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The Influence of Apical Lesions on Electronic Tooth-Length Measurements – an *in vitro* Study

Wpływ obecności zmian okołowierzchołkowych na elektroniczny pomiar długości zęba – badania *in vitro*

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Abstract

Objectives. Investigating the influence of apical lesions on tooth-length measurements with the Root ZX apex locator (Morita, Japan) and checking a modified method of uncovering the apical part of the canal.
Material and Methods. Eighteen freshly extracted human teeth with attached apical lesions were investigated. Tooth lengths were measured with the Root ZX and a No. 10 K-file in an alginate mould according to the method of Katz et al. (1996) (group A). After removal of lesions, the teeth were embedded in freshly mixed alginate and measured again (group B). Then the file was secured in place with a composite material. The apical 4 mm of the canal of each tooth was exposed by grinding with a water-cooled high-speed diamond bur. Distances from the file tip to the dentino-cemental junction and to the apical foramen were measured with an endodontic microscope (Karr, Switzerland) under ×17 magnification.
Results. The tooth lengths measured in group A were longer than in group B in 9 cases (by 0.25 to 1.25 mm). In the presence of the apical lesions, the measurements were too long in 7 canals by 0.15 to 1.3 mm. The mean difference between group A and B was 0.36 mm, with a standard deviation of 0.3 mm. There was a statistically significant difference between both groups at the probability level of $p < 0.05$. The modified method of uncovering the apical part of the canal proved to be useful.
Conclusions. The presence of apical lesions negatively affects electronic tooth-length measurements (**Adv Clin Exp Med 2006, 15, 4, 607–611**).

Key words: apical lesions, electronic tooth measurement, Root ZX.

Streszczenie

Cel pracy. Ocena wpływu obecności zmian okołowierzchołkowych na elektroniczny pomiar długości zębów z użyciem endometru Root ZX (Morita, Japonia). Zbadano ponadto własną metodę szlifu odkrywającego przebieg kanału w okolicy wierzchołka korzenia zęba.
Materiał i metody. Badania przeprowadzono na 18 świeżo usuniętych zębach ze zmianami okołowierzchołkowymi, które pozostały na wierzchołkach korzenia zębów po ekstrakcji. Długość zębów zmierzono z użyciem pilniczka o rozmiarze 10 wg ISO w modelu alginatowym zgodnie z metodą Katza (grupa A). Po usunięciu zmian z wierzchołków korzeni zębów zęby ponownie umieszczono w świeżo zarobionym alginacie i zmierzono długości (grupa B). Pilniczki używane do pomiarów unieruchomiono przez wypełnienie komory płynnym kompozytem. Wykonano szlif odsłaniający wierzchołkową część kanału z użyciem diamentowego wiertła na wiertarkę szybkoobrotową. Zmierzono odległości między końcem narzędzia a otworem anatomicznym pod 17-krotnym powiększeniem, używając mikroskopu endodontycznego (Karr, Szwajcaria).
Wyniki. Długości uzyskane podczas pomiarów w grupie A były dłuższe od tych z grupy B w 9 przypadkach (różnica wynosiła 0,25–1,25 mm). W zębach ze zmianami zmierzone długości były za długie w 7 kanałach (0,15–1,3 mm). Różnica średnich obu grup wyniosła 0,36, a odchylenie standardowe 0,3. Wystąpiła istotna statystycznie różnica między obiema grupami przy poziomie istotności 0,05. Zmodyfikowana metoda szlifu okolicy wierzchołkowej okazała się użyteczna.
Wnioski. Obecność zmian okołowierzchołkowych wpływa negatywnie na dokładność elektronicznego pomiaru długości zęba (**Adv Clin Exp Med 2006, 15, 4, 607–611**).

Słowa kluczowe: zmiany okołowierzchołkowe, elektroniczny pomiar długości zęba, Root ZX.

The apex locator has proved to be a useful tool, as it has been demonstrated many times to be more accurate than radiological methods of measuring tooth length [1, 2]. The Root ZX, a dividing frequency tool, is not only accurate, but also little affected by difficult clinical situations. There are few data on factors that impact electronic root canal measurements. Until now, authors have shown the influence of foramen diameter, ion concentrations, and preflaring on tooth length [3], but even these factors have been analyzed in very few studies. In the presence of a minor foramen, apex locator readings are correct. In case of resorption or periapical pathosis, which quite often coexist, the readings can be less accurate [4]. Thus the present study aims firstly at investigating the influence of apical lesions on tooth-length measurements using the Root ZX apex locator (Morita, Japan) and, secondly, at checking a modified method of grinding the apical part of the canal.

