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# Evaluation of Different Retreatment Techniques in Single-Root Teeth by using Cone Beam Computed Tomography

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"Trabalho apresentado à Universidade Fernando Pessoa como

parte dos requisitos para obtenção do grau de

Mestre em Medicina Dentária."

Atesto a originalidade do trabalho,

_____

(Sara Sonim Garcia Benabon)

**RESUMO**

**Objectivo:** O presente estudo teve como objetivo a parametrização do material obturador removido durante o retratamento endodôntico, bem como a quantificação dos detritos extruídos pelos diferentes sistemas de instrumentação em análise.

**Materiais e Métodos:** 40 dentes monocanalares, com Tratamento Endondôntico prévio, foram selecionados e divididos em 2 grupos (n=20) de acordo com os sistemas em teste: Reciproc 25® (VDW, Munich, Germany) e Reciproc 25® adjuvado pela lima Xp-Endo Finisher® (FKG, La Chaux de Fonds, Switzerland). Todos os dentes foram digitalizados pela técnica "*Cone-Beam Computed Tomography*", antes e depois da remoção do material obturador. Foi calculada a área do material obturador remanescente recorrendo ao software de análise Adobe Photoshop CC 2015®, de forma a poder inferir, dados sobre a eficácia da remoção.

Os detritos extruídos pelo Foramen Apical foram coletados para Tubos de Eppendorf, sendo que, para cada dente, a sua quantidade foi pesada.

Os dados obtidos foram colocados em tabelas do Microsoft Excel e analisados estatisticamente recorrendo ao GraphPad Prism® versão 5.00 para Windows, GraphPad Software, San Diego Califórnia. O nível de significância foi fixado em 5% para todos os testes ($p < 0,05$).

**Resultados:** Não houve diferenças significativas na remoção de material obturador entre os sistemas em teste. A XP-Endo Finisher® originou maior quantidade de detritos extruídos.

**Conclusões**: A XP-Endo Finisher® não contribuíu para uma melhor remoção de material obturador e promoveu uma maior extrusão apical de detritos.

**Palavras-Chave**: "*Retratamento Endodôntico"; "remoção de gutta-percha"; "Reciproc 25®"; "Xp Endo Finisher®"; "Tomografia computorizada de feixe cónico"*

## ABSTRACT

**Objective:** The present study aim to parameterize the filling material removed during Endodontic retreatment, as well as to quantify the debris extracted by the apical foramen during the use of different systems.

**Material and Methods:** 40 single-canal teeth with Endodontic treatment were selected and divided into 2 groups (n = 20) according to the systems in test: Reciproc 25® (VDW, Munich, Germany) and Reciproc 25® supplemented by XP-Endo Finisher® (FKG, La Chaux de Fonds, Switzerland). All teeth were scanned by *a Cone-Beam Computed Tomography* technique before and after the filling material' removal. The total area of the remaining filling material was measured using the analysis software Adobe Photoshop CC 2015®, in order to infer data about the efficiency of the technique in test.

The debris extracted by the Apical Foramen were collected into Eppendorf Tubes and, for each tooth, its amount was weighed.

All data collected were organized into Microsoft Excel tables and, then, statistical analysed using GraphPad Prism® version 5.00 for Windows, GraphPad Software, San Diego California. The level of significance was set at 5% for all the tests ($p < 0.05$).

**Results:** There were no significant differences in the removal of filling material between the systems in test. XP-Endo Finisher® produced more apical debris extrusion.

**Conclusions**: XP-Endo Finisher® did not contribute to a better removal of filling material and promoted more apical debris extrusion.


**Keywords**: "*Endodontic retreatment"; "gutta-percha removal"; "Reciproc 25®"; "XpEndo Finisher®"; "Cone-Beam Computed Tomography"*.

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## GENERAL INDEX

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## Index of abbreviations

ADE- Apical Debris Extrusion

CEJ- Cementoenamel Junction

ET- Eppendorf Tubes

g- Grams

ISO- International Organization for Standardization

MD- Mesio-Distal

mL- Milliliters

mm- Millimeter

Ncm- Newtons per centimetres

Ni-Ti- Nickel Titanium

NSER- Non-Surgical Endodontic Retreatment

NSET- Non-Surgical Endodontic Treatment

R25- Reciproc 25®

RC- Root Canal

RCS- Root Canal System

Rpm – Rotation per minute

WL- Working Length

XP-F- XP-Endo Finisher®

# I. INTRODUCTION

Nowadays, it is widely accepted that a natural tooth with a good prognosis does not have to be lost or replaced (Kasam & Mariswamy, 2016). Root canal (RC) treatments have saved millions of teeth that, once, have been considered lost.

