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Comparison of the Shaping Ability of Hyflex® CM™ Files with ProTaper Next® in Simulated L-Curved Canals

Porównanie skuteczności opracowania sztucznych kanałów w kształcie litery L dwoma systemami maszynowymi: Hyflex® CM™ i ProTaper Next®

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of article

Abstract

Background. The aim of root canal treatment is to eliminate microorganisms from the root canal system. It consists of removing the infected pulp and shaping root canal system in order to facilitate irrigation and placement of a medicament or permanent filling material. In the last decade, many types of rotary root canal instruments have been introduced, varying in cross-section, blade and pitch design, and taper.

Objectives. The purpose of this study was to compare the shaping ability of Hyflex®CM™ Files with ProTaper Next®.

Material and Methods. Twenty resin blocks with simulated L-curved canals were used in this experimental study and randomly divided into two groups (ten in each). The canals were prepared with Hyflex CM Files and ProTaper Next to an apical size of 25 according to the recommendations of the manufacturer by crown-down technique. Each instrument was used only once. Before and after preparation blocks were fixed in a constant position and photographed. To investigate the shaping ability of instruments the amount of material removed at the different levels in the root canal, the change of working length and transportation of apex were measured. The results were statistically analyzed using *t*-test.

Results. There was a trend for the ProTaper Next to remove less material from the inner aspects of the canals in apical area when compared with Hyflex CM Files. In the present study, a significantly greater change of working length took place after use of ProTaper Next ($p < 0.01$). The difference between the average apical transportation in the compared systems was also statistically significant ($p < 0.01$).

Conclusions. Within limitation of this study, both systems prepared canals without significant shaping errors and no instruments fractured. Hyflex CM Files and ProTaper Next maintained artificial curvature well and were safe. Hyflex CM Files are more flexible than ProTaper Next (**Dent. Med. Probl. 2015, 52, 1, 54–61**).

Key words: Hyflex CM Files, ProTaper Next, root canal preparation, resin blocks.

Słowa kluczowe: Hyflex CM, ProTaper Next, opracowanie kanałów korzeniowych, bloczki żywiczne.

The aim of root canal treatment is to eliminate microorganisms from the root canal system. This can be achieved by chemo-mechanical preparation of the canal, which consists of removing the infected pulp and shaping root canal system in order to facilitate irrigation and placement of a medicament or permanent filling material [1]. The ideal preparation of the root canal is in the form of a continuously tapered shaped with the smallest diameter at the apical foramen and the widest diameter at the

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orifice [2]. At the same time, the procedure should avoid any iatrogenic events, such as transportation of the root canal, fracture of the instruments, formation of a ledge or perforation of the tooth [3].

Shaping the canal is the most time-consuming and difficult factor of root canal therapy. This can be achieved either by classical hand or by mechanical preparation [4]. Hand technique can be time-consuming and especially in narrow and curved canals aberrations can occur because larger instruments tend to straighten the canal [5]. In such canals, more flexible instruments made of nickel-titanium have been effective in minimizing complications during preparation. Niti-alloy (nitinol) has several advantages over stainless steel such as its greater flexibility due to superelasticity, the shape memory effect and a better resistance to torsional fracture [6]. In the last decade, many types of rotary root canal instruments have been introduced, varying in cross-section, blade and pitch design, and taper [7].

Hyflex® Controlled Memory™ NiTi Files (Coltene-Whaledent) (Fig. 1) are produced by an innovative methodology (patent pending) which uses an unique thermomechanical process that controls memory of material, making the files extremely flexible but without the shape memory of other NiTi files [8]. This gives the file the ability to follow the anatomy of the canal very closely, reducing the risk of ledging, transportation or perforation. The instruments were made from a specific nickel-titanium alloy that has been claimed to have a lower per cent in weight of nickel (52%). The manufacturer claims that these instruments are up to 300% more fatigue-resistant than instruments made from conventional NiTi wire [8]. Hyflex CM Files respond to pressure, torque and resistance with a lengthening of the spirals, which