Material and Methods

Eighteen human single-rooted teeth which had been previously extracted with attached apical lesions were investigated. The diameter of apical pathosis was from 3 to 6 mm. Following extraction, the teeth were stored in isotonic saline solution for up to 12 hours. Tooth lengths were measured with the Root ZX and a No. 10 K-file in an alginate mould and the data was recorded (group A). This model was developed by Katz et al. [5] and used in other studies [4, 6]. After removal of lesions, the teeth were embedded in freshly mixed alginate and afterwards measured a second time (group B). Then the file was secured in place with some composite material. From this point, each procedure was carried out under two-fold magnification. To localize the apical foramen, the tip of a No. 10 K-file was introduced without use of force through the apical foramen (Fig. 1). With a strong source of light and the file in place, it was possible to define the location of the canal and the cut surface. The apical 4 mm of the canal of each tooth was exposed by grinding with a water-cooled high-speed diamond drill until the apical part of the file was visible under a thin layer of dentine. Then the rest of the tissue was removed by the means of a scalpel and a No. 10 H-file. The distances from the file tip to the dentino-cemental junction and to the apical foramen were measured under an endodontic microscope (Karr, Switzerland) at ×17 magnification and AverMedia software (Fig. 2). All measurements that were beyond the apical constriction were designated as positive and all which were coronal to the apical constriction (CDJ) were considered negative [7]. The statistical analysis was carried out using the Student t-test for dependent variables.

Fig. 1. The tip of a No. 10 K-file was introduced approximately 2 mm deep through the apical foramen

Ryc. 1. Koniec narzędzia o rozmiarze 10 wg ISO wprowadzono do kanału przez otwór anatomiczny na głębokość około 2 mm

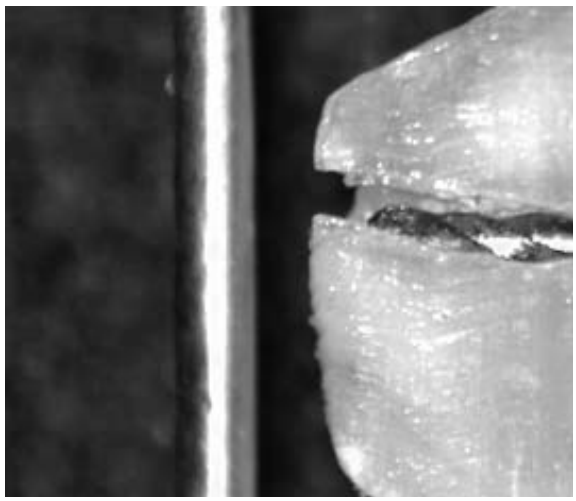

Fig. 2. The microscopic image of the apical portion of a tooth from the study. The needle is an object with known diameter used to calibrate the Aver Media program before measurements

Ryc. 2. Obraz mikroskopowy odsłoniętej części kanału. Igła do znieczuleń o znanej średnicy umożliwia kalibrowanie programu służącego do pomiaru odległości na zdjęciach (program Aver Media)

Results

The tooth lengths measured in group A were longer than in group B in 9 cases (by 0.25 to 1.25 mm) (Table 1). In the presence of apical lesions the measurements were too long in 7 canals by 0.15 to 1.3 mm. The difference between group A and B on average was 0.36 mm, with a mean deviation of 0.3 mm. There was a statistically significant difference between both groups at the probability level of $p < 0.05$.

Table 1. Tooth lengths. Distances from the file tip to apical foramen and CDJ

Tabela 1. Długości zęba. Odległość między końcem pilniczka a otworem anatomicznym i fizjologicznym

No (Lp.)	Tooth length in group A (Długość zęba w grupie A) mm	Tooth length in group B, (Długość zęba w grupie B) mm	Difference of lengths, mm (Różnica długości) mm	Distance from file tip to CDJ in group B, mm (Odległość między końcem pilniczka a otworem fizjologicznym w grupie B)	Distance from file tip to apical foramen in group B, mm (Odległość między końcem pilniczka a otworem anatomicznym w grupie B)	Distance from file tip to CDJ in group A, mm (Odległość między końcem pilniczka a otworem fizjologicznym w grupie A)	Distance from file tip to apical foramen in group A, mm (Odległość między końcem pilniczka a otworem anatomicznym w grupie A)
1	10	10.5	–0.50	0.4	1.5	0.65	1.75
2	15	14.75	025	0.4	0.8	0.15	0.55
3	14	13.5	0.5	0.1	0.3	–0.4	–0.2
4	16.5	15.5	1	0.5	1	–0.5	0
5	17.5	17.25	0.25	–0.3	0	–0.55	–0.25
6	12	12	0	–0.3	–0.2	–0.3	–0.2
7	14.25	14	0.25	0.2	0.5	0	0.25
8	17.25	17.5	–0.25	0.1	0.7	–0.15	0.45
9	9	9	0	–0.6	0.4	–0.6	0.4
10	23.5	23	0.5	0	0.4	–0.5	–0.1
11	8	8	0	0.3	0	0.3	0
12	10	9	1	–0.3	0	–0.3	–1
13	11.75	11	0.75	0	0.1	–0.75	–0.65
14	11	11	0	0.3	0.5	0.3	0.5
15	8	8	0	–0.2	–0.1	–0.2	–0.1
16	15.25	14	1.25	0.2	0.6	–1	–0.66
17	10.5	10.5	0	0	0.2	0	0.2
18	11.25	11.25	0	0	0.2	0	0.2
Mean (Średnia)	10.8	11.9	2.7	0	0.25	–0.25	–0.33
Standard deviation (Odchyl. standard.)	2.5	4.5					