Although the Non-Surgical Endodontic Treatment (NSET) is, currently, a common, safe and predictable treatment with a success rate exceeding 93% (Silva *et al*., 2018), 25-40% of patients require retreatment due to some failure on NSET (Kasam *et al*., 2016; Tarallo *et al.*, 2018).

Non-Surgical Endodontic Retreatment (NSER) is the first choice to re-establish the health of periapical tissues when NSET doesn't succeed. The process requires the complete removal of the filling material from the Root Canal System (RCS) for a proper microorganism clearance (Khedmat *et al*., 2017).

In a NSER, a good removal of material filling is crucial. It must be duly done, at a three-dimensional level: there are several steps such as cleaning, shaping and filling of the RCS that should be perfectly performed (Ozyurek & Ozsezer-Demiryurek, 2017) in order to better assure success.

A variety of techniques have been proposed to remove filling materials from the RCS, including the use of Endodontic hand files, Nickel Titanium (Ni-Ti) rotary instruments, Gates Glidden burs, heated instrument, ultrasonic instruments, laser, and the use of adjunctive solvents, among others (Kasam & Mariswamy, 2016).

An ideal instrument should be able to remove all gutta-percha and sealer in a short working time, without deforming the RC space, with a minimum level of apical debris extrusion (ADE) and no instrument separation or occurrence of other untoward events. Currently, no Endodontic Retreatment technique has been able to demonstrate all of these features (Azim *et al*., 2018).

The Reciproc (R25) is a simple technique that use only a taper instrument made off super elastic Ni-Ti M-Wire that presents greater flexibility and resistance of cyclic fatigue than conventional Ni-Ti wire (Gavini *et al.*, 2012).

The XP-Endo Finisher® (XP-F) is a Ni-Ti MaxWire, a special alloy that is characterized by his expansion at body temperature and presents helical movements inside the RC. The remaining filling volume is significantly reduced after its use. (Vaz-Garcia, *et al.*, 2018). According to the manufacturer, this instrument does not remove tooth structure when activated in the RC. (De-Deus, *et al.*, 2019).

During de NSER, the ADE (root filling materials, necrotic pulp tissue, bacteria and irrigants) can cause pain and an inflammatory reaction in the apical region (Yilmaz *et al.*, 2018). The amount of that debris can influence the magnitude of that reaction (Uslu, *et al.*, 2018). The incidence of these complications is reported to range between 1.4 and 16% (Burklein *et al.*, 2014; Jain, 2018) and, so, avoiding or decreasing the ADE from the apical foramen might be an important factor for successful Endodontic Treatment (Yilmaz, *et al.*, 2018).

This project aimed to evaluate the effectiveness of different Endodontic Retreatment systems in its capacity of RC filling removal and to compare the amount of debris extruded from the apical foramen during the retreatment procedures.

The null hypothesis formulated were:
- higher values would be found in the amount of filling material removal in the group where the XP-F instrument was used;
- the R25 would cause less ADE.

## II. MATERIALS AND METHODS

Favourable opinion for this study was obtained by the Ethics Committee of the Health Sciences Faculty of Fernando Pessoa University (Annex 1).

### 1. Type of Study

Cross-sectional descriptive observational study of Endodontic Retreatment Systems.

### 2. *In vitro* Analysis

This project aimed to know the effectiveness of 2 distinct Endodontic systems in their capacity to remove the filling material: R25 (VDW, Munich, Germany) alone or supplemented by the XP-F (FKG, La Chaux de Fonds, Switzerland).

Only one operator did the whole experimental process.