Fig. 1. Hyflex CM Files basic set

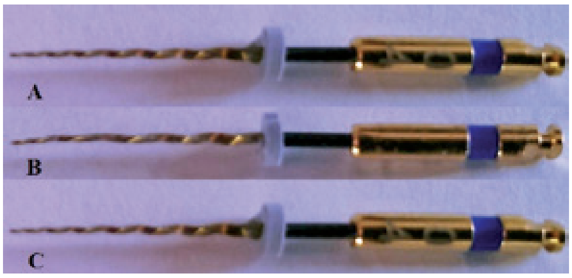

Fig. 2. Hyflex CM Files. A – before use. B – after use. C – after heat treatment

Fig. 3. ProTaper Next X1, X2 and X3 files

allows the file to avoid binding to the walls. By the heat treatment (e.g. during autoclaving) the instrument will return back to its original shape, enabling it to be re-used (Fig. 2). This system has double fluted cross section with uniform taper of 4%, 6% and 8% [9].

ProTaper Next® (Dentsply Tulsa Dental Specialities) consists of 5 files in different lengths namely X1,X2, X3, X4 and X5. In sequence, these files have yellow, red, blue, double black and double yellow identification rings on their handles (Fig. 3). ProTaper Next files are the convergence of 3 significant design features. The first is a variably tapered on a single file. The file with a decreasing tapered improves flexibility, limits shaping in the body of the canal and conserves coronal 2/3 dentin. Another design feature is the utilization of heat treatment technology, resulting in M-WIRE. Research has shown that M-WIRE, a metarugically improved version of NiTi, reduces cyclic fatigue by 400% when comparing files of the same D0 diameter, cross-section and taper [10]. The third design is an offset mass of rotation. A file with an offset design generates a travelling mechanical wave of motion along its active portion, resulting in only 2 points of contact between the file and dentin. This feature serves to decrease engagement and increase the capacity to auger debris out of a canal. What is more, the file with an offset mass of rotation will more safely and efficiently create the same-sized shape as would be required from a larger, stiffer, fixed-tapered file with centered mass of rotation.

Material and Methods

In the present study, 20 resin blocks (Endo Training-Blocks®, Dentsply Maillefer) with simulated artificial L-curved root canals were used and randomly divided into 2 groups (10 blocks in each). The canals were made with the use of silver cones with 2% taper and apical size 15. All canals were 17 mm long, consisting of a 11 mm long straight coronal part and a 6 mm long curved apical part. Before shaping, the blocks were filled with black ink. The canals were prepared by using a TECNIKA® endo motor (Dentsply Mailefer) with a constant speed of 500 revolutions per min (rpm) and torque set up to 2.5 N·cm (25 mN·m) for Hyflex CM Files and speed of 300 rpm and torque 2 N·cm for ProTaper Next. After each instrument, 2 mL of distilled waters were used as an irrigant. To produce efficient irrigation, the apical foramen communicated with the outside of the resin block. The canals were prepared with Hyflex CM and ProTaper Next to an apical size of 25 according to the recommendations of manufacturer by crown-down technique. Each instrument was used only once.

Before and after preparation, the blocks were fixed in a constant position and photographed. Photographs were taken with Canon EOS 600D® with Tamron AF® lens 18–200 mm, F 3.5–6.3 and MeiKe C-AF® ring. The distance between the lens and the block was 20 cm. The images were saved as JPEG files. Then, pre-operative and post-operative images were superimposed by GIMP 2.6®(Fig. 4).

To investigate the shaping ability of endodontic instruments, the amount of material removed at the different levels in the root canal, the change of working length and transportation of apex were measured.

