Comparative evaluation of apically extruded debris during root canal instrumentation using two Ni-Ti single file rotary systems: An *in vitro* study

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**Abstract**

**Background:** Apical extrusion of debris during instrumentation is detrimental to the patient.

**Aim:** The aim of this study was to evaluate the apical extrusion of debris during root canal instrumentation using two single file rotary Ni-Ti systems.

**Materials and Methods:** Thirty freshly extracted mandibular premolars with straight roots were sterilized and divided into two groups instrumented using: One Shape rotary Ni-Ti system with Endoflare orifice shaper (Group 1) and Neo-Niti rotary Ni-Ti system with C1 orifice shaper (Group 2). Preweighed Eppendorf tubes fitted for each tooth before instrumentation. During instrumentation, 1 mL of distilled water with a 30-gauge needle was used to irrigate after every instrument. Tips of the tooth were irrigated with 2 ml distilled water after removal from Eppendorf tubes. The total volume of irrigant in each group was the same 8 ml. All tubes were incubated at 68°C for 15 days and subsequently weighed. The difference between pre- and post-debris weights was calculated, and statistical analysis was performed using independent *t*-test and level of significance was set at 0.05.

**Results:** The difference between pre- and post-weights was significantly greater for the One Shape system.

**Conclusions:** The Neolix Niti single file was associated with less extrusion compared to One Shape single file system.

**Keywords:** Apical extrusion; Neo Niti; One Shape; single file system

**INTRODUCTION**

The cleaning of the root canal system and the removal of inflamed and/or necrotic tissue remain one of the most important steps in endodontic therapy.[¹] Dentine chips, pulp tissue fragments, necrotic tissue, microorganisms, and intracanal irrigants may be extruded from the apical foramen during the canal instrumentation, which may cause pain or flare-up.[²]

The interappointment flare-up is a true complication characterized by the development of pain, swelling, or both, which commences within a few hours or days after root canal procedures and is of sufficient severity to require an unscheduled visit for emergency treatment.[³] The causative factors of interappointment flare-ups comprise mechanical, chemical, and/or microbial injury to the pulp or periradicular tissues.[²,⁴] In asymptomatic chronic periradicular lesions associated with infected teeth, there is a balance between microbial aggression and host defense in the periradicular tissues. Microorganisms that are extruded apically during chemomechanical preparation cause the host to be challenged by a larger number of irritants than before. Consequently, the transient disruption in the balance between aggression and defense will cause the host to mobilize an acute inflammation to reestablish the equilibrium.[³]

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At present, all preparation techniques and instruments are associated with extrusion of debris, even when the preparation is maintained short of the apical terminus. Vande Visse and Brilliant were the first to quantify the amount of apically extruded debris during instrumentation.[6] Several studies reported that instrumentation with an in-and-out motion tended to produce more apically extruded debris than instrumentation with rotational motion.[7] This has led to the assumption that engine-driven rotary instruments produce less extrusion than hand instrumentation as rotary instruments have a tendency to pull the debris into their flutes, thus leading the debris out of the root canal in a coronal direction.[7]

Recent advances for root canal preparation have focused on the concept “Less is more.” Single file system was used to shape the root canal completely from start to finish. They have advantages such as lower cost, decreased shaping time allowing the clinician to spend more time on cleaning the canal with more advanced irrigation technique. Furthermore, the system eliminates procedural errors using a single instrument rather than using multiple files.[8]

Recently, ORIKAM Healthcare Private Limited (France) has introduced a new file system called “Neo-Niti.” The company claims that innovative electric discharge machining process is responsible for its unique and superior behavior.

MICRO-MEGA® offers One Shape®, Ni-Ti instrument in the continuous rotation for quality root canal preparations. One Shape® allows for curved canal negotiation with an instrumental and easy dynamic. Its nonworking tip ensures an effective apical progression avoiding obstructions which are often preceded by instrument separation. Both the systems are single files with one coronal shaping instrument.

Thus, the purpose of this study is to compare in vitro the amount of debris extruded apically using One Shape and Neo-Niti rotary instruments. The null hypothesis is that there is no difference between these file systems in the apical extrusion of debris.