From a total of 224 teeth, previously extracted and endodontically treated by Students of the pre-clinical classes of Endodontics in the Health Sciences Faculty of Fernando Pessoa University, 40 were selected that fulfilled the following inclusion criteria:

- oval-shaped canals
- single apical foramen
- absence of dental anomaly;
- absence of prosthetic crowns;
- absence of horizontal and/or vertical fractures;
- teeth with closed apex;
- permanent teeth;
- teeth without signs of cracks;
- presence of a single RC.
- teeth displaying a good filling.

## 3. Preparation of the Sample

The selected teeth were using the same protocol – a manual technique constituted by:

- instrumentation of the first 2/3 of RC ("*crown-down*")
- instrumentation of the apical 1/3 of the RC ("*step-back*")
- filling with lateral condensation technique.

Firstly, the sample was radiographed in a Mesio-Distal (MD) direction using a system of digital radiographies, Vista Scan® (Dürr Dental SE, Höpfigheimer, Germany) for posterior selection of teeth that fulfil the previously mentioned inclusion criteria.

The 40 best teeth were scanned, in the same way, using a fixed support where they were helded, by 3 Shape X1® "*Cone-Beam Computed Tomography"* (CBCT) scanner (3Shape Medical A/S, Copenhagen K., Denmark).

The teeth were randomly divided into 2 groups (n=20), taking into account that the 2 groups had equal number of incisors, canines and pre-molars.

After the retreatment procedure, all teeth were similarly anew exactly scanned as describe before.

The images obtained were then transferred to an image analysis system (Adobe Photoshop CC 2015®) and the remaining filling material was, then, quantified.

To quantify the eventual amount of ADE during the instrumentation process all teeth were placed into new Eppendorf Tubes (ET) covers. Using a warmed ball burnisher to make holes in the covers and insert the tooth until the cementoenamel junction (CEJ), so each tooth remained suspended in the interior of the ET, to collect the debris inside.

Two layers of varnish (Risqué®, São Paulo, Brazil) were placed to seal the cervical part of the tooth around each tooth near the CEJ. Then a needle was introduced in the cover of each ET, laterally to the tooth to balance the pressure inside the tube (Figure 1).

**Figure 1-** Photographic illustration of the experimental setup.

The number of the teeth correctly identified each ET, so that they could be individually weighted and the amount of ADE could also be respectively registered.

First of all, each ET used was weighted 3 consecutive times by an analytic balance LPC-513L (VWR, Leuven, Belgic) before the instrumentation process beginning. This measurement was produced in order to obtain the mean for the initial weight.

After the preparation of the test set, each tooth was immersed in a warm bath at a temperature of 36 °C, to mimic physiologic conditions (Figure 2) in order to proceed to the filling material removal techniques in test.


**Figure 2 –** Teeth immersed in a warm bath at a temperature of 36 °C

Once finished all this procedures, each ET was again weighed as described above, so that, it could be calculate the average of ADE.

To quantify the amount of debris in the end of the procedures each ET was filled with 2,5% NaOCl until the irrigant volume performed 1.25ml.

Three controls ET (C1, C2, C3) were full with the same amount of NaOCl and previously weighed 3 times, as described before.

Then, all ET were placed in an incubator for 8 consecutive days at a constant temperature of 40°C, with the lids open, allowing the liquid to evaporate (Figure 3 and Annex 2).

**Figure 3 -** Incubator at 40°C with the Eppendorf Tube lids open

The ET were again weighed 3 times (Annex 3) as described above. The total amount of ADE was calculated as the difference between the pre and post retreatment weight.

## 4. Retreatment Procedures

All used retreatment systems were applied by following the manufacturer's instructions. In both experimental groups, the instruments were placed in a contra-angle hand piece in a motor Wave One® (Dentsply Maillefer, Ballaigues, Switzerland).
For each tooth, the determination of the working length (WL) was obtained by radiography in a BL (Bucco-Lingual) direction.

