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Accuracy of Working Length Determination using IOPA Grid Technique and Apex Locator: An *In vivo* Study

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Research Article

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ABSTRACT

Background: The study consisted of 40 teeth which comprised of 10 maxillary incisors, 7 mandibular incisors, 5 maxillary canines, 2 mandibular canines, 3 maxillary premolars, 4 maxillary molars and 9 mandibular molars (68 canals). The working length of these teeth were measured by apex locator (Morita ZX), confirmed by a diagnostic radiograph and tooth length by IOPA on which a grid was fixed with a salotape. The radiographs were taken by paralleling technique with the help of a cone beam indicating device. These teeth were further divided into three groups and correction factors of 1.5 mm, 1 mm and 0.5 mm were applied to the values of the tooth length obtained by the IOPA grid technique according to the criteria given by Morfis et al. It was discovered in the process that maxillary and mandibular canines couldn't be put into any of the groups so a fourth group was made which consisted of these teeth and probability of the correct correction factor was analysed.

Result: A Statistical analysis of the data indicated that the 49% of the cases in whole study showed 1 mm as the correct correction factor to be deducted from the tooth length measured by the IOPA grid.

Conclusion: IOPA grid can prove as substitute in maximum number of cases in case of absence of a Apex locator.

INTRODUCTION

Determination of working length and its maintenance during cleaning and shaping procedures are the key factors for successful endodontic treatment. Radiology plays a very important role in determination of this working length. It is widely accepted that root canal preparation and filling should terminate in the area where histologically the pulp tissue ends. Therefore a thorough knowledge of the root canal anatomy especially of the apex area, and the ability to determine accurately the root length may have an important effect on the prognosis of endodontic therapy [1].

Previous studies have shown that radiology does involve some projection errors and may not give an accurate estimation of the length, but some studies have incorporated certain techniques and made these errors insignificant. Some of these techniques include the use of an IOPA grid and a cone beam indicating device to ensure parallelism in the radiography technique.

On the other hand, the acceptance of apex locators is increasing with the introduction of devices of the third and fourth generation, that allow the location of apical narrowing of the root canal regardless of the canal contents present. The apex locator used in this study is Morita ZX, it is a third generation apex locator based on the ratio method introduced by Kobayashi and Suda. In this method the quotient of two simultaneously measured impedance of two different frequencies are calculated to reveal the portion of an endodontic file inside the canal, this quotient reduces rapidly when apical constriction is reached because the capacitance at the apical constriction is highest compared to other portion of the canal, the instrument gives a signal at this point [10-12].

Kuttler and Blayney JR stated that the narrowest apical portion of the canal or the cementodentinal junction is the ideal limit for instrumentation and obturation, this point generally occurs 0.5 mm to 1 mm short of the radiographic apex as stated by Morfis et al. conducted a study wherein they examined the apical region of 213 permanent teeth and came to a conclusion that the foramina were not located always near the radiographic apex and also concluded that if certain correction factors were deducted from the values of their radiographic tooth length, accurate values can be obtained and success rates in endodontic treatment can be improved.

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In this study we have tried to combine the application of correction factors and the use of IOPA grid to obtain the radiographic working length values and have further compared them to the working length values obtained by the apex locator (Morita ZX) to determine the success rates of the radiographic technique in cases where apex locators cannot be used or are not available.

MATERIALS AND METHODS

Patients indicated for the root canal therapy were selected for this study. The patients selected were above 14 years of age, did not have open apices, external root resorption [19], any fractures in the coronal/root aspect of the tooth, were devoid of any developmental disorders that affected the teeth, did not have acutely curved roots and female patients in the study were not pregnant. A concise case history was taken and patients were made to fill a consent form to be made a part of this study. Radiograph of the indicated tooth was taken by fixing a IOPA grid on the radiograph facing the tube head. The radiograph was taken with the help of a cone beam indicating device into which the assembly of radiograph and IOPA grid were inserted, IOPA grid being fixed to the radiograph with the help of a salotape [20-22].

