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EDITORIAL

Brazilian Endodontics has been marked by recent technical advances based upon serious research. This new concept is a result of the enthusiastic participation of young researchers and the experience accumulated by their professors. New laboratories dedicated to biologic and physical studies in Endodontics are being created. This has lead the Endodontic Teaching and Research Foundation to edit the Brazilian Endodontic Journal. This is the first journal in Brasil dedicated to Endodontics being published in English, which permits Brazilian studies to be read all over the world, thus facilitating their diffusion and enhancing the exchange with international study centers.

If this Journal was made possible due to hard work, dedication and the encouragement of the members and friends of the editorial committe, a lot more has to be done to make it regular and consistent. Welcome professor, researchers, specialistis and collaborators from Brazil and abroad to publish their experiences, in order to disscuss Endodontics as a science, redefining its principles and pratice.

We are open for suggestions and criticism. We are a group, under God , indivisible, with minds open to teaching and research. Thank you for reading the Brazilian Endodontic Journal.

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INFLUENCE OF ROOT CANAL PREPARATION ON ANAEROBIC BACTERIA IN TEETH WITH ASYMPTOMATIC APICAL PERIODONTITIS

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Root canal preparation has been considered one of the most important phases of root canal therapy. The development of technique for the growth and isolation of anaerobic bacteria shows that they are much more prevalent in root canals with apical periodontitis than previously thought. Independent of the technique used to prepare the infected root canal, elimination of bacteria is achieved by the mechanical cleansing with files and the use of an effective antimicrobial irrigant and dressing. How much the canal should be enlarged has not get been is not standardized. The authors studied the influence of root canal preparation on anaerobic bacteria in teeth with asymptomatic apical periodontitis using bacterial samples and microbiological analysis, taking as the master apical file, the third and fourth instrument after the initial file that binds slightly at the apical third. Preparing of the root canal using a non antisseptic irrigant (saline solution) reduced the number of anaerobic bacteria but did not eliminate them. When 1% sodium hypochlorite was used as an irrigant, the qualitative reduction was more significant but did not eliminate all of them. *Peptostreptococcus prevoti* and *Clostridium histolyticum* were the prevalent bacteria. The concept of enlarging the root canal three or four sizes larger than the initial file is not enough to eliminate bacteria from infected root canals.

Key Words: Anaerobic bacteria, root canal preparation, apical periodontitis

INTRODUCTION

Root canal preparation has been considered to be one of the most important phases of root canal therapy. In the treatment of nonvital teeth removal of necrotic tissue with its colonies of bacteria from the main canal is of utmost importance. By enlarging and giving it its shape for obturation, most bacteria in the dentinal tubules are physically removed as well[26].

The development of techniques for the growth and isolation of anaerobic bacteria shows that they are much more prevalent in root canals than previously thought.

Many factors influence the growth and colonization of bacteria in the root canal: the availability of nutrients, low oxigen tension and bacterial interactions [18,22-24].

Independent of the technique used to prepare the infected root canal, there is a general agreement that the elimination of bacteria is achieved by the mechanical cleansing with files and the use of an effective antimicrobial irrigant and dressing [1,9,16].

The use of the best possible irrigant is of great importance. Research has show the antimicrobial effectiveness of sodium hypochlorite[2,3,6,8,13,14,19,20]. Its germicidal activity is due to the formation of hypochlorous acid when in contact with organic debris. This acid exerts its effect by the oxidation of sulfhydryl groups of bacterial enzyme systems, disrupting the metabolism of the microorganisms[14,16].

However, there are different opinions about the ideal concentration of sodium hypoclorite. SHIH et al.[19] irrigated previously prepared canals innoculated with *Streptococcus faecalis* and *Staphylococcus aureus*, with 0.5% and 5% sodium hypochlorite. The bactericidal action of 5% sodium hypochlorite was superior only during the early periods. After 7 days, about 80% of the teeth presented positive cultures, independent of the two concentration used.