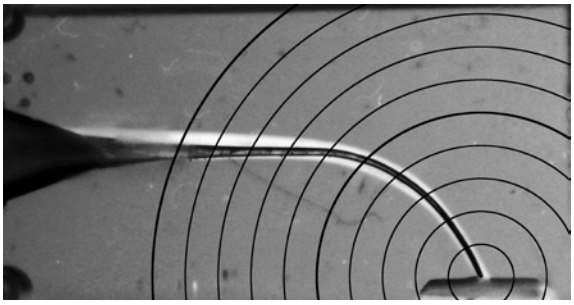

Fig. 4. Measurement circles

The amount of resin removed from both the inner and the outer sides of the canal in 1 mm steps were measured. Ten circles with the center of each in the apical point were plotted. A radius of the first circle was 1 mm from the apical point of the canal and radius of the last circle was 10 mm from the apical point, resulting in total of 20 measurements points (10 points on each wall). Measuring points are places where circles intersect with the canal walls before shaping. The amount of the removed material during shaping was defined by the distance between measuring points and the canal wall after the shaping procedure. The measurements were calculated in computer software after x200 image magnification, with accuracy to 0.01 mm.

The final length of each canal was investigated following the preparation with an endodontic ruler and a magnifying glass with accuracy to 0.25 mm. The loss of working length was determined by subtracting the final length from the original length of each canal (17 mm).

Transportation, i.e. apex shift towards the inside or outside, was calculated by the difference between an average amount of material removed from the outer curvature of a canal and an average amount of material removed from the inner curvature of a canal (measurement point 1 for the outer and inner curvature of a canal). When the difference was negative it meant that the apex was transported towards the inner wall of a canal, and positive on the outer one.

The results were statistically analyzed using the Student's *t*-test. The level of statistical significance was set at $p < 0.05$.

Results

Amount of Resin Removed

The comparison of an average amount of material removed (both from the inner and outer curvature) have been presented on Tables 1 and 2 and Figs 5 and 6.

Taking into consideration the outer curvature of canal, in 1, 2 and 3 measurement points greater amounts of removed material were observed in the canals shaped using the ProTaper Next, but only in point 2 the difference was statistically significant ($p < 0.05$). In the other points, greater average amount of removed resin were noticed for canals which were prepared with Hyflex CM and were statistically significant in 6 measurement points: 5–9 ($p < 0.001$) and 10 ($p < 0.05$). The smallest amounts of removed material were found in 1 measurement point for Hyflex CM and in point 5 for ProTaper Next. The biggest were confirmed in points

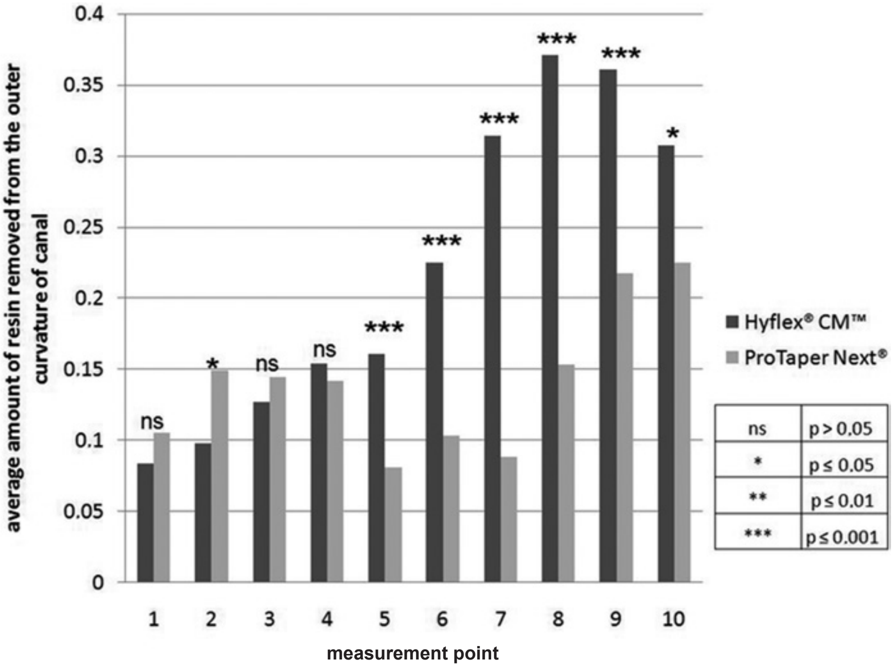

Fig. 5. Average amount of material removed from the outer curvature of canal (mm)

