Original article

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IN VITRO COMPARISON OF THE ACCURACY OF TWO APEX LOCATORS OF DIFFERENT GENERATIONS

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The accuracy of apex locators is very important for the correct working length determination of the root canal, and thus for successful endodontic treatment.

The aim of this study was to compare *in vitro* the accuracy of iPex II (the fourth generation) and Adaptive (the sixth generation) apex locators.

The material consisted of 28 root canals (16 premolars). The working length of all root canals was determined first by entering K-file #15 up to the apical foramen, what was checked by visual tracking of the top of the file. The fixed working length was then measured with a digital caliper and the obtained values were used to control measured canal lengths in two experimental groups. The teeth were immersed in the alginate before electronic measurements in order to simulate the clinical situation. In the first experimental group, the working length of the root canals was measured with iPex II, and in the second with Adaptive apex locator. All measurements were performed up to the apical foramen in the dry canal.

The results of One-way ANOVA showed that there was not statistically significant difference between examined experimental groups ($p > 0.05$). The biggest difference existed in comparison the values of Adaptive apex locator and the control group, and the lowest in comparison iPex II and Adaptive apex locators.

It can be concluded that both apex locators are accurate enough for clinical practice although they belong to different generations.

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Key words: *Adaptive, apex locator, iPex II, working length*

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Introduction

The accuracy of apex locators is very important for the correct working length determination of the root canal, and thus for successful endodontic treatment (1, 2). It is generally accepted that the endodontic treatment should be limited within the root canal (3, 4). The distance from a coronal reference point to the apical point at which canal preparation and obturation should terminate represents the working length of the root canal (5, 6).

There are six generations of apex locators and each generation has its working principle (7-9). The common characteristic of apex locators from the third to the sixth generation is a determination of the working length by using two or more frequencies. It enables the precise measurements in the presence of the electrolytes in the canal (10). The electric circuit must be established regardless of the principle used and it is achieved by the electrodes that are connected to the oral mucosa and to the endodontic instrument (8, 11).

iPex II apex locator (NSK Nakanishi inc., Tokyo, Japan) belongs to the fourth generation of apex locators, and Adaptive apex locator (Optica Laser, 405-10A, Sofia, Bulgaria) is a representative of the sixth generation. The difference between these two apex locators is that iPex II apex locator measures working length in the conditions of the dry canal (eventually in moist one), while Adaptive works in a wet canal as well as in the dry one (12-14). Both apex locators have been recently introduced, so there are not many data in the literature about them. This prompted us to investigate *in vitro* their accuracy in working length determination of the root canal, to see if they are reliable for clinical use.

The aim of this study was to compare *in vitro* the accuracy of iPex II (the fourth generation) and Adaptive (the sixth generation) apex locators. The working hypothesis was that there is a statistically

significant difference in the precision of these two apex locators since they belong to the different generations of apex locators.

Material and methods

The research was conducted at the Dental Clinic in Niš, at the Department of Restorative Dentistry and Endodontics. The material consisted of 28 root canals of 16 human premolars that were extracted for orthodontic reasons. The teeth had completed root growth and they were without visible fractures and resorptions. The width of the apical foramen was nevertheless sufficient to easily see the position of the top of the canal instrument at the visual working length determination. Teeth were stored in formalin from the extraction to the research start.

The access cavities were prepared on the occlusal tooth surface with a round diamond drill, in diameter 107-126 μm (Mesinger, Germany) using turbine with a water-air cooling. Trepanation of tooth and the removal of coronal pulp were done after that, by round steel drill (Mesinger, Germany). The root canals entrances were then found.

Pulp extirpation was done using the barbed broach #25 and #30, depending on the diameter of the canal. The root canals then were irrigated with 2 ml of 0.5% NaOCl and their patency was checked using a K-file #15. All teeth were used in research as there were no obstructions in the canals and were marked with numbers from one to 16. A total of 28 canals were included in the study. Out of 16 premolars, six were with one canal, eight with two and two with three root canals. The tops of the buccal and oral cusps were marked with felt pen and there the stopper of endodontic instrument leaned during the measurements of working length of the canal. The working length of the root canal was measured up to the apical foramen in the dry canal.

