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Canal Aberration Assessment in Simulated Root Canals: a Comparative Study

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ABSTRACT

Aim: The aim of this study was to compare time of preparation and canal aberrations in a simulated root canals after using three different rotary systems: Endostar E5, Endostar E3 and T One File Gold. **Materials and Methods:** A total of 90 endodontic training blocks were used in this study and divided into three groups consisting of 30 each (n = 30). Blocks processing was performed by thirty dentists without any prior experience in rotary instrumentation techniques. In the first group blocks were prepared using Endostar E5, in second one with Endostar E3 and in third one with T One File Gold system. The preparation time was measured. The postoperative image of each block was taken by stereomicroscope and canal aberrations (ledge and instrument fracture) was recorded. Statistical analysis was done by SPSS software. **Results**: Instrumentation with T One File Gold system is significantly faster compared to instrumentation with Endostar E5 and Endostar E3 systems ($p < 0.05$). There are no statistically significant differences in the type and number of procedural errors between Endostar E5, Endostar E3 and T One File Gold systems when the operators have no previous experience in rotary instrumentation techniques. **Conclusion:** Under the conditions of this study, the incidence of examined canal aberrations were similar for all tested systems. The preparation time was significantly shorter with single file system.

Keywords: endoblocks, root canal preparation, canal aberration, simulated root canals.

1. INTRODUCTION

The proper shaping of the root canal is one of the basic preconditions for the long-term success of the endodontic treatment. The instruments designed for treatment of root canals are constantly updated and developed. In current trends of instrumentation increasing attention is given to rotary instrumentation techniques with Ni-Ti rotating instruments. The reason for this is primarily the speed and efficiency of the cleaning and shaping of the root canal.

Time needed for canal preparation is significantly longer with manual than with rotary instrumentation techniques (1). At the same time, time consumption depends on the experience of the therapist (2). Ni-Ti endodontic rotary systems provide canal preparation with fewer procedural errors (3, 4). However, complex anatomy of the root canal makes the mechanical preparation one of the most difficult tasks and errors are possible regardless of the applied instrumentation technique. The apical area of the root canal is the most difficult area to clean and to maintain the natural canal shape (5), so the procedural errors, such as ledge formation and instrument fracture are most common in this part of the canal (6).

A ledge is iatrogenic created irregularity of the root canal wall, which occurs when the file attempts to continue in a straight line rather than the curved path of the canal and "stuck" in the dentinal wall which interferes with the placement of the intracanal instrument to the apex. It most often occurs on the outer side of the curvature as a platform. Therefore, the greater the curvature of the root canal, it is likely forming ledges. Further application of force in the zone of ledge will result in root canal perforation.

The fracture of Ni-Ti files can occur due to torsion and fatigue. Torsional fracture occurs when the top or any other part of the instrument is blocked in the canal, while the handle is still turning and there is accumulation of torsional stress within the material. After exceeding the elastic limit of metal, fracture occurs on the instrument tip. The other type of instrument fracture is caused by metal fatigue resulting in flexural fracture. The fatigue is greater when the instrument is used in a curved canal (7).

According to some opinions, untrained therapist is the main factor of failure in working with Ni-Ti rotary instruments (8).

2. GOAL

The aim of this study was to compare procedural errors in rotary instrumentation with five, three and one file in simulated root canals (endo blocks), and the time of manipulation. Operators were dentists with no previous experience in rotary instrumentation techniques.

3. MATERIALS AND METHODS

Simulated canals

Ninety acrylic-resin simulated root canals with a single curvature of 60°, a taper of 0.02, an apical diameter of 0.15 mm and length of 16.5 mm (Endo Training Bloc; VDW co; Munich, Germany) were used in this study. The blocks were randomly divided into 3 groups (n = 30).

Instrumentation of simulated canals

The instrumentation of all blocks was performed by thirty dentists without any prior experience in rotary instrumentation techniques. Before starting work, all participants were instructed on proper working with Endostar E5, Endostar E3 Basic Rotary System and T One File Gold systems.

The patency of the root canals was confirmed with a stainless steel #10 K-file (Poldent Co., Warsaw, Poland). All files were used in full clockwise rotation with constant rotational speed of 250 rpm generated by NSK endo-mate TC (Endo-Mate TC, NSK, Nakanishi Inc., Tokyo, Japan) and changing torque from 0,5 to 4 Nm according to the manufacturer's instruction. Endo-prep gel (Cerkamed; Poland) was used as a lubricant before using of each file and 1,5% NaOCl (Semikem, Bosnia and Herzegovina) was used as a irrigant.

Group 1:

In this group, the canals were prepared using Endostar E5 (Poldent Co., Warsaw, Poland). System Endostar E5 is classical multi-sequential system based on the crown-down technique which consists of 5 nickel-titanium files, numbered 1, 2, 3, 4, 5 and marked with blue stripes on the handle. The method for canal preparation was as follows:

- a file with one strip was used to prepare the first 6 mm,
- a file with two strips was used to prepare the next 5 mm,
- a file with three strips was used to prepare the next 1-2 mm,
- a file with four strips was used to prepare the next 1-2 mm,
- a file with five strips was used to the full working length of 16.5 mm,
- a file with four strips was used to the full working length of 16.5 mm,
- a file with three strips was used to the full working length of 16.5 mm.

