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C. ESTRELA, MSc, PhD



G. B. SYDNEY, MSc, PhD

J.A.P. FIGUEIREDO,
MSc, PhD

Editorial



To the Master and Advisor, Prof. Dr. Hidelberto Francisco Pesce

The History of humanity
 is based upon biographies
 Dante Alighieri "the voice of silent centuries"
 Joana D'Arc, "Orleans' lady and French mother"
 Leonardo Da Vinci, "Master of arts and science"
 Shakespeare, "The creator of a new world"
 Every person has the liberty
 to write his biography
 Pesce, "Masters' sheppard"
 Pesce, "The actor of shining pieces"
 Pesce, "Every moment's Master"
 ...But a flower is born
 and the essence in reality
 due to the creator's ability
 made purity and ideal become entwined
 This is your trophy, our master!
 The thesis of life...
 Pesce, the show must go on...
 Your theater made us actors, gave us light
 made us shine, made us doctors
 Pesce, thank you very much
 We miss you so...
 The same way your master left,
 Now, you are with him, to witness the beautiful
 moments shared when he was present,
 celebrating every victory, assisting every follower.
 Remember his saying:
 Regardless the unencounters, thank for the encounters
 And our friendship will go through the abstract
 with no silver or gold
 and, although invisible to our eyes,
 your speech would be there, everyday
 Thank you for the encounters, and from the encounters, Beбето
 Now we know that Van Gogh horses are still alive.

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CEP. 90560-004 BRAZIL PHONE: 55- 51- 222- 20 31

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CAPACITY OF L 929 AND BALB/C 3T3 FIBROBLASTS TO SURVIVE ON HUMAN DENTIN DISCS

Carlos Alberto de SOUZA COSTA, DDS, MS, PhD
Universidade Estadual Paulista, Araraquara, SP, Brazil.
Carl Thomas HANKS, DDS, PhD
University of Michigan/ School of Dentistry, Ann
Arbor, Michigan - USA.

The objectives of this study were to evaluate the viability of two different fibroblast cell lines seeded on human dentin as well as to determine the appropriate acidic agent for that purpose. Twenty-four dentin discs were obtained from extracted human molars and stored in 70% ethanol for 5 days. Those dentin discs were divided according to acid treatment and the cell line plated on them: Group 1- citric acid/L929; Group 2 - citric acid/Balb/c 3T3; Group 3- EDTA/L929; Group 4- EDTA/Balb/c 3T3. The dentin discs were conditioned with 0.5 EDTA for 2 min. or 50% citric acid for 30 sec., rinsed in PBS and culture medium (MEM+10%FBS or DMEM+3%NuSe). On the dentin discs, 1×10^5 cells/cm² (L929 or Balb/c 3T3) were plated and allowed to grow for 24 hours at 37°C in humidified air atmosphere containing 5% CO₂. The cell number was determined under inverted light microscope and the cell morphology accessed by scanning electron microscopy. It was showed that the number of L929 cells attached on dentin discs was higher than Balb/c 3T3 cells for both dentin etching. The surface of the dentin discs conditioned with citric acid exhibited higher number of cells than the discs treated with EDTA for both plated cell lines. The ANOVA and Fisher's PLSD tests showed significant difference in the cell number on dentin discs among all Groups. In conclusion, the L929 or Balb/c 3T3 cell lines can to survive on human dentin discs and the citric acid was better acid conditioner than EDTA.

Key Words: Dentin, fibroblasts, acidic agent.

INTRODUCTION

Several *in vitro* studies have shown that dental materials present variable levels of cytotoxicity when in direct contact with pulp cells^{1,2,3}. *In vivo* studies showed that pulp tissue has an important capacity of repair when submitted to pulp capping with dental materials^{4,5}. Bacteria and their products have been implicated as the most important toxic agent to pulp tissue⁶. For dental materials, despite that discussion, when a dentin barrier is present between the dental material and pulp tissue, the pulp is apparently not damaged even whether that material is a confirmed toxicant. However, *in vitro* studies have shown that when dentin adhesive systems or composite resin are applied on top of dentin discs, the resin components can diffuse through dentin tubules to reach the pulp chamber^{3,7}. In several *in vitro* studies using "pulp device" to evaluate the diffusion and cytotoxic effects of dental materials the workers have plated cells on the bottom of the pulpal compartment, which stay far from the dentin disc. This situation does not simulate the *in vivo* condition, in which the pulp cells (i.e. odontoblasts) are in intimate contact to dentin. Consequently, when the dental material diffuses through the dentinal tubules to reach the pulp chamber space of the "in vitro pulp device", this compartment is full of fluid. In this way, the toxicant can be diluted and little amount of material may take a contact with the cell culture, providing erroneous results⁷. Appropriate datas concerning the cytotoxic effects of dental materials after

diffusion across dentinal tubules can be obtained using dentin discs with cells plated on their surfaces. This research protocol applied to access the cytotoxicity of dental materials can mimic the *in vivo* situation rather than previous methods of study. In addition, to interpret the results of *in vitro* cytotoxicity tests, is important to choose cell lines recommended by either the ISO or ADA specification⁹, moreover to work with appropriate "pulp devices" and similar conditions to human teeth. The purpose of this study was to evaluate the viability of two different fibroblasts cell lines plated onto human dentin discs that were previously treated with different acid conditioners.

MATERIAL AND METHODS

Twenty-four dentin discs were prepared from extracted healthy human molars, stored in 70% ethanol at room temperature until they were sectioned. The teeth were cleaned of debris and periodontal ligament tissue before being sectioned. The dentin discs were cut with a low-speed wheelsaw at 230 rpm using 10.2 cm diameter diamond wafering blades (CO-153, 320 grit; Mager Scientific Inc., Dexter, MI), followed by hand sanding with 450 and 600 grit silicon carbide paper each for approximately 15 figure-eight rotations. The discs were evaluated to certify that all enamel was removed from the occlusal surface and the pulp horns were not cut through.

The dentin discs, approximately 500µm thick, were kept in 70% ethanol for 5 days before their use. Usually, only one disc was taken from each human tooth.

After washing each dentin disc 3 times in PBS, it was conditioned for 2 minutes either with 0.5M EDTA or 50% citric acid for 30 sec. Twenty-four discs were divided into 4 groups as described on table 1. After dentin etching, the dentin discs were rinsed 3 times in PBS. The discs were subsequently rinsed 3 times in Minimum Essential Medium- MEM (Gibco Laboratories, Grand Island, NY) supplemented with 10% Fetal Bovine Serum- FBS (Gibco Laboratories), or Dulbecco's Modified Eagle Medium-DMEM (Gibco Laboratories) supplemented with 3% Nu Serum (Colaborative Research, Bedford, MA, USA), depending of which cell line was plated.

The discs were maintained in wells (16 mm in diameter) of 24-well dishes (Well Dishes, product#3542, Coostar Corp., Cambridge, MA) in 1 ml of MEM plus FBS, or

in 1 ml of DMEM plus 3% Nu Serum, each supplemented with glutamine and penicillin-streptomycin (Gibco Laboratories).

Monolayer cultures of L929 or Balb/c 3T3 mouse fibroblasts were maintained and passaged in 25-cm² flasks in complete MEM or DMEM, respectively. The monolayer cultures were plated at approximately 10.000 cells/cm² in each well of 24-well dishes and allowed to grow for 24 hours at 37°C in a humidified air atmosphere containing 5% CO₂.

After 24 hours, the complete medium was carefully removed from the well and 1 ml of vital dye fluorescein diacetate (FDA, Vector Laboratories, Burlingame, CA) in phosphate buffered saline (0.02mg/ml) was applied for 10 minutes in each well. The number of vital cells was visualized and counted by ocular reticle (Periplan GF 12.5, Leitz Wetzlar, Germany) on inverted light microscopy with U.V. light (Leitz -Germany). The photomicrographs were took under OXIOSCOP phase contrast microscope adapted to MC 100 digital camera (Leitz, Germany).

The pulp cells on dentin discs were evaluated by Scanning Electron Microscopy (AMRAY Scanning EM, Model 1000B, Cambridge, MA) after fixation of specimens in 2.5% glutaraldehyde (Electron Microscopy Sciences-EMP, Fort Washington, PE, lot #971030) in Sorensen's phosphate buffer, post-fixation in 1% osmium tetroxide (Electron Microscope Sciences, EMS, lot #971218, F.T Washington, PA), and critical point drying. Three replicate experiments were performed for each series.

Comparison among groups was made by one-way ANOVA and Fisher's PLSD statistical test at P<0.05 (Stat View 4.5, Abacus Concepts Inc., CA, USA).

RESULTS

The technique applied for cutting human tooth gave rise to a smear layer on dentin, which covered the dentin disc surface and partially closed the dentinal tubules. Dentin etching with 0.5M EDTA for 2 min. removed partially the smear layer and most of the dentinal tubule openings could be seen. However, some fragments of smear layer were still scattered over the dentin surface (Figure 1). However, in those specimens in which the dentin discs were conditioned with 50% citric acid for 30 seconds, the entire smear layer was removed, apparently with no visual damage to the dentin (Figure 2).

A higher number of L 929 or Balb/c 3T3 cells attached to

the dentin disc surface was observed when the dentin was conditioned with 50% citric acid than with 0.5M EDTA. Furthermore, the number of L 929 cells attached to the dentin surface was higher than the number of Balb/c 3T3 cells for both dentinal etching procedure (Figures 3 and 4). The cells plated on dentin discs showed no attachment to enamel (Figure 5). In addition, the distribution of both cell lines plated on the dentin was not homogeneous.

The evaluation of cell morphology by scanning electron microscopy showed that both fibroblast cell line plated on the dentin disc surface exhibited spindle-shaped and flattened characteristics, which was remarkable to Balb/c 3T3. These cellular morphological characteristics indicated cell attachment to the dentin

substrate (Figure 6). Consequently, it was possible to confirm that the human dentin is an appropriate substrate to cell growth. When rounded cells were observed, they were in process of cell division.

The relationships among treatment of dentin discs, cell number and cell line plated is observed on the Table 2.

The ANOVA test indicated a significant difference in the cell number present on human dentin discs among all Groups in which L 929 or Balb/c 3T3 were seeded and citric acid or EDTA was applied ($p < 0.05$). The Fisher's PLSD analysis indicated a significant difference between all groups ($p < 0.05$). ANOVA and Fisher's PLSD statistical tests are shown in Table 3 and 4, respectively.

Table 1. Relationship between treatment and number of dentin discs for every Group and cell lines.

Group	Discs	Treatment	Cel line
1	6	Citric acid (30 sec.)	L 929
2	6	Citric acid (30 sec.)	Balb/c 3T3
3	6	0.5MEDTA (2min.)	L929
4	6	0.5MEDTA (2min.)	Balb/c3T3

Table 2. Number of cells present on dentin disc surface, according to the acid conditioner and the cell line

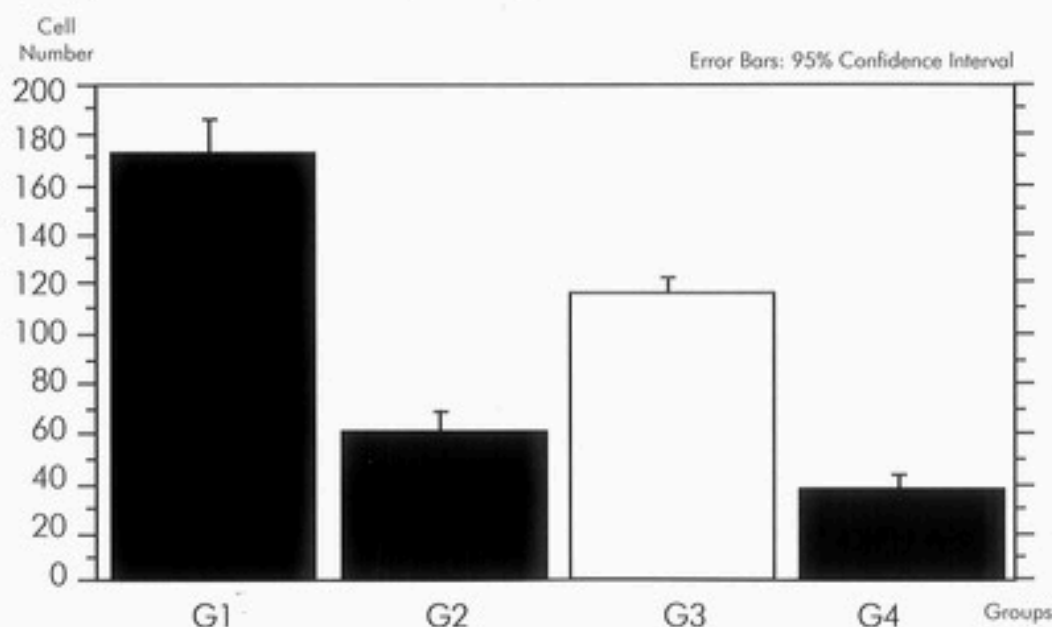


Table 3. ANOVA Table for Cell Number

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Group		66434.301	22144.767	282.110	<.0001
Residual	20	1569.938	78.497		

Model II estimate of between component variance: 3677.712

Table 4. Fisher's PLSD for Cell Number. Effect: Group. Significance Level: 5%

	Mean Diff.	Crit. Diff.	P-Value	
G1,G2	111.850	10.670	<.0001	S
G1,G3	56.783	10.670	<.0001	S
G1,G4	136.350	10.670	<.0001	S
G2,G3	-55.067	10.670	<.0001	S
G2,G4	24.500	10.670	.0001	S
G3,G4	79.567	10.670	<.0001	S

DISCUSSION

Cell culture methods for toxicity testing of dental materials are controllable, fast and relatively inexpensive¹⁰. They are often better standardized than *in vivo* experiments¹¹. Animal and human experiments, on the other hand, are much more time consuming and expensive. They require approval of ethics committees and are controversial in the public mind. However, the *in vitro* tests have been criticized as not being predictive of the actual biological response in use¹². Therefore, it seems that the results reported to *in vivo* studies can not be directly extrapolated to clinical situations. This problem might be partially solved when the *in vitro* tests are modified in an attempt to simulate the clinical procedures. Generally speaking, to access the cytotoxicity of dental materials *in vitro*, a suitable pulp device should be used with adequate pulp pressure and, the human dentin discs should have a defined thickness and hydraulic conductance. Moreover, an appropriate cell line must be used to perform cytotoxic studies as well as the cells should spread homogeneously on dentin discs, imitating the odontoblastic layer. In the present study, as the first step of a sequence of researches, the human dentin discs were successfully plated with two different mouse fibroblast cells. This result indicates the possibility to mimic *in vivo* situation by the placement of dentin discs with culture of cells on its surface in the "in vitro pulp device".

Many studies have shown that after cutting human teeth

a smear layer is produced on the dentinal surface^{13,14}. PASHLEY¹⁵ defined the smear layer as a layer of cutting debris that serves as a natural cavity liner and cannot be rinsed or scrubbed off. It reduces hydraulic conductance by 80-90%, but only reduces diffusion about 25-30%¹⁶. To maximize dentine permeability for cytotoxicity testing, the smear layer may be removed with acids or EDTA. However, the smear layer may be kept in place to simulate the clinical procedures in which no acidic agents are recommended for application on dentin. In the present study, the smear layer created after cutting the dentin remained on both surfaces of the dentin discs (occlusal and pulpal). The smear layer on the pulpal surface must be removed in order to simulate the *in vivo* situation, in which no smear layer is observed between odontoblast layer and dentin. Consequently, the smear layer was removed applying either 0.5M EDTA for 2 min. or 50% citric acid for 30 sec. and two cell lines were seeded on dentin discs pulpal surface. These procedures were performed to simulate the presence of odontoblast cell line underlying dentin. PASHLEY¹⁷ reported that dentin and pulp function as an integrated unit, generally termed pulpo-dentin complex. The present study can not mimic this biological complex. However, the possibility of cell culture to grow on human dentin permits to obtain results of *in vitro* cytotoxic tests similar to short term tests performed *in vivo*. Nevertheless, it is important to show, as a preliminary study, that fibroblast cells can survive in direct contact with human dentin as well as to determine the most appropriate treatment of dentin in order to allow

an adequate cell growth. In this way, this study showed that both cell lines can survive on dentin discs after application of either EDTA or citric acid on dentin surfaces. However, the number of L 929 cells was apparently higher than Balb/c 3T3 cells on dentin discs. In addition, the dentin discs conditioned with 50% citric acid allowed a higher plating density than EDTA for both cell lines. We may speculate that the application of citric acid on dentin removed smear layer as well as seemed to promote higher releasing of molecules metabolically active from dentin tissue than 0.5M EDTA. These molecules, such as bone morphogenic proteins (BMPs) and transforming growth factors (TGFs), may interact with membrane receptors of cells and finally stimulate mitotic activity. In addition, debris (smear layer) on dentin surface may interfere with attachment of cells. Consequently, a few cells may remain on the dentin disc after rinsing of the dentin discs during the processing of the specimens. Smear layer was observed on dentin discs conditioned with 0.5M EDTA. In these specimens, for both cellular lines evaluated, only few cells remained attached on dentin surface.