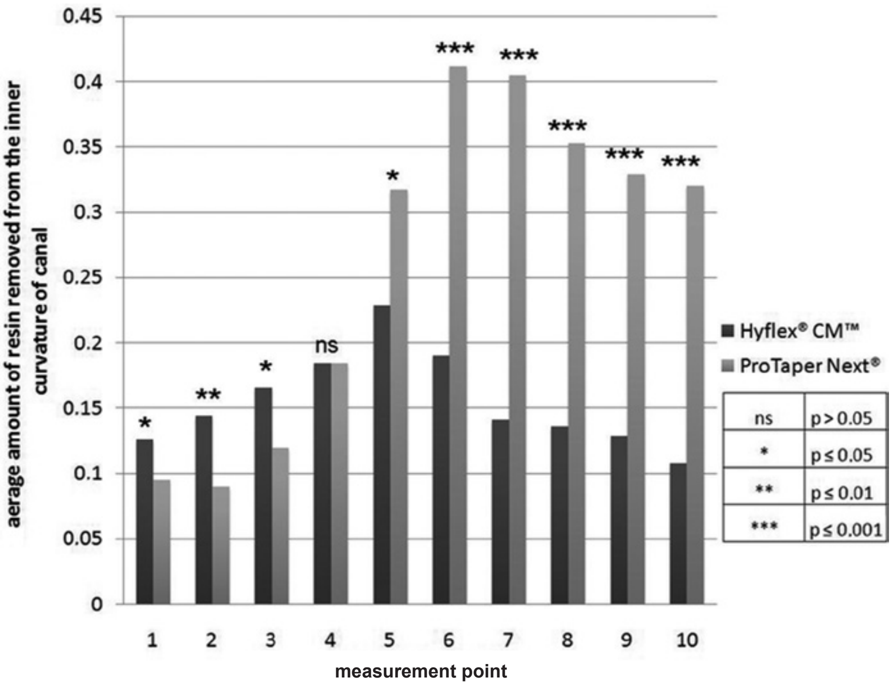

Fig. 6. Average amount of material removed from the inner curvature of canal (mm)

8 and 9 for Hyflex CM, and in points 9 and 10 for ProTaper Next.

Comparing the amount of material removed from the inner curvature, the differences were statistically significant in 9 measurement points (1––3, 5–10). In points 1–4 greater average amounts of removed material were found in the canals shaped using Hyflex CM. The smallest amounts of removed material were calculated in 10 measurement point for Hyflex CM and in point 2 for ProTaper Next. The biggest were confirmed in points 5 and 6 for Hyflex CM, and in points 6 and 7 for ProTaper Next.

Change of Working Length

The comparison of change in working length was presented in Table 3.

A statistically significant difference was found in case of a change in canal length for Hyflex CM and ProTaper Next ($p < 0.01$). A significantly greater change took place after use of ProTaper Next (0.22 ± 0.082 mm) as compared to shaping with Hyflex CM (0.08 ± 0.079 mm).

Table 1. Comparison of average amount of resin removed from the outer curvature of canal (mm)