Group 2:

In this group, the canals were prepared using Endostar E3 Basic Rotary System (Poldent Co., Warsaw, Poland). This system is consist of three files: a file with taper 0.08 and tip diameter 30 marked with one strip, a file with taper 0.06 and tip diameter 25 marked with two strips and a file with taper 0.04 and tip diameter 30 marked with three strips. The method for canal preparation was as follows:

- a file with one strip was used to prepare the first 8 mm,
- a file with two strips was used to prepare two-thirds of canal followed by a check of working length with hand file,
- a file with two strips was used to the full working length of 16.5 mm,
- a file with three strips was used to the full working length of 16.5 mm.

Group 3:

In this group, the canals were prepared using T One File Gold (Global Top Inc., Goyang, Korea), which is a single file system. A file with taper 0.06 and tip diameter 25 was used for preparation.

Preparation time

The time for canal preparation, which included active instrumentation, replacement of files and irrigation, was recorded.

Assessment of canal preparation

A postoperative image of each sample was taken under the same conditions using stereomicroscope (Novex RZ-series, Euromex microsopes BV; NL) at magnification of 10X. Each image was assessed for the presence of ledge and instrument fracture. The tendency to canal perforation, which in simulated conditions could not occur, is also registered as ledge formation.

Statistical analysis

Statistical analysis was done by SPSS (IBM SPSS Statistics 21, SPSS inc., Chicago, USA). ANOVA was used to analyze the preparation times, and Chi-square test was used to analyze the incidence of canal aberrations.

4. RESULTS

Preparation time

Instrumentation with one file showed significantly faster compared to the instrumentation with three and five files ($p<0.05$). Mean instrumentation time was 128.4 ± 13.9 s for Endostar E5 system, 109.4 ± 11.9 s for Endostar E3 system and 85.8 ±10.2 for T One File Gold system.

Group (n=30)	instrument fracture	ledge
Endostar E5	4	13
Endostar E3 Basic Rotary System	3	13
T One File Gold	4	14

Table 1. Type and number of procedural errors in relation to the system of instrumentation

Procedural errors

As shown in Table 1. the most common procedural error was the ledge formation (Figure 1 and Figure 2) which have been recorded in 13 endo blocks processed

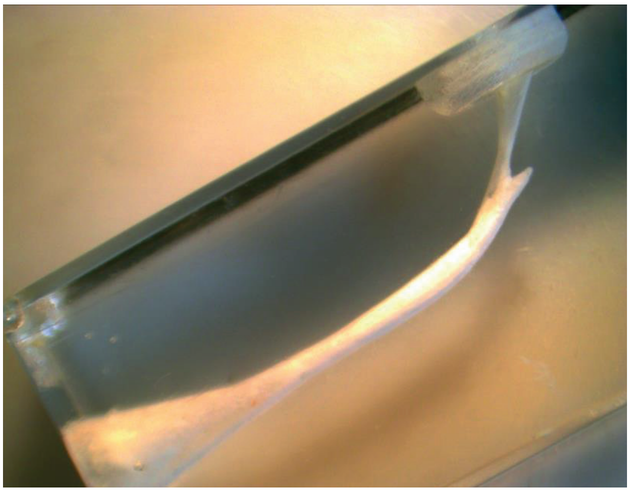

Figure 1. Extensive ledge formation under the stereomicroscope (10x).

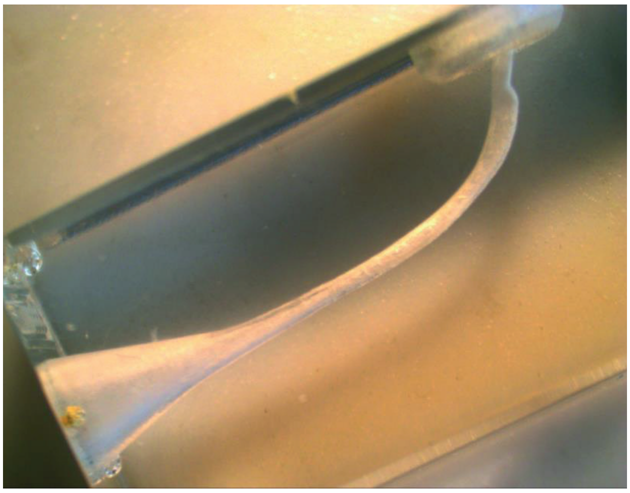

Figure 2. Ledge formation under the stereomicroscope (10x).

by Endostar E5 and Endostar E3 systems, and 14 endo blocks instrumented by T One File Gold system. The instrument fracture (Figure 3) was recorded in 4 blocks processed by Endostar E5 and T One File Gold and 3 blocks instrumented by Endostar E3 system. There were no statistically significant differences in type and number of procedural errors related to the system of instrumentation.

