



## In Vitro Study Comparing the Efficacy of Radiograph and Apex Locator in Determining Working Length in Human Maxillary Molars

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### ABSTRACT

*The objective of this invitro study was to find out if a buccal curve in the palatal roots of maxillary molars affected the clinician's ability to accurately determine working length. 30 extracted intact human maxillary 1<sup>st</sup> and 2<sup>nd</sup> molars were sorted by palatal root curvatures as J and C type and angle of curvature was determined using Schneider's method.*

*Straight line access was made and a No #20 file was placed into the canal until the tip was visible at the apical foramen under stereomicroscope. The file, tooth and calibration wire were radiographed on one image using the RVG system and the actual (file) and radiographic (tooth) length were determined using the RVG digital ruler. The same No# 20 file was used with apex locator to record Apex locator length (EL).*

*Result showed radiographic length (RL) appeared shorter on average than actual length (AL) and apex locator length (EL). A statistically significant difference was seen between the actual length and radiographic length as the degree of curvature increases. Also there was no significant difference between the J type and C type curve. The use of apex locator is a valuable adjunct for working length determination especially in case of palatal root of maxillary molars.*

### INTRODUCTION

Correct working length determination is the key factor leading to success in root canal treatments. Root canal preparations and filling should not extend beyond the root nor leave uninstrumented areas inside the root canals<sup>1</sup>.

The ideal apical end point of endodontic instrumentation and obturation has been deter-

ined to be the cemento-dentinal junction, which occurs on an average 0.5mm to 1mm short of the apical foramen<sup>2</sup>. In addition, the apical foramen cannot be visualized on a radiograph. Thus the radiographic vertex is often used as a measuring point clinically, though studies have shown that the radiographic vertex does not always coincide with the apical foramen<sup>2,3</sup>.

Radiographic working length determination for palatal root of maxillary molars may be difficult because of the super-imposition of anatomic structures (i.e., zygomatic arch, maxillary sinus and a buccal curve in apical one-third of the root). This curvature occurs 55% of the time in maxillary first molars and 37% of time in maxillary second molars<sup>4</sup>.

Electronic apex locators (EAL) introduced in 1962 to determine the root length during root canal treatment has become an invaluable tool in modern endodontic practice.

The purpose of the present in-vitro study was to

- a) To determine if the presence of a buccal curvature in palatal roots of maxillary molars affected the ability of clinician to accurately determine the working length.
- b) To quantitatively determine the relationship between the presence of various degrees of buccal curvature in palatal root of maxillary molars and differences found between radiographic length (RL) and Actual length (AL) and length determined with an apex locator (EL).
- c) To determine if the use of an apex locator could play a significant role in working length determination in maxillary molars

## MATERIALS AND METHOD

Thirty extracted intact human maxillary 1<sup>st</sup> and 2<sup>nd</sup> molars without apical resorption were selected. Each tooth was radiographed from mesio-distal direction using conventional film (Kodak), using a paralleling technique, constant radiation exposure and developing time. Fig( 1)

Using these radiographs the teeth were then sorted by palatal root curvature into the descriptive categories suggested by Nagy et al into J- type and C- type.( FIG 2).

Teeth were placed into the J-type group if the palatal root was straight until the apical 3 to 4mm at which level a sharp buccal curvature occurred much like the letter 'J'. (FIG 3A)

Teeth were placed into the C- type if the palatal root had a gradual curve from the coronal and

middle third of the root and extended to the root apex much like the letter 'C'(FIG 3B).

The radiographs were scanned and the angle of palatal root curvature was determined using Schneider's method using Corel draw11 software. A flat coronal reference point was created by reducing 3mm from the occlusal table with a long straight fissure bur and straight line access was made through each tooth sample.

The coronal and middle portion of the palatal canal was flared with Gates Glidden burs using crown down technique and irrigating with normal saline solution. Canal patency was verified with a #8 file and each sample was instrumented to the verified apical foramen with a No #20 file size.

Actual length (AL) and radiographic length (RL) were measured in the following manner.

A No #20 Niti file was used to represent the AL from the coronal reference plane to the apical foramen. The file was introduced into the palatal root of the tooth until the tip of the file was visible under the stereomicroscope, Fig(4). An endodontic rubber file stop was used to mark the file at its coronal reference then withdraw & set aside. A calibration device, consisting of a 7mm length of rectangular orthodontic arch wire was then prepared and also set aside.

