SIXTH GENERATION ADAPTIVE APEX LOCATOR

Slavcho Dimitrov*, Dimitur Roshkev**
*Department of Conservative Dentistry, Faculty of Dental Medicine, Medical Academy, Sofia, Bulgaria
** OPTIKA LASER /OPTICS LASER/, Sofia, Bulgaria

SUMMARY:

A comparative analysis is made which is grounded on literary data concerning the advantages and disadvantages of apex locators of various generations that have been created following two different principles /19, 28/. The PURPOSE of this study is to create a method and a device that combine the established advantages of fourth and fifth generation instruments.

While measuring the working length of the root canals of 30 extracted human teeth /dry and filled with animal blood and sodium hypochlorite/, experimental research work was carried out which has served as a basis for creating both a method and an adaptive apex locator that combine the advantages of the two previous generations of appliances.

The prolonged direct and juxtaposing studies have made it possible to create a steady algorithm for adapting the method for measuring the working length of the root canal depending on the canal's moisture characteristics. The method has been implemented in the apex locator of the so called sixth generation – the adaptive type.

Measurement with the adaptive apex locator has made it possible to eliminate the necessity of drying or moistening of the canal, as well as to achieve high degree of measurement precision in the presence of blood, of additionally imported liquid /sodium hypochlorite/, or while manipulating dry canals.

Clinical observations are yet to come that will help assess the device's ability to determine the working length of root canals under various clinical conditions and situations.

Key words: adaptive apex locator, working length.

Every endodontist is familiar with the importance of the correct determining of the length of the root canal /RC/ as well as of the accurate registering of the point of the apical stenosis as regards the favourable treatment. Almost all authors define as optimum a working length of up to the level of the physiological narrowing, also known as physiological or biological openings /1, 2, 3, 4, 7, 10, 11, 13, 14, 16,17,22,23/.

In clinical practice, radiography is a common method for determining the working length /WL/ of the RC /20/. The methods that apply endodontic instruments are most common since they result in a very high degree of accuracy /4, 6, 8, 12, 15, 26/.

The percentage of inaccuracy of the radiographic method is relatively insignificant; yet, amongst the main reasons for such inaccuracy we should outline the following:

- radiographic image is two-dimensional which makes it impossible to see the outlet of the anatomical foramen vestibularly and lingually to the apex of the tooth;
- the instrument is seen as projected onto the apical tip, whereas in reality it protrudes out of the RC foramen that is on the lateral root surface.

The accuracy of the radiographic method also depends on the quality of radiography, as well as on the quality of the X-ray films /9/.

These peculiarities determine the errors that may ensue should treatment predominantly rely on radiographic method. If projected to a two-dimensional image, chances are that the canal curvatures may be shadowed and lost. Along with this, a common error as regards the outcome of the treatment is to determine the RC as shorter, with the ensuing perforation.

Some of the above shortcomings of the radiographic method can be avoided through the electrometric method for determining the WL of the RC called apex location. In apex location, by transmitting low-intensity current or a special sequence of current impulses through the root canal, its electrical characteristics are measured /21, 22, 24, 30/.

So far, five generations of instruments have been created which constantly evolve and are being improved. Appliances exist that are in-built in the endodontic tips /14, 18/.

Currently, fourth and fifth generation devices are mostly employed. What is typical of the fourth generation devices is that they measure and compare the complex electrical characteristic features of the RC through two or more frequencies of electrical impulses /13, 28/. A significant disadvantage of the fourth generation devices is that they need to perform in relatively dry or in partially dried canals. In some cases, this necessitates additional drying, and with heavy exudate or blood the method becomes inapplicable.

To cope with those problems, a measuring method has been developed based on comparisons of the data taken of the electrical characteristics of the canal and additional mathematical processing/13, 18, 19, 25/. Apex locators of this type, which are known as fifth generation devices, increase

accuracy in determining the place of apical foramen by several per cent. Devices employing this method perform very well in the presence of blood and exudate but they experience considerable difficulties while operating in dry canals. Therefore, additional insertion of liquids in the canal is exerted almost always. Low toxicity of measurement in dry canals, as well as the need to insert extra liquid still predetermine the preferences of doctors in dental medicine in favour of fourth generation devices /3,13,18,19, 27/. Comparative studies of the device accuracy depending on the type of canal instrument and on the material it was made of have been carried out /25, 29/.

Immediately upon putting fifth generation devices on the market, efforts were directed towards combining the new advantages of those devices with the long established achievements in this field of science that had been implemented by means of fourth generation appliances /5 /.

