# Lack of correlation between radiographic density of filling and fluid infiltration

Ricardo **MACHADO**[1]
Eduardo Donato Eing Engelke **BACK**[2]
Luiz Fernando **TOMAZINHO**[3]
Emmanuel João Nogueira Leal **SILVA**[4]
Ulisses Xavier da **SILVA NETO**[5]
Erick Miranda **SOUZA**[6]
Luiz Pascoal **VANSAN**[7]

doi: http://dx.doi.org/10.1590/2178-3713.4.3.042-046.oar

## ABSTRACT

**Objective:** The aim of the present study was to determine whether there is a correlation between fluid infiltration and visible radiographic voids in root filling. **Methods:** A total of 56 mandibular incisors with straight single canals, complete root formation and no anatomical complexities were selected for this research. Teeth were instrumented by means of Profile System 04 up to file 35 under the same irrigation protocol. Filling was performed by lateral condensation. Subsequently, mesiodistal radiographs were taken for each root and the quality of filling was assessed by calculating the percentage of voids based on the total area. Samples were further assembled into a fluid infiltration set-up. Pearson's correlation test was used to assess the correlation between fluid infiltration and void areas in root canal fillings. **Results:** Means and standard deviations of fluid infiltration were 0.311 ± 0.215 μL/min and the percentages of radiographic voids were 7.97% ± 3.93%. **Conclusion:** No correlation was found between these two variables (P = 0.587). According to the results of this study, the amount of fluid infiltration detected in lower incisors is not influenced by the percentage of radiographically visible voids.

**Keywords:** Endodontics. Dental cements. Dental infiltration.

[1]Professor, Postgraduate program in Endodontics, Hermann Institute. Professor of Multidisciplinary Clinics I (Endodontics), Paranaense University (UNIPAR).

[2]Professor, Postgraduate program in Endodontics, Hermann Institute.

[3]Professor of Multidisciplinary Clinics I and II and Integrated Internship II (Endodontics), UNIPAR.

[4]Professor of Endodontics, University of Grande Rio (UNIGRANRIO).

[5]Professor of Endodontics, Doctorate, Masters and Undergraduate programs, Catholic University of Paraná (PUC/PR).

[6]Professor of Endodontics, Federal University of Maranhão (UFMA).

[7]Professor, Department of Restorative Dentistry, School of Dentistry — University of São Paulo/ Ribeirão Preto.

**How to cite this article**: Machado R, Back EDEE, Tomazinho LF, Silva EJNL, Silva Neto UX, Souza EM, Vansan LP. Lack of correlation between radiographic density of filling and fluid infiltration. Dental Press Endod. 2014 Sept-Dec;4(3):42-6. DOI: http://dx.doi.org/10.1590/2178-3713.4.3.042-046.oar

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

Submitted: May 13, 2014. Revised and accepted: May 14, 2014.

Contact address: Eduardo Donato Eing Engelke Back
E-mail: eduback@hotmail.com

## Introduction

Appropriate root canal filling remains a purpose of paramount importance in endodontic therapy,[1-6] since it aims at preventing nutrient or bacteria from entering into the root canal system and, as a result, cause reinfection. From a clinical perspective, periapical radiograph is the diagnostic tool most widely used to provide information regarding the final quality of root filling. Together with other factors, radiographic density of root filling can be considered a predictor for successful endodontic therapy. Recently, Liang et al[7] assessed radiographs and cone-beam scans and observed that root filling with areas of lower radiographic density is strongly associated with a negative clinical outcome of root canal treatment. Areas of lower radiographic density suggest lack of filling material or poorly condensed region, in which a void is likely to be present. Voids in root canal filling favor nutrients or bacteria to enter into the apical area. For this reason, there is a consensus that filling voids should be avoided.[7]

Even though there is no clinical evidence that the ability of a root filling material to prevent the influx of fluids or bacteria is as a factor that influences the outcomes of root canal filling, the literature comprises a large number of studies about sealing. Fluid infiltration is one of the models most commonly used, since it prevents samples from being damaged.[8] With this method, root filling is subjected to a fluid under constant air pressure within a closed system. Should any through-to-through void be present, the amount of fluid infiltration is quantified via air bubble movement in the micropipette as a result of the convective water displacement through the void. Due to the quantitative nature of the model, it is possible to assume that the larger the size of a given void, the higher the amount of fluid infiltration.[1,3] Thus, at least in theory, the larger the areas of lower radiographic density within a given filling, the lower the sealing ability of a given root canal filling.