The research included three measurements of the working lengths of all 28 root canals. The first measurement was a control group, while the second and the third measurements represented experimental groups.

In the control group, the working length of the root canal was determined visually by using K-file #15. The file was placed in the canal up to the apical foramen, and position of the top of the instrument was checked by observation under a magnifying glass with 5 × magnification (Hunan, China). The fixed working length was then measured with a digital caliper (Asimeto 307-06-1, Canada) with an accuracy of 0.01 mm and thus the control value was obtained.

Measurements in experimental groups were done after immersion of teeth in alginate since the alginate had the role to simulate the clinical situation. Alginate (Tropicalgin, Zhermack, Italy) was mixed according to the manufacturer's instruction and thus was inserted in a plastic bowl. The two-thirds of teeth roots were immersed in alginate, before its binding. All measurements were performed within two hours after mixing of alginate, while it still possessed humidity. The circuit was *in vitro* closed during the electronic measurements by labial and canal electrodes of corresponding apex locator which were connected with the alginate. The root canals were dried with paper points before measuring since the study was conducted under conditions of the dry canal.

In the first experimental group working lengths of the root canals up to the apical foramen were measured with iPex II apex locator (NSK Nakanishi inc., Tokyo, Japan), and in the second experimental group with Adaptive apex locator (Optica Laser, 405-10A, Sofia, Bulgaria). K-file #20 was used for measuring the working length of the root canal with apex locators. One value was measured for each sample and both devices, in a dry canal, up to the apical foramen. iPex II apex locator signaled the apical foramen with mark 0.0 on the screen, and Adaptive apex locator visually and by a beep. Measurements were first performed on all samples by one locator, and then with the other, so it was a total of 28 measurements for each group.

Statistical analysis was performed using the software package SPSS version 16.0 (SPSS Inc., Chicago, Illinois). Data were presented as the mean and standard deviation, and also as median, minimum and maximum value. Data normality was tested by Shapiro-Wilk test. Comparison of working lengths of the root canals of control and experimental groups was performed by One-way ANOVA (Analysis of variance).

Table 1. The working lengths values of the root canals of experimental and control groups

Groups	iPex II apex locator	Adaptive apex locator	Control group	F value	p value
	n = 28	n = 28	n = 28		
Working lengths (mm)	19.19 ± 1.88	18.94 ± 1.54	19.34 ± 2.12‡	0.32†	p > 0.05*
	18.89 (16.77-23.65)	19.41 (15.92-21.47)	19.06 (16.29-23.81)‖		

*no statistically significant difference
†One-way ANOVA, ‡mean ± standard deviation, ‖median (min-max value)

Results

Shapiro-Wilk test showed normal distribution of data in all examined groups. The values of the working lengths of the root canals of iPex II apex locator (19.19 ± 1.88 mm) were closer to the values of the control group (19.34 ± 2.12 mm) than the values of Adaptive apex locator (18.94 ± 1.54 mm).

The One-way ANOVA showed that there was not statistically significant difference in working lengths of the root canals between examined groups ($p > 0.05$)(Table 1).

Discussion

Precise determination of the working length of the root canal is a key factor that affects the outcome of endodontic treatment (2, 15, 16). Treatment of root canal up to the apical constriction represents a risk that part of the diseased pulp tissue might remain in the apical region and lead to treatment failure (17, 18). Therefore, treatment up to apical foramen is recommended (17).

The use of electronic devices for working length determination of the root canal has gained great popularity, especially in recent years with the introduction of the latest apex locators, which allow the measurements and in a humid environment (6, 17).

In our study, we applied alginate as a material to simulate the clinical situation because of its good electrical conductivity. The other good properties of alginate are that is inexpensive, easy to prepare, stable for hours and relative stiffness of alginate model that prevents fluid movement within the canal and premature readings (19, 20). It has been applied in a number of *in vitro* studies (6, 10, 17, 21). In the research of Lipski et al. alginate has proven to be a reliable medium for replacement of in vivo conditions during the electronic working length measurement. There was no statistically significant difference between the *in vitro* and *in vivo* measurements (21).