The IOPA was taken using Gnatus X-ray machine (Brazil, standard of 70 kvp and 7 ma with a max exposure time of 3.20 provided with a total filtration of 1 mm aluminium). Access cavity was made with a round bur which was further extended by EX-24 bur, Diagnostic files 6, 8, 10, 15 K files (Mani) were inserted and were connected to a third generation apex locator (Morita ZX) and the working lengths were measured, this working length was confirmed by a diagnostic radiograph (by inserting a diagnostic file to the length measured by apex locator, the length was confirmed) [23-29]. The tooth length was measured by counting the horizontal lines of the IOPA grid that were superimposed on the radiographic film. The distance between two horizontal lines of the grid and the apex locator were tabulated and according to the criteria set by Morfis et al. the correction factors were deducted from the values of the IOPA grid. Comparison was done between the IOPA grid values after deduction of the correction factor and the values of the apex locator.

RESULTS

As per the criteria given by Morfis et al. we divide our sample size of 40 teeth (68 canals) into 3 groups **(Tables 1-4)**:

Each group has five main columns "A","B","C", "D" and "E"

A: Working length calculated by the apex locator

B: Working length calculated by tactile and confirmed by a radiograph

C: Tooth length measured by the IOPA grid

D: C-A (Working length calculated by the apex locator was subtracted from tooth length measured by the IOPA grid)

E: C-Correction factor (this column was absent in group 4 since we did not have a fixed correction factor like other three groups)

On Evaluation of all the teeth in our sample, maximum cases (49%) showed 1 as the correct factor that can be deducted from the measurement of the IOPA grid.

Table 1. Group 1: For the mandibular incisors, distal root of mandibular molars, maxillary premolars, mesial root of maxillary molars; working length should be 1.5 mm short of the radiographic apex.

Sr. No	Tooth	Details	A (mm)	B (mm)	C (mm)	Correction Factor	D (C - A)	E (C-1.5)
1	32		19.5	19.5	21	1.5	1.5	19.5
2	41		19	19	20	1.5	1	18.5
3	41		18.5	18.5	20	1.5	1.5	18.5
4	46		19	19	20.5	1.5	1.5	19
5	46		19	19	20	1.5	1	18.5
6	26		20	20	21.5	1.5	1.5	20
7	32		19.5	19.5	21	1.5	1.5	20
8	25		21.5	21.5	21.5	1.5	0	20
9	14	Buccal	17	17	18.5	1.5	1.5	17
9	14	Palatal	17	17	18.5	1.5	1.5	17
10	15	Buccal	17.5	17.5	18	1.5	0.5	16.5
10	15	Palatal	17.5	17.5	18	1.5	0.5	16.5
11	46		18.5	18.5	20	1.5	1.5	18.5
12	36		21	21	22	1.5	1	20.5
13	31		17	17	18	1.5	1	16.5
14	41		18	18	18.5	1.5	0.5	17
15	46		17	17	17.5	1.5	0.5	16

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16	46		20	20	20.5	1.5	0.5	19
17	17		16	16	17	1.5	1	15.5
18	46		14	14	15.5	1.5	1.5	14
19	32		18.5	18.5	19.5	1.5	1	18
20	27		18.5	18.5	19.5	1.5	1	18
21	36		16	16	16.5	1.5	0.5	15
22	46		18	18	18.5	1.5	0.5	17
23	46		20	20	20.5	1.5	0.5	19
24	47		16	16	17	1.5	1	15.5
25	17		15.5	15.5	17	1.5	1.5	15.5
		Mean	18.11	18.11	19.11			
		Std. Deviation	1.76	1.76	1.72			

Table 2. Group 2: For the mandibular premolars and mesial root of mandibular molars, it should be 1 mm short of the radiographic apex.

Sr. No	Tooth	Details	A (mm)	B (mm)	C (mm)	Correction Factor	D (C - A)	E(C-1)
1	46		18.5	18.5	19.5	1	1	18.5
2	47		15	15	16	1	1	15
3	46		19	19	20	1	1	19
4	36		18	18	18.5	1	0.5	17.5
5	46		19	19	19.5	1	0.5	18.5
6	36		20	20	21	1	1	20
7	46		16.5	16.5	17.5	1	1	16.5
8	46		20	20	21	1	1	20
9	36		18	18	18.5	1	0.5	17.5
10	36		18	18	18.5	1	0.5	17.5
11	46		15	15	16	1	1	15
12	46		17.5	17.5	18.5	1	1	17.5
13	47		15	15	16	1	1	15
14	46		20	20	21	1	1	20
15	46		20.5	20.5	21	1	0.5	20
16	46		17.5	17.5	18.5	1	1	17.5
	Mean		17.97	17.97	18.81			
	Std. Deviation		1.83	1.83	1.78			

Table 3. Group 3: For the maxillary incisors, palatal root of maxillary molars and distal root of maxillary molars, working length should be 0.5 mm short of the radiographic apex.