The most desirable concentration would be one that combines maximal antimicrobial effect with minimal toxicity. SPANGBERG et al.[21] found that 0.5% sodium hypochlorite dissolves necrotic but not vital tissue and has considerably less toxicity for HeLa cells than a 5% solution. THÉ et al.[25] evaluated tissue response to various concentrations of sodium hypochlorite in guinea pigs and no significant differences were found in inflamatory response for the concentration range of 0.9% to 8%. SIMÕES et al.[20] verified a mild inflamatory response when 1% sodium hypochlorite was used in the connective tissue of mice.

In terms of active chloride level, package and validity time, 1% sodium hypochlorite is the ideal concentration[11,17].

How much the canal should be enlarged is still controversial. WALTON and TORABINEJAD [28] reported that the root canal must be enlarged enough to permit adequate débridment as well as manipulation and control of obturating materials and instruments, but not so much that the chances of making procedural errors and needlessly weakening the root are increased. However, it is difficult to standardize implementation on clinical basis. There are no definable criteria for determining how much the canal should be enlarged. Each clinician has his own enlargement limit. Irregularities in the shape of the canals are still obvious and present in almost all of them. Much of the surface area of the canal is never touched by the instruments because of anatomic variations. The irregularities, lateral and accessory canals may be filled with necrotic tissue and bacteria. A classical test for determining the correct width of any canal preparation was the finding of clean white dentin shavings on the file's flutes. Because of the root canal anatomy this does not indicate a thorough removal of tissue, debris and bacteria.

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WALTON[27] and MIZRACHI et al.[12] evaluating canal debridment concluded that there was little relationship between clean shavings and the quality of debridment. GROSSMAN[7] and WEINE[29] introduced a rule based on the initial size of the file that binds at the apical portion of the canal. The master apical file is three or four sizes larger than the initial file depending on the presence of vital or necrotic tissue but this has not been proved to be really enough.

The aim of this study was to analyze the prevalence of anaerobic bacteria in the root canal of infected teeth related to the degree of enlargement and the irrigating solution.

MATERIAL AND METHODS

Thirty upper anterior teeth with asymptomatic apical periodontitis and intact pulp chamber walls from patients 18 to 40 years old were selected for this study. They all of them showed periapical bone destruction in the radiographic examination. Teeth with pathologic gingival pockets were not included.

BACTERIAL SAMPLES

The teeth were cleaned with an ultrasonic unit and isolated with a rubber dam. The tooth, the clamp and the rubber dam were cleansed with 0.4% iodate-alcohol and 70% alcohol. Access preparation was performed using a round bur in a high-speed handpiece and, before entering the pulp chamber, a new cleansing with 70% alcohol was done. To complete the access a round bur in a conventional handpiece was used.

A Hedströen # 15 file (Maillefer) was then introduced into the root canal, the working length was determined and the instrument pressed against the canal wall, turned itself a quarter and removed taking on its flutes canal fluid and dentin shavings. The instrument had its handle removed by a sterile and adequate wire cutter and transfered to a tube containing the transport medium and labeled.

Preparation was performed using K-files (Maillefer) and the root canal diameter determined by the instrument that bound slightly to the canal walls at the correct working length. Enlargement was done using four files larger than this instrument.

Microbiological samples were taken after the third and fourth instrument as described before. A total of 90 samples were taken.

MICROBIOLOGICAL SAMPLES

The transport medium was thioglicolate for anaerobies (Difco). The time between sample collection and laboratory analysis was 12 hours. As soon as the samples arrived they were anaerobically inoculated in the GasPak system for 48 hours at 37°C. Gram stained technique and aerotolerance tests were then performed. Colonies were sown on two Columbia Agar plates for anaerobics, supplemented with sheep blood (5%), vitamin K (1 mg/ml) and Hemina (5 mg/ml) and again incubated. The next step consisted of a new Gram stained technique and Vitek Systems analysis for rapid, computer-assisted identification of anaerobic and microaerophilic bacteria. The Vitek Systems uses an anaerobic identification card (ANI) and a specific computer program. Thirty wells in the card a contain 28 biochemical substrates and one negative control. The tests used in the ANI card are based on the microbial degradation of specific substrates and detected by a variety of indicator systems. Once the bacterial suspension is inserted into the card port by a transfer tube and sealed, it is incubated for four hours at 35-37°C. The bacteria do not use the substrate, but only test the enzyme they have. Positive and negative wells are then determined by visually comparing the wells to a positive color guide in the benchtop Vitek Off-line viewer. The results are entered into the Vitek System utilizing a simple, fast entry program on the data terminal. The patterns are analyzed automatically and an identification report is printed. It is a qualitative analysis, not quantitative for the anaerobic.

