing spot and the direction of the probe insertion differs from one measuring time to another.[20] These sources of inaccuracy can be significant when the results of periodontal treatment are evaluated. In the present study use of a stent provided the same probing spot and probe insertion for furcation measurement.

Furcation probing depth and CAL are two important clinical parameters to determine diagnosis and prognosis of the diseased site. Furcation probing is relatively simple but suffers from lack of a stable reference point. The GMP is influenced by disease in terms of enlargement (coronal positioning) and recession (apical positioning). Periodontal therapy also influences the GMP to move apically, coronally, or to remain unchanged as to pre operative position. The gold standard for measuring changes in periodontal status are measurement of CAL using CEJ or RAL (relative attachment level) from a fixed reference point other than CEJ such as stent or restoration.[21] RAL is the only means of measuring therapeutic benefit as it is difficult to detect a subgingivally located CEJ[22] or when the CEJ is obscured by calculus.[23] Measurements using the stents appear to be more reliable than subgingival CEJ readings.[16]

The use of a curved probe for horizontal measurement and furcation depth might not represent accurate measurements in millimeters due to the geometry involved when using a curved probe. A change in the horizontal defect depth of 1 mm at the tip of the curved probe may be reflected by a smaller change than 1 mm.[11] Curved Naber's probe with alternate bands of 3 mm markings is suitable for diagnosis of furcation defect rather than for prognosis.

In this study the straight UNC-15 probe was convenient to record furcation depth changes in mm with a minimum degree of manipulation for probe insertion. The periodontal measurement studies have rounded the measurements to the nearest 0.5 mm or 1 mm.

In the present study the various GMP changes (mean pre-post difference) versus furcation depth measurement showed a notable range of 0.94 with a stent to 1.45 mm without using the stent. However the range of pre-post operative furcation depth measurement was minimal (1.08 to 1.09 mm) using a stent. A greater number of treated furcation sites (53) demonstrated no change in GMP as compared to 22 sites with an apical shift and 11 sites having a coronal shift of GMP. Although there was overall significant GMP change ($P<0.05$), the maximum number of sites with unchanged GMP postoperatively served as a good reference point. Lindhe et al.[24] reported gingival recession (following a Modified Widman Flap [MWF] without osseous recontouring) by measuring the distance between stent and gingival margin six months post operatively. Isidor et al.[25] reported gingival recession at the three month follow up examination for a MWF and reverse bevel flaps. The periodontal literature reports gingival recession following both nonsurgical and surgical therapy. However, the term GMP is preferred as the gingival position can exhibit coronal, apical, or no shift after periodontal therapy.

Coppes[26] measured pocket depths at an interval of several days without the use of a fixed reference point. The reproducibility in that study was found to be 1 mm or less for 94% of the measured tooth surfaces, but a difference of up to 6 mm was observed between the first and second measurements. Such a large difference was not seen in this study which may be because of the custom acrylic stents producing identical fixed reference points. This suggestion is supported by results presented by Hassell et al.[20] who found a considerable variation if measurement was performed at various sites in the same pocket.

Badersten et al.,[27] in their study on 15 patients, measured pocket depth and attachment levels twice with an interval of one week using a metal onlay to provide reference points. Both the pocket depth and attachment level measurements

deviated 1 mm or less at 99% of the measured surfaces. However, a study by Isidor et al.[25] measuring pocket depth and attachment level on 17 patients found a difference of 1 mm or less in around 95% of the surface.

Studies by different investigators have shown the probing force and pocket depth may be correlated, while some investigators have failed to observe such a relationship. However, van der Velden and de Vries[28] found the reproducibility of pocket depth measurements similar with and without standardization of the probing force. Furthermore, an earlier study by Gabathuler and Hassell,[29] using a pressure sensitive periodontal probe, observed "each investigator has his own characteristic probing technique." Therefore, it seems unlikely deviations observed between the first and second measurements in the present study can be explained by variations in the probing force, since all measurements were performed by the same investigator. A fixed reference is needed for CAL measurements. The CEJ is not an ideal reference, as identification is often complicated by its subgingival location and lack of clear demarcation felt by probing. Alternatively, an occlusal stent can be used for recording CAL. The stent not only serves as a fixed reference but also, when provided with markings along the periphery, helps the clinician direct the probe tip into the same location every time. Watts,[30] however, found the stent makes little difference in the overall reproducibility of probing depths. On the other hand, Badersten and coworkers[17] have reported, in comparison to using the CEJ as a reference, the use of occlusal stents results in improved reproducibility of CAL measurements. In the present study as well the use of a suitable stent may have contributed to the high reproducibility of horizontal furcation measurement.