### 4.1 Reciproc 25® Group

The R25 is a single file system. The instrument R25 (25.08) was moved in the apical direction in a reciprocating motion, using a slow in-and-out pecking motion of about 3 mm in amplitude with a light apical pressure combined with brushing action against the lateral canal walls. After 3 or 4 pecking motions, the instrument was removed and cleaned. This file was used at 300rpm and torque (2N/cm). The canals were irrigated by applying a total of 2mL of 2,5% NaOCl during the instrumentation. Any irrigant that eventually overflowed through the crown was absorbed with cotton rolls. (Figure 4)

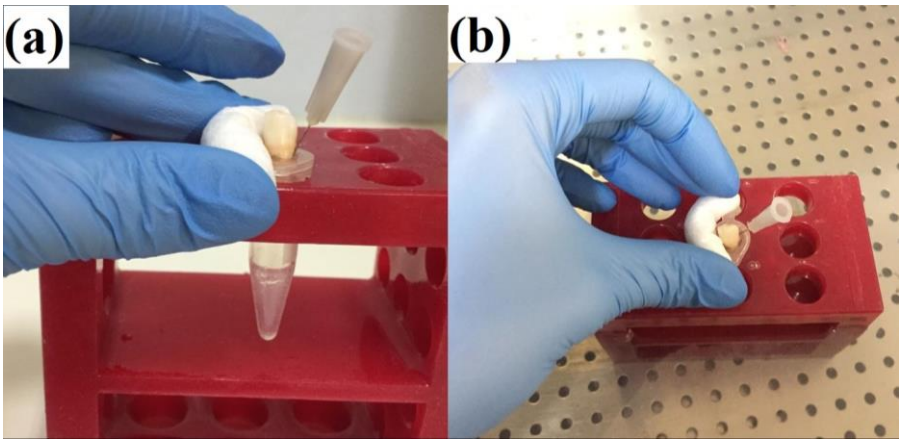


**Figure 4 –** Illustration of the cotton roll absorbing the eventual overflow of irrigant**:** (a) tooth outside the warm bath; (b) tooth inside the warm bath.

### 4.2 XP-Endo Finisher® Group

As recommended by the manufacturer, the instrument was removed from the plastic tube immediately before the XP-F file was inserted into the RC, being the depth of this first insertion a value that would vary from 7 to 8mm. Until this point, rotation has not been activated. From this moment on, the XP-F file started to rotate slowly and gently at 800 rpm and 1 Ncm, until the WL was reached.

The instrumentation process was divided in 6 periods of 10 seconds each. In each and every period the file was removed from the RC and the tooth was irrigated. For the all 6 periods, a total of 1 mL of 2.5% NaOCl was used.
Finally, each RC was irrigated with 2 mL of 2.5% NaOCl using a syringe needle 1 mm short of the WL. Any irrigant that eventually overflowed through the crown was absorbed with cotton rolls, as described before.

## 5. Statistical Analysis

The data, before and after filling material removal and the amount of the ADE, were collected into Microsoft Excel tables and then statistical analysis to compare the experimental groups was performed using GraphPad Prism® version 5.00 for Windows, GraphPad Software, San Diego California. The level of significance was set at 5% for all the tests ($p < 0.05$). A D'Agostino & Pearson normality test was applied to evaluate the normality of data distribution. A ANOVA (one-way) test was applied to compare whether there were significant differences between the VP and BL projections. Moreover, a Student t-test was applied to check for differences in the weight of the debris.
All tests were carried out in order to compare between the groups tested, which system was more effective.

## III. RESULTS

Analysis of the total area revealed no statistical differences between the systems in test ($p > 0.05$) (Chart 1). There is no significant difference in the percentage of the filling material' reduction, between both groups.

In addition, group R25 had no difference regarding the percentage of RC filling removal in both directions. In the MD the percentage of removal was up to 84% and in BL was 87%. On the other hand, in the group R25 supplemented by XP-F there was a higher percentage of RC filling removal in the MD direction 95% comparing to the BL 90%; however this difference had no statistical significance.

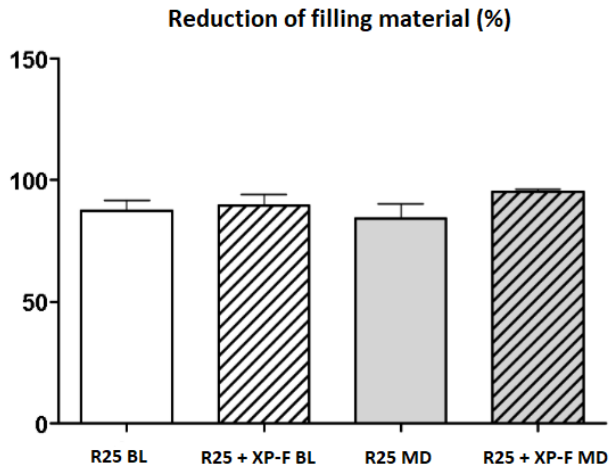


**Chart 1-** Percentage of reduction of the root canal filling in two views – Bucco-Lingual (BL) and Mesio-Distal (MD)

There is a significant difference (chart 2) between the ADE during the use of XP-F compared when it was not used ($p < 0.0001$).