To minimize measurement and magnification variables, each tooth was placed in a buccal-lingual direction next to No #20 file and calibration was on a Radiovisiography Sensor (Suniray) .Three objects were placed onto the RVG sensor using a polyvinyl siloxane jig to standardize the angle and distance from the x ray source. From the image taken and using the digital ruler feature of the RVG system, the palatal root of the tooth was measured from the radiographic apex to the coronal reference point (FIG5A&B). This tooth measurement represents (RL) Using the digital ruler again the distance from the tip of No #20 Niti file and edge of endodontic file stop was measured. This represented the (AL). Each RVG image was calibrated using the orthodontic arch wire of known length.(FIG 6).

The electronic measurement (EAL) was achieved using the ipex apex locator [NSK].

The teeth were placed in contact with 2% agar gel to simulate the periodontium in a plastic container. Both the specimen and the lip clip of the electrode were glued with acrylic resin to the lid of the container to prevent displacement. (Fig 7) No #20 Niti file was used according to the manufacturer's instructions. The termination point used in this study was the '00' on the meter designated by the manufacturer as the Apex.

This electronic length (EL) was measured and noted on the RVG as in the case of RL and AL. All tooth samples and files were measured 3 times using the digital ruler on the RVG system to the nearest length of a mm. Analysis of correlation was used to test for a relationship between the amount of curvature and the AL-RL difference (in mm).

In addition difference in the types of curve (J versus C) was compared with the regression analysis

## RESULTS:

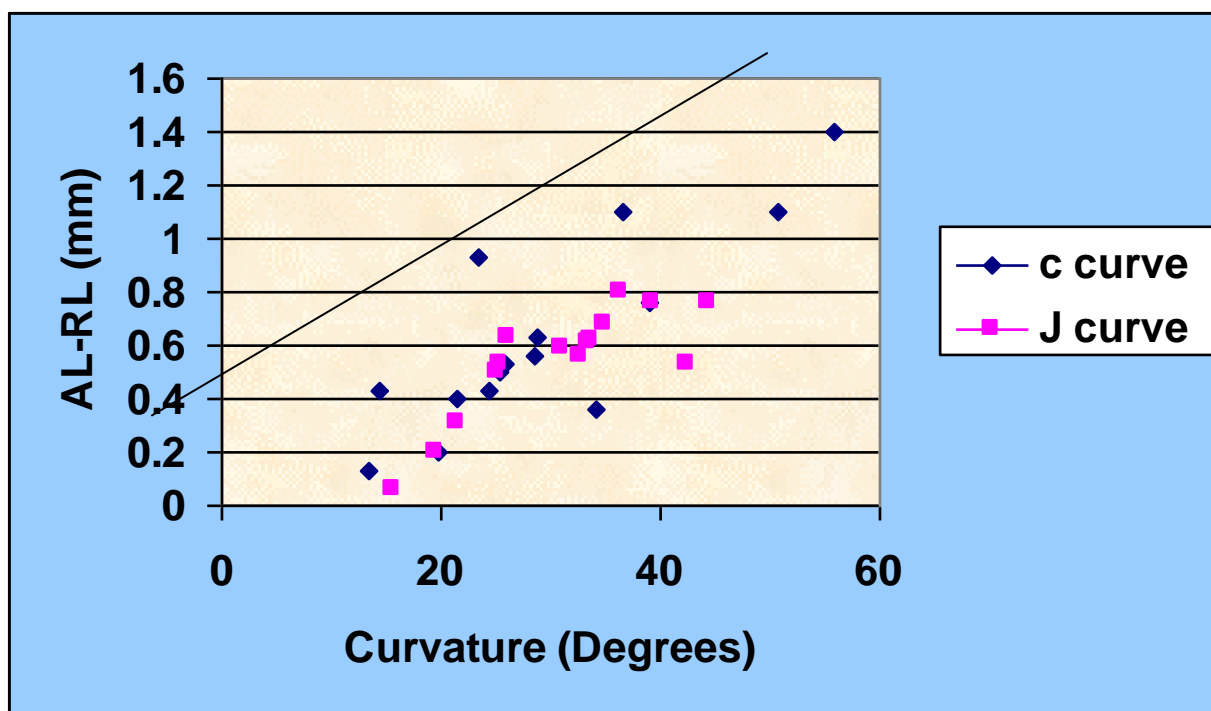
**Results:** - The AL, RL and EL value differences are shown in Table I (mm).  $P < 0.001$