Van der Sluis et al[9] were the first to make an attempt to establish a correlation between sealability results and density of root filling. Using a fluid infiltration method and a categorical analysis of root filling quality, they were unable to detect a correlation between these two variables. More recently, using mesial roots of lower molars and the same methodological approach, Wu et al[10] observed a significant correlation between the two variables. Therefore, this correlation remains as a controversial topic in Endodontics. It is also worth noting that both previous studies used more than one experimental group to investigate this possible correlation. However, there seems to be no rationale in using more than a single experimental group while testing a correlation, since, from a statistical point of view, any random factor might affect a single sample, but not all the others. Moreover, in the previous studies, radiographic voids were subjectively qualified, thereby rendering the use of a rank-based correlation necessary (Spearman's rank correlation coefficient). Spearman's correlation coefficient usually detects a general monotonic trend, while Pearson's coefficient is more efficient in detecting linear relationships between variables.

Thus, the present study aims at using a large single experimental group to correlate the amount of fluid infiltration and filling areas of lower radiographic density in lower incisors, using a parametric statistical approach. The null hypothesis is that Pearson's correlation demonstrates no correlation between these two variables.

## Material and methods

### Specimen selection

This research was approved by the Institutional Review Board of Catholic University of Paraná (protocol #5314). A total of 56 extracted human mandibular incisors with straight single canals and complete root formation were selected for this research. Crowns were removed with a diamond-cutting saw (Buehler, Ltd. Lake Bluff, USA) so as to obtain specimens with a standard length of 12 mm. The specimens were kept in distilled water until testing time.

### Specimen preparation

Working length was established by subtracting 1 mm from the point where the file was visible at the apical foramen. The coronal and middle thirds of each canal were prepared using Gates Glidden drills (Dentsply-Maillefer, Ballaigues, Switzerland) sizes 4, 3, and 2 placed 2 mm deeper in the root canal in comparison to the previous instrument. Apical foramens were enlarged up to size 25 with a K-Flexofile (Dentsply-Maillefer, Ballaigues, Switzerland), and the apical thirds were prepared with Profile 04 System (Dentsply-Maillefer, Ballaigues, Switzerland) up to file 35 at the working length. The canals were irrigated at each change of instruments with 2 mL of freshly prepared 2.5% NaOCl solution (Fórmula & Ação, São Paulo, Brazil), and a final flush of 3 mL of 17% EDTA (pH 7.7) (Fórmula & Ação, São Paulo, Brazil) for 3 minutes. Five milliliters of sterile water were used as a final rinse.

## Canal filling

The root canals were dried with paper points, and a pre-fitted size 35.04 gutta-percha cone (Dentsply-Maillefer, Ballaigues, Switzerland) was used as the master cone. The latter was coated with 0.25 ml of AH Plus sealer (Dentsply-Tulsa Dental, Tulsa, USA) and placed in the canal up to the full working length. Subsequently, finger spreader C (D1 0.3, taper 0.02) (Dentsply-Maillefer, Ballaigues, Switzerland) and standard accessory cones B8 (Tanari, São Paulo, Brazil) were used. The filled roots were stored at 37°C and 100% humidity for 7 days so as to allow the sealer to set.