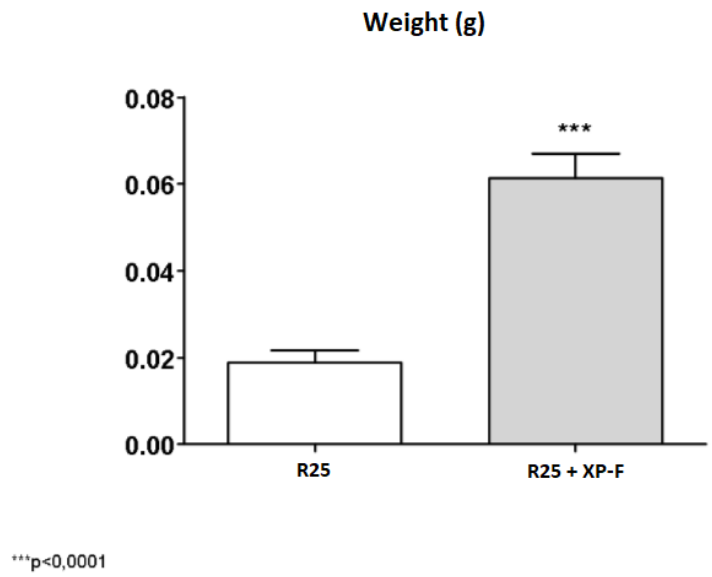


**Chart 2-** Weight of apical debris extrusion in grams (g)

## IV. DISCUSSION

The success of Endodontic Retreatment can be measured by the efficiency of removing the filling material. The more filling material is expunged, the more likely it is granted that the cause of the previous treatment failure may be eliminated (Oliveira *et al*., 2018).

It should be emphasized that the results of this study should not be applied directly to clinical situations. In the *in vitro* studies, the apex of the tooth is suspended in air, while, *in vivo*, the apex would be surrounded by granulomatous or periapical tissues, that could serve as a natural barrier, restricting the amount of ADE (Kfir *et al.*, 2017). Results may also differ because of the positive and negative pressures at the apex, (Tanalp & Güngör, 2014) as the vacuum effect, in the ET may prevent ADE (Mittal *et al*., 2015).

In opposition to the present study, some studies, Versiani *et al*., (2011) e De-Deus *et al*., (2019) have shown that using only rotary files for canal cleaning during endodontic retreatment is not sufficient.
In fact, the XP-F was introduced to the market as a supplementary file. As reported by it's manufacturer, this file may be used as an universal complement file in the NSER, providing that the final file size is at least an ISO# 25 (Kfir *et al.*, 2017).

The R25 system was originally designed for the complete preparation of the RC by using a single file and later was adapted for retreatment. The R25 has a S-shaped cross section that promote a higher cutting capacity comparing with others rotary Ni-Ti systems, as Mtwo® or WaveOne® systems, used in reciprocating motion in the purpose of filling material' removal (Capar, *et al.*, 2015; Alves, *et al.*, 2016; Nevares, *et al.*, 2016).

The studies Alves *et al.*, (2016) and Silva *et al.*, (2018) show that the use of the XP-F, when introduced as a supplementary technique, significantly reduces, the quantity of filling material. One of the reasons for the disparate results of the present study may be the fact that in some of the above mentioned studies had applied different protocols.

In this study, students of the pre-clinical classes of Endodontics performed the Endodontic Treatment. They all used the same protocol during the instrumentation and the filling material was introduced by lateral condensation technique. The previous mentioned studies (Alves *et al*., 2016; Silva *et al*., 2018) always used the same operator during the all procedure. That maybe a factor that potentially could interfere with results.