**MATERIALS AND METHODS**

Thirty freshly extracted mandibular premolar teeth were selected and disinfected with chloramine T. Radiographs in buccal and proximal directions were taken for the presence of a single canal. The teeth were cleaned of debris and soft-tissue remnants and stored in distilled water. To ensure standardization of tooth length of 16 mm, all teeth were measured and decoronated with a high-speed diamond disk. Then, an access cavity was prepared in each tooth. Working length was determined by advancing a size 10 K-file into the canal until it was just visible at the foramen and then subtracting 1 mm from this measurement. The size of the minor constriction was standardized, and any tooth where the size 15 K-file extruded beyond the apical foramen was excluded. For each tooth, one Eppendorf tube was preweighed for three consecutive measurements using an electronic weighing machine. The selected teeth were mounted on rubber caps of vials through standardized holes created using a biopsy punch. The apical part of the root was suspended within the Eppendorf tube, which will act as a collector for extruded debris, and the whole assembly was placed in a vial. The assembly was then randomly divided into two groups using the coin toss method: Group 1 - One Shape system and Group 2 - Neo-Niti system. To prevent bias on the basis of visibility, the glass vials were painted on the exterior with single color coding for each group: black for Group 1 and red for Group 2. The operator was blinded as regards the rotary system for each group. A bent 27-gauge needle was forced alongside the stopper to equalize the internal and external air pressure. Canal preparation and irrigation were conducted by a single operator for both groups.

**Group 1**

One Shape Ni-Ti rotary instruments were used at 400 rpm at a maximum of 2.5 N/cm torque according to the manufacturer’s instructions. The Endoflare which has a tip size of #25 and taper of 0.12 was used in the coronal 3 mm of the canal in an in-and-out motion. This was followed by the use of the One Shape file with a tip size of 25 and taper of 0.6% in an in-and-out motion without pressure.

**Group 2**

Neo-Niti files were used at a speed of 300 rpm as per the manufacturer’s recommendations. The size 25/0.12 taper instrument (C1) was used for coronal flaring only in the coronal two-third. The size 25/0.06 taper instrument (A1) was used up to the full working length using pecking motion and cleaning the instrument in between and following the established standardized irrigation protocol.

During root canal instrumentation, 1 ml of distilled water was used after every time the instrument is withdrawn.

**Figure 1:** Eppendorf tubes with extruded debris. (a) One shape system, (b) Neolix NiTi system
from the canal. Irrigation was performed with an in-and-out motion of the syringe using a side-vented 30-gauge needle placed (Max-i-Probe, Max-i-Probe, Dentsply Rinn) up to 3 mm of the working length. The total volume of irrigant in each group was the same - 8 ml (4 ml during instrumentation + 2 ml final irrigant + 2 ml external wash) for every tooth. The apex was prepared till #25 file in both instrumentation techniques. The external tip of the tooth was irrigated using 2 ml distilled water. The Eppendorf tubes were stored in an incubator at 68°C for 5 days to facilitate the evaporation of the moisture before weighing the dry debris using an electronic balance.

Weighing was carried out on an electronic balance for three consecutive weights for each sample, and the average was calculated. The evaluator was blinded to the preparation technique used for the respective groups. The measurements obtained were statistically analyzed.

Statistical analysis was done using SPSS, version 12 (SPSS Inc., Chicago, USA). The mean variance of the variables was analyzed using independent t-test, and the P value was set at 0.05.

RESULTS

The results of the independent t-test are tabulated in Table 1. The Neo-Niti file system performed most efficiently and showed the minimum amount (P < 0.05) of apical extrusion of debris among the two file systems used.

DISCUSSION

One of the most significant complications as a consequence of apical extrusion is an interappointment flare-up due to inflammatory reactions. It causes resorption, edema, and postoperative pain which is an undesirable occurrence both for the patient and the dentist.[2,7] Many factors affect the amount of extruded debris such as the preparation end-point, irrigation solution type and quantity, instrumentation size, technique, and instrument type.[9,10]

| Group               | n  | Mean    | SD   | SEM  | Mean difference | P     |
|---------------------|----|---------|------|------|-----------------|-------|
| Preweighted         |    |         |      |      |                 |       |
| One shape system    | 15 | 2.200   | 0.109| 0.028| −0.031          | 0.401 |
| Neo-NiTi system     | 15 | 2.230   | 0.086| 0.022|                 |       |
| Postweighted        |    |         |      |      |                 |       |
| One shape system    | 15 | 2.278   | 0.137| 0.035| 0.041           | 0.333 |
| Neo-NiTi system     | 15 | 2.237   | 0.087| 0.022|                 |       |
| Different           |    |         |      |      |                 |       |
| One shape system    | 15 | 0.078   | 0.135| 0.035| 0.072           | 0.049*|
| Neo-NiTi system     | 15 | 0.007   | 0.002| 0.001|                 |       |