Measure-ment point	Rotary system						T-test value	P test significance
	Hyflex CM Files			ProTaper Next				
	x arithme-tic mean	Me median	SD standard deviation	x arithmetic mean	Me median	SD standard deviation		
1	0.0835	0.0861	0.0321	0.1048	0.1048	0.0163	1.871	p > 0.05
2	0.0972	0.0969	0.0410	0.1486	0.1308	0.0601	2.238	**p < 0.05**
3	0.1265	0.1151	0.0436	0.1439	0.1243	0.0669	0.0690	p > 0.05
4	0.1538	0.1448	0.0365	0.1416	0.1178	0.0787	0.444	p > 0.05
5	0.1606	0.1432	0.0416	0.0808	0.0781	0.0341	4.695	**p < 0.001**
6	0.2246	0.2201	0.0450	0.1027	0.1065	0.0447	6.073	**p < 0.001**
7	0.3140	0.2978	0.0487	0.0877	0.0784	0.0435	10.956	**p < 0.001**
8	0.3706	0.3540	0.0551	0.1529	0.1295	0.0553	8.818	**p < 0.001**
9	0.3607	0.3537	0.0504	0.2173	0.1911	0.0730	5.112	**p < 0.001**
10	0.3072	0.3028	0.0580	0.2246	0.2027	0.0789	2.667	**p < 0.05**

Table 2. Comparison of average amount of resin removed from the inner curvature of canal (mm)

Measure-ment point	Rotary system						T-test value	P test significance
	Hyflex CM Files			ProTaper Next				
	x arithme-tic mean	Me median	SD standard deviation	x arithmetic mean	Me median	SD standard deviation		
1	0.1258	0.1284	0.0356	0.0947	0.0949	0.0272	2.193	**p < 0.05**
2	0.1440	0.1485	0.0352	0.0899	0.0904	0.0292	3.734	**p < 0.01**
3	0.1657	0.1574	0.0371	0.1197	0.1311	0.0383	2.730	**p < 0.05**
4	0.1845	0.1802	0.0348	0.1844	0.1818	0.0376	0.004	p > 0.05
5	0.2284	0.2358	0.0476	0.3175	0.3199	0.0998	2.547	**p < 0.05**
6	0.1902	0.2025	0.0442	0.4123	0.4179	0.1506	4.475	**p < 0.001**
7	0.1408	0.1562	0.0444	0.4048	0.3949	0.1234	6.366	**p < 0.001**
8	0.1360	0.1596	0.0490	0.3527	0.3325	0.0861	6.922	**p < 0.001**
9	0.1289	0.1497	0.0511	0.3288	0.3236	0.0716	7.182	**p < 0.001**
10	0.1079	0.1065	0.0520	0.3199	0.3185	0.0769	7.223	**p < 0.001**

Table 3. Comparison of change in working length for Hyflex CM Files and ProTaper Next

Rotary system	The parameters of canal's length change (mm)				
	min	max	x arithmetic mean	Me median	SD standard deviation
Hyflex CM Files	0	0.2	0.08	0.10	0.079
ProTaper Next	0.1	0.4	0.22	0.20	0.092
Comparison	**p < 0.01**				

Table 4. Comparison of apical transportation

Rotary system	The parameters of canal's apical transportation				
	min	max	x arithmetic mean	Me median	SD standard deviation
Hyflex CM Files	–0.145	0.049	–0.042	–0.037	0.062
ProTaper Next	–0.029	0.051	0.010	0.011	0.025
Comparison	**p < 0.01**				

Apical Transportation

The comparison of apical transportation was presented in Table 4.

In 8 cases for Hyflex CM and in 4 for ProTaper Next the apical transportation took place towards the inside wall of a canal (negative value). The average value was negative – 0.042 ± 0.062 in case of Hyflex CM and positive 0.010 ± 0.025 in case of ProTaper Next. The difference between the average apical transportation in the compared systems was statistically significant ($p < 0.01$).

Discussion

The purpose of this study was to compare the shaping ability of Hyflex CM Files with ProTaper Next.

For the evaluation of root canal preparation two experimental models are most often used: simulated root canal in resin blocks or root canals in extracted human teeth. Simulated root canals provide a standardization of root canal diameter, length and curvature in terms of angle and radius and allow direct comparison of the shaping ability of different instruments [11]. However, the resin might not represent clinical conditions owing to differences in the surface texture, hardness and cross sectioning of dentine [12]. Moreover, a major drawback of using rotary instruments in resin blocks is the heat generated [5, 13]. An increase in temperature as a result of friction of a file against canal walls softens resin material, leading to binding of cutting blades and separation of the instruments [14]. Despite some disadvantages, the use of resin block provides the same examination conditions and ensures repeatability of results interpretation.