With lateral condensation technique is harder to fill lateral and accessory canals (DuLac *et al.*, 1999) and takes more time to fill the RC in comparison to the thermoplastic gutta-percha technique (Endal, *et al.*, 2018). To overcome this limitation, it was introduced the continuous-wave technique which uses thermoplasticized gutta-percha. Warm gutta-percha adapts, naturally, more effectively to the RCS' irregularities (Guess, *et al*., 2003).
So, it can be presumed, that when using the lateral condensation technique, it would be easier to remove the filling material, if necessary. Logically, it can be further concluded that techniques users of thermoplasticized gutta-percha, in obtaining an enhanced three-dimensional adaptation to the RC, lead to a more challenging removal of the filling material.

For filling, Alves, *et al.* (2016) used a single cone technique without warming the gutta-percha and Silva *et al*. (2018) used the continuous wave technique. In both of this studies the XP-F reduced equally the volume of filling material. The present study, that used cold lateral condensation technique, did not notice any differences in the quantity of removal filling material, comparing with the studies above describe.

NaOCl was the irrigant used in this study, such as in the ones of Alves *et al*., (2016) and Silva *et al*., (2018). One of the major goals of a NSER is to eliminate the filling material and as well the, frequently present, bacteria and their by-products, aiming to achieve the most higher level of RCS' disinfection. NaOCl is the most used irrigant to reduce the bacterial load in clinical Endodontics practice (Iandolo *et al*., 2017). However, the present research did not take into account the temperature of the irrigant: in fact, some articles reported that the effect of NaOCl heated can be 210 times faster compared to its use at room temperature (Woodmansey, 2005; Iandolo *et al*., 2017).

In this study, in order to mimic physiologic conditions, it was used a warm bath at a temperature of 36 °C in which the teeth were immerse for a period of 1 hour before the NSER begin. All the procedures of both groups were done at that temperature, opposite to other studies in which the teeth were only immerse in a warm bath when XP-F was used (Alves *et al*., 2016; Silva *et al*., 2018). Actually, we didn´t found any study done with the same procedure as this one. All the related articles that used a warm bath, only used it with the XP-F. This study is a more realistic simulation of the clinical practice because during all the NSER *in vivo*, all instruments are at a body temperature.

Although that, the NaOCl was introduce at a room temperature; nevertheless, when inserted into the RC its temperature tended to increase. In a future research the NaOCl should be heated before, in order to better avail all the potential benefits of its heating.
It seemed relevant to this study to remove the filing material at a body temperature to mimic a real clinical situation. Furthermore, the studies of Alves *et al*., (2016) and Silva *et al*., (2018) kept all specimen at 37°C and 100% humidity for 2 weeks to allow the sealer that was used in the RC during filling to settle completely and to simulate oral conditions.

In the present study this was not necessary because the teeth used were sealed, at least 3 months before the NSER and kept in a proper ambient storage. So, the sealer was completely settled. Possibly, due to the fact that the teeth used for this study had been sealed for months, the NSER was more difficult to perform than in the studies of Alves *et al*. (2016) and Silva *et al*. (2018) where filling took place only two weeks before the NSER. The set sealer is completely done and has the greatest dimensional changes at 4 weeks (Allan *et al*., 2001; Ørstavik *et al*., 2001). Taking this in consideration, it can be concluded that the previous mentioned studies, did not wait enough time for the sealer to set correctly. That could be the fact that justifies the results not concordants between those studies and the present one, since different protocols were applied.

Another major goal of the present research was to study the amount of ADE. The study of Kfir *et al*. (2017), with the same purpose, makes reference to a number of elements (n=30) higher than this study. However, Alves *et al*. (2016) used the same number of

elements of the present study and, indeed, Silva *et al*. (2018) used less (n=10). This is not a factor that could explain the differences of results because this study used an acceptable number of elements compared to the previous mentioned studies and the sample used allowed checking the eventual significant differences between techniques.

During the NSER, besides the anatomical complexities as isthmuses, bifurcations, dumbbell-shaped canals, probably the most commonly encountered anatomical challenge may be a curved canal. (Reddy, *et al.,* 2011).
Alves *et al*. (2016) used curved canals in their study. Silva *et al*. (2018) chosen to use oval-shaped canals as this study. So, this is not a variable of the protocol that could explain the difference between the result of the present study and the studies mentioned, because Alves *et al*. (2016) and Silva *et al*. (2018) show that the use of the XP-F, when introduced as a supplementary technique, reduces the quantity of filling material, on the contrary to the present study that used straight canals, a priori easier to deal during NSER, compared to curved ones.