*P<0.05 (independent t-test was used). SD: Standard deviation, SEM: Standard error of mean, NiTi: Nickel-titanium

Mature mandibular premolars between the age group of 25 and 40 years with single straight root and canal were used in the study. Thus, the results are valid only for teeth with fully formed apices and straight canals.[8]

Studies have shown that when instrumentation was performed to the apical foramen, significantly more debris was forced apically than when instrumentation was 1 mm short. In the present study, the working length was 1 mm short of the apical foramen so that variables which may affect results could be minimized.[6,11,12]

Irrigation is a necessary and important phase of cleansing the canal.[13] Distilled water was used as an irrigant to avoid any possible weight increase due to NaOCl crystal formation. The tubes were stored in an incubator to evaporate the moisture and weigh the dry debris. The 27-gauge needle functioned as an air vent to permit extrusion of irrigant.[14]

According to Abou-Rass and Piccinino, deep delivery of the irrigation solution into root canals results in more effective removal of debris. The disadvantage of this method of delivery may be an increased apical extrusion. In the present study, the total volume of 8 ml of distilled water was used for irrigating root canals between each file. The 30-gauge side-vented needle tip was inserted passively and never allowed to bind as the irrigant was being deposited into the canal. In addition, it has also been documented that a size 30-gauge irrigation needle fits freely at depths just short of the physiologic terminus providing sufficient volume of irrigant for efficient flushing action.[15] Various studies have shown that simple modifications in irrigation methodologies by selecting side-vented needles may be advantageous for the prevention of apical extrusion.[16]

Al-Omari and Dummer[17] reported that techniques involving a linear filing motion, such as step-back techniques, create a greater mass of debris than those involving some sort of rotational action. In previous studies, rotary Ni-Ti systems were mostly associated with less apical extrusion than manual instrumentation. To reduce the operator time and cost, newer single file system has gained popularity. The newer single-file Ni-Ti systems such as Neo-Niti and OneShape are designed to completely prepare root canals with only one instrument.

According to Küçükyılmaz et al.,[18] One Shape demonstrated less apical extrusion of debris than ProTaper and Reciproc file system. Nayak et al.[19] showed that between One Shape and Wave one, One Shape produces less apical extrusion. Hence, it was clear that single rotary file system exhibits less apical extrusion than multi-file rotary systems and reciprocation file systems.

In this study, NeoLix Niti single file system showed significantly better results and pushed less debris apically [Figure 1b] than One Shape single file system [Figure 1a].
The results were in conflict with those of Elmsallati et al.,[20] who showed that the short pitch design extruded less debris than the medium and long pitch design, since One Shape had a shorter pitch as compared to Neolix Niti system. However, standardization of apical diameter was not considered as well as the fact that Tinaz et al.[21] showed an increase in the extrusion of debris as the extent of apical patency increased.

Diemer et al,[22] compared the effect of pitch length and stated that the increasing variable pitch decreases the tendency to screw in and also reduces the helical angle which in turn reduces the apical extrusion, thus rationalizing the results in the present study wherein the Neolix Niti is characterized by a much greater variable pitch of 2.25–6.00 mm over the length of the file as compared to the constant pitch design of the One Shape.

The fluting volume which serves to accumulate debris is dependent on the pitch and depth of fluting. Hence, it can be implied that files with greater fluting volume will promote less extrusion of debris as compared to those with less fluting volume which may be the case in the present study.

Koch et al.[23] stated that files with constant helical angle allow debris to accumulate and varying the helical angle enhances removal of debris more efficiently. The Neolix Ni-Ti file possesses a variable helical angle of 28° to 16° from tip to rear as compared to the constant helical angle of the One Shape which explains the screwing in effect of One Shape and enhanced extrusion of debris while using the same.

The three-point contact of the blades at the tip with a changing triangular cross section of the One Shape may result in the greater generation of debris as compared to rounded gothic tip with nonhomothetic rectangular cross section with two-point contact of the Neo-Niti system.

The null hypothesis that there is no difference in the apical extrusion of debris between the two-file systems was rejected.

CONCLUSION
Both the rotary single-file systems used resulted in extrusion of debris beyond the apical foramen. The Neolix Niti single file system showed significantly less amount of extrusion than the One Shape single file system.

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Conflicts of interest
There are no conflicts of interest.

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