When assessed by SEM, the cells were flattened and shaped, indicating, such as related on dental literature⁸, cell attachment to the dentin substrate^{18,19}. SCHMALZ et al.⁸ showed growth of L929 cells on bovine dentin discs treated with 50% citric acid for 30 seconds. They described that cell growth depends on number of cells seeded and suggested that a good spread cells on dentin discs was about 2×10^4 cells/cm². The

present study did not show cells homogeneously spread on dentin discs. However, only 10.000 cells/cm² were plated on dentin and the cell culture was maintained in incubator for 24 hours. Previous studies showed that L929 cells survive for a longer time on dentin⁸. Consequently, it is probably that whether the fibroblast cell line is seeded for long time, these cells might spread evenly on dentin discs becoming nearly to confluence, such as shown by SCHMALZ et al.⁸.

It seems that the higher plating density of L929 cells than Balb/c 3T3, observed for both dentin etching occurred due the L929 cell line generally shows the highest metabolic activity. Consequently, the L 929 cells grew on the dentin discs faster than Balb/c 3T3 cell line⁹.

In conclusion, the present study showed that both fibroblast cell lines can survive on human dentin discs up to 24 hours after plating. The citric acid was an appropriate dentin treatment in order to remove the smear layer as well as to allow a number of cells to survive on dentin discs.

These findings suggest that human dentin disc with surface covered by fibroblast might be adapted to "in vitro pulp device", which allow application of inner pulp pressure. However, in order to evaluate the possible cellular confluence complementary studies are needed to establish what concentration of cells must be plated on dentin as well as to determine how long the dentin discs with cells must remain in incubator. Consequently, new in vitro research protocols may be developed to simulate in vivo studies, at least for the first 6-12 hours after injury²⁰.

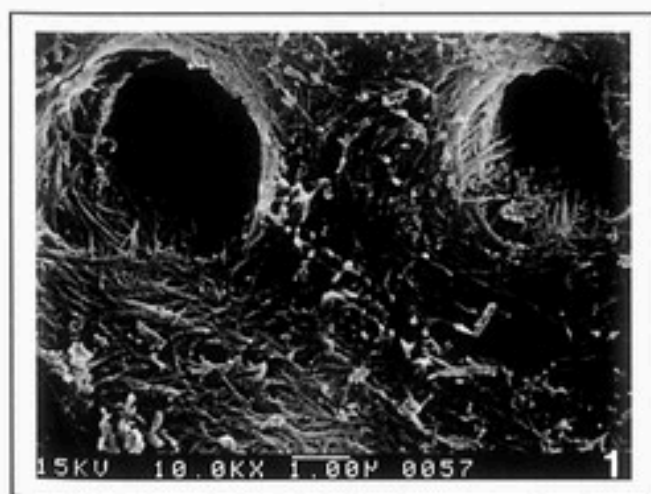


Figure 1. Dentin disc conditioned with 0.5M EDTA for 2 minutes. Rests of smear layer can be seen on dentin surface. Scanning electron micrograph (original magnification x 10.0 KX).

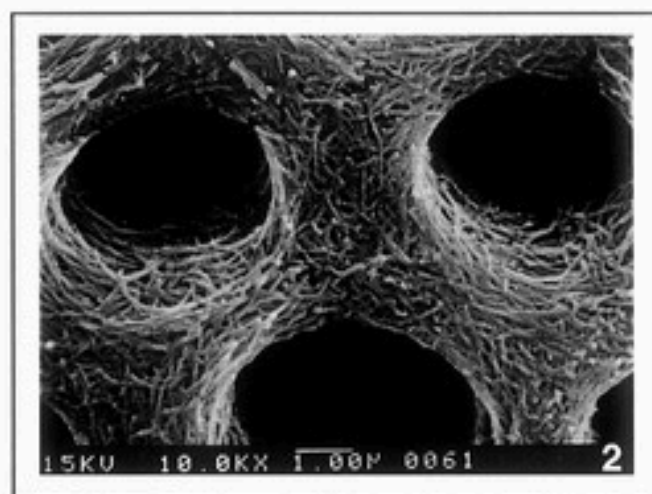


Figure 2. Dentin disc conditioned with 50% citric acid for 30 seconds. The dentinal tubule openings can be seen with no smear layer on the dentin surface. Scanning electron micrograph (original magnification x 10.0 KX).

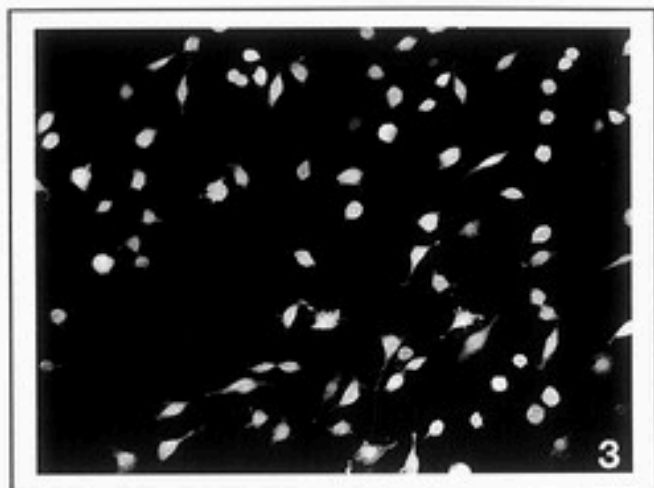


Figure 3.

Dentin disc conditioned with citric acid. Cells (1×10^4 cells/cm²) were plated and incubated for 24 hours at 37°C in a 5%CO₂ with 100% relative humidity. The L929 cells (stained with fluorescein diacetate) remained viable, however not even scattered on dentin substrate. Inverted light microscopy, 400X.

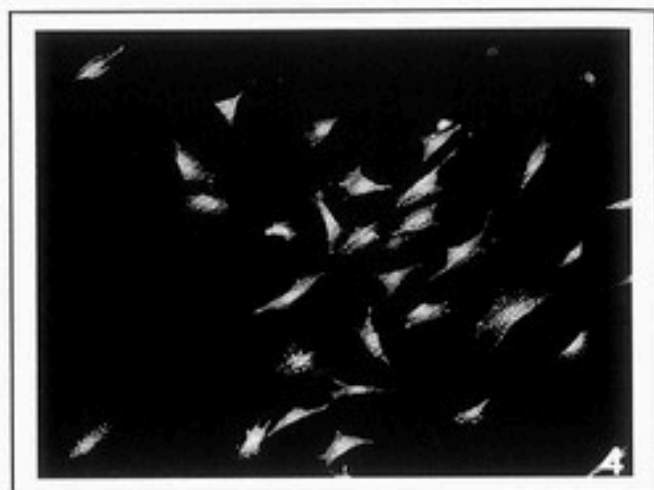


Figure 4.

Balb/c 3T3 cells not even scattered on dentin disc conditioned with citric acid. A few cells with different characteristics were observed when compared to Figure 3. Inverted light microscopy, 400X.

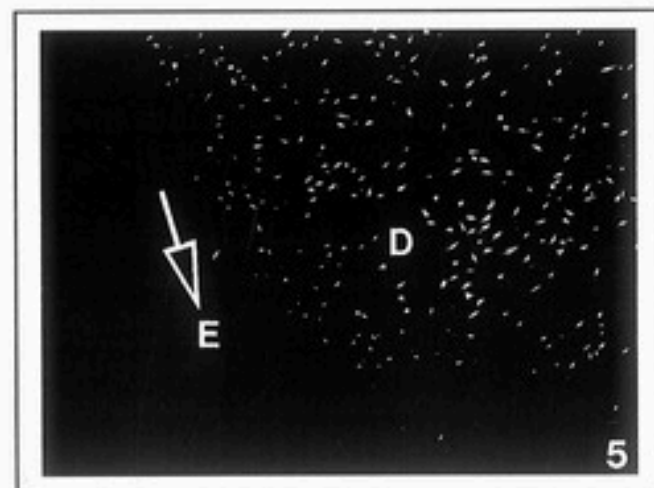


Figure 5.

Pulp cells not even spread on dentin surface (D). Note the absence of cells on enamel (arrow - E). Inverted light microscopy, 125X.

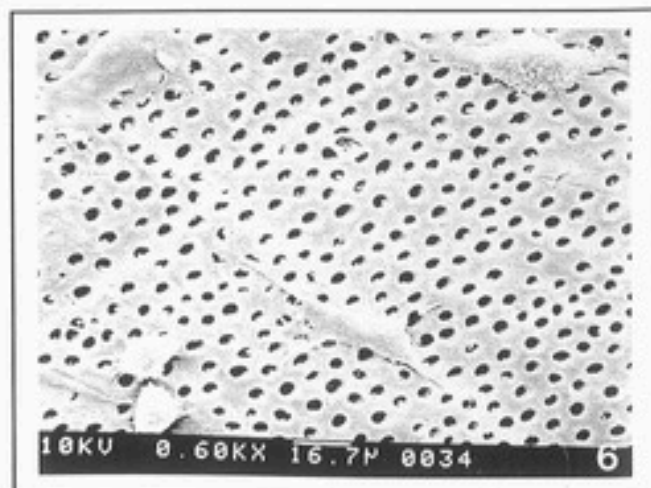


Figure 6.

Dentin surface conditioned with citric acid, which show L 929 cells with spindle-shaped and flattened morphology indicating cell attachment to the dentin substrate. Scanning electron micrograph (original magnification x 0.6 KX).

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Correspondence: Prof. Dr. Carlos Alberto de Souza Costa
821 Mt. Pleasant Avenue
Ann Arbor, Michigan -USA
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COMPUTERIZED METHOD FOR COMPARATIVE MORPHOMETRICAL, ANALYSIS OF TWO ROOT CANAL OBTURATION TECHNIQUES.

João Carlos GABRIELLI BIFFI, DDS, PHD
Universidade Federal de Uberlândia, Uberlândia, MG, Brazil
Carlos Alberto GARCIA MANIGLIA, DDS, PHD
Universidade Federal de Uberlândia, Uberlândia, MG, Brazil
Elizeu Alvaro PASCON, DDS, PHD
Universidade Federal de Uberlândia, Uberlândia, MG, Brazil

The purpose of this work was to quantitatively analyze the areas occupied by gutta-percha, debris, sealer, and empty spaces after root canal obturation, using a computerized imaging technique. The mesial and palatal roots of 40 maxillary first molars were used. Following instrumentation using the telescopic technique and obturation by hand lateral condensation and ultrasonic technique, the roots were cross sectioned from the apical to the cervical third in five cross sections with a circular diamond saw under abundant water spray. The images of 400 sections were obtained using a Dental View computer program, stored, and digitized using a Windows Autocad program (Version 12) by tracing a line at the external boundary of each root canal and the limits of its internal components. Each contour line received a defined color and they were standardized for all analyzed sections. Thus, every set of components inside the canal could be identified and grouped. These contours were used to calculate the area for each component. After statistical analysis, the results showed that significant differences were observed only for the gutta-percha component. The values for these areas were highest, followed by the sealer; the areas occupied by the debris were smaller, and the empty spaces came last. The results showed no significant differences between gutta-percha, cement, pulp tissue debris, and empty spaces areas related to the techniques utilized. However, there were significant differences between the same areas related to root types.

Key words: endodontics therapy, root canal obturation.

INTRODUCTION

The morphological complexity of the root canal system is a crucial factor for endodontic therapy. When several instrumentation techniques were evaluated for cleansing effectiveness, none of them completely removed pulpal debris, especially in the apical third^{17,11,6,15,15}. The inability to clean the canal is almost always related to lack of instrument contact with all canal walls^{17,13}. This raises the question: what would be the most adequate way to fill the inefficiently instrumented root canal system.

According to GROSSMAN⁹, a good root canal obturation must completely fill the space which was previously occupied by the pulp tissue, while at the same time being stable and biologically compatible. To achieve this goal, there must be strict application of the following procedures: access and root canal preparation at the working length, selection of filling material, sealer manipulation, master cone adaptation, and adequate lateral condensation.

The most common root canal filling method is the lateral condensation technique. However, after using this technique, obturation material, debris and spaces are found in different areas of the root canal system. Gutta-percha is widely used for root canal filling, but it does not seal the apical third nor adhere to dentin, thus a sealer must be used to completely fill all the remaining space.^{20,3} The "union" between sealer and the gutta-percha cone is only mechanical, and the sealers also do not chemically adhere to dentin¹⁶.

According to WEST et al.¹⁸, ideally, a fine layer of sealer should be placed on the canal walls before using a solid core obturation material. When lateral condensation technique is used, sealer would not only help fill the space between gutta-percha cones and the walls, but also fill space and irregularities in the canal system. This technique is widely accepted and commonly used to compare to other techniques^{2,3}. Evaluation of apical sealing has been done mostly by using dye penetration techniques. Although the use of this technique accounted for more than 20% of all papers published in 1989 and 1990, WU and WESSLINK¹⁹ considered it of limited value because there is no scientific support correlating it to clinical findings.

BEER et al.⁴ demonstrated that a solid core of gutta-percha should be the major component of the root canal filling because all sealers and pastes are irritants. They investigated the amount of canal space occupied by each filling constituent using lateral incisors.

Using maxillary molars and evaluating two instrumentation techniques, MANIGLIA and BIFFI¹³ concluded that the amount of debris remaining in the canal system was directly related to the initial canal anatomy rather than any instrumentation technique. The study was done by computerized mapping of the canal lumen in crosscut slices of the root, and determining the presence of tissue debris remaining after canal instrumentation.

The purpose of this work was to quantitatively evaluate, by computerized morphometrical analysis, the presence of gutta-percha, pulp tissue remnants (debris), sealer, and empty spaces inside the canal system, after a efficient instrumentation of the root canal and using two different filling techniques, in the mesiobuccal and palatal roots of maxillary first molars.

MATERIAL AND METHODS

This investigation used the mesial-buccal and palatal roots of forty recently extracted human maxillary first molars with vital pulp. After extraction the teeth were fixed in a 10% buffered formalin solution for at least 48 hours.

The teeth were mounted in a mannequin, to simulate the clinical condition. After isolation with a rubber dam, they were instrumented using the telescopic technique¹⁷. An attempt was made to keep

instrumentation shorter of the apex^{8,9}, by introducing the instrument until visually seen at the apical foramen and retract it 1 mm. Half of the teeth were randomly selected for obturation using lateral condensation and the other half using the ultrasound condensation. After positioning the master cone at the pre-established working length, the largest finger plugger which would reach 1 to 2 mm from the working length was selected, inserted into the canal, and secondary cones placed until the fill was completed. Colored standardized master cones were used to differentiate them from secondary cones. The differentiation and the relationship between them was studied in a previous paper which quantified the total area occupied by the gutta-percha master and secondary cones¹³.

The ultrasound technique was performed using an ENAC ultrasound machine (Model OE-3/Osada Electric CO. LTD.) following the manufacturer's instructions.

LABORATORY PROCEDURES

The three roots were separated with a diamond disk (100 mm diameter by 0.20 mm thickness) under abundant water spray (Figure 1A, B). The separated roots were radiographed from buccal-lingual and mesial-distal views using standardized techniques to expose and develop the films. Each root was fixed by the coronal part in the cutting device table and sliced into 5 one millimeter crosscut sections (Figure 1C, D, E, F, G) beginning 1,5 mm from the apex (section 1), in order to reach an area where obturation material could be seen. For each of the 400 images, the structures inside the canal were systematically identified by one of the authors.(CAGM) Using a stereomicroscope, the images were analyzed and photographically documented with 64 ASA Ektachrome film. The picture of each section was taken in the cervical-apical direction. The image from each Ektachrome slide was captured by a TV camera into the Dental View program connected to a Targa video board, through a device which allows visualization without image distortion, and stored in floppy disks. (Figures 2A, B) The images from the floppy disks were displayed in a high resolution video monitor and contoured using the Autocad for Windows (V.12) program. The contour line went

through the canal lumen and all the previously identified elements inside the canal space, using a digitizing table.

Each contour line was marked with a different color and standardized in all analyzed sections. All contour lines and the canal lumen were measured in area units and stored in a data bank. The area units were transformed into percent values to render the results analysis more meaningful.

Statistical analysis was calculated considering the following variables: a) independent: palatal and mesial-buccal roots, and lateral condensation and ultrasound obturation; b) dependent: gutta-percha, sealer, debris, and empty spaces. The bilateral test was applied to a 0.05 level of significance. The critical value of F, found through the "Snedecor F Table, was equal to 3.98. Through this analysis, the existence or absence of differences in the content between the four areas analyzed for the two root types and the two obturation methods, as well as the interaction between the roots and obturation, could be observed. Since the roots were divided into five sections, five analyses of variance were made.

RESULTS

The results showed statistically significant differences between the measured areas of gutta-percha, sealer, and debris, relative to both root types:

- the values of gutta-percha areas (per cent of total space) in the palatal root were significantly greater than the mesial-buccal root;
- the values of sealer areas in the palatal root were significantly greater than the mesial-buccal, except for section 2, where there were no differences;
- the values for debris areas in the mesial-buccal root were greater than the palatal, except for section 1, which had no differences.

There were no significant differences between all areas relating the two obturation methods. However, section 2, showed empty space areas were significantly greater than in the lateral condensation method.

Regarding the interaction between roots and obturation methods, there were no significant differences among the measured areas. This means that there were no differences, in either root type, due to the obturation methods.

The non-parametric Friedman method in a bilateral test at the level of 0.05 was applied to determine if significant differences existed among the area values studied (gutta-percha, sealer, debris, and empty spaces) between the two root types, and between the obturation methods, for each of the five section groups. The decision was made based upon the table for Qui-square critical values. For X^2 , $K = 3$ critical value was 5.99 and for $K=4$ it was 7.82. This test corresponds to the analysis of variance because there were only 20 analyzed elements.