Previous *in vitro* studies examined the accuracy of apex locators in working length determination up to the apical foramen or apical constriction. However, apical foramen proved to be better for this type of research because it can locate consistently (22). We compared the accuracy of the apex locators up to the apical foramen for this reason. In the control group, apical foramen was visible and working length measurement was performed under the control of the eye. This indicates that apical foramen is a reliable point not only for examination of apex locator accuracy but also for comparison the apex locators measurements with the actual length of the root canal, which was visually determined.

The results of our research confirmed the null hypothesis as there was no statistically significant difference in working length determination of the root canal between the examined apex locators as well as between them and the control group. We compared the working length values of the three groups using One-way ANOVA, which is a better option than to apply Student's t-test three times because the possibility of errors is reduced. Some authors applied the same statistical test for comparing the values of more than two groups like us, while others applied the Student's t-test (6, 10, 12, 23).

The reason for the absence of statistically significant difference in the accuracy of iPex II and Adaptive apex locators can be the same physical principle of operation (two or more frequencies) (10). iPex II apex locator showed greater accuracy since its working lengths values of the root canals were closer to the values of the control group than the values of Adaptive apex locator. Higher precision of iPex II apex locator can be explained by the fact that the study was conducted in the dry canal because the fourth generation of apex locators to which it belongs is generally more accurate in the dry canal than in the moist one. On the other hand, Adaptive apex locator belongs to the sixth generation of apex locators that adapts to the conditions in the canal, so that the research was done and in the conditions of wet canal results would probably be different (14).

There are some studies that examined the accuracy of iPex II apex locator, while the precision of Adaptive apex locator was not examined. In the study of Kocak et al. iPex II apex locator showed accuracy in working length determination in a dry canal as well as in the presence of different irrigants (23). However, the aim of our study was different. The accuracy of iPex II apex locator was also examined in the study of Gurel et al. In that in vitro study iPex II apex locator showed accuracy in 50% of specimens and there was not a statistically significant difference between examined apex locators (Raypex 5, Raypex 6, iPex and iPex II) (12).

Conclusion

Our research showed that Ipex II apex locator is more precise since its values were closer to the control group compared to the Adaptive apex locator. However, it can be concluded that both devices are accurate enough due to the fact that this difference in precision was not statistically significant, so their use in clinical practice is recommended. It may also be concluded that representatives of the new generation of apex locators are not always more accurate in comparison to older generations, as it was demonstrated in this paper.

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IN VITRO POREĐENJE PRECIZNOSTI DVA APEKS LOKATORA RAZLIČITIH GENERACIJA

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Preciznost apeks lokatora je veoma važna za tačno određivanje radne dužine kanala korena, a time i za uspešan endodontski tretman.

Cilj ove studije bio je da se *in vitro* uporedi preciznost iPex II (četvrta generacija) i Adaptive (šesta generacija) apeks lokatora.

Materijal je činilo 28 kanala korena (16 premolara). Najpre je radna dužina svih kanala korena određivana unošenjem K-turpije #15 do apeksnog otvora, što je proveravano vizuelnim praćenjem vrha turpije. Fiksirana radna dužina je zatim merena digitalnim nonijusom, a dobijene vrednosti su služile za kontrolu merenih dužina kanala u dve eksperimentalne grupe. Zubi su uranjani u alginat pre elektronskih merenja, radi simulacije kliničke situacije. U prvoj eksperimentalnoj grupi radna dužina kanala korena je merena iPex II apeks lokatorom, a u drugoj, sa Adaptive apeks lokatorom. Sva merenja su izvršena do apeksnog otvora u suvom kanalu.

Rezultati jednostrane ANOVA su pokazali da nije bilo statistički značajne razlike između ispitivanih eksperimentalnih grupa ($p > 0,05$). Najveća razlika je postojala u poređenju vrednosti Adaptive apeks lokatora i kontrolne grupe, a najmanja u poređenju iPex II i Adaptive apeks lokatora.

Može se zaključiti da su oba apeks lokatora dovoljno precizna za kliničku praksu, iako pripadaju različitim generacijama.

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Ključne reči: *Adaptive, apeks lokator, iPex II, radna dužina*