According to the XP-F manufacturer, this instrument does not remove the tooth structure (De-Deus, *et al.*, 2019). Nevertheless, it makes more ADE when used as a supplementary stage in cleaning oval canals (Kfir *et al.*, 2017). The present study also showed that XP-F contributed to more amount of ADE, but did not contribute as a supplementary efficient file, when removal of filling material is the issue.

Among problems presented, all instrumentation systems induce ADE. Nowadays, according to the various publications available on the subject, there is no system that does not produce ADE (Bürklein *et al..,* 2014; Kfir *et al.*, 2017; Hizarci *et al.*, 2019).

The results obtained in this study alert Professionals to be aware of the potential complications associated to ADE, and to adapt the best system to each clinical case, when performing NSER, always thinking in minimising the debris extrusion.

## V. CONCLUSIONS

After the bibliographic research in the main Scientific Research Engines, no articles published yet, states that there is a system that completely removes the filling material or that does not cause ADE. In this study, two systems were taken in consideration related to its performance in NSER.

Considering the limitations of the study, after statistical analysis of the data obtained from the clinical protocols in test, it can be concluded that:

- both techniques remove equally the filling material;
- XP-F system does not bring any improvement as a supplementary technique;
- all instrumentation techniques used produce apical extrusion of debris;
- the average debris produced by the R25 technique is significantly smaller than that produced by the XP-F system ($p < 0.001$);

As the professional, in cases of NSER, should privileged instrument that removes the higher quantity of the filling material and cause less ADE, in light of the results shown by the present study, it can be concluded that it is advisory to use only the R25, as it proved to be an efficient technique.

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# VII. ANNEX

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Exmo. Senhor
Prof. Doutor Luís Martins
Director da FCS

Porto, 31 de Outubro de 2017

Exmo. Senhor Prof. Doutor,

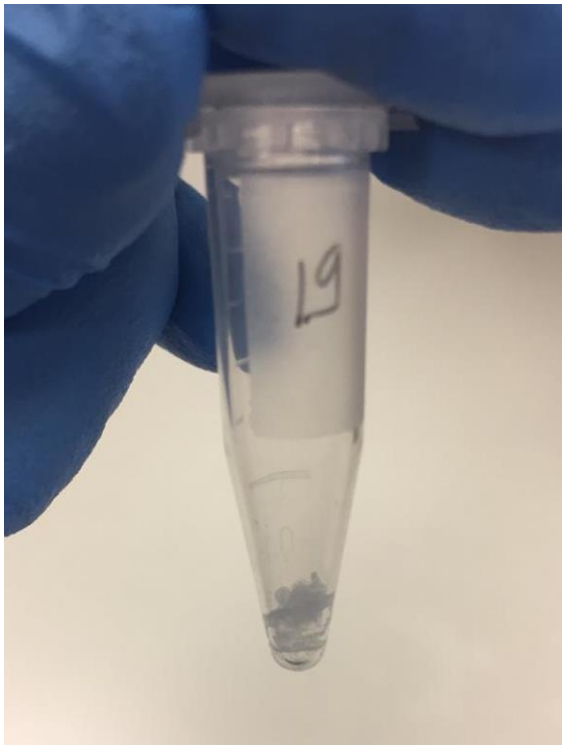
A Comissão de Ética, depois de apreciado o projeto de investigação da Professora Ana Teles, em colaboração com as alunas Joana Ferreira Azevedo, Renata de Jesus Constante e Marina Caetano Remoaldo, intitulado "Análise com micro-tomografia computorizada da eficácia de quatro sistemas de retratamento endodôntico na remoção do material obturador", considera nada haver a opor ao mesmo.

Com os melhores cumprimentos.

A Presidente da
Comissão de Ética da UFP

Teresa Martinho Toldy

**Annex 1 -** Ethics Committee Approval




**Annex 2 –** Crystals resulted from the evaporation of the irrigant collected in the Eppendorf Tube.


**Annex 3 –** Weighing of the Eppendorf Tube.