Significant differences were found in all studied areas. Gutta-percha area values were always greater, followed by sealer, debris and empty spaces, except in six sections where empty spaces were greater than debris.

Similar analysis was done to verify whether there were significant differences between the five root sections of all the studied areas from each combination of the two root types and the obturation methods. The bilateral test was also applied with a level of 0.05 and the decision by the Qui-square.

Gutta-percha areas showed significant differences among the five sections: it was greatest in section 5, followed by sections 4, 3, 2, and 1, without exceptions. There were significant differences for sealer areas only in the laterally condensed palatal root where the areas were greatest for section 5, followed by section 4, 1, 3, and 2. Mesial-buccal roots filled by ultrasound had the greatest sealer areas in section 5, followed by 4, 2, 1, and 3.

There were no significant differences for debris areas among the five sections, in all conditions. Insufficient data did not allow for statistical analysis in the palatal root obturated by ultrasound. Regarding empty spaces, there were differences among the five sections only for the mesial-buccal root obturated by ultrasound, where section 4 showed the greatest area, followed by 5, 2, 3, and 1.

In order to verify the existence or not of positive correlation between the total area measurements and the canal lumen by computerized mapping, the Spearman coefficient correlation test, was applied. The test was bilateral at the significance level of 0.05. Critical value for r_s was equal to 0.30. The value obtained in the test was 0.987, which indicated a positive and significant correlation between the two measurements.

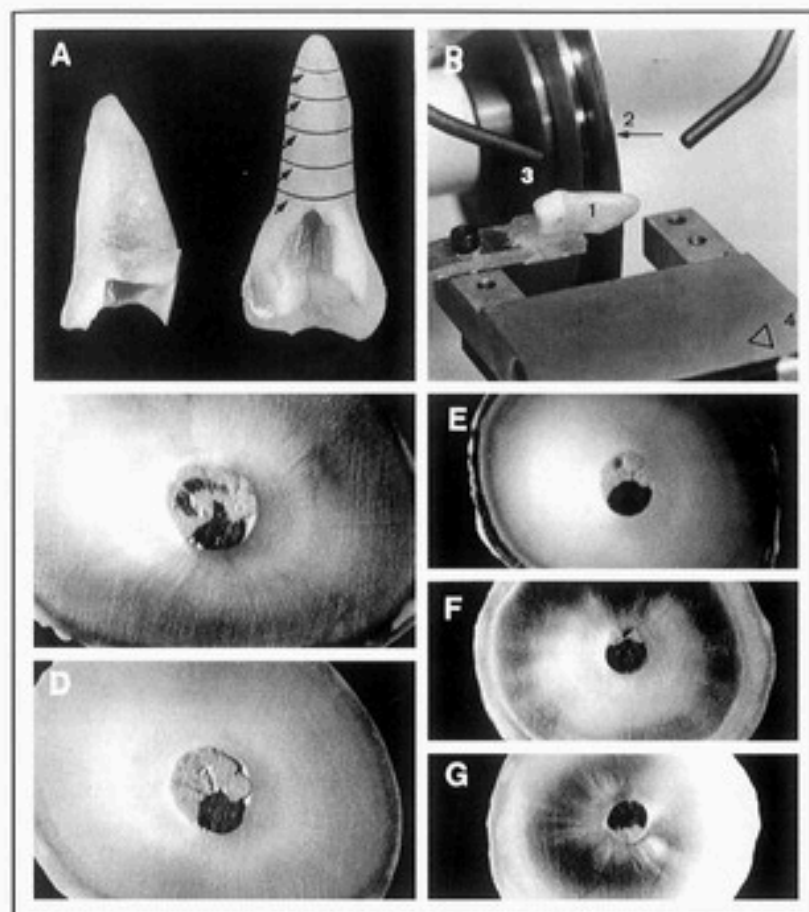


Figure 1.

A. Palatal and mesial-buccal roots and the sequence of cross cuts;
 B. Cutting machine and details of: 1. plastic sheet and fixed root; 2. diamond disk; 3. irrigation canules; and 4. millimetric scale in machine table.
 C. Palatal root crosscut; the master cone is the dark round mass and the secondary cones are the light areas.
 D, E, F and G. Palatal root after segmentation.



Figure 2.

A and B. Frontal e lateral view of video-camera and slide support (arrow);
 C. Video camera monitor (1), computer (2), digitizing table (3) and computer video monitor (4).

Figure 3.
 A. Captured image after tracing the analyzed structures;
 B. Superposition of contour lines of the canal elements over one section image on the high resolution monitor;
 C. Selection by software menu of each element within the canal system;
 D. Differentiated contours with color corresponding to each mapped element.

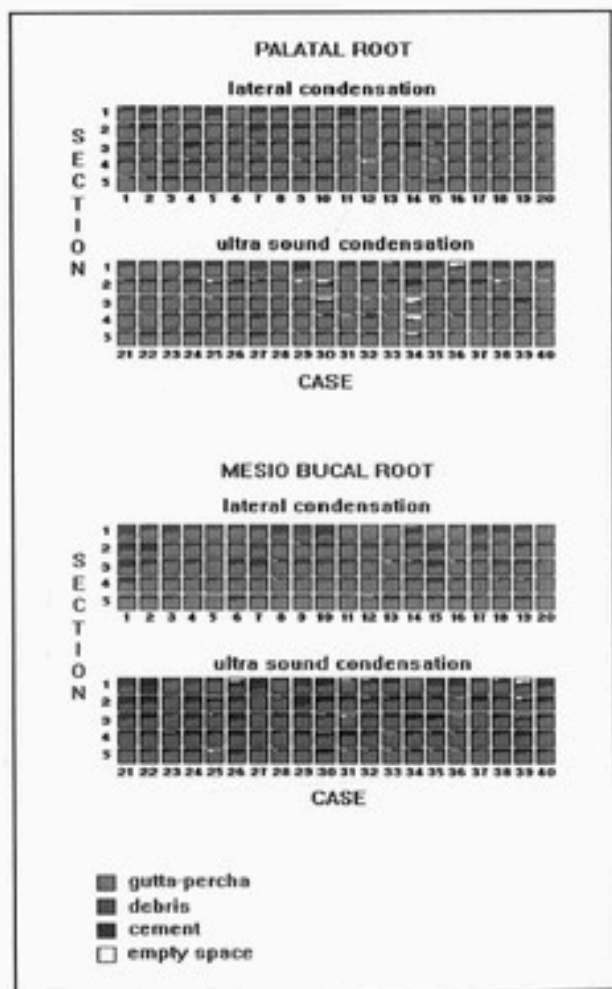
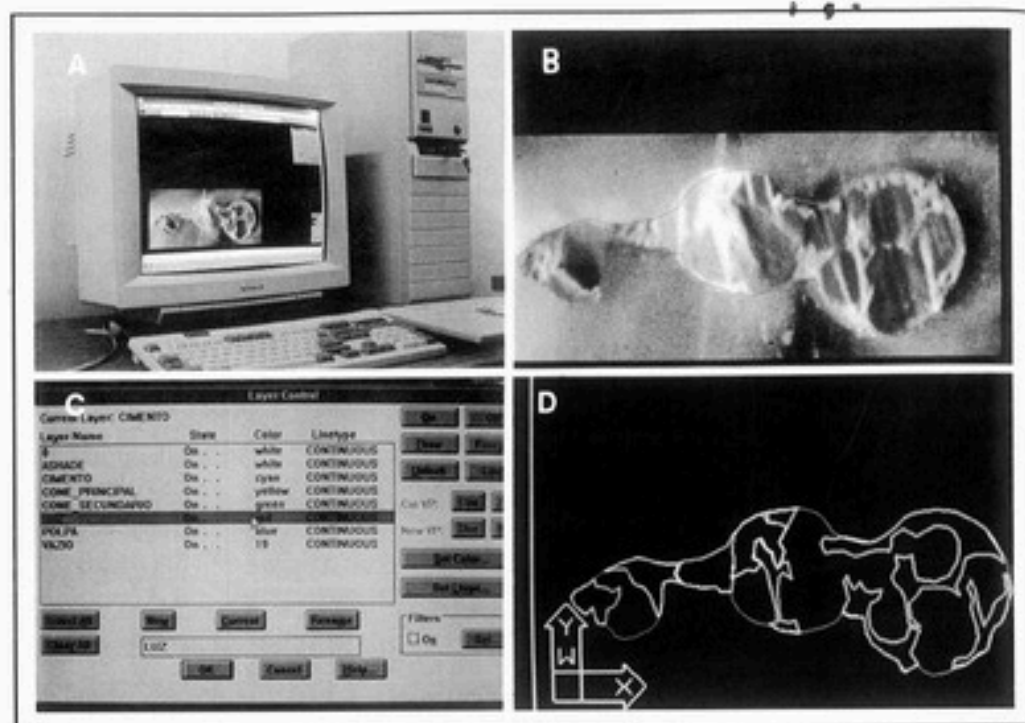


Figure 4.
 Representation, in percent, of all elements present within the root canal after obturation. The roots are numbered on the horizontal, while the sections are on the vertical position. Roots from 1 to 20 are manual lateral condensation, and 21 to 40 are ultrasound condensation.

DISCUSSION

In this study, forty fully developed maxillary first molars with separate roots were used.

Our results demonstrated that although post-obturation radiographs showed a uniformly filled root canal in a normal buccal-lingual view, there was no uniformity in the mesial-distal view, especially for the mesial-buccal root, which could be attributed to internal anatomy. BEYER-OLSEN et al.⁵ suggested that the observed areas corresponded to empty spaces and/or debris in the filled canal. This was confirmed in our study.

Obturation quality has been commonly assessed by dye penetration^{16,17}. However, OSINS et al.¹⁴ demonstrated that this technique lead to false conclusions because the sealer dissolves during testing. Considering the high success rate for endodontic therapy, this permeability probably does not influence the outcome. WU and WESSLINK¹⁹ accept the relative value of this technique because there is no scientific support related to clinical findings. They recommended that research should concentrate on developing evaluation methods, instead of analyzing sealing ability of materials and methods of obturation. Furthermore, they concluded that there are no techniques or materials that hermetically seals the apex.

The method used in this work was proposed by BIFFI et al.⁷ The obturation is evaluated on crosscut root sections, which allowed five different levels of examination. The drawback of this technique is the loss of dentin and obturation material during cutting, and the frictional heat development which may alter obturation dimensions. To limit this problem, the diamond disk should be as thin as possible and abundant water spray must be directed to the cutting area. However, when there were doubts about the photographed components. The original sections were analyzed again by stereomicroscope to assure precise area identification. Furthermore, computer software is being developed to electronically identify the elements inside the obturated canal by differentiation of grey levels in black and white images.

The first slice was made 1.5 to 2.0 mm from the apex to avoid the complex delta anatomy, and begin where the root filling was seen. The specimens were not placed in resin blocks because resin debris might have contaminated the obturation. The tooth root was attached horizontally to a plastic disk and both were cut.

MAGEEAN¹² stated that debris inside the obturated canal system could account for the endodontic failure rate. The results of this work corroborate his findings. Debris found in the mesial-buccal root were more prevalent than the palatal root and were statistically significant. These results confirm our previous findings that internal anatomy and the present pathosis are much more important than any technique in achieving complete debridement of the canal.

The amount of sealer varied according to the section examined, but no significant statistical differences between the obturation methods were found. Empty spaces were almost always the least frequently found variable, except in the ultrasound method section 2, where they were significantly greater. We believe that the increased presence of empty spaces in section 2 may be related to inadequate plugger positioning when placing the first secondary gutta-percha cone. The plugger should ideally be placed within 1.0 or 2.0 mm of the working length before placing the first secondary cone.

These findings demonstrated that complete apical seal is compromised by the amount of remaining tissue left. There were also significant differences between gutta-percha areas related to root types. The palatal root presented the greatest area of material. This fact demonstrated that straight circular canals could be easily instrumented and obturated, and all spaces were filled by gutta-percha and sealer in higher and smaller quantities respectively. However, in canals with more complicated internal anatomy, where the instruments usually do not reach, pulp debris and empty spaces were higher (Figure 4). The area decreased sequentially from section 5 to section 1, and the differences were significant.

Although gutta-percha is present in all sections, as shown in Figures 1 and 2, their values are far less than those obtained by BEER et al.⁴, who found that more than 90% of the canal area must be filled by the material.

CONCLUSIONS

The data obtained by statistical analysis of all studied contours demonstrated correlation between all measurements from the elements inside the root filling and the canal lumen, thus the method showed a high degree of reliability.

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Correspondence: João Carlos Gabrielli Biffi

DEOCR - Universidade Federal de Uberlândia

Rua Pará, 1720 - Bloco B - sala 25

38405-382 Uberlândia, MG - Brazil

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EVALUATION OF SOME PHYSICO-CHEMICAL PROPERTIES OF DIFFERENT CONCENTRATIONS OF SODIUM HYPOCHLORITE SOLUTIONS

Danilo Mathias Zanello GUERISOLI, DDS, MSc

Universidade de São Paulo, Ribeirão Preto, SP, Brazil

Reginaldo SANTANA DA SILVA, Chemical Technician

Universidade de São Paulo, Ribeirão Preto, SP, Brazil

Jesus Djalma PÉCORA, DDS, MSc, PhD, Chairman

Universidade de São Paulo, Ribeirão Preto, SP, Brazil

In this study, some physico-chemical properties (density, surface tension, pH, viscosity, wetting capacity and conductivity) of sodium hypochlorite solutions at the concentrations of 0.5%, 1.0%, 2.5% and 5.0% were evaluated. It was found that density, pH, viscosity, wetting capacity and conductivity of the solutions are directly proportional to their concentration of sodium hypochlorite. Surface tension values did not show significant differences between the solutions.

Key words: irrigating solutions, sodium hypochlorite, physico-chemical properties.

INTRODUCTION

Since its introduction to Dentistry in 1917 by BARRET¹, sodium hypochlorite (NaClO) has proven to be efficient as a root canal irrigating solution due to its properties as tissue solvent, deodorant and bactericide^{2,5,12}. Although variations may occur regarding the concentration of this solution, the active principle remains the same^{3,4,7}. For maximum efficiency, the shelf-life of these solutions must be observed, since the chlorine loss is rapid^{6,8,10}. Undoubtedly, sodium hypochlorite is the most used irrigating solution in the instrumentation of root canals worldwide. Due to the lack of information about the properties of these solutions, some physico-chemical properties (density, surface tension, pH, viscosity, wetting capacity and conductivity) of sodium hypochlorite solutions, at concentrations of 0.5%, 1.0%, 2.5% and 5.0% were studied in this investigation.

MATERIALS AND METHODS

The chlorine concentrations of the hypochlorite solutions at 0.5%, 1.0%, 2.5% and 5.0% were evaluated by titration, iodometry method.

The densities of the solutions were obtained by the relation between mass and weight, using an electronic analytical balance (CG-Libror model 3200 H) and a graduated measuring glass (100 ml, Pyrex).

To determine the surface tension of the solutions, a tensiometer (Fischer Scientific, Surface Tensiomat 21) was used.

pH was measured with a pH meter (Digimed, DMPH-2). The viscosity values were obtained using an Ostwald viscometer, based on the flow time of a liquid from a bulb through a capillary when subjected to its own weight. The flow time of the solution was compared with the time of a known viscosity liquid (water), thus, the viscosity of the solutions were obtained. Ten repetitions were made for each experimental group.

The wetting capacity measurements were made by the Draves method modified by PÉCORA et al.⁹: a 250 ml student beaker was filled with 200 ml of the liquid to be tested, leaving a 2 cm space from the border of the beaker to the surface of the solution. A 2-cm piece of thread (Corrente, 100% cotton) was then dropped from the border of the beaker, touching the surface of the liquid. The time spent for the thread to become completely wet and hit the bottom of the beaker was measured. Twenty repetitions for each solution were made.

The conductivity values were obtained by using an ohmmeter (Analion C-701).

All the measurements were made at 25 °C.

RESULTS

The results obtained are shown in Table 1.

The density of the solutions changed in direct proportion to their concentration. The linear regression and correlation tests showed a direct relation between the results and a correlation at the level of 1.0%.

The results found for the surface tension indicate similar values for the NaClO solutions.

The pH test showed a direct relation between the solutions and correlation at the level of 1.0%.

Variance analysis showed significant statistical difference

at 1% for the viscosity of the studied solutions.

The Tukey test showed that the solutions can be divided into 2 groups, with different values of viscosity. Group 1, formed by the 0.5% and 1.0% sodium hypochlorite solutions had the lowest viscosity values and group 2, formed by the 2.5% and 5.0% NaClO solutions had the highest.

The values for the wetting capacity of the tested solutions revealed that 1.0% and 2.5% sodium hypochlorite solutions are statistically the same; 0.5% NaClO has a lower capacity to wet the thread, while 5.0% NaClO has the highest wetting capacity.

The conductivity test showed less resistance to the electrical current as the concentration of NaClO increased.

Table 1. Mean values of the physico-chemical properties of the NaClO solutions.

Property	Substance			
	0.5% NaClO	1.0% NaClO	2.5% NaClO	5.0% NaClO
Density (g/cm ³)	1.00	1.04	1.06	1.09
Surface tension (dynes/cm)	74.3	75.0	75.7	73.8
PH	11.98	12.60	12.65	12.89
Viscosity (centipoise)	0.956	0.986	1.073	1.110
Wetting capacity (time)	2 hrs. 20 min.	1 hrs. 27 min.	1 hrs. 23 min.	18 min.
Conductivity (miliSiemens)	26.0	65.5	88.0	127.5

DISCUSSION

Increased density of the studied solutions was proportional to the concentration, due to the higher mass of NaClO present in the more concentrated solutions.