Sr No.	Tooth	Details	A	B	C	Correction Factor	D (C - A)	E (C-0.5)
1	12		20.5	20.5	21	0.5	0.5	20.5
2	22		23.5	23.5	24.5	0.5	1	24
3	21		20.5	20.5	20.5	0.5	0	20
4	22		28.5	28.5	29	0.5	0.5	28.5
5	11		18.5	18.5	19.5	0.5	1	19
6	11		23.5	23.5	25	0.5	1.5	24.5
7	11		22	22	23	0.5	1	22.5
8	12		24	24	24.5	0.5	0.5	24
9	21		22.5	22.5	23	0.5	0.5	22.5
10	26	Distal	19	19	20	0.5	1	19.5
11	26	Palatal	23	23	24	0.5	1	23.5
12	21		21	21	22	0.5	1	21.5
13	17	Distal	15.5	15.5	16	0.5	0.5	15.5
13	17	Palatal	16.5	16.5	17	0.5	0.5	16.5
14	27	Distal	18.5	18.5	19.5	0.5	1	19
14	27	Palatal	18.5	18.5	19.5	0.5	1	19
15	17	Distal	16	16	17	0.5	1	16.5
15	17	Palatal	16	16	17	0.5	1	16.5
		Mean	20.42	20.42	21.22			
		Std. Deviation	3.45	3.45	3.45			

Table 4. On our evaluation and segregation of our sample size in 3 groups, it was observed that there was no criteria that divided the maxillary

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and mandibular canines, so we tried to calculate the probability of the right correction factor in case of canines by doing the same thing as in other three groups,"C"-"A" (Working length calculated by the apex locator was subtracted from tooth length measured by the IOPA grid) and we designated as Group 4.

Sr. no	Tooth	Details	A	B	C	Correction Factor	D (C - A)
1	13		22	22	22.5	-	0.5
2	13		20.5	20.5	21.5	-	1
3	23		20.5	20.5	21.5	-	1
4	23		28	28	28.5	-	0.5
5	43		20.5	20.5	21.5	-	1
6	33		23.5	23.5	24.5	-	1
7	23		22	22	22.5	-	0.5
	Mean		22.43	22.43	23.21		
	Std. Deviation		2.70	2.70	2.56		

Our results were as under **(Tables 5-9)**:

Table 5. Group 1 (correction factor 1.5).

Percentage of cases	Precise correction factor
37%	1.5 as the correction factor
30%	1 as the correction factor
30%	0.5 as the correction factor
4%	0 as the correction factor

Table 6. Group 2 (correction factor 1).

Percentage of cases	Precise correction factor
69%	1 as the correction factor
0%	1.5 as the correction factor
31%	0.5 as the correction factor
0%	0 as the correction factor

Table 7. Group 3 (correction factor 0.5).

Percentage of cases	Precise correction factor
33%	0.5 as the correction factor
6%	1.5 as the correction factor
56%	1 as the correction factor
6%	0 as the correction factor

Table 8. Group 4 (correction factor 0).

Percentage of cases	Precise correction factor
57%	1 as the correction factor
0%	1.5 as the correction factor
43%	0.5 as the correction factor
0%	0 as the correction factor

Table 9. Overall study showed the following.

Percentage of cases	Precise correction factor
49%	1 as the correction factor
32%	0.5 as the correction factor
16%	1.5 as the correction factor
3%	0 as the correction factor

On evaluation of all the teeth in our sample, maximum cases (49%) showed 1 as the correct factor that can be deducted from the measurement of the IOPA grid.