	Tooth No Curvature (degrees)	Actual length (AL) mm	Radiographi c length (RL) mm	AL-RL mm	Apex locator RL (EL) mm	(AL-EL) mm
1	15.341	18.06	17.93	0.13	18.07	0.01
2	19.849	17.60	17.40	0.20	17.65	0.05
3	16.321	18.02	17.96	0.06	18.03	0.01
4	15.524	18.80	18.74	0.06	18.81	0.01
5	21.583	18.01	17.61	0.40	18.03	0.02
6	21.346	19.06	18.75	0.31	19.07	0.01
7	19.472	19.03	18.83	0.20	19.04	0.01
8	24.419	17.00	16.57	0.43	17.04	0.04
9	25.397	18.48	17.98	0.50	18.58	0.10
10	25.306	18.53	18.00	0.53	18.46	0.01
11	25.215	18.50	18.00	0.50	18.51	0.01
12	26.125	17.80	17.17	0.63	17.82	0.02
13	25.867	20.14	19.61	0.53	20.15	0.01
14	28.877	17.00	16.37	0.63	17.01	0.01
15	31.036	18.21	17.62	0.59	18.23	0.02
16	32.618	18.24	17.68	0.56	18.25	0.01
17	34.185	18.05	17.69	0.36	18.07	0.02
18	33.346	19.10	18.49	0.61	19.11	0.01
19	33.541	17.03	16.41	0.62	17.05	0.02
20	36.675	17.67	18.57	1.10	17.68	0.01
21	36.438	20.00	19.20	0.80	20.01	0.01
22	34.916	17.89	17.21	0.68	17.82	0.02
23	39.126	20.13	19.37	0.76	20.14	0.01
24	39.150	19.12	18.36	0.76	19.13	0.01
25	42.516	18.04	17.51	0.53	18.05	0.01
26	44.312	18.16	17.40	0.76	18.18	0.02
27	50.777	19.95	18.85	1.10	20.00	0.05
28	55.938	18.26	16.86	1.40	18.31	0.05
29	56.321	17.55	16.05	1.50	17.55	0.05
30	57.120	19.02	18.01	1.10	19.07	0.05

According to results derived as shown in Table I , RL appeared shorter on average than the AL & EL. The Difference between actual length (AL)

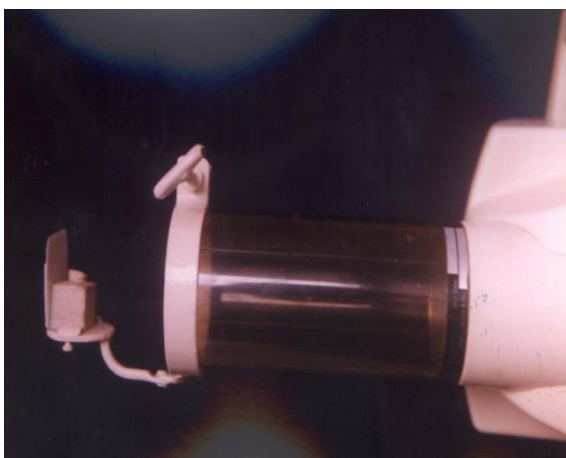
and Apex locator Length (EL) was not found to be statistically significant.

GRAPH I



The relationship between curvature and the AL-RL difference was a line through zero with a significant slope ( $p < 0.001$ ). There was a significant difference between actual length and Radiographic length in canal curvatures larger

than 25 degrees. As the degree of curvature increased the difference between AL & RL also increased. There was no canal type curvature interaction thereby indicating no difference between the J type and C type of curve.