The NaClO solutions showed surface tension values similar between them. These surface tension values are close of the value found for water (72.73 dynes/cm²). This can be undesirable, since a high surface tension can avoid the contact between the liquid and the surface.

Sodium hypochlorite solutions are alkaline and the higher their concentration, the higher will be the pH, due to the quantity of NaOH molecules present. The high pH values of sodium hypochlorite does not represent a disadvantage, since its action is limited to the surface of the tissue^{11,13}.

The viscosity of the NaClO solutions increased with

the NaClO concentration.

The wetting capacity of the solutions was dependent on the NaClO concentration, in a directly proportional relation (the shorter the time, the higher wetting capacity).

The conductivity of the studied solutions showed to be directly proportional to their concentrations. This can be explained by the number of available ions present in the media, higher in the more concentrated solutions.

CONCLUSIONS

Based on the methodology and the results obtained, it can be concluded that:

1. Density, viscosity and surface tension of the sodium hypochlorite solutions are similar to water.
2. Density, pH, viscosity, wetting capacity and conductivity are directly proportional to NaClO concentration, while surface tension is not.

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Correspondence: **Dr. Jesus Djalma Pécora**

Department of Restorative Dentistry,

Ribeirão Preto Dental School, University of São Paulo

Av. do Café s/n

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EVALUATION OF DENSITY OF CALCIUM HYDROXIDE PASTES IN DOGS MANDIBLES

Carlos ESTRELA, MSc, PhD, Chairman

Universidade Federal de Goiás, Goiânia, Go, Brazil

Iussif MAMEDE NETO, DDS

Universidade Federal de Goiás, Goiânia, Go, Brazil

Cynthia Rodrigues de A. ESTRELA, DDS

Universidade Federal de Goiás, Goiânia, Go, Brazil

Jesus Djalma PÉCORÁ, MSc, PhD, Chairman

Universidade de São Paulo, Ribeirão Preto, SP, Brazil

INTRODUCTION

Intracanal dressing continues to be the target of discussions. Considerations about the real necessity of its use in pulpal necrosis and apical periodontitis, the selection of the substance to be used, the time it should remain in the root canal, its effect on different microorganisms found in endodontic infections and its influence on tissue healing are justifications for new research structured within adequate critical analysis and well established methodologies.

Considering the amount of research carried out, calcium hydroxide has withstood criticism and experimentation and has proven to be the best therapeutic option as an intracanal dressing. The principle action of calcium hydroxide involves the ionic dissociation into hydroxyl ions and calcium ions and its influence on tissue healing and microbial control⁶⁻¹³. ESTRELA and PESCE¹² chemically analyzed the release of hydroxyl ions and calcium ions from calcium hydroxide pastes in connective tissue of dogs and demonstrated that when calcium hydroxide is placed within the root canal, 45.89% and 54.11% were dissociated into hydroxyl ions and calcium ions, respectively. HOLLAND¹⁵ analyzed histochemically the biological process of tissue healing using calcium hydroxide, and reported the formation of five zones: clotting superficial necrosis zone, superficial grainy zone, deep grainy zone, proliferation zone and connective tissue zone. He also reported the importance of calcium ions in the mineralization process. The influence of calcium hydroxide on microorganisms was studied by ESTRELA et al.¹³ who analyzed the action of hydroxyl

Calcium hydroxide influences the enzymatic activity of bacteria which is reflected in growth, cellular division and bacterial metabolism. The chemical and biologic actions of calcium hydroxide on tissue and bacteria have made this medication indispensable in Endodontics. The correct filling of the root canal is as important as the effectiveness of calcium hydroxide, because the lack of direct contact of this dressing interferes with its mechanism of action. In order to better visualize the filling of the pulpal cavity, radiopaque substances, such as zinc oxide, iodoform and barium sulfate have been added to calcium hydroxide. However, when the root canal is well filled, dentin and calcium hydroxide paste in association with saline solution clinically present themselves with the same radiopacity, causing the disappearance of root canal light. The aim of this work is to study the density of calcium hydroxide pastes with different vehicles, with no association with radiopaque substances and in comparison with dentin density. Considering the results of this work, it can be observed that it is not necessary to add radiopaque substances to calcium hydroxide pastes, because pastes used without them showed densities similar to dentin. In addition, when any substance is added to calcium hydroxide, even an inert one, it represents one more factor influencing biological processes and possibly of diminishing the amount of hydroxyl and calcium ions available, which represents one of the reasons for its use.

Key Words: Calcium hydroxide, intracanal dressing, density

ions on microbial enzymes in the cytoplasmic membrane, causing changes in the transport of nutrients and in the structure of organic components. This interference in biosynthetic processes that are essential to the life of microorganisms can also be analyzed through the process of lipid peroxidation and influenced by hydroxyl ions. Thus, the quantity of hydroxyl ions existing can lead to the enzymatic deactivation of bacteria.

Some studies have recommended the addition of other substances to calcium hydroxide, with the aim of improving some of its properties. Among these substances are vehicles that can speed up or slow down ionic dissociation, substances that aid the filling of the pulpal cavity by means of their consistency, substances that are used as antimicrobial medium and medium that enhance radiopacity.

The correct filling of the canal is as important as the effectiveness of calcium hydroxide because since the lack of direct contact of this dressing interferes with its mechanism of action⁶⁻⁷. In order to better visualize the filling of the pulpal cavity, radiopaque substances, such as zinc oxide, iodoform and barium sulfate have been added to calcium hydroxide. However, when the root canal is well filled, dentin and calcium hydroxide paste in association with saline solution clinically present themselves with the same radiopacity, causing the disappearance of root canal light.

Considering these factors, the aim of this work is to study the density of calcium hydroxide pastes with different vehicles, with no association with radiopaque substances and in comparison with dentin density.

MATERIAL AND METHODS

This study was carried out on root canals (2nd and 3rd mandibular premolars) of dogs' mandibles, divided into blocks. Samples were kept in saline solution for 7 days. Teeth were prepared until ISO #50 K-file (Maillefer, Switzerland), 1 mm short of the apical foramen, using the cervical preparation technique. The cervical third was enlarged with #2 Gates-Glidden burs. Three ml of 1% sodium hypochlorite was used for irrigation after each file, during instrumentation of the root canals. Root canals were then dried and filled and placed in 17% EDTA (pH 7.2) for 3 min, and then dried again.

Twelve root canals were filled with a mixture of

calcium hydroxide paste (Pro-analise, Quimis, Mallinkrodt Inc., USA) and one of the 3 vehicles: saline, propylene glycol 400 and camphorated paramonochlorophenol (CPMC), with the consistency of tooth paste. Root canals were filled with the aid of the last file used in canal preparation. Simultaneously to the movement of penetration/removal and anti-clockwise rotation of file, pastes were condensed and compressed by means of a file and absorbent paper points, until the complete filling of cervical third could be observed^{7,8}. After placement of the calcium hydroxide paste, the teeth were radiographed together with an aluminum step-wedge (Alcan Alumínio do Brasil S.A., Porto Alegre, RS, Brazil) in order to evaluate the densities of teeth and dentin. After obtaining radiographs showing the image of the aluminum step-wedge, canals of each group were emptied using #10 file K-file (Maillefer) and flushed with saline solution and radiographed again to confirm if they had been completely emptied, having in mind their reuse for the application of the two other pastes. After root canals had been filled with the other pastes, teeth were radiographed again in order to verify if they had been completely emptied.

Analysis of density of calcium hydroxide pastes was performed using an aluminum step-wedge manufactured according to SCARPARO et al.²⁰. The chemical composition of the aluminum alloy was as follows: 6063 alloy; Al-base; Si-0.60%; Fe-0.35%; Au-0.10%; Mn-0.10%; Mg-0.90%; Ar-0.10%; Zn-0.10%; Ti-0.10%; Others-0.15%. This alloy was used to manufacture a 7-step wedge ranging from 4.0 to 10.0 mm in height; 3 cm in length and 3 mm in width. Its dimensions were adjusted to the size of film and to the contrast produced between steps of radiographic image. Thus, each radiograph showed the image of the aluminum step-wedge in the region of the tooth in which the optical density could be compared.

Three periapical radiographs (Kodak, UltraSpeed, USA) were taken of each tooth, as follows: (1st) initial, (2nd) showing the root canal filled and densitometer and (3rd) final after complete emptying. All radiographs were taken using the same machine (Dabi-Atlante, Spectro II, 70KV, 10mA, Ribeirão Preto, SP, Brazil), with a 4-cm focus-film distance and 0.5-s exposition. Radiographic processing was performed at once for the three groups, through time-temperature method. An acrylic support was used while the radiographs were taken, always holding the same position. All radiographs showed quality image,

sharpness and contrast appropriate for analysis.

Parameters were established between the steps that ranged from 1 to 7, for dentin and for calcium hydroxide pastes, in order to assess density. With this objective, 3 appraisers individually observed each radiograph using a negative viewer located in an appropriated room and determined comparatively dentin density with calcium hydroxide pastes, in each root. The final parameter of assessment was quantified by the step (1 to 7 - density values were expressed in aluminum-equivalent mm/Al/Eq.) corresponding

to paste and to dentin density. A comparative and statistical analysis can be established by means of the average of the values corresponding to the wedge's steps. The three thirds of root were analysed together. Figure 1 shows the aluminum step-wedge that was manufactured for this study; Figures 2 to 5 show teeth after root canal preparation and after placement and complete filling of the canal with calcium hydroxide pastes, in which densities of dentin can be compared with densities of pastes used in the process.

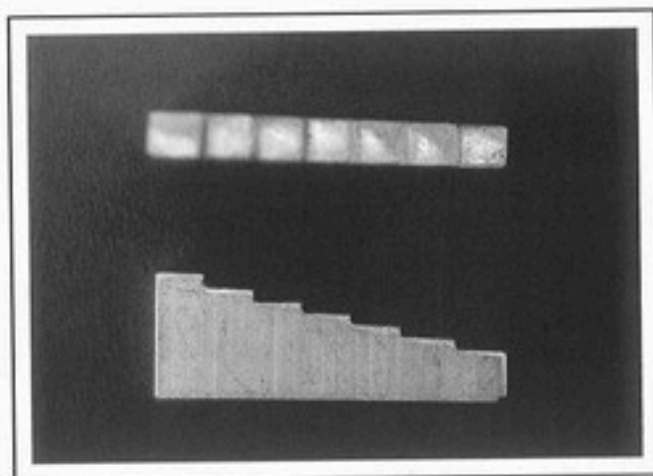
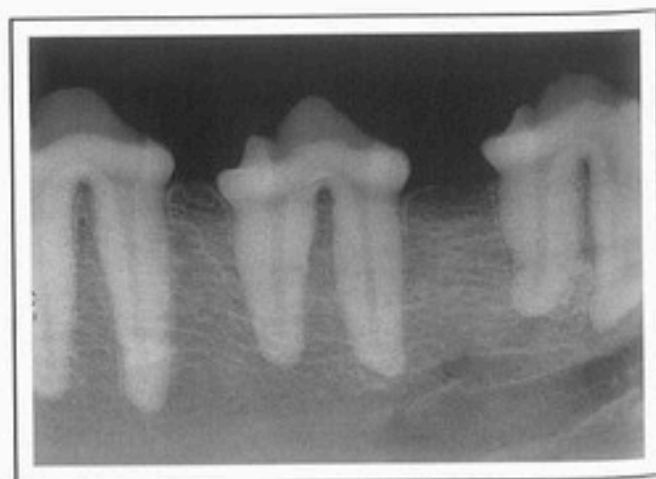


Figure 1.
Aluminum step-wedge



Figures 2
2.nd. and 3.rd. premolars after preparation.

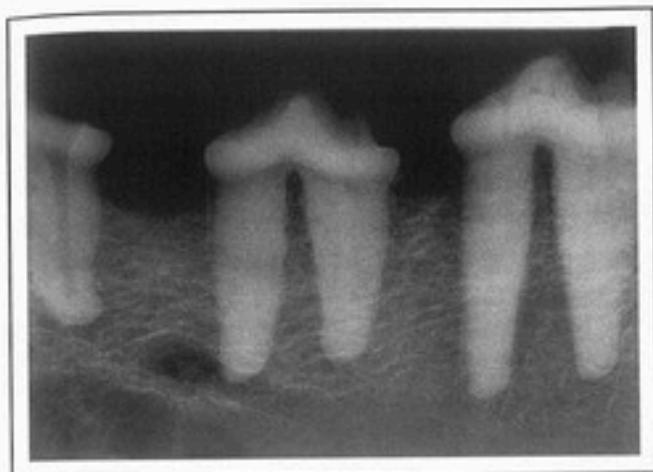


Figure 3.
3. After canal filling with calcium hydroxide with saline solution.



Figure 4
After canal filling with calcium hydroxide with propylene

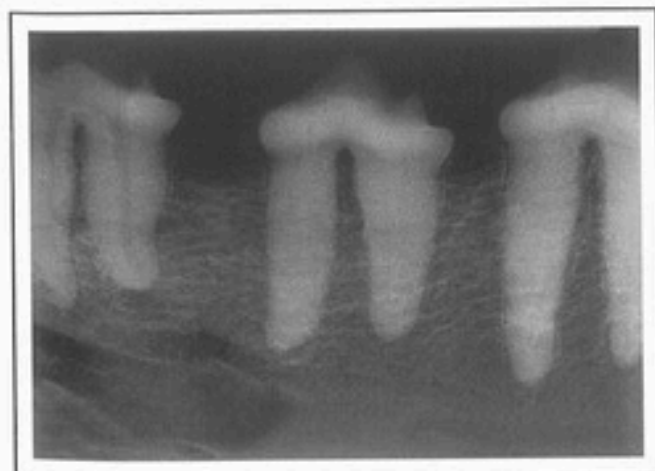


Figure 5.
After canal filling with calcium hydroxide with CPMC

RESULTS AND DISCUSSIONS

Some parameters for the use of intracanal dressing can be established from the better understanding of the mechanism of action of calcium hydroxide on tissues and microorganisms. The comparison of densities between different groups of calcium hydroxide pastes and between each group of calcium hydroxide paste and dentin was performed in pairs using the Wilcoxon non-parametric test for paired observations, at a significance level of 5%. In terms of coincidence, there was no significant difference between the three assessments performed by different appraisers. The comparison of the variation between appraisers revealed a coincidence of 89% in the assessment performed, and the Kappa values ranged from 0.60 to 0.65 for each pair of appraisers. The results of this study did not show statistically significant differences when the densities of calcium hydroxide pastes were compared between them nor when they were compared with dentin densities, as expressed in Table 1 and can be visualized in Figures 2 to 5.

The radiographic images provide important information. Different studies suggest methods of image analysis^{1-5,14,19,20}. However, it is difficult to analyze a three-dimensional aspect presented in just one plane. CARVALHO⁴, interpreting radiographs of bone lesions that were experimentally produced in dry human mandibles, reported that the deformities restricted to the cancellous bone were only observed in larger proportions. Images became clear when, by means of enlargement of deformities, jointed trabeculae and the inner surface of the lingual and/or buccal cortex were destroyed.

The methodology of this study using an aluminum step-wedge for density analysis has been used by others. SCARPARO et al.²⁰ developed an exploratory methodology to analyze bone density in the mandible, using an aluminum step-wedge as a numerical referential. PUPIN et al.¹⁹ evaluating bone density through optical reading of the molar region in dry mandibles, observed that there were no statistically significant differences between bone density values of the right and left sides.

Within the context of this research, it is important to emphasize that the correct preparation of root canal is essential to the cleansing process, also helping the filling with calcium hydroxide paste. Compression of paste relies on its appropriated consistency aided by the use of a suitable filling technique.

Considering the results of this study, it can be observed that it is not necessary to add radiopaque substances to calcium hydroxide pastes, because pastes used without them showed densities similar to dentin. In addition, when any substance is added to calcium hydroxide, even an inert one, it represents one more factor influencing biological processes and possibly of diminishing the amount of hydroxyl and calcium ions available, which represents one of the reasons for its use.

Knowing that the biological effects of calcium hydroxide lead to the activation of alkaline phosphatase, which, in turn, positively influences the mineralization process and favor the deactivation of bacterial enzymes aiding the antimicrobial effect, the importance of the speed with which hydroxyl ions are released together with their availability in the environment in which their effectiveness is desired can be deduced.

Another factor to be analyzed is the possibility that calcium hydroxide is reabsorbed in the root canal, with only the radiopaque substance remaining and giving the false idea that it keeps on acting. This factor should be considered carefully, because has been no advantage of adding other substance to calcium hydroxide has been noted⁶⁻¹³.

ESTRELA⁶ analyzed the antimicrobial effectiveness of calcium hydroxide diffused by different substances. Microorganisms tested were *Streptococcus mutans*, *Streptococcus faecalis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Candida albicans* and a mixture of these microbial samples. Among the vehicles tested were: saline solution, CPMC, chlorhexidine, Flagyl® (Metronidazole), Otosporim® and sodium lauryl sulfate. During the comparison of the results obtained in the experimental periods of exposition - 1 minute, 48 and 72 hours, and 7 days - the absence of antimicrobial synergy between calcium hydroxide and tested vehicles called the attention and supported the recommendation for the use of an inert and periapical-tissue-non-aggressive vehicle, such as saline solution and distilled water. These vehicles influence antimicrobial activity as they speed up ionic dissociation and diffusion and at the same time facilitate hydroxyl ions transportation and activity in dentinal mass. Thus, the vehicle acts like an assistant in this process, giving calcium hydroxide chemical characteristics (dissociation, diffusibility and filling) that are decisive to the antimicrobial potential and tissue healing capacity.