DISCUSSION

Most experts agree that the canal preparation should terminate at the CDJ. However, the term "CDJ" is a histological term and a microscope is needed to find it [2]. Clinically this is not practical. Clinically we have to determine the most accurate or very near to accurate position of the anatomical apex, in order to perform successful root canal treatment, because if the biomechanical preparation remains short of the apical constriction, in both vital and necrotic pulp conditions [3] or if the anatomical apical

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foramen is inaccessible, then the risk of failure of root canal therapy increases [4].

The method of determining the anatomical apex by tactile sensation only is not completely reliable method. In the study performed by Seidberg et al. he observed that only 60% clinicians could locate the anatomical apex by this method. The anatomic variations in the apical constriction location, its size, tooth type age makes working length assessment by tactile sensation unreliable [5] Morfis A et al. did the scanning electronic microscopic study. Their results showed that more than one main foramen was observed in all groups, with varied sizes of the accessory apical foramina, in some cases, the size was even larger than the main foramen making the apical morphology of the root canals very complicated. In their observation the mean value of the center of main foramen from the anatomic apex never exceeded 1 mm, our study also states that maximum number of cases show 1 mm as the correct correction factor.

Paul et al. suggested that the combination of methods should be used for accessing true position of anatomical apex [6] Blaine M et al. [4] concluded that morphology of the apical area of single rooted teeth is complicated, variable and requires careful attention and assessment [7]. Gordon MPJ et al. concluded that in 90% cases the anatomic apex is up to 0.5 mm from the tip and in 100% cases it is within 1.00 mm [8].

In 1957, Ingle used the pre-treatment radiograph in a mathematical procedure for determining working length. The original tooth image was measured on the pre-treatment radiograph, following substraction of a standard 2-3 mm from that length to compensate for distortion. There are several ways to determine the working length of the root canal viz radiographs, electronic apex locators, tactile sense, patient response, knowledge and experience, predetermined normal tooth length, use of paper points, mathematical equations etc. Accuracy in length determination is necessary to avoid damage to the apices of teeth and to the periapical tissues during instrumentation, thus providing better conditions for healing after endodontic treatment.

The advantage of apex locators is that they are supposedly accurate, easy and fast and reduce exposure to radiation. Artificial perforation can be recognized and it is the only method that can measure length to the apical foramen and not the radiographic apex. Morita ZX the apex locator used in this study is a third generation apex locator and almost eliminates all the possible disadvantages of a apex locators. If a combination of methods are used like using a IOPA grid with radiographs and confirming the reading with a diagnostic radiograph, it can help us do our endodontic treatment devoid of a apex locator and also more economically, bearing in mind the high cost of apex locators. This particular study in no way questions the accuracy and reliability of a apex locators but rather is trying to show more combination of methods that can be used in case of absence of a apex locator. If the dentist has an apex locator, then to this method of placing a IOPA grid can be useful because it can reduce the attempts made to measure the anatomic apex. The dentist can clinically assess the case first, in case of deep caries, the diagnostic radiograph can itself be taken by placing a IOPA grid, so a rough assessment of the working length is sought in case root canal therapy is indicated thus saving the patient the inconvenience of diagnostic radiographs, maximum cases in our study show 1 mm as the correction factor to be deducted from the IOPA grid reading, the file can be inserted at that length and the reading can be confirmed by the apex locator or by a diagnostic radiograph in case of absence of apex locators. Use of a cone beam indicating device is mandatory in case this method has to be used, thus ensuring minimum distortion in the radiographs by ensuring parallelism.

Further we would like to add that the sample size used in this study is small, and the results of this study should be confirmed by a larger sample size, though it has a small sample size the results are in agreement with the studies done by Kutler et al. all this scientists stated that the distance of the radiographic apex from the anatomic apex is within 0.5 to 1 mm, which are similar to the results in our study, 49% show 1 mm as the distance and 32% show 0.5 as the distance from the radiographic apex to the anatomic apex. 16% and 3% cases which show 1.5 and 0 as their correction factors, we assume this values in accordance with the variations in the root canal anatomy as proved by several researchers earlier.

CONCLUSION

IOPA grid on a radiograph along with a cone beam indicating device can surely help in the assessment of the correct working length up to which the obturation should be done; it can be a substitute to apex locators in maximum number of cases.

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