When comparing the shaping abilities of different instruments, it is important to have similar apical preparation diameter [15]. In this investigation, the final apical diameter in all groups was a size 25.

In the present study, the amount of material removed from the inner and outer curvature of a canal, the loss of working length and apical transportation were compared.

In our study both systems prepared canals without significant shaping errors and no instruments fractured. Hyflex CM Files and ProTaper Next maintained artificial curvature well and were safe. The preparation of the canal with Hyflex CM Files resulted in more centric canal preparation. It was noticed especially in apical part of the canal, where the amount of removed resin in outer and inner curvature were quite similar.

The next measured parameter was the loss of working length. It has been shown in many studies that root canal instrumentation leads to changes in working length (WL) [5, 16]. It is important to control the WL to avoid over and under-extension. Controlling the WL during treatment maintains the apical constriction and allows for effective obturation of the canal system [17].

The observed loss of working length can be caused by a variety of factors. The WL may change as a curved canal is straightened [18, 19]. The loss may also be related to the accumulation of dentinal and pulpal debris in the apical 2 to 3 mm of the canal, or other factors such as failing to maintain foramen patency, skipping instrument sizes or failing to irrigate the apical 1/3 adequately. The working length is lost owing to ledge formation or to instrument separation and blockage of the canal [20].

In the study [21] where the shaping ability of ProTaper Next and ProTaper Universal® were compared, the loss of the WL was observed, and was smaller for canals which were prepared using ProTaper Next with the difference statistically significant. Saber et al. [22], who compared the shaping ability of ProTaper Next, iRaCe® and Hyflex CM rotary NiTi files maintained that the use of ProTaper Next resulted in significantly greater canal straightening than other files. Greater canal straightening results in bigger change of the working length. In present study, a significantly greater change took place after use of ProTaper Next.

The last measured parameter was apical transportation. By definition described in 2003 by the American Association of the Endodontics (AAE), apical transportation may take place by removal of the canal-wall structure on the outside of canal curvature, owing to the propensity of the files to self-return to their original straight shape during preparation of the canal [23]. Weine et al. [24] stated that if transportation has occurred it is impossible to get back to the original canal shape, particularly in curved canals.

Various studies have demonstrated that NiTi rotary instruments in comparison to stainless files can better maintain the original shape of the canals [25, 26]. According to McSpadden research, less canal transportation occurs when the file has greater flexibility, an asymmetrical cross-section design and a radial land [27]. Lack of radial lands causes the file during instrumentation to concentrate all the pressure of the cutting edges on the canal wall and tends to straighten the curvature [27]. Schäfer et al. [28] maintained that the size of a taper is one of the main factors involved in apical root transportation, because an increase in the taper reduces instrument flexibility and therefore recommended that Ni Ti files with tapers greater than 4% should not be used to shape the apical area of curved canals.

Kumar et al. [29] in evaluating canal transportation of Twisted Files® and Hyflex CM Files underlined the difference between canal transportation was not significant. Also Zhao et al. [30] showed no statistical difference in canals transportation between Twisted Files and Hyflex CM Files. Saber et al. [22] in their study, where ProTaper Next, iRaCe and Hyflex CM were compared, found no significant differences between the 3 groups with respect to apical transportation. In the study [21] about comparing the shaping ability of ProTaper Next with ProTaper Universal, the difference between apical transportation was statistically significant. The transportation towards inner aspect was smaller for canals which were prepared with ProTaper Next. In the present study, the difference between the average apical transportation in the compared systems (Hyflex CM and ProTaper Next) was also statistically significant.

Within limitation of this study there was trend for the ProTaper Next to remove less material from the inner aspects of the canals in apical area when compared with Hyflex CM Files. This suggests that Hyflex CM Files are more flexible than ProTaper Next. However, it can be concluded that both systems respected original canal curvature well.

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