In this study, watery hydrosoluble (saline solution), viscous hydrosoluble (propylene glycol 400) and oily (CPMC) vehicles were compared, and it could be observed that the consistency of paste and filling technique were important factors, since there were no differences among their densities nor when their densities were compared to dentin densities, although research identifies advantages in the use of pastes with hydrosoluble vehicle, such as saline solution.

CONCLUSIONS

Based on the results of this study, the following conclusions are made:

1. There were no statistically significant differences between optical reading values of densities of pastes analyzed or when they were compared to dentin density.
2. Addition of radiopaque substances to calcium hydroxide is not necessary, because calcium hydroxide paste density is similar to dentin density, provided that the root canal had been properly filled.

TABLE 1. Densities of pastes and dentin by steps (values expressed in aluminum/equivalent/mm)

Roots	Pastes			Dentin
	Ca(OH) ₂ + S	Ca(OH) ₂ + PEG	Ca(OH) ₂ + CPMC	
1	5	5	5	5
2	5	5	5	5
3	5	5	5	5
4	5	5	5	5
5	5	4	4	5
6	4	4	5	5
7	5	5	5	5
8	5	5	5	5
9	4	5	5	5
10	5	5	5	5
11	5	5	5	5
12	5	5	4	5
Averages	58	58	58	60
	N	Mean		
Dentin	12	5,00000		
CH+ S	12	4,83333		
CH+ PEG	12	4,66667		
CH+ CPMC	12	4,83333		

(Wilcoxon Matched-Pairs signed-ranks test)

CH - calcium hydroxide
S - saline

PEG - propylene glycol
CPMC - camphorated paramonoclorophenol

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Correspondence:

Prof. CARLOS ESTRELA, Rua B 1, Quadra 6, Lote 2, Setor Bueno, Goiânia, GO,
CEP 74530-180, Brazil, Phone (FAX) 55 62 251 0408

AN IN VITRO STUDY OF THE QUALITY OF ROOT FILLINGS IN TEETH OBTURATED BY LATERAL CONDENSATION OF GUTTA-PERCHA OR THREE DEE GP OBTURATORS

Paul M. H. DUMMER, DDS, MSc, PhD

University of Wales College of Medicine, Cardiff, UK

Alberto ROSSI JUNIOR, DDS

Brazilian Armed Forces, Santana do Livramento, Brazil

Tatiana Selliach Duarte, DDS

Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

The aim of this in vitro study was to compare the extrusion of filling material, radiographic quality of fill, apical and coronal dye leakage, and speed of filling in teeth obturated with either cold laterally condensed gutta-percha or Three Dee GP Obturators. A total of 82 extracted teeth with single roots were included in the study. All canals were prepared with a stepdown technique using a rotatory nickel titanium system with copious irrigation. Radiographs taken of the teeth to show the maximum degree of canal curvature were then exposed and the angle, radius and the position of the curvature determined. This information about the canals, together with their working length and diameter at end-point was used to divide the teeth into two experimental and two control groups. A total of 38 teeth were filled with Three Dee GP Obturators, 38 with lateral condensation of gutta-percha while 6 teeth remained unfilled and acted as controls. Following obturation, the teeth were radiographed in two planes and the technical quality of fill assessed on a four-point scale. The teeth were immersed in India ink for 90 hours and cleared with methyl salicylate in order to determine linear dye penetration. Apical extrusion of sealer and gutta-percha occurred significantly more often with Three Dee GP Obturators ($P < 0.05$). There was no significant difference in the radiographic quality of fill or apical and coronal dye leakage between the techniques. Canal obturation with Three Dee GP Obturators was significantly quicker ($P < 0.0001$) than lateral condensation. Under the conditions of this study, Three Dee GP obturators proved a satisfactory alternative to lateral condensation of gutta-percha.

Key words: root canal obturation, thermoplasticized gutta-percha, Three Dee GP Obturators

INTRODUCTION

It is generally believed that warm vertical compaction of gutta-percha into root canals produces an improved quality of obturation compared with lateral condensation^{1,11}, probably because the heat-softened material is compacted into canal irregularities inaccessible to cold condensation techniques. However, conventional warm vertical compaction is time consuming and difficult to carry out⁵.

Various innovative methods of introducing warm gutta-percha into the canal have been developed in an attempt to make the technique simple and more rapid. YEE et al.¹⁴ described the injection of thermoplasticized gutta-percha whilst JOHNSON⁷ introduced the concept of a coated carrier which was marketed subsequently as Thermafil Endodontics Obturators (Tulsa Dental Products, Tulsa, OK, USA). Since its introduction, numerous investigations have been carried out on Thermafil Obturators with most finding them to be comparable or better than lateral condensation in terms of dye penetration^{2,3,4,5,10,12}, radiographic density^{4,5,6}, speed of obturation^{4,5} and ease of retreatment¹³. Some studies have concluded that the extrusion of filling material beyond the apex with the Thermafil technique is higher than with lateral condensation^{2,4,6} whilst others have demonstrated that Thermafil Obturators have a similar incidence of extrusion of filling material when compared with lateral condensation⁵.

Recently a new thermoplasticized gutta-percha product, similar to Thermafil Obturators, has been introduced with the commercial name - Three Dee GP

(Specialitie Septodont, Santmaur des Fosses, France). No studies have evaluated the filling potential of this material. The aim of this study was to compare Three Dee GP Obturators and lateral condensation of gutta-percha during the filling of root canals in extracted teeth.

MATERIALS AND METHODS

Three Dee GP Obturators

Three Dee GP Obturators are a new system for the obturation of root canals (Figure 1). Each obturator consists of a plastic carrier coated with a layer of alpha phase gutta-percha, a metal shank with rubber stop and plastic handle (Figure 2). A series of size verifiers are also provided (Figure 2). The innovative design of the obturators allows easy removal of the handle and metal shaft from the plastic gutta-percha coated carrier; this overcomes one of the potential drawbacks of the Thermafil technique where the handle has to be severed with a bur.

Selection of teeth

A total of 82 human extracted incisor, canine and premolar teeth, with single roots and canals, and mature closed apices, were selected for the study. The teeth had been stored in ethanol and then 0.1% thymol water following extraction. The canals were radiographed perpendicular to their plane of maximum curvature and the canal images assessed as illustrated in Figure 3. Thus, the angle and radius of curvature, as well as the position of the beginning of the curve in relation to the coronal reference point, were noted. This information, together with the working length and diameter of the canals at their endpoint, was then used to divide the teeth into two experimental groups each containing 38 teeth and two control groups each containing 3 teeth. The use of data on canal shape ensured that the groups were balanced with respect to the defined constraints.

Access cavities were prepared and the canals cleaned and shaped exclusively with ProFile NiTi Rotatory instruments (Maillefer Instruments SA, Ballaigues, Switzerland) using a stepdown technique. Preparation of the apical stop continued for three sizes greater than the file which bound first at the full working distance. Irrigation with 2% sodium hypochlorite was performed

throughout and the patency of the canals was confirmed following preparation by passing a size 15 file just through the foramen.

Obturation of canals

Canals in the experimental groups were obturated with either lateral condensation of gutta-percha or Three Dee GP obturators. Canals in the control groups remained unfilled.

Lateral condensation: A well-fitting master cone which gave "tugback" at the working length was selected for each root canal. The canals were dried thoroughly with paper points and a thin coat of sealer (Tubliseal, Kerr Sybron, Romulus, MI, USA) applied to the walls. The master cone (Kerr Sybron) was then lightly coated in sealer and placed slowly into the root canal to the full working length. Lateral condensation was carried out using accessory cones with endodontic spreaders placed in the first instance to 1-2 mm of the working distance. Condensation continued until the spreader could no longer penetrate the coronal mass of gutta-percha. At the coronal part of the obturation, the gutta-percha cones were warmed, cut and vertical condensation carried out with pluggers.

Three Dee GP obturators: Obturation of canals was carried out following the manufacturer's instructions. Initially, the appropriate size of obturator was selected on the basis of the prepared canal diameter and after reference to the carrier blanks of the verification kit (Figure 2). The rubber stop on each obturator was positioned to coincide with the working length and the device then placed the oven for the appropriate time in order to soften the gutta-percha. A small amount of sealer (Tubliseal) was then applied to the coronal region of the canal and the obturator removed from the oven and seated immediately to the full working distance. At the coronal orifice the handle was removed and vertical condensation completed with pluggers.

Assessment of obturation

Speed of obturation: The time taken to obturate canals was determined for both techniques and included active filling only; it did not include preparatory time.

Extrusion of sealer and gutta-percha: The extrusion of sealer and/or gutta-percha through the apical foramen was recorded using a simple yes/no scheme.

Radiographic quality: Radiographs of each filled tooth were taken in two planes: bucco-lingually (buccal) and mesio-distal (proximal). The quality of obturation was determined separately for the apical and coronal halves of each canal using a four-point scale⁸.

1. This was characterized as a well-condensed filling which obturated the entire prepared root canal, was well adapted to the canal wall and showed only a few minor areas of relative radiolucency (less than 0.25 mm in diameter);

2. This was characterized as an imperfectly condensed filling that might be a little short (less than 0.5 mm), and that showed irregularities of less than 1 mm in the adaptation;

3. This was characterized as inadequately condensed with irregularities of less than 2 mm, a filling that might be 1.5 mm short;

4. This was characterized as poorly condensed with irregularities of more than 2 mm, a filling that might be more than 2 mm short.

Apical leakage: Apical leakage was detected using a dye (India Ink). After filling, the teeth were covered with nail varnish except for their apical 1 mm and the coronal access. The specimens were immersed in the India Ink for 90 hours. The teeth were then removed from the dye and the nail varnish removed with a scalpel blade. The specimens were immersed in various concentrations of alcohol before being stored in methyl salicylate. The maximum depth of dye penetration via the apical foramen and coronal orifice was assessed independently using a stereo microscope.

Teeth in one of the control groups were varnished completely in order to occlude the foramen while the teeth in the other group were varnished as described previously. Both groups remained unfilled and were subjected to dye penetration.

Data management

Data was recorded directly onto coding sheets and then stored in a PC. Subsequent statistical analyses were carried out using MINITAB, an interactive statistics package. Significant differences between the techniques were assessed as follows: obturation time, Kruskal-Wallis test; extrusion of sealer and/or gutta-percha, Chi-square test; radiographic quality, Two-sample t-test; dye leakage, Two-sample t-test.

RESULTS

Speed of obturation

The average time taken to fill canals with Three Dee GP Obturators was 1.158 min and with lateral condensation 4.802 min. The difference between the techniques was significant ($P < 0.001$).

Extrusion of sealer and gutta-percha

The numbers of canals with extruded sealer and/or gutta-percha in each technique is given in Table 1. Sealer was extruded in 14 of 38 canals filled with Three Dee GP obturators and in just 5 canals obturated with lateral condensation. The difference between the groups was significant ($P < 0.05$).

In relation to the extrusion of gutta-percha, 4 canals filled with Three Dee GP obturators had evidence of gutta-percha extrusion while no canals were affected in the lateral condensation group. The difference between the groups was significant ($P < 0.05$).

Radiographic quality

The mean scores for the radiographic quality of obturation for Three Dee GP obturators and lateral condensation is given in Table 2. The distribution of the canals in the four-point scale⁸ is given in Table 3. There were no significant differences between the groups in either apical or coronal half.

Dye leakage

Apical linear dye penetration was 3.35 ± 3.07 mm in those canals filled with Three Dee GP Obturators and 2.00 ± 1.47 mm in those filled by lateral condensation. The coronal linear dye penetration was 4.83 ± 4.13 mm in those canals filled with Three Dee GP Obturators and 3.75 ± 3.41 mm in those filled by lateral condensation (Table 4). In both cases the differences were not significant (Fig. 4).

Control teeth

In those teeth where the canal was prepared, not filled and the foramen occluded with varnish no penetration of dye occurred. In those teeth which were prepared, not filled and the foramen remained patent, dye penetrated the entire length of the canals.

Table 1. Comparison of sealer and gutta-percha extrusion between Three Dee GP Obturators and lateral condensation

	Three Dee GP obturators	Lateral condensation
Sealer		
Yes	14	5
No	24	33
Total	38	38
	$\chi^2 = 5.684$ $P < 0.05$	
Gutta-percha		
Yes	4	0
No	34	38
Total	38	38
	$\chi^2 = 4.222$ $P < 0.05$	

Table 2. Comparison of the radiographic quality of Three Dee GP Obturators and lateral condensation

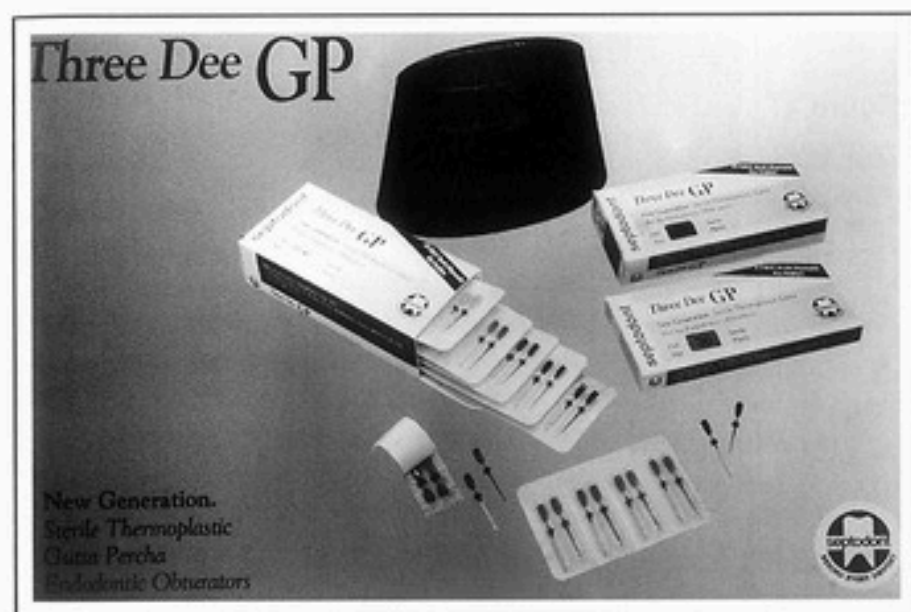
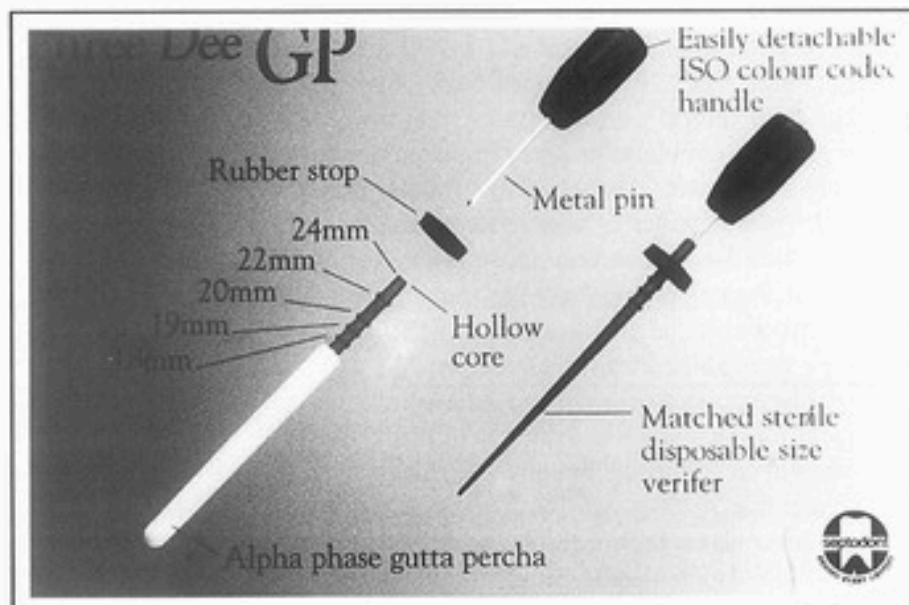
	Three Dee GP obturators (n=38)	Lateral condensation (n=38)	Value of t	P
Apical half				
Buccal	1.45±0.89	1.24±0.63	-1.19	> 0.05
Proximal	2.00±1.19	1.95±1.14	-0.20	> 0.05
Coronal half				
Buccal	1.42±1.00	1.11±0.45	-1.77	> 0.05
Proximal	2.61±1.33	3.08±1.22	1.62	> 0.05

Table 3. Comparison of the radiographic quality of Three Dee GP obturators and lateral condensation using a four-point scale by Kersten et al (1986).