Analysis of the advantages and disadvantages of apex locators of the so called fourth and fifth generation have prompted us to AIM at devising a method and an appliance that combine the established advantages as regards accuracy of the first method with the second method's convenience and detailed information concerning the state of the cut canal. The method and the device should ensure high accuracy of determining the spot of the cement dentine line regardless of the moisture in the canal /the presence of non-extirped pulp, exudates, irrigants, dry or dried canal/.

MATERIAL AND METHODS

Achieving this goal presupposes devising a measuring method that combines the advantages of the methods for measuring in dry canals and in moist canals /19, 28/. This requires: preliminary definition of the canal's electrometric parameters that simply characterise its degree of moistness, and establishing a steady criterion for electronic switching of the measuring method. The purpose is to ADAPT the manner of measuring in accordance with the actual characteristic features of the environment to measure.

The major parameters that are subject to studying and enhancing are as follows:

- the number of frequencies to measure;
- characteristics of the impulses of the separate frequencies;
- creating a method for mathematical transformation of the measured electrical characteristics of the canal;
- creating a method for assessing the canal moistness depending on the location of the measuring instrument's apex;
- establishing steady criteria that concern the moments when programs adapt according to the canal's electromechanical features ;
- developing models of experimental simulation of various measurement environments (on testing devices).

Preliminary studies were carried out.

· plastic tooth models with previously shaped canals and 30 freshly extracted teeth were employed in the preliminary research;

· simulation moistness was achieved by filling canals with irrigants /sodium hypochlorite, blood plasma, animal blood/.

The circuit employed to carry out preliminary research /see fig. 1./ comprised:

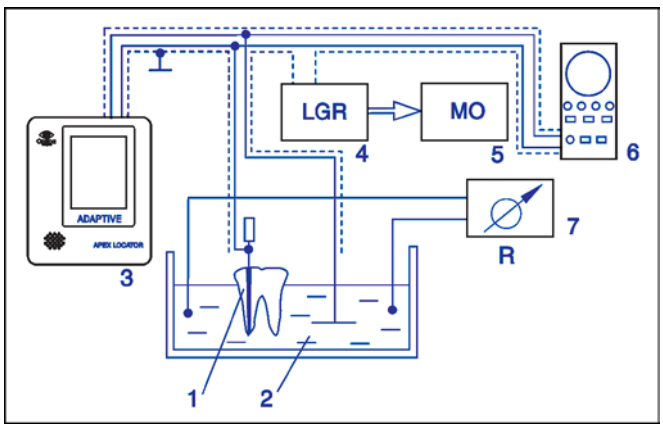

Fig. 1.
1. Studied tooth models or extracted teeth
2. Conducting solutions
3. Apex locator
4. LGR-meter
5. MO controller for mathematical data processing
6. Oscilloscope
7. Ohm-meter

During experimental studies, we took into consideration certain preliminary conditions for elaborating an adaptive measurement method. Those included:

- the technical and clinical experience gained during development, manufacture and operation of fourth and fifth generation apex locators;
- the suggestions and recommendations during tracking and studying the performance of fourth and fifth generation of apex locators, in compliance with the requirements of ISO 13 485 : 2003;
- the experience of the engineering and medical team while defining the parameters of the appliance, the control of measurement accuracy and clinical control over the measuring method.

RESULTS AND DISCUSSION:

The prolonged direct and juxtaposing studies have made it possible to create a steady algorithm for adapting the method for measuring the working length of the root canal depending on the canal's moisture characteristics. The method has been implemented in the apex locator of the so called sixth generation – the adaptive type /see fig. 2./.