Discussion

Although electronic tooth length measurements are precise in 90–95% of cases [8], there are some factors which can make it difficult to take precise readings. Apart from Myers's phenomenon [9], the lack of a minor foramen (CDJ), perforations, ramifications, and bifurcations have their crucial importance [6, 10]. An important factor is to prevent electric current from escaping through metal or temporary restorations, blood, or pus. Another factor disturbing measurements is pulpitis, which is connected with changes in ion concentrations [11]. The influence of periapical pathosis is only mentioned in the literature on the basis of clinicians' experience, but has not yet been scientifically proven [12]. In the present study a No. 10 K-file was used for measurements. Katz et al. [5] have suggested that the use of a larger file can increase accuracy. Another point of view is that a small file is usually used during the first penetration of the canal to gain maximal tactile sense. Another study shows that the file size is not so important if an apical foramen is present [13].

Although this was only an *in vitro* study, the outcomes are similar to the author's clinical experience. The results show that length measurements of teeth without periapical lesions should be decreased by 0.5 mm in order not to enlarge the apical constriction. This has been already proved by Shabahang et al. [14].

Alginate was used as a conducting medium for the electronic apex locator, which was proposed by Katz et al. [5]. Thus, in order to simplify the test procedure in *in vitro* models, medium having similarities in resistance to periodontal tissues has been frequently used [15].

In order to reveal the file, grinding of the apical part of the root was performed according to the method described by Nguyen [4]. This method was criticized by Stein and Corcora [16] because in this way the apical part of the canal can be accidentally removed. In the present study the procedure, modified by the author, concerning the localization of the apical part of the canal found its application. There was no loss of the apical part of the canal during the grinding. Moreover, the grinding method is easier than the method of multilayer sections described by Stein and Corcora [16]. Other authors used SEM to measure distances in the apical part of the canal, which was difficult and caused some damaged samples [17]. The current method is similar in its simplicity to one described by Weiger et al. [18]. In this method, roots that had been previously notched were split into two parts that were later examined separately under the microscope. This, however, does not allow for fixing the file in place after the measurements, which is crucial in the opinion of the author of this study. For the precise localization of the apical foramen it proved helpful to mark it with a No. 10 K-file and observe the tooth under a strong light source.

The difference obtained in the present study of 0.36 mm between teeth with and without periapical lesions may be significant in endodontic treatment. It is even more important in devices such as the Tri Auto ZX, where a hypothetical minor foramen is automatically found and the canal would be enlarged up to this point. On the other hand, the outcomes in group B were clinically acceptable in 94.5% of cases, similar to but slightly higher than those obtained by other authors [19, 20]. This suggests that the measurements were not influenced by the apical resorption. The reason for obtaining longer measurements for teeth with apical lesions is unclear. It could be caused by the difference in ion concentrations between the inside of the canal and the apical lesions in group A or alginate (periodontal tissue) in group B. According to Kovacević and Tomislav [11], the accuracy of measurements deteriorated with decreasing ratio between the internal and external ion concentrations. Another reason could be some differences in conductivity of apical lesions and alginate. Other authors [21, 22] stated in their studies that the length of the canal featuring with larger conductivity is oversized. Thus further studies of lesion conductivity are indispensable.

The current study presents evidence for the conclusion that the presence of apical lesions in the tooth impacts predictably to a minor extent on the accuracy of measurement. However, this statement should be proved by further clinical studies as well as experiments on teeth with larger apical lesions and using other apex locators. It should also be considered whether measurements in teeth with apical lesions are influenced by apical resorption. The results of this research suggest that the presence of apical lesions negatively affects tooth length measurements and that the modified method of discovering the apical part of the canal proved to be useful.

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