	Three Dee GP Obturators					Lateral condensation					χ^2	P
	1	2	3	4	tot	1	2	3	4	tot		
Apical half												
Buccal	29	3	4	2	38	32	4	1	1	38	2.424	>0.05
Proximal	20	4	8	6	38	19	8	5	6	38	2.051	>0.05
Coronal half												
Buccal	32	0	2	4	38	36	0	2	0	38	4.235	>0.05
Proximal	13	4	6	15	38	8	2	7	21	38	2.934	>0.05

Table 4. Comparison of the dye leakage(mm) of Three Dee GP Obturators and lateral condensation

	Three Dee GP obturators	Lateral condensation	Value of t	P
Apical	3.35±3.07 n=29	2.00±1.47 n=4	-1.44	> 0.05
Coronal	4.83±4.13 n=35	3.75±3.41 n=34	-1.19	> 0.05

**Figure 1.** Three Dee GP Obturation system**Figure 2.**

Three Dee GP Obturator with plastic carrier and carrier blank from the verification kit used to confirm the diameter of canals.

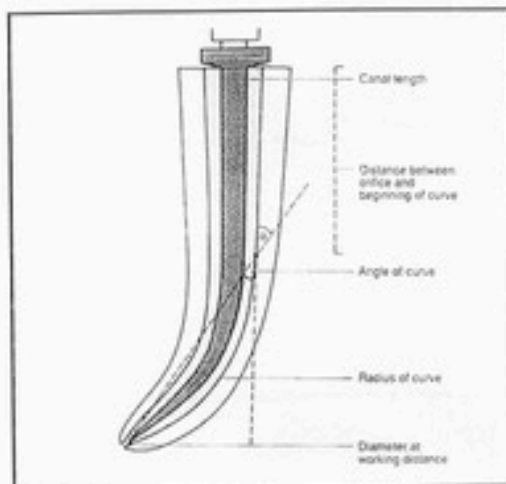
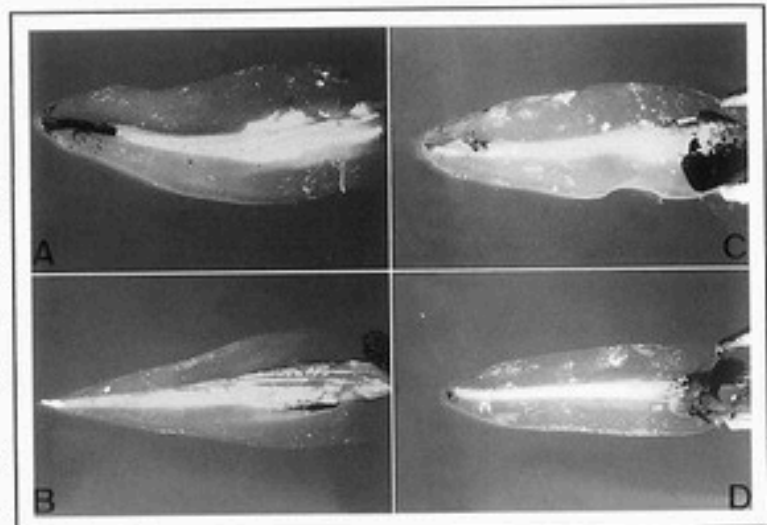


Figure 3.
Diagrammatic representation of the various parameters measured during the assessment of canal shape.

Figure 4.

- A. Specimen obturated with LC technique and with apical dye leakage.
- B. Specimen obturated with LC technique without apical dye leakage but with coronal dye leakage.
- C. Specimen obturated with Three Dee GP Obturators with apical dye leakage.
- D. Specimen obturated with Three Dee GP Obturators without apical dye leakage.



DISCUSSION

Prior to canal obturation the experimental groups were balanced exactly for anatomical features in order to ensure that true comparisons between the groups were possible. DUMMER et al.⁴ has suggested that allocation into experimental groups should be based on this method rather than relying on random allocation which does not always guarantee matching groups.

Three Dee GP obturators were significantly quicker than lateral condensation of gutta-percha. Although speed of obturation taken in isolation is not the most important criterion by which a technique should be judged, it must form part of the overall assessment⁴. This confirms the efficient nature of those filling techniques using coated carriers and suggests that there is little difference between the established Thermafil Obturators and these new Three Dee GP Obturators.^{4,5}

The extrusion of sealer and gutta-percha through the apical foramen is a disadvantage of the Three Dee GP obturator technique. Although the extrusion of sealer was greater than gutta-percha, both occurred more often in the Three Dee technique compared to lateral condensation of gutta-percha. Similar findings have been

reported by CLARK and ELDEEB², DUMMER et al.⁴ and GUTMANN et al.⁶ with Thermafil Obturators and it is clear that the coated carrier technique predisposes to this phenomenon, presumably as a result of the 'piston' affect of driving the coated carrier down the narrow canal and the lack of an escape route for excess sealer and gutta-percha. It is important to appreciate that only minimal amounts of sealer are necessary using this technique. On the other hand, the extrusion of sealer with Three Dee GP obturators probably confirms the successful compaction of gutta-percha into the canal system⁴.

Radiographic quality of obturation was determined using both buccal and proximal projections. This study confirmed the results reported by KERSTEN et al.⁹ and DUMMER et al.⁴ that a mesio-distal (proximal) radiographic projection demonstrates a view of the root filling that is significantly poorer than the normal bucco-lingual clinical view. As a result, the scores from the proximal radiographs were often significantly worse. The radiographic scores

of the experimental groups were similar to confirm that for this parameter they produced equally good fillings.

Although some specimens were lost during the clearing process the results of the dye leakage study showed there were no significant difference between the two groups. However, the Three Dee GP obturators had a greater level of dye leakage than lateral condensation of gutta-percha in both the apical and coronal halves.

CONCLUSIONS

Under laboratory conditions, Three Dee GP Obturators were comparable with lateral condensation in terms of radiographic quality of fill and apical and coronal dye leakage. Three Dee GP Obturators were associated with significantly more extrusion of sealer and gutta-percha. Lateral condensation was significantly slower than using Three Dee GP Obturators.

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Correspondence: Professor Paul M. H. DUMMER
 Department of Adult Dental Health, Dental School
 University of Wales College of Medicine
 Heath Park, Cardiff CF4 4XY, UK
 Accept April 15, 1998.

EFFECT OF REDUCTION OF THE SURFACE TENSION OF DIFFERENT CONCENTRATIONS OF SODIUM HYPOCHLORITE SOLUTIONS ON RADICULAR DENTINE PERMEABILITY

Jesus Djalma PECORA, DDS., MSc., PhD, Full Professor
Universidade de São Paulo, Ribeirão Preto, SP, Brazil
Manoel D. SOUSA-NETO, DDS, MSc, PhD
Universidade de São Paulo, Ribeirão Preto, SP, Brazil
Danilo M. Zanello GUERISOLI, DDS
Universidade de São Paulo, Ribeirão Preto, SP, Brazil
Melissa Andréia MARCHESAN, DDS
Universidade de São Paulo, Ribeirão Preto, SP, Brazil

The authors compared the effect of reducing the surface tension of sodium hypochlorite solutions at the concentrations of 0.5, 1.0, 2.5 and 5.0% on radicular dentine permeability. Forty-five maxillary human canines were prepared by step-back instrumentation technique and submitted to morphometric study. Sodium hypochlorite solutions increased dentine permeability more efficiently than water. Sodium hypochlorite solutions associated with 0.1% lauryl diethyleneglycol ether sodium sulfate were more effective than pure solutions in increasing dentine permeability. The apical region of the maxillary canines showed the least permeability.

Key words: radicular dentine, sodium hypochlorite, surfactant.

INTRODUCTION

Sodium hypochlorite has been used as a disinfectant since the 18th century, but its use in dentistry began only in the second decade of the current century, when BARRETT² indicated irrigation of the root canal with Dakin's liquid. Currently, sodium hypochlorite is used worldwide for endodontic treatment due to its highly desirable properties as a bactericide, deodorant and tissue solvent^{3, 6, 9}.

Many authors have studied the effect of sodium

hypochlorite on dentine permeability and concluded that this solution increases the permeability of dentine tissue^{1, 4, 12}. The high surface tension of sodium hypochlorite solutions, similar to water, prevents an intimate contact between this liquid and dentine. A decrease of this surface tension has been studied by many authors^{7, 8, 10}.

The purpose of this study was to evaluate the effect of different concentrations of sodium hypochlorite solutions on radicular dentine permeability, when associated with 0.1% lauryl diethyleneglycol ether sodium sulfate.

MATERIALS AND METHODS

A total of 45 recently extracted human maxillary canines were kept at 4°C in 0.1% thymol solution until use. The irrigating solutions used in this experiment were 0.5, 1.0, 2.5 and 5.0% sodium hypochlorite and the same concentrations associated with 0.1% lauryl diethyleneglycol ether sodium sulfate. Distilled and deionized water was used as control.

The samples were washed in running water for 24 hours in order to eliminate all thymol residues and then dried with air. The outer surface of the root was covered with 2 layers of cyanacrylate. Access to the pulp chamber was performed by routine clinical technique.

The teeth were randomly distributed into 9 groups of 5 teeth each and all teeth were instrumented as follows: determination of the working length in the apical limit,

and use of 3 files in increasing sequential size from that which determined the anatomic diameter, with constant irrigation. The amount of irrigating solution used was 10.8 mL.

The teeth were then irrigated with 10.8 ml distilled water to remove any remaining solution used during instrumentation. The teeth were immersed in 10% copper sulfate for 30 min, in a vacuum for the first 5 min. The teeth were then dried with paper points and placed in a 1% rubenic acid alcohol solution, for 30 min and in a vacuum for the first 5 min. Rubenic acid reveals copper ions, forming a stained compound ranging in color from deep blue to black, depending on the quantity of copper ions present⁵.

Upon completion of this reaction to reveal the extension of penetration of copper ions, the tooth was placed in an acrylic resin block and 500- μ m thick transverse sections were obtained with a diamond disk from the coronal, middle and apical regions. During the sectioning process, constant irrigation with water was used to prevent dentine burn.

According to established criteria, 2 samples of each region were used (the first and fourth slices of each radicular third). The slices were then filed under tap water to a thickness of approximately 100 μ m and washed for 4 hours to eliminate dentine powder and other residues. After this, the samples were submitted to dehydration with increasing alcohol solution series, cleared in xylene and mounted on glass slides for microscopic examination.

The quantification of the penetration of copper ions was done by morphometry, with a 400-point grid (500 μ m interpoint distance). Although the area had an irregular contour, it was considered a regular circle for evaluation purposes.

The number of points in the stained and non-stained areas of the dentine were counted, and the percent of copper ion penetration in the dentine was calculated by the following equation:

$$p(d)\% = \frac{PM}{PT - PC} \times 100$$

where: PM = points in the stained area, PT = total number of points counted, and PC = points in the canal area.

Preliminary tests were performed in order to verify if the sample distribution was parametric or not. Analysis of variance was performed using transformed data (square root). In order to detect the differences between the average values of the results, the data were submitted to the Tukey test.

RESULTS

Table 1 shows the average copper ion penetration in the radicular dentine of the studied teeth, expressed in percentage.

Analysis of variance showed a statistically significant difference ($p < 0.01$) between the tested solutions and the three sectioning levels of radicular dentin (apical, middle and cervical).

The addition of 0.1% of lauryl diethyleneglycol ether sodium sulfate was sufficient to reduce the surface tension of the irrigating solutions by almost 50%.

The Tukey test revealed that the addition of the surfactant to the sodium hypochlorite solutions caused a significant increase in dentine permeability when compared to the same solutions without surfactant. The same test also showed that sodium hypochlorite solutions, pure or associated with surfactant, caused a significant increase of dentine permeability when compared to water.

The Tukey test indicated that the thirds were different and lower permeability values were obtained in the apical third.

DISCUSSION

Sodium hypochlorite solutions are used worldwide, mainly at the concentrations of 0.5, 1.0, 2.5 and 5.0%. In this study, it was observed that the addition of 0.1% of lauryl diethyleneglycol ether sodium sulfate reduced the surface tension of the irrigating solutions by almost 50%.

Dentine permeability was increased significantly by the addition of surfactant to the sodium hypochlorite solutions (Tukey test). This test also demonstrated that sodium hypochlorite solutions, with or without surfactant, caused a significant increase of dentine permeability when compared to water.

These results can be explained as follows: a) water has a high surface tension (71.31 dynes/cm) and does not have any chemical action on the organic components present in the root canal; b) 0.5% sodium hypochlorite has a surface tension similar to water (68.8 dynes/cm), and at higher concentrations has a surface tension greater than water, but acts on organic components. The addition of 0.1% lauryl diethyleneglycol ether sodium sulfate reduces the surface tension of these solutions; c) The reduction of the surface tension increases the wetting capacity of the solutions,

accelerating the chemical reaction^{8,10}.

The permeability of the thirds was statistically different and the apical third showed the lowest permeability values.

CONCLUSIONS

Based on the methods employed in this experiment and results obtained, we conclude that:

1) sodium hypochlorite solutions at the concentrations of 0.5, 1.0, 2.5 and 5.0%, associated or not with 0.1% lauryl diethyleneglycol ether sodium

sulfate, were more efficient than water increasing dentine permeability;

2) sodium hypochlorite solutions at the concentrations of 0.5, 1.0, 2.5 and 5.0% associated with surfactant were more effective at increasing dentine permeability than the same solutions without surfactant;

3) the apical region of the root canal of the maxillary human canines presented less dentinal permeability than the middle and cervical thirds.

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Correspondence and offprint requests:

Prof. Dr. Jesus Djalma Pécora,
Departamento de Odontologia Restauradora
Faculdade de Odontologia de Ribeirão Preto
Universidade de São Paulo - Av. do Café s/n
14040-904 Ribeirão Preto - SP - Brazil
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pH ANALYSE OF VEHICLES AND CALCIUM HYDROXIDE PASTES

Carlos ESTRELA, DDS, MSc, PhD, Chairman
Universidade Federal de Goiás, Goiânia, GO, Brazil
Jesus Djalma PÉCORA, DDS, MSc, PhD, Chairman
Universidade de São Paulo, Ribeirão Preto, SP, Brazil
Reginaldo Santana SILVA, Chemistry Technician
Universidade de São Paulo, Ribeirão Preto, SP, Brazil

Calcium hydroxide is one of the most used as intracanal medication in teeth with apical periodontitis. Its success is due to its antimicrobial and mineralizing properties, which are intrinsic to the dissociation and diffusion of calcium and hydroxyl ions. The effect of pH on the transport of nutrients and organic components through the cytoplasmic membrane determines its toxic action on bacteria. This also activates the hydrolytic enzyme alkaline phosphatase, which is closely related to the process of tissue mineralization. Considering that the release of hydroxyl ions from calcium hydroxide is essential to the mineralization and microbial control processes, it is important to investigate the necessity of using vehicles that favor a quick ionic dissociation and, in addition, maintain a high pH during the entire period of activity. The pH of the following phenolic substances was studied: paramonochlorophenol (PMC, 5 g) associated to Furacin[®] (28 ml) and camphorated paramonochlorophenol (CPMC), alone and associated with 24 mg (0.12%) of calcium hydroxide P.A. The pH of the following non-phenolic substances was also studied: sodium lauryl diethylene ether sulfate (0.1%), Tween 80 (0.1%), de-ionized distilled water, propylene glycol associated with 24 mg (0.12%) of calcium hydroxide P.A., stored in plastic containers. Pastes with non-phenolic vehicles (de-ionized water, propylene glycol, sodium lauryl diethylene

ether sulphate and Tween 80) showed high pH values (above 12). The paste, with CPMC as vehicle, showed a pH around 7.8 and CPMC alone remained at a pH of 5. PMC-Furacin showed a pH of 7.0 and the paste containing this substance showed a pH of 10 during the period of observation.

Key words: calcium hydroxide, intracanal dressing

INTRODUCTION

Calcium hydroxide is one of the most used as intracanal medication in teeth with apical periodontitis. Its success is due to its antimicrobial and mineralizing properties, which are intrinsic to the dissociation and diffusion of calcium and hydroxyl ions².

HEITHERSAY¹⁷ reported that calcium hydroxide has been extensively employed in endodontic therapy since the use of calxyl by HERMAN¹⁸, in 1930. The action of hydroxyl ions from calcium hydroxide, producing a high pH, represents an essential characteristic, since it induces the formation of a mineralized barrier, as reported by HOLLAND¹⁹.

The effect of calcium hydroxide on bacteria

and tissue is directly related to its ionic dissociation into calcium and hydroxyl ions. ESTRELA et al.¹⁰ reported this action explaining that its high pH inhibits enzyme activities that are essential to bacterial life, i.e., metabolism, growth and cellular division. The effect of pH on the transport of nutrients and organic components through the cytoplasmic membrane determines its toxic action on bacteria. This also activates the hydrolytic enzyme alkaline phosphatase, which is closely related to the process of tissue mineralization. Thus, this medication presents two fundamental enzyme properties: the inhibition of bacterial enzymes leading to an antimicrobial effect and the activation of tissue enzymes such as alkaline phosphatase leading to a mineralizing effect.

The effects of calcium, barium and strontium hydroxides on pulpal capping used in dog dental pulps were assessed by HOLLAND et al.²¹. Sedimentation of strontium and barium carbonate grains occurred, similar to the grains observed with calcium hydroxide. Since barium and strontium do not exist naturally in the animal body, these grains were from the capping material. Birefringent coarse grains are not observed with other hydroxides such as magnesium or sodium hydroxide, due to the fact that sedimentation only occurs with hydroxides whose solubility is similar to that of calcium hydroxide. Magnesium hydroxide is insoluble and sodium hydroxide is highly soluble in pulpal fluids. Barium hydroxide is slightly more soluble than strontium hydroxide, which can be observed because barium hydroxide grains are found deeper than strontium hydroxides grains.