Uniform thickness of the custom stent used in this study can be prepared by using a vaccum tray forming machine. The occurrence of two major probing errors, i.e., probing direction and insertion were avoided in the newly designed furcation stent. The simple construction, feasibility, and its use noninvasively (without reentry) are the positive aspects of the stent. The lack of approximation of perforation on the stent with the furcal entry was rectified by remaking the stent. The fit of the stent was not a problem in this three month study.

The furcation diagnosis and presurgical/ intrasurgical measurements (reproducibility and validity) of furcation involvement has been extensively studied by Eickholz et al.[5,9,31] using Naber's probe and the principle of tangent described by Pontoriero et al.[32] The color coded Naber's probe marked in 3 mm increments is best used for the furcal diagnosis/classification based on Hamp et al.[33] Although, the post surgical assessment of furcation measurement by the above authors are limited. To assess post surgical changes in furcation depth following various flap techniques using Naber's probe is a difficult task as most often the measurements are rounded to .5 or 1 mm. To facilitate presurgical to post surgical furcation measurement including furcation diagnosis, a straight PCP UNC-15 probe is dependable and convenient allowing for a lower degree of visual and rounding error. Eickholz and Ti-sunkim[31] reported no significant difference between pre and intra surgical CAL-H (clinical attachment level – horizontal) measurements using Naber's probe, the TPS, and PCP UNC-15 probe. The disto lingual furcations ($p<0.025$) were underestimated by the TPS and PCP UNC 15 probe. Although, the Naber's probe is designated as the 'gold standard,'[9] based on its inherent drawbacks, the UNC PCP 15 probe marked in mm was used effectively in the present study.

The range of gain in CAL-H reported after treatment of class II furcations in humans ranges from 1.08 mm to 3.5 mm.[34] This numerical data is difficult to measure using Naber's probe because of 3 mm color coding. However, several authors[35,36] have used caliberated periodontal probes for prognostic assessment of furcation treatment and anatomic reference points that would be subject to variation during duplicate measurements done at one to two weeks intervals and three to nine months post surgery. These ambiguous literature results necessitate a fixed reference point for CAL-H as it exists for CAL-V (clinical attachment level- vertical).

In the present study the utility of the furcation stent for measurements is limited to the buccal aspect. Except in the interproximal furcal areas, the lingual furcation measurements are also

feasible using the furcation stent and definitely would be better than the imaginary tangent principle. Most often the furcation treatment evaluation is done for buccal and/or lingual furcations. The present study demonstrates the reliability of the furcation stent for the buccal aspect. Its utility is also feasible for lingual furcations using the lingual extension of the occlusal stent. The physical fixed reference point provided by the furcation stent for CAL-H is also better than the imaginary tangent principle which is widely used in the literature.

Conclusion

Within the limitations of the present study, it may be concluded CAL-H of the furcation involvement using the PCP UNC-15 probe and a newly designed stent provides reproducible information about the furcation depth in multirooted teeth. Further, the reproducibility of this stent should be evaluated for lingual furcation involvement. To assess the validity both presurgical, intrasurgical, and postsurgical assessment of furcation depth using the furcation stent would be useful information.

Clinical Significance

A fixed reference point is needed to record more precise and reliable measurements of the horizontal component of furcations, free from detection, stability, and reproducibility errors. In order to overcome these problems a custom stent provides a fixed reference point for measurement of the horizontal component of furcation and can be used pre- and post-surgically without re-entry. The simple modified furcation stent has shown greater reproducibility of furcal depth measurements than direct probing without the stent. The furcation stent definitely addresses the problems of existing methods of horizontal furcal depth measurements reported in the literature. The major advantages of the newly designed stent are the simple construction and non-invasive application, which translates to wide practical applications.

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