## Radiographic analysis

After storage, all specimens were radiographed in a mesiodistal direction in order to provide bucco-lingual views of the filled roots. Radiographs were taken with Max S-1 x-ray equipment (J Morita Mfg Corp, Kyoto, Japan) with a 0.8 mm X 0.8 mm tube focal spot and Kodak Insight film (Eastman Kodak Co, Rochester, USA). All films were processed in an automatic processor using standardized methods. All images were scanned, stored in TIFF format and further analyzed by means of AxioVision 4.5 Software (Carl Zeiss Vision, Hallbergmoos, Germany). For each image, the total filled area of the root was determined and quantified. Then, the radiolucent areas within the filled area were also identified and quantified (Fig 1). Finally, the percentage of radiolucent areas within root filling was calculated for each sample.

## Apical infiltration analysis by means of the fluid infiltration method

The fluid infiltration method was used to determine infiltration. The root apex was connected to a Luer-type metal needle by means of a plastic tube. The fluid infiltration allowed by the tested groups was quantified according to the movement of a small air bubble inside a 25 μL micropipette (Microcaps, Fisher Scientific, Philadelphia, USA). The inside of the pipette and the entire system were filled with distilled water, and a pressure of 10 psi was applied at the apical side of the root. After ensuring that there was no infiltration at the connections, the system was activated and balanced for 4 minutes. The volume of fluid was calculated by observing air bubble displacement and expressed in μL/min. 10psi. Measurements were made at 2-minute intervals in a total period of 8 minutes.[1,3]

## Statistical analysis

Considering a sample size larger than 30 specimens,[11] a parametric correlation test was chosen (Pearson's correlation) to assess whether the percentage of lower radiolucency is correlated to fluid infiltration data. The significance level was set to 0.05.

## Results

All specimens showed variable, but measurable radiographic voids areas in the fillings ranging from 1.27% to 20.1% with an average of 7.97% ± 3.93, and fluid infiltration varying from 0.114 to 1.141 μL/min with an average of 0.311 ± 0.215 μL/min.

Pearson's correlation test was unable to find a correlation between the two analyzed variables ($P = 0.587$; Pearson's correlation coefficient, $r = -0.07$).

## Discussion

The fluid infiltration model requires at least one void extending from the coronal to the apical third of the root

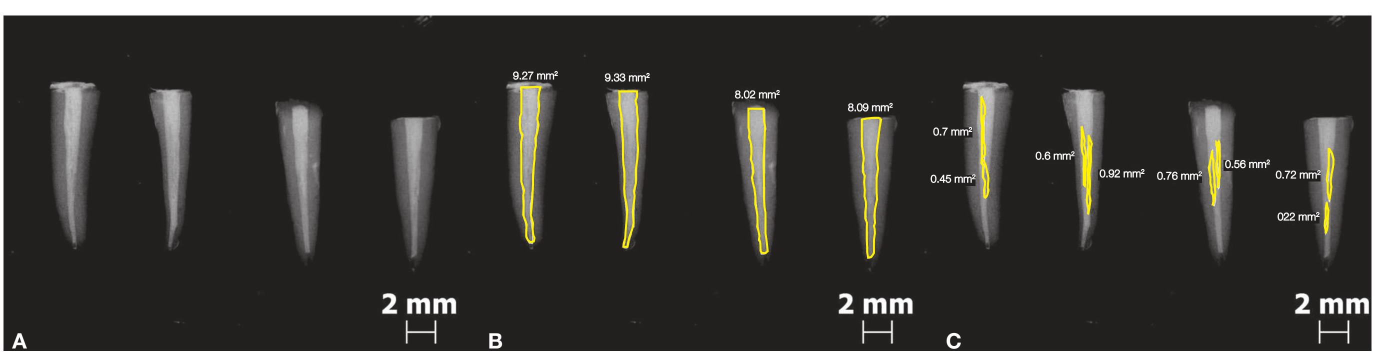


**Figure 1. A**) Root fillings; **B**) Total areas (mm$^2$); **C**) Void areas (mm$^2$).

in order to detect fluid movement along a filled root. This means that in order to record fluid infiltration values, the root filling should present, at least, a continuous void with an open end at the coronal chamber and the other at the apical portion. In theory, the diameter of a continuous void could be estimated by the Poiseuille formula: $V = \Delta P . \pi . r^4 / 8 . \eta . L$, in which P is pressure, r is radius of a continuous void (to be calculated), L is the length of void (12 mm), and η is the viscosity of water solution at room temperature. Considering the mean volume observed in the present study (0.311 μL), the radius of the hypothetical continuous void equals to 0.19 μm, which represents a void of 0.38 μm in diameter. Such a void, if present, is likely not to be identified as an area of lower radiographic density, as studied herein.[12,13]