GORDON and ALEXANDRE¹⁴ analyzed two properties of calcium hydroxide on bovine pulpal tissue: variations in pH and calcium ion concentration. Their results suggest that the effects of calcium hydroxide are mainly pH dependent and its efficacy may result from lower solubility.

ESTRELA and PESCE³ chemically analyzed the release of hydroxyl ions from calcium hydroxide in dog connective tissue. The percentage of the existing hydroxyl ions (45.89%) and calcium ions (54.11%) can be obtained taking into account the molecular weight of calcium hydroxide (74.08).

Much research^{1, 9, 11, 13-16, 18, 24, 26, 30-33} has assessed the pH of different materials and dental structures, pointing out the importance of pH on tissues and microorganisms. Considering that the

release of hydroxyl ions from calcium hydroxide is essential to the mineralization and microbial control processes, it is important to investigate the necessity of using vehicles that favor a quick ionic dissociation and, in addition, maintain a high pH during the whole period of activity.

The purpose of this study was to evaluate the pH of different vehicles and calcium hydroxide pastes.

MATERIAL AND METHODS

The pH of the following phenolic substances was studied: paramonochlorophenol (5g) associated with Furacin[®] (28 ml) and camphorated paramonochlorophenol (SS White, RJ, Brazil), alone and associated with 24 mg (0.12%) of calcium hydroxide P.A. (Merck, USA). The pH of the following non-phenolic substances was also studied: sodium lauryl diethylene ether sulfate (0.1%), Tween 80 (0.1%), de-ionized distilled water, propylene glycol associated with to 24 mg (0.12%) of calcium hydroxide P.A. (Merck, USA), stored in plastic containers.

After the active homogenization of the phenolic substances they were kept inactive for 1 hour and then the initial pH of each one was determined using tornassol paper (Merck, USA), allowing a gradual analysis of values from 0 to 14. In this case, tornassol paper was chosen because, since it is not possible to analyze concentrated organic substances with a reference-electrode digital pH meter. The other substances were associated with 24 mg (0.12%) of calcium hydroxide P.A. (Merck, USA) and the changes in their pH were measured with of a digital pH meter (Digimed, SP, Brazil). The pH analyses of vehicles and vehicles added to calcium hydroxide pastes were performed 160 days and the results were recorded on an electronic chart. All the tests of this study were performed three times.

RESULTS AND DISCUSSION

The basic principle for the selection of any intracanal medication is the understanding of its mechanism of action on the predominant microorganisms in endodontic infections. The antimicrobial

substances from antibiotics and/or chemotherapeutics, cause two kinds of effects on microorganisms: 1) inhibit growth or reproduction 2) induce cellular deactivation. These effects can be observed in cellular wall synthesis, cellular wall structures, protein synthesis, chromosomal replication and in the intermediate metabolism. The mechanism of action of calcium hydroxide as an antimicrobial medication could be better understood²⁻¹¹ adopting as reference the knowledge of microbiological and pharmacological properties of antibiotics/chemotherapeutics and their effects on microorganisms and, more specifically, their sites of action. ESTRELA et al.² reported that it is important to analyze the effect of pH on growth, metabolism and bacterial cellular division, in isolation. However, the existence of a pH gradient through the cytoplasmic membrane must be considered, which is responsible for producing energy for the transport of nutrients and organic components to the interior of the cell. This gradient can be affected by a change in environmental pH, influencing chemical transport through the membrane.

PUTNAM²⁸, describing the adjustment of intracellular pH, reported that pH influenced different cellular processes such as: a) cellular metabolism; b) alteration of shape, mobility, adjustment of transporters and polymerization of cytoskeleton components; c) activation of cellular proliferation and growth; d) conductivity and transport through the membrane; e) isosmotic cellular volume. Thus, many cellular functions can be affected by pH and the enzymes essential to cellular metabolism are among them.

Considering all the reasoning on pH processes and isolated activities at essential enzymatic sites, it is enlightening to associate calcium hydroxide, a substance with a high pH, with harmful biological effects on bacterial cells in order to explain its mechanism of action. With this aim, ESTRELA et al.⁸ studied the biological effect of pH on the enzymatic activity of anaerobic bacteria. Since enzymatic sites are located in the cytoplasmic membrane, which is responsible for essential functions such as

metabolism, cellular division and growth, and take part in the last stages of cellular wall formation, biosynthesis of lipids, transport of electrons and oxidative phosphorylation, the authors believe that hydroxyl ions from calcium hydroxide develop their mechanism of action in the cytoplasmic membrane. The effect of the high pH (12.6) calcium hydroxide, influenced by the release of hydroxyl ions, is able to alter the integrity of the cytoplasmic membrane by means of chemical injuries to organic components and transport of nutrients, or by means of the destruction of phospholipids or unsaturated fatty acids of the cytoplasmic membrane, observed in the lipidic peroxidation process, which is a saponification reaction¹⁰.

The high pH of calcium hydroxide can activate alkaline phosphatase, which can start or favor mineralization^{19,29}. Two other calcium-dependent enzymes (adenosine triphosphate and pyrophosphate) can also favor the mechanism of tissue healing.

Clinically, several substances have been used as vehicles for calcium hydroxide^{2-11,19-21} to enhance its antimicrobial action, speed of ionic dissociation and chemo-physical properties. The use of hydrosoluble vehicles (distilled water or saline solution) is controversial, because when they are compared with camphorated paramonochlorophenol (oily vehicle) doubts arise regarding calcium hydroxide antimicrobial action.

Much research has evaluated the pH of substances and structures and their effects on tissues^{9,11,13-16,22,30-33}. The present study observed the pH of pastes during a period of time ranging from 0 to 160 days. The results showed that pastes with non-phenolic vehicles (de-ionized water, propylene glycol, sodium lauryl diethylene ether sulfate and Tween 80) presented a high pH value (above 12), whereas the paste with CPMC as vehicle presented a pH around 7.8 during the entire period of observation. The vehicle CPMC alone maintained a pH of 5. PMC-Furacin showed a pH of 7 during the period of observation and the paste with this substance presented a pH of 10, as showed in Figures 1 to 3.

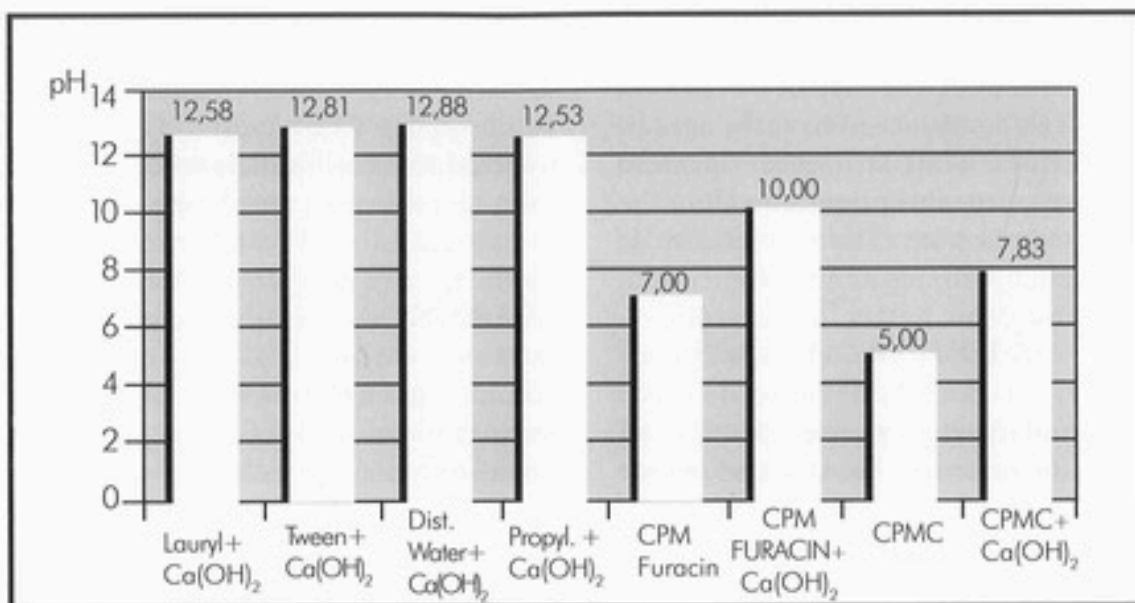


Figure 1. pH of vehicles and calcium hydroxide pastes

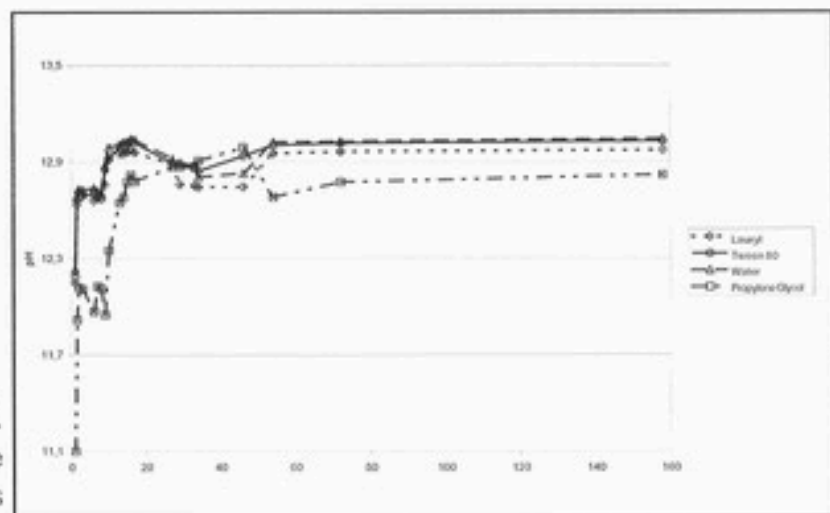


Figure 2. pH of vehicles and calcium hydroxide pastes

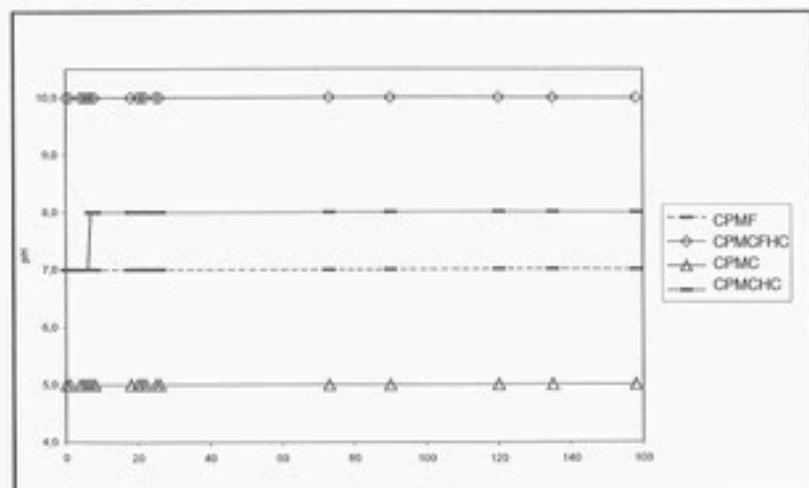


Figure 3. pH of vehicles and calcium hydroxide pastes

The importance of studying these vehicles is related to the fact that they are indicated for use in association with calcium hydroxide for different reasons. In 1891, Walkhoff suggested the use of PMC based on the antiseptic properties of phenol which was associated to camphor with the objective of minimizing its irritating potential²⁷. When camphorated paramonochlorophenol (CPMC) is used in association with calcium hydroxide it acts as an oily vehicle because camphor is considered an essential oil and presents low solubility in water.

LEONARDO et al.²⁴ evaluated the changes in the pH and in the release of calcium ions in calcium-hydroxide-based endodontic products. Samples containing 1.5 of material for each 6 ml of distilled water were prepared for analyses of pH changes. During a period of 0 to 60 days, results showed that the pH varied from 12.28 to 12.46 for calcium hydroxide hydrosoluble pastes, from 10.94 to 12.33 for Calen^o and from 10.80 to 12.51 for Calen^o with CPMC. In this paste the proportion was 0.15 ml of CPMC to 1.75ml propylene glycol to 0.05 g colofônia to 1.0 g zinc oxide P.A. and 2.5 g calcium hydroxide P.A.²³. NAUMOVICH²⁶ analyzing the surface tension and pH of drugs used in root canal therapy reported the pH of phenol-camphor pH to be 4.4.

ANTHONY et al.¹, analyzing the effect of three vehicles on the pH of calcium hydroxide, reported that the high potential for tissue irritation by CPMC would make saline a logical choice for mixing with calcium hydroxide powder to make a temporary paste filling. Another study concerning the irritating potential of CPMC was carried out by FAGER and MESSER¹² who analyzed the systemic distribution and excretion of camphorated monochlorophenol following insertion into the pulp chambers of cat canine teeth with or without periapical lesions. Cotton pellets containing ¹⁴C-labeled CPMC were sealed into the four canine teeth of each cat, and the teeth and tissue were analyzed for radioactivity. Radioactivity was detected in the blood within 30 min and in urine within 2 hours of placing cotton pellets into the teeth. After 24 hours, more than 50% of the CMCP had been lost from the teeth and up to 20% had been excreted in the urine. CMCP was not concentrated in any tissues examined. Although CMCP passed rapidly and extensively beyond the apical foramen and into the circulation, the lack of binding in the tissues and the rapid urinary excretion are likely to minimize systemic toxic effects. Taking into account the necessity of hydroxyl ions in

order to obtain the expected effects from calcium hydroxide as an antimicrobial and mineralizing agent, it is crucial to choose pastes that maintain high pH levels and that allow its dissociation and diffusion, such as distilled water and saline solution^{2,11}.

Chemical characteristics of vehicles, whether they are hydrosoluble or oily, together with their ionic dissociation and diffusion capability, can be considered more important properties than the antimicrobial action of the vehicle, because calcium hydroxide alone already has this property, which, in case of an association, might not show a synergic effect or might even show an opposite reaction.

HOLLAND et al.²⁰ evaluated the effect of hydrosoluble and non-hydrosoluble intracanal dressings in the healing process of dog teeth with periapical lesions. Calcium hydroxide associated with saline solution and calcium hydroxide associated with camphorated paramonochlorophenol (Frank's paste) were used. Six months after the obturation of root canals, the authors observed the highest rates of healing with the used of intracanal dressing with hydrosoluble paste containing saline solution. Thus way, the importance of chemical characteristics of vehicles (their hydrosolubility) in regard to antimicrobial power, is remarkable, since they influence the speed of ionic dissociation and diffusion. When calcium hydroxide is chosen due to its antimicrobial effectiveness, the vehicle assumes a supportive role in this process, giving calcium hydroxide some chemical characteristics (dissociation, diffusibility and filling) that are decisive to the antimicrobial potential and tissue healing capability. Based on these chemical properties, the best vehicle to be added to calcium hydroxide is the one that presents hydrosoluble characteristics such as distilled water or saline solution.

CONCLUSION

Pastes with non-phenolic vehicles (de-ionized water, propylene glycol, sodium lauryl diethylene ether sulfate and Tween 80) showed high pH values (above 12). The past with CPMC showed a pH around 7.8 during the period of observation and CPMC alone a pH of 5. PMC-Furacin showed a pH of 7,0 and the paste containing this substance showed a pH of 10 during the period of observation.

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Correspondence: Professor CARLOS ESTRELA,
Rua B1, Quadra 6, Lote 2,
Setor Bueno, Goiânia, GO, Brazil,
CEP 74230-108, Phone (FAX) 62-251 04 08.

MARGINAL LEAKAGE IN ROOT FILLINGS AND ROOT PERFORATIONS DUE TO THE TECHNIQUE AND CEMENT CONSISTENCY

MILTON CARLOS KUGA, DDS, MSc, PhD

Universidade Sagrado Coração, Bauru, SP, Brazil

MARIA VICTÓRIA LAURIS FAYAD, DDS, MSc

Universidade Sagrado Coração, Bauru, SP, Brazil

MARCO ANTÔNIO H. DUARTE, DDS, MSc, PhD

Universidade Sagrado Coração, Bauru, SP, Brazil

SYLVIO DE CAMPOS FRAGA, DDS, MSc, PhD

Universidade Sagrado Coração, Bauru, SP, Brazil

JOSÉ CARLOS YAMASHITA, DDS, MSc

Universidade Sagrado Coração, Bauru, SP, Brazil

60 extracted human canines had their root canals instrumented and later, perforations simulated in level of third medium radicular. The teeth were divided in 6 groups in agreement with the presence or not of retention on the perforation base, root filling technique and cement consistency. These groups were immersed in a 2% methylene blue solution for 7 days at 37°C. Through the analysis of the infiltrations it was possible to classify the groups of the best for the worst being them: group II (with retention at the perforation base and root filling by the lateral condensation technique), group I (identical to the group II but with no retention at the perforation base), group IV (with retention at the perforation base and root filling by the Tagger hybrid technique), group III (identical to the group IV but with no retention at the perforation base), group VI (with retention and root filling by the lateral condensation technique with dense consistency cement), group V (identical to the group VI but with no retention at the base of the perforation). Besides significance was observed at a level of 5% between the groups II and V; II and IV, and the retention didn't interfere in the final result of marginal leakage.

KEY WORDS: retrograde filling; root perforation; periapical surgery

INTRODUCTION

Endodontic science has had a huge scientific and technologic improvement, particularly as to the root canal treatment for there is still a high rate of failure in this aspect as verified by TAVANO et al. 19 (1971). Also TAMBURUS¹⁶ (1983) found that 52,83% of cases had been inappropriately conducted.