5. DISCUSSION

The purpose of this study was to evaluate differences in the canal aberrations after using three different rotary systems. Operators were beginners in rotary instrumentation techniques. The study was performed on simulated root canals.

Although the preparation on simulated root canals is not completely identical as working in vivo, these blocks are suitable for the assessment of procedural errors that occur during the instrumentation of the canal, as well as for estimation the time required for rotary instrumentation techniques. Variations of anatomy that are normally seen on extracted teeth (differences in the morphology of access cavity and root canals, hardness of the dentin, working length...) are excluded on simulated blocks (9). Shape, length and hardness of canals on simulated blocks are in standardized form and are exactly the same, which eliminates the need for a larger number of samples. Due to the transparency of blocks, it is possible to clearly see some procedural errors occurred during the treatment of root canals.

The occurrence of canal aberrations is associated with the apical diameter of the processed canal, wherein the number of aberrations increases as the apical diameter is over 35 (10). In this study, the root canals are processed by crown-down technique, using Endostar E5 (apical diameter of last file in system is 30), Endostar E3 (apical diameter of last file in system is 20) and T One File single file system (apical diameter of one file in system is 25). Therefore, the canal aberrations that have been identified in this study are not associated with the apical diameter of the processed canals.

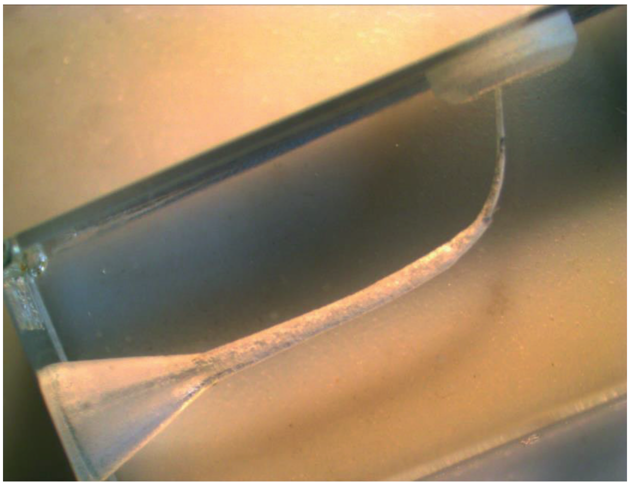

Figure 3. Instrument fracture under the stereomicroscope (10x).

As researchers already stated, canal aberrations could be attributed to operators' inexperience in working with rotary files (2, 11).

In this study, ledge formation proved to be the most common procedural error during canal preparation, although with no statistically significant differences between the used systems. This is in agreement with previous research Sonntag et al (12). The existence of the curvature of the canal is the most significant variable in the incidence of ledge formation (11). For processing canals with the complex morphology, it is necessary to use the Ni-Ti rotary files with smaller taper but higher flexibility (13). Schäfer found that flexibility of Ni-Ti instruments decreases with increasing of file taper, and for processing apical third of curved canals recommended using files with taper less than 0.04 (9).

Ledge formation in this study could occur due to forcing major instruments in the curved canal.

In this study there was no statistically significant difference in the number of separated instruments among the tested systems, which is consistent with previous research (12), although the number of separated files is higher than in the above mentioned study.

The occurrence of instruments fractures can be attributed to inexperienced operators as the most consistent and most predictable parameter. Mandel et al stated that incidence of instrument fracture decreased with the number of processed blocks, indicating the importance of the gained experience of each operator (8).

It has to be considered that in this study operators were beginners in rotary instrumentation, without clinical or any practical experience. Therefore, it can be said that experience is the key factor for successful rotary canal treatment. This is in agreement with the research Yared et al (14) and Munoz et al (2) which showed that the majority of procedural errors occurred with most inexperienced operator.

A possible reason for the file fracture in the plastic simulated block is existence of friction that leads to an increase in temperature, softening of the plastic and the blade interlocking into the wall, resulting to separation of the instruments (16).

Single-file systems were invented to simplify the process of rotary canal treatment and to prevent cross-contamination of instruments. In this study, the canals were processed significantly faster with single file system compared to other tested systems, which corresponds to the previous studies (17, 18).

The obtained results are not only related to the processing time, but also to the total time required for the establishment of patency, canal irrigation, file replacing and recapitulation. Processing time depends on the operator s experience and is inversely proportional to the experience (2). Previous studies stated that quality of canal treatment depends on the type of used rotary technique as well as the file number in the system (18), which in our study also proved to be an important factor.

6. CONCLUSION

Taking into consideration the limitations of this study it can be concluded that, operators with no previous experience in rotary instrumentation techniques do similar procedural errors during root canal processing, regardless of the used instrumentation system. The preparation time was significantly shorter with single file system.

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