In laterally compacted root fillings, the occurrence of spreader tracks within filling is frequently recorded,[14,15] particularly in cases in which the space opened by the finger spreader is not completely filled by the accessory cone as it is rarely placed up to the same depth.[16] It could be speculated that the areas of lower radiographic density found in this study are the result of spreader tracks. While spreaders are never adjusted to the apical end of the canal, spreader-driven voids are likely to become a "dead-end" or "*cul-de-sac*" type voids. These types of voids, if present, contrary to "through-and-through" voids, do not allow complete fluid infiltration from the coronal to the apical third of the filling. Similarly, Van der Sluis et al[9] used filled mandibular incisors and maxillary and mandibular canines, but were unable to observe a correlation between radiographic quality and fluid infiltration. Unlike the present study, these authors used a score-based void determination system; therefore, they could not establish a parametric value for the voids. However, they reported a mean score for mesiodistal radiographs equivalent to "an imperfectly condensed filling that might be a little short (0.5 mm or less), and that might show irregularities of less than 1mm in the adaptation." This score, in general terms, could be considered equivalent to the percentage of voids observed in the present study. Thus, as hypothesized here, it is likely that "*cul-de-sac*" radiographic voids were also prevalent in the sample studied by Van der Sluis et al,[9] which hindered a potential correlation.

On the other hand, contradicting the findings of present study and the research conducted by Van der Sluis et al,[9] Wu et al[10] observed a significant correlation between fluid infiltration and radiographically categorized voids in mesial roots of mandibular molars. Researchers have thoroughly documented a high incidence of canal isthmus (up to 89%) in mesial roots of mandibular molars.[17,18] According to recent micro-CT results, current root canal filing techniques are unable to fill this portion of the root canal system, which is normally left uninstrumented and unfilled.[19] Thus, it is likely that a direct venue from the coronal to apical third of the root may be present in those areas of the root, perhaps explaining the high correlation between radiographic voids and fluid infiltration found by Wu et al[10] in lower molars. Additionally, Wu et al.[10] categorized the radiographs according to the longest void in root filling, which may be more closely related to the presence of "through-and-through" voids.

One may argue that voids were estimated by using only mesiodistal radiographs, which could not be clinically relevant. This decision was based on the findings of previous reports which observed a significantly higher number of areas of lower radiographic density at a side view than by a bucco-lingual incidence. Since our purpose was to correlate those areas and fluid infiltration data, the inclusion of bucco-lingual radiographs would certainly reduce the percentage of voids detected in the present study, thereby lowering the power of analysis and possibly leading to data misinterpretation.

The present study attempted to determine a correlation between areas of lower radiographic density and fluid infiltration values by using parametric-obtained data, rather than the categorized-based model used in previous studies. The study also utilized a large sample size (56 teeth), and no other independent variable was added to the design in order to allow for a parametric and direct correlation between the variables. Even using those strict methodological requirements, a significant correlation could not be detected in the present study, and, therefore, the null hypothesis has been confirmed.

According to the results of the present study, the percentages of areas of lower radiographic density do not correlate with the fluid infiltration values in mandibular incisors. Even though these results can be used to question the clinical validity of the fluid infiltration model, they may be, however, attributed to the prevalence of dead-end voids, which limited the possibility of the method to correlate with radiographic voids.

## Conclusion

Considering the results of this *in vitro* study, it can be concluded that the amount of fluid infiltration detected in lower incisors is not influenced by the observation of lower radiolucency in root filling.