However, these rates are more alarming when are related to the endodontic complications and diseases on the adjacent periodontal structures as demonstrated by KUGA⁸ (1995) when clinically and radiographically assessing parentodontic surgeries, observed total success in 45,31% of the situations, that is, 54,69% showed doubtful or failed diagnosis.

Dearth of information is even worse when related to the root perforations. When unbearable numbers were attained by the use of calcium hydroxide intracanal dressing, KUGA et al.¹⁰ (1990) decided to

perform the surgical exposition of the area and fill the root perforation by the Tagger et al. hybrid method. However, to carry out this technique it is required na endoontic access and extremely favorable periodontal conditions.

SELTZER et al.¹⁵ (1970) verified periodontal occurrences following accidental perforations with round burs, carried out in pulpal chamber floor of 21 monkey teeth. In 7 teeth the perforations were immediately filled with ZOE or associated to amalgam. In 8 teeth, there was an interval of one week to 18 month, between the perforation and its filling. The remaining teeth received no treatment. The degree of periodontal response ranged from mild to severe, depending on the moment that the perforation was filled.

In addition, it was observed that the more severe reactions were seen when the perforated region was not immediately filled, while in the cases where they were left open epithelial proliferation occurred in the area and there was resorption of the adjacent alveolar root and bone. Similar results were found by BIGGS et al.³ (1988).

A question is raised thus, as to which would be the best material to seal these perforations. ISIDOR; STOCK⁷ (1992) recommended to fill with composite resin (Retoplast) employing previously the GLUMA dentinal bonding system. Silver amalgam is considered as acceptable in the conventional retrograde fillings by FRANK et al.⁵ (1992) comparing to the findings of BERNABÉ² (1981) who observed the best results when using gutta percha particularly in the conditions of acceptic canal.

KUGA et al.⁹ (1990) testing several filling cements in the perforations, found satisfactory results the ZOE derivated materials and, for materials as amalgam and glass ionomer cements disastrous results were found, supporting the findings of TANZILLI et al.¹⁸ (1980).

In a more recent study, with the aim of finding the materials which would best fill the retrograde fillings cavities TANOMARU FILHO¹⁷ (1992) evaluated several techniques and cements and found the best results for Sealer 26 (as compared to CRCS and N-RICKERT cements) as to the marginal sealing, even when associated to the poorer sealing technique. This finding suggests that the type of cement, more than the technique, has great influence in the marginal sealing.

However in root perforations the positioning and maintainance of the retrofilling material in place is

* * *

motive of concern. Considering the data obtained by KUGA et al.⁹ (1990) it can be understood that because of the amalgam retrograde fillings displacement, to perform an additional retention on the cavity preparation base or root perforation would be an efficient method to maintain the material in place.

According to what was said above, it becomes clear that there are empty spaces in the literature as to the rationalization of materials and methods to make more feasible the corrective surgeries of root perforations.

The aim of the present study was to evaluate the sealing capacity of several perforation sealing techniques as well as to verify the influence of the additional retention at the perforation base on sealing quality.

MATERIAL AND METHODS

Sixty extracted human canines having their root canals instrumented by the step back technique, as proposed by WEINE²² (1989) and as master apical file and standardization of the apical stop the number 50 K file.

With a round steel n° 12 bur perforations in the buccal surface at the root medium third were carried out until the root canal was reached.

Then, the roots were sealed with a layer of Araldite (Ciba-Geigy) and subsequently two layers of nail polish were applied, assuring that they would be 1mm away from the perforation margin.

Completed this stage, the roots were divided in 6 groups each with 10 elements and the following treatments were carried out:

Group I- root canal filling by the lateral condensation technique without retention at perforation: the root canals were subjected to obturation using as cement the Sealer 26 (Dentsply, Petrópolis, R.J. Brazil) in the ratio 2.0g : 1.1g (powder/resin), and further laterally condensed. The filling material excess were seccioned with a heated Donaldson condenser. The overflow of material laterally through the perforation was adapted back into place whit the aid of a Holleback 3s spatule giving a physiologic root contour.

Group II- root canal filling by the lateral condensation

technique with retention at the perforation: the procedure was identical to group I, however the retention at the perforation base was carried out with a inverted cone shaped bur nº 331/2 in all its perimeter, previously to the filling procedure.

Group III - root canal filling by the hybrid technique without retention at the perforation: the root canal filling were carried out according to technique proposed by KUGA et al.¹⁰ (1990) and the remaining steps identically to the previously described groups.

Group IV - root canal filling by the hybrid technique with retention at the perforation: the same steps described for group III in addition to the retention described for group II

Group V - root canal filling by the lateral condensation technique without retention at the perforation using dense consistency cement: the procedure was identical to group I, except by the cement consistency which for this group

was 2,4g : 0,68g (powder/resin) as preconized by TANOMARU FILHO¹⁷ (1992).

Group VI - root canal filling by the lateral condensation technique with retention at the perforation using dense consistency cement: the procedure was identical to group V, with addition of the retention described for group II.

Immediately after the conclusion of the fillings the teeth had their apical portion isolated with fused wax nº 7 envolved with gauze and immersed in 2% methylene blue solution remaining in sterilizer at 370 C, for 7 days.

At the end of 7 days, the teeth were washed in running tap water and longitudinal sections were made bucal-lingual direction with diamond discs in low speed with concomitant irrigation.

The marginal leakage pattern was postulated according to KUGA et al. 9 (1990) and subjected to Kruskal Wallis statistical tests and comparison of Mann-Whitney.

	1	2	3	4	5	6	7	8	9	10
I	1	0	0	0	1	2	2	0	0	0
II	0	0	0	0	1	1	1	1	0	1
III	0	1	1	2	2	2	1	1	1	1
IV	1	1	2	0	0	0	1	2	1	1
V	2	2	1	1	1	1	1	2	1	2
VI	2	1	1	1	1	1	2	1	2	1

Table 1. The scores of leakage magnitude according to the experimental groups

GRUPO	SOMA DE POSTOS	POSTO MÉDIO	N. DE VALORES
I	217,0	21,70	10
II	195,0	19,50	10
III	354,5	35,45	10
IV	286,0	28,60	10
V	400,0	40,00	10
VI	377,5	37,75	10

critical value: 11,07 at a level of 5%

$H_{obs} = 14,52109$ (significant)

Table 2. Sum of the score and medium score calculated by the Kruskal-Wallis test.

RESULTS

The obtained scores according to the experimental groups are displayed in Table 1. Through the marginal infiltration analysis on the root perforation fillings it was possible to evidence the presence of significant differences between the groups. Table 2 represents the sum of the score and the respective medium score of the experimental groups. Testified the differences between the groups, it became pertinent to perform the confrontation Mann-Whitney, having $Z_{crit} = 2,67$ it was possible to prove the significance between the following groups:

GROUPS	Zobs
II x V	2,936047
II x VI	2,80537

DISCUSSION

The root walls perforations can be caused by: a) iatrogenic causes, b) resorption processes or c) invasive carious lesion. The treatment choice of these root perforations depends upon several factors, among them is the level of root compromise, previous endodontic and periodontic considerations, nature of the sealing material and period of time between the perforation and the treatment.

Obviously, the conservative treatment, with the use of calcium hydroxide ** is the best alternative. However, when it is impossible to dry the root canal and/or pronounced dimensions perforation, surgical procedures can be considered.

The local technical difficulties associated to the operator ability are critical to the case prognosis. MEISTER et al. 12 (1974) describe frequent chronic periodontal pocket formation and consequent furcation involvement in perforations corrective surgeries in molar teeth.

Comparing to the findings of the literature and the results obtained in the present study, it was decided to discuss the methodology and subsequently some explanations on the results obtained.

Studies carried out "in vitro" not always represent the true clinical conditions. PITT FORD 14 (1983) compared the results of marginal leakage in fillings carried out with two materials based in ZOE (Kalzinol, Endoseal) and two potentially adhesives

(Aspa IV and Poly F) to the tissue response in dog teeth filled with the same materials.

He concluded that the obtained marginal leaking magnitude correspond directly to the tissue responses in vivo. However it must be pointed out that the dog sampling was too small. Despite of this, we believe that the marginal leakage testings can qualitatively define the physical-chemical behavior of the techniques and materials employed in Endodontics.

HOLLAND et al. 6 (1996) compared the marginal leakage in endodontical fillings performed with calcium hydroxide cements (Apexit, Sealapex, CRCS and Sealer 26) with the control; based in ZOE. The roots were immersed under vacuum provided by a na Arthur Pfeiffer pump, evidencing the superiority of the calcium hydroxide derived materials over the ZOE materials, and peculiarly, Sealapex, Apexit and Sealer 26 presented no differences among one another.

In the present study the teeth were not maintained in vacuum based on the investigation of MASTERS et al. 11 (1995) who compared the marginal leakage of methylene blue solution at 2% in experimental tubes or root canals, filled or not with gutta percha, under vacuum or not. They concluded that the root canals, filled or not, had more leakage than the glass tubes as well as the presence of vacuum had not interfered in the final results.

DAZEY; SENIA 4 (1990) and MOLONEY et al. 13 (1993) preconized the simulation of root perforations made with cone burs in 45 degrees with the root long axis. However the cavities with round burs are more similar to the clinical reality of a root resorption.

We chose to follow a methodology similar to KUGA et al. 9 (1990) who analysed several perforations fillings, obtaining better results for the materials derived from Rickert cement, particularly the Rickert SP. This same study, evidenced, in some cases, the detachment of the sealing material of the perforated area, suggesting the need of additional retention.

We, therefore, opted for making the retention with inverted cone burs in groups II, IV and VI, even though in this study the resin cement derived from AH26, containing calcium hydroxide named Sealer 26 was the material of choice.

Sealer 26 was selected by its high sealing properties, as observed by HOLLAND et al. 6 (1996) in conventional fillings, and for TANOMARU

FILHO¹⁷ (1992) in retrograde fillings single or combined. Sealer 26 showed superiority over the CRCS and N-Rickert materials.

Biologically, BERBERT 1 (1978) added calcium hydroxide to AH 26, at a ratio of 5% or 20% and following an evaluation period of 7, 30, 70 and 90 days he noted an apical cement hyperplasia when a greater concentration of calcium hydroxide was used.

Being the Sealer 26 derivated from AH 26, containing 37% of calcium hydroxide, associated to the good bonding to dentinal walls, we found its use appropriated in a number of manipulation and consistency situations.

By the analysis performed in the present study, we can conclude that, in a decreasing order from better to worse, the classification of the groups is:

1. root canal filling by lateral condensation with retention at the perforation base (group II)
2. root canal filling by lateral condensation without retention at the perforation base (group I)
3. root canal filling carried out by the hybrid technique with retention at the perforation base (group IV)
4. root canal filling carried out by the hybrid technique without retention at the perforation base (group III)
5. root canal filling by the lateral condensation technique and dense consistency cement with retention at the perforation base (group VI)
6. root canal filling by the lateral condensation technique and dense consistency cement without retention at the perforation base (group V).

Significance at a level of 5% was observed between the groups II and V, II and VI, that is, item 1 differs significantly from items 5 and 6.

Another reasonable observation refers to the non-interference of the retentions at the perforation base on the sealing capacity of the investigated techniques.

The consistency similar to the one utilized in the conventional filling procedure showed superiority over those situations where dense consistency was used both with the active lateral condensation technique and with the hybrid without additional retention technique.

Due to the fact of being the resin pasty and the dense consistency possessing more powder

quantity, we believe that in this latter situation, the reduction of resin percentage may have interfered on bonding and, as a consequence, on the sealing provided by Sealer 26.

Clearly, in groups I and II when the extrusion of cement occurred through the perforation, there was initially the tendency of depression formation on the cement surface, and in some cases there was the need of additional cement in identical consistency by external via. In groups V and VI any extruded material was removed, and posteriorly a dense consistency was pressed.

When using the hybrid technique, the overflowed material consisted of cement (normal consistency) and plastified gutta percha. In these situations the behaviors were practically identical, exception made to the difference between II and III (hybrid without retention).

Apparently, the area of retention did not play its primary role, that is, the retention itself and internal contention of cure shrinkage of the filling materials. We believed that this procedure was useful to increment the amount of Sealer 26 at the perforation base. It was observed that in all experimental groups the ones with no retentive preparations were inferior to the ones with preparations.

DAZEY; SENIA⁴ (1993) performed perforations in half sections of extracted human canines with n0 2 burs, one at the apical third and the other at the apical level. Then, after impermeabilizing the sections were filled with amalgam (Tytin), Ketac-Silver or Prisma VCL Dycal and immersed in 2% methylene blue solution for 10 days at room temperature. Subsequently, the half sections were longitudinally cut and the leakage magnitude was measured.

It was concluded that, both for amalgam and Ketac-Silver the marginal sealing was deficient and no differences were found between one another showing an infiltration average of 2,9mm. The opposite was found for Prisma VCL Dycal for perforations at the apical as well as coronal level. No difference was found between them. Contrarily, the preparations performed with cement the leakage were significantly higher for group I (palatal half sections).

MOLONEY et al.¹³ (1993) filled single rooted extracted human teeth with gutta percha and

AH26 and perforated them at the level of the root apical third in 15 degrees to the tooth long axis, with n0 112 bur for fissure. Subsequently, the perforation repair was carried out with amalgam (Valliant Palladium) plus primer, EBA cement or glass ionomer cement (Ketac-Silver) and the root implanted in rats subcutaneous tissue for 5 days. Latter, the samples were immersed in radioactive solution for 7 days and the leakage was measured. They concluded that all groups showed leakage, however the EBA (1,68mm) presented the lowest leakage, differing significantly from Ketac-Silver (2,69mm).

According to what was discussed in this chapter and what was observed in the literature it is concluded that further studies are needed to elucidate better material alternatives for the surgical filling of root perforations. This study opens new ways to future clinical and laboratory research.

CONCLUSION

According to the obtained data it was concluded:

1. By the analysis carried out in this study

in a decreasing order, from better to worse the groups classification is:

- 1.1 root canal filling by lateral condensation technique with retention at the perforation base (group II) ;
- 1.2 root canal filling by lateral condensation technique without retention at the perforation base (group I) ;
- 1.3 root canal filling by the hybrid technique with retention at the perforation base (group IV) ;
- 1.4 root canal filling by the hybrid technique without retention at the perforation base (group III) ;
- 1.5 root canal filling by lateral condensation technique with dense consistency cement and retention at the perforation base (group VI) ;
- 1.6 root canal filling by lateral condensation technique with dense consistency cement and without retention at the perforation base (group V) .

2. Significance was found at a level of between groups II and V, and II and VI, that is, item 1 differs significantly from itens 5 and 6.

3. Retention does not interfere in the final result of the marginal leakage.

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Correspondence: Professor Milton Carlos Kuga

Faculdade de Odontologia
Universidade do Sagrado Coração
Baurú - SP

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2. HOLLANDR, SOUZA V, MELLO W: The effect of the filling material in the tissue reactions following apical plugging of root canals with dentin chips: a histologic study in monkey teeth. **O Surg O Med O Pathol** 55: 398-401, 1983

Books:

1. ESTRELA C, FIGUEIREDO JAP: **Endodontia - Princípios Biológicos e Mecânicos**. Artes Médicas, São Paulo, 1988. 819p.

Chapter in a book:

1. TROPE M, CHIVIAN N: Root resorption. In: COHEN S, BURNS RC: **Pathways of the pulp**. 6th ed. Mosby, St. Louis, p.486-512, 1994

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1. SUNDQVIST G.: **Bacteriological studies of necrotic dental pulps**. Thesis, University of Umea, 94p, 1976

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DO BRASIL CENTRAL
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A ENDODONTIA DO ANO 2000

Goiânia, 24 a 25 de setembro de 1999

Programação

6ª Feira (24 de setembro)

Matutino

8:00 8:30 Abertura Oficial do Congresso

8:30 12:20 Aspectos Microbiológicos da Endodontia
Prof. Ramachandran Nair
University Of Zurich Zurich - Switzerland

Vespertino

14:20 18:20 Tratamento do Dente com Necrose Pulpar
Prof. Roberto Roberto Holland
Universidade Estadual Paulista UNESP Araçatuba - SP

Coordenador Prof. Omar Zina
Universidade de Várzea Grande - Cuiabá - MT

Sábado (25 de setembro)

Matutino

8:00 8:50 Obturação do Sistema de Canais Prof. M. R. Leonardo
Universidade Estadual Paulista UNESP Araraquara - SP

9:00 9:50 Retratamento em Endodontia Prof. G. B. Sydney
Universidade Federal do Paraná Curitiba - PR

10:20 11:10 Biologia do Periápice Prof. J. A. P. Figueiredo
Universidade Luterana do Brasil Porto Alegre - RS

11:20 12:10 Cirurgia Parendodôntica Prof. P. F. E. Bernabé
Universidade Estadual Paulista UNESP Araçatuba - SP

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Prof. Paulo César de Azevedo
Universidade Federal De Uberlândia - Uberlândia - MG

Vespertino

14:00 15:00 Instrumentos de Níquel-Titânio Prof. H. P. Lopes
Associação Brasileira de Endodontia do Rio de Janeiro - RJ

15:00 16:00 Novos Aparelhos de Preparo dos Canais Prof. S. V. Barbosa
Universidade de Brasília - DF

16:10 17:50 Novas Técnicas de Instrumentação Prof. M. E. Machado
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