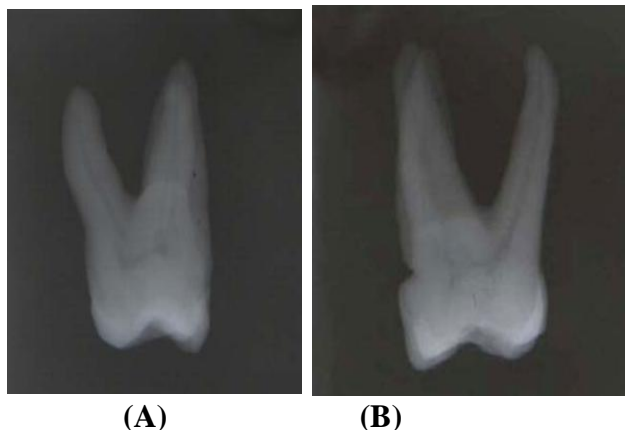


**FIG 1:** Each tooth was radiographed from mesiodistal direction using paralleling technique.



**FIG 2:** C type J type curvatures of palatal roots

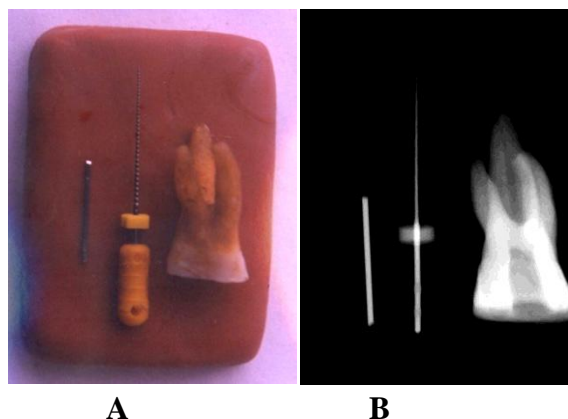




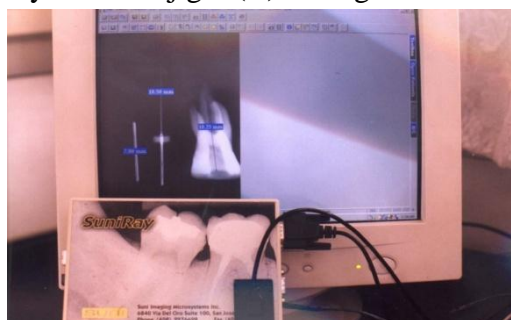
**Fig.3** (A) C type canal and 3 (B) J type canal



**Fig 4:** Tip of File Visible Under Stereomicroscope



**FIG 5 (A):** Calibration wire, file, tooth placed on polyvinylsiloxane jig **5 (B):** Image on RVG.



**FIG 6:** Measurements taken using digital ruler feature of the RVG



**FIG 7:** Measurements taken on apex locator.

## DISCUSSION

In this invitro study, extracted maxillary molars were used to find out if a buccal curve in the palatal root affected the ability of a clinician to accurately determine working length.

Although many studies have looked at the mesiobuccal root of maxillary molars, the palatal root has not received as much attention in regard to palatal anatomy for canal instrumentation and obturation.

Schneider's angle was used to qualitatively determine the degree of canal curvature present and determine if a relationship existed between curvature and AL-RL difference and AL-EL difference. Results showed a statistically significant difference between Radiographic working lengths as the degree of curvature increases.

RL also appeared on the average to be shorter than the AL of curvature, irrespective of the type of J or C curve, this finding supports the work of Stein and Corcoran (1992)<sup>5</sup>. This findings may be in part due to a) The curvature in the palatal root is typically viewed in the buccal-lingual orientation creating a geometric illusion that makes the viewed length appear shorter than the actual length.

b) Also as the apical foramen does not always coincide with the radiographic vertex.

Thus using only radiographic length to determine working length may produce over instrumentation into the periradicular tissues. These findings are in conjunction with the findings of El Ayouti et al<sup>6</sup>.

RVG was used with digital ruler feature. The purpose of keeping all three objects(file, tooth and calibration unit) on one sensor was to eliminate

operator variance and bias in measurement procedures.

Larger files deviated less from the known lengths on RVG images, so large size No # 20 was selected to measure AL and all measurements were taken in a positive/negative zoom mode using the RVG system.

The use of electronic apex locator to determine working length has gained in popularity<sup>7</sup>. The apical limit used was the apical foramen. The apex locator reading was nearly same as that of the actual length of the palatal root. This study also agrees with others (Usen et al 2007, 2008)<sup>8,9</sup> that Electronic apex locators are more accurate than radiographs and greatly reduce the risk of instrumenting and filling short or beyond the canal terminus.

## CONCLUSION

The ability of a clinician to accurately determine working length based solely on radiographic interpretation may be impaired because of the significant buccal curvature in the palatal roots of maxillary molars.

As the degree of curvature increases the discrepancy between AL and RL and AL and EL will increase significantly.

There are limitations in using radiographs as a sole means of determining working length and hence must be combined with adjuncts such as electronic apex locators

The electronic apex locator with its high degree of accuracy & ease of working is highly recommended adjunct in working length determination in case of palatal root of maxillary molars

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