## References


1. Hirai VH, Silva-Neto UX, Westphalen VP, Perin CP, Carneiro E, Fariniuk LF. Comparative analysis of infiltration in root canal fillings performed with gutta-percha and resilon cones with ah plus and epiphany sealers. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;109(2):131-5.
2. Ridell K, Petersson A, Matsson L, Mejàre I. Periapical status and technical quality of root-filled teeth in swedish adolescents and young adults. A retrospective study. Acta Odontol Scand. 2006;64(2):104-10.
3. Silva-Neto UX, Moraes IG, Westphalen VP, Menezes R, Carneiro E, Fariniuk LF. Infiltration of 4 resin-based root-canal sealers used with a single-cone technique. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104(2):53-7.
4. Sundqvist G, Figdor D, Persson S, Sjogren U. Microbiologic analysis of teeth with failed endodontic treatment and the outcome of conservative re-treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998;85(1):86-93.
5. Wu MK, Fan B, Wesselink PR. Diminished infiltration along root canals filled with gutta-percha without sealer over time: a laboratory study. Int Endod J. 2000;33(2):121-5.
6. Wu MK, Van der Sluis LW, Ardila CN, Wesselink PR. Fluid movement along the coronal two – thirds of root fillings placed by three different gutta-percha techniques. Int Endod J. 2003;36(8):533-40.
7. Liang YH, Li G, Wesselink PR, Wu MK. Endodontic outcome predictors identified with periapical radiographs and cone-beam computed tomography scans. J Endod. 2011;37(3):326-31.
8. Derkson GD, Pashley DH, Derkson ME. Microinfiltration measurement of selected restorative materials: a new in vitro method. J Prosth Dent. 1986;56(4):435-40.
9. Van der Sluis LW, MK, Wesselink PR. An evaluation of the quality of root fillings in mandibular incisors and maxillary and mandibular canines using different methodologies. J Dent. 2005;33(8):683-8.
10. Wu MK, Bud MG, Wesselink PR. The quality of single cone and laterally compacted gutta-percha fillings in small and curved root canals as evidenced by bidirectional radiographs and fluid transport measurements. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;108(6):946-51.
11. Dawson-Saunders B, Trapp RG. Basic and clinical biostatistics. 2nd ed. Norwalk, CT: Appleton and Lange; 1994.
12. Bergmans L, Moisiadis P, De Munck J, Van Meerbeek B, Lambrechts P. Effect of polymerization shrinkage on the sealing capacity of resin fillers for endodontic use. J Adhes Dent. 2005;7(4):321-9.
13. Huybrechts B, Bud M, Bergmans L, Lambrechts P, Jacobs R. Void detection in root fillings using intraoral analogue, intraoral digital and cone beam ct images. Int Endod J. 2009;42(8):675-85.
14. Eguchi DS, Peters DD, Hollinger JO, Lorton L. A comparison of the area of the canal space occupied by gutta-percha following four gutta-percha obturation techniques using Procosol sealer. J Endod. 1985;11(4):166-75.
15. Schmidt KJ, Walker TL, Johnson JD, Nicoll BK. Comparison of nickel-titanium and stainless-steel spreader penetration and accessory cone fit in curved canals. J Endod. 2000;26(1):42-4.
16. Souza EM, Wu MK, Van der Sluis LW, Leonardo RT, Bonetti-filho I, Wesselink PR. Effect of filling technique and root canal area on the percentage of gutta-percha in laterally compacted root fillings. Int Endod J. 2009;42(8):719-26.
17. Gu L, Wei X, Ling J, Huang X. A microcomputed tomographic study of canal isthmuses in the mesial root of mandibular first molars in a Chinese population. J Endod. 2009;35(3):353-6.
18. Von Arx T. Frequency and type of canal isthmuses in first molars detected by endoscopic inspection during periradicular surgery. Int Endod J. 2005;38(3):160-8.
19. Versiani MA, Pécora JD, Sousa-Neto MD. Root and root canal morphology of four-rooted maxillary second molars: a micro-computed tomography study. J Endod. 2012;38(7):977-82.