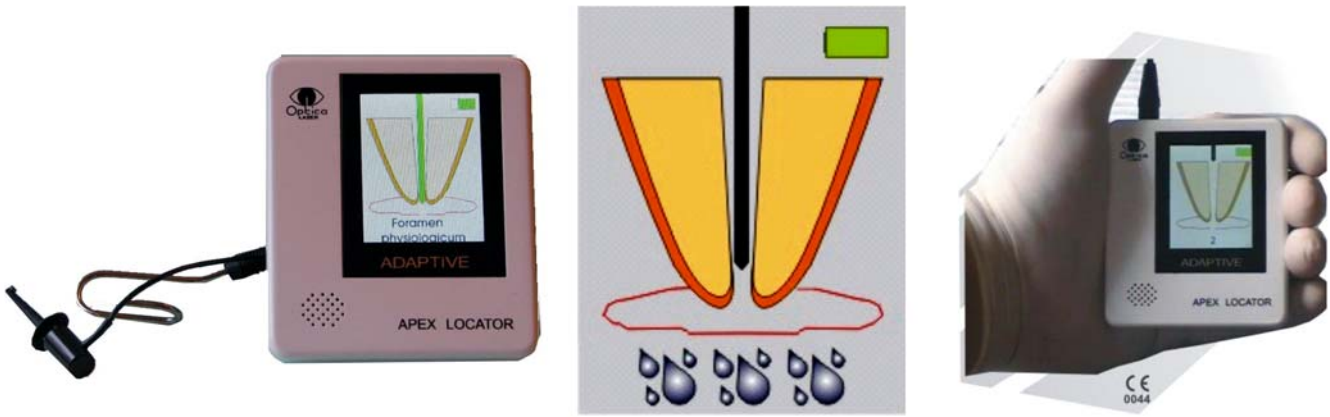

Fig. 2. /a, b, c/

The apex locator is manufactured in compliance with the requirements of ISO 13 485. A series of comparative tests have been made to confirm conformity.

Due to modern technology, the sixth generation adaptive apex locator is a pleasant, small-sized device no larger than a dentist's palm /see fig. № 2 - c/.

The measuring mode provides for graphic information to be displayed on colour multimedia displays. By a clinicist's wish, the adaptive apex locator will retrieve audio information either through the familiar beeping signals typical of the fifth generation apex locators, or through sensible speech messages.

Analysis of the results obtained during comparative RC measurement of 30 extracted teeth of the same dry or moist RC / filled with blood or with sodium hypochlorite/ has shown that the apical narrowing is localised at the identical working length of the canal instruments, regardless of whether the canals are filled with blood or with sodium hypochlorite. Since the measurement data of the working lengths of all extracted teeth in the experiment /30 altogether/ were identical, we considered it irrelevant to introduce them in a table.

The display of the apex locator is split into 2 sectors.

At the stage of penetrating the root canals by means of an endodontic device, information is obtained about the start of measurement when touching the outermost and the inner dentine structures. In the RC, before the apex zone / sector II/, the device provides information that we are in contact with the dentine.

Prior to reaching the apical zone /sector II/, and after a sound signal, the screen displays the zones reached by the tip of the instrument. The device issues sound or speech information that repeats the data on the display /"two" – if the tip is in zone II before the physiological narrowing; "one" – if the tip is in zone I before the physiological narrowing/.

Further motion of the endodontic instrument produces a sound signal of increasing frequencies / indicating that the device expects for the tip of the instrument to penetrate into the zone of physiological narrowing/. The symbol of a moist canal is displayed /see fig. № 2 – c/ which shows that the device has measured moisture in the canal and has duly adapted to measuring within liquid.

The appearance of the message "apex" means that the tip of the instrument is between the physiological narrowing and the anatomical foramen. The message "over" means that the tip has passed through the anatomical foramen.

The results of the experimental studies of extracted human teeth show that the adaptive apex locator combines the advantages of the measuring method of both fifth and fourth generations. This is made possible owing to the extra functions of preliminary determination of the canal moistness. Within just a thousandth of the second, during the penetration of the tip of the canal instrument, precise measurement, mathematical analysis and determination of the canal moistness are performed. Depending on the constantly measured moistness, and entirely on its own, the device adapts the measuring method for either a dry or a wet canal.

The opportunity to define the process of penetrating along the entire tooth canal has predetermined the significant distinctions between devices of the preceding generations and the apex locators of the adaptive class.

CONCLUSION:

The prolonged direct and juxtaposing studies have made it possible to create a steady algorithm for adapting the method for measuring the working length of the root canal depending on the canal's moisture characteristics. The method has been implemented in the first Bulgarian apex locator of the so called sixth generation – the adaptive type.

Measurement with the adaptive apex locator provides for eliminating the necessity of drying or moistening of the canal, as well as for achieving high degree of measurement precision in the presence of blood, of additionally imported liquid /sodium hypochlorite/, or while manipulating dry canals.

Clinical observations are yet to come that will help assess the device's ability to determine the working length of root canals under various clinical conditions and situations.

BIBLIOGRAPHY

1. Ботушанов , П.,- Електрометрично определяне работната дължина на кореновите канали при ендодонтско лечение. Пробл. на стоматологията VI, 1978, 62-67.

2. Ботушанов, П., Ст. Владимиров,- Клинично проучване на възможностите за измерване дължината на кореновите канали с методите дигитално-тактилно усещане и периодонтална чувствителност. Стомат.,С., 4, 1983, 6-10.

3. Ботушанов, П. И., С. Б. Владимиров, - Ендодонтия – теория и практика, 2002, Пловдив, I издание 590.

4. Владимиров, Ст., Определяне дължината на кореновите канали при ендодонтско лечение, - Кандидатска дисертация, 1986, Пловдив.

5. Stavrianos Ch., Ст. Владимиров, Л. Вангелов и др. Определяне на работната дължина на коренови канали с витална и некротична пулпа чрез апекслокатора Foramatron D 10, Зъболекарски преглед, 2006, 2, 82-87.

6. Backman, C., R.Oswald, D.Pitts – A radiographic comparison of the root canal instrumentation technologies.J. of Endodontics, 1992, 18, 19.

7. Besner, E., A. Michanowicz, J. Michanowicz, Practical Endodontics, A Clinical Atlas Mosby – Year Book, 1994, 280.

8. Bramante, C., A. Berbert – A clinical evaluation of some methods of determining tooth length. Oral Surgery 37, 1974, 463 – 473.

9. Brown, R., V. Hadley, D. Chambers, - An evaluation of Ektaspeed plus film versus ultra speed film for Endodntic working length determination. J. of Endodontics, 24, 1998, 54 – 56.

10. Cohen Stephen, Richard Burns Pathways of the Pulp. The C. V. Mosby Company Sarut Louis, 1976, 680.

11. Dahlin, J., - Electrometric determination of apical foramen, A new aid for endodontic experiment and therapy. Quintessence 28, 1977, 27 -55.

12. Gelfand, M., Etal – Reliability of radiographic interpretation. J. of Endodontics, 9, 1989, 9, 71 -75.

13. Gordon M., N. Chandler. Electronic apex locators. Int. End. J., 37, 2004, 425 – 437.

14. Grimberg F., G. Banegas, L. Chiacchio et al. In vivo determination of root canal: a preliminary report using the Tri Auto ZX apex-locating hand piece. Int.End. J., 35, 2002, 590-3.

15. Heling, B., A. Karmon – Determining tooth length with bisecting angle radiography. J. of the British Endodontics Society 9, 1976, 75 – 79.

16. Hoer D., T. Attin . The accuracy of electronic working length determination. Int.End., J., 37, 2004, 125-31.

17. Kaufman AY., S.Keila, M., Yoshpe, Accuracy of a new apex locator: an in vitro study. Int. End., J., 35, 2002,186-92.

18. Kobayshi, Ch., H. Suda, A new engine – driven canal preparation system with electronic canal measuring capability. J. of Endodontics, 23,1997, 751 – 756.

19. Kobayshi, Ch., H. Suda, New Electronic Canal Measuring Device Based on the Ratio Method, V. of Endodontics, 20, 1994 № 3, 111 – 114

20. Larheim, T., S. Eggen. – Determination of tooth length with a standardized paralleling technique and calibrated radiographic measuring film, Oral Surgery 48, 1979, 374 – 378.

21. Marmasse, A., - Dentistrie operatoire. Therapeutique endodontique 5th edn., J. B. Baillere, Paris.

22. Martinez - Lozano MA., L. Forner- Navarro, Jl Sanchez-Cortez et al., Methodological considerations in the determination of working length. Int.End.J., 34, 2001, 371- 376.

23. Messing, J. C. R. Stock. A colour Atlas of Endodontics Wolfe Medical Publications Ltd. 1988, 273.

24. Narita, M., A new root canal technique. Part II. Evaluation of the technique Bulletin of the Kanagowa Dental College, 1, 1973, 93 – 99.

25. Nekoofar MH., K. Sadeghi, ES. Akha et al., The accuracy of the Neosono Ultima EZ apex locator using files of different alloys: an in vitro study. J. of the Californian Dent., Assoc., 30, 2002, 681-4.,

26. Olson, A., et al., The ability of the radiograph to determine the location of the apical foramen. Int. Endodontics Journal 24, 1991, 28 – 35.

27. Pommer O., O. Stamm, T. Attin. Influence of the canal contents on the electrical assisted determination of the length of root canals . J. of End ., 28, 2002, 83-5.

28. Sunada, I., New method for measuring the length of the root canal. J. of Dental Research, 41, 1962, 375 – 387.

29. Thomas AS., GR. Hartwell, PC. Moon, The accuracy of the Root ZX electronic apex locator using stanless-steel and nickel-titanium files. J. of End., 29, 2003, 662-3.

30. Welk AR., JC Baumgarrtner, JG Marshal, An in vivo comparison of two frequency-based electronic apex locators, J.of End., 29, 2003, 497-500.

Address for correspondence:
Slavcho Dimitrov,
Department of Conservative Dentistry, Faculty of Dental Medicine,
Medical University, Sofia,
1, Georgi Sofiiski str., 1431 Sofia, Bulgaria
E-mail: stiviart@abv.bg