RESULTS

Table 1 shows the microorganism population in the root canal of all teeth. A minimun of three and a maximum of five different microorganisms were identified in each tooth. Tables 2 and 3 show the microorganisms identified after the use of the third and fourth instrument.

Table 1. Anaerobic bacteria identified in the initial sample.

GROUP 1		GROUP 2	
Propionibacterium acnes	*AGPR*	*Eubacterium histolyticum*	*AGPR*
Propionibacterium granulosum	*AGPR*	*Propionibacterium acnes*	*AGPR*
Prevotella bucae	*AGNR*	*Propionibacterium granulosum*	*AGPR*
Prevotella intermedia	*AGNR*	*Prevotella bucae*	*AGNR*
Prevotella melaninogenicus	*AGNR*	*Prevotella intermedia*	*AGNR*
Peptostreptococcus asaccharolyticus	*AGPC*	*Prevotella melaninogenicus*	*AGNR*
Fusobacterium nucleatum	*AGNR*	*Peptostreptococcus asacharolyticus*	*AGPC*
Lactobacillus	*AGPR*	*Fusobacterium nucleatum*	*AGNR*
Peptococcus	*AGPC*	*Lactobacillus*	*AGPR*
Actinomyces viscosus	*AGPR*	*Peptococcus*	*AGPC*
Clostridium ramasun	*AGPR*	*Actinomyces viscosus*	*AGPR*
Clostridium hastiforme	*AGPR*	*Peptostreptococcus prevotii*	*AGPC*
Bifidobacterium sp	*AGPR*	*Clostridium hystoliticum*	*AGPR*
Bacteroides distosonis	*AGNR*		
Bacteroides capillosus	*AGNR*		

AGNR = Anaerobic Gram-negative rods; AGPR = Anaerobic Gram-positive rods; AGPC = Anaerobic Gram-positive coccus. GROUP 1 = Saline solution as irrigant. GROUP 2 = 1% sodium hypochlotrite as irrigant

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Table 2. Anaerobic bacteria identified in the second sample - 3rd. instrument.

GROUP 1		GROUP 2	
Prevotella buccae	*AGNR*	*Peptostreptococcus prevoti*	*AGPC*
Prevotella intermedia	*AGNR*	*Clostridium histolyticum*	*AGPR*
Clostridium ramasum	*AGPR*		
Clostridium hastiforme	*AGPR*		
Propionibacterium acnes	*AGPR*		
Propionibacterium granulosum	*AGNR*		
Peptostreptococcus ascharolyticus	*AGPC*		
Bifidobacterium sp	*AGPR*		
Bacteroides distosonis	*AGNR*		
Bacteroides capillosus	*AGNR*		

AGNR = Anaerobic Gram-negative rods; AGPR = Anaerobic Gram-positive rods; AGPC = Anaerobic Gram-positive coccus. GROUP 1 = Saline solution as irrigant. GROUP 2 = 1% sodium hipochlorite as irrigant.

Table 3. Anaerobic bacteria identified in the third sample - 4th instrument.

GROUP 1		GROUP 2	
Clostridium ramasun	*AGPR*	*Propionibacterium acnes*	*AGPR*
Prevotella bucae	*AGNR*	*Clostridium histolyticum*	*AGPR*
Propionibacterium granulosun	*AGPR*		
Propionibacterium acnes	*AGPR*		
Bifidobacterium sp	*AGPR*		
Bacteroides distosonics	*AGNR*		
Bacteroides capillosus	*AGNR*		

AGNR = Anaerobic Gram-negative rods; AGPR = Anaerobic Gram-positive rods; AGPC = Anaerobic Gram-positive coccus. GROUP 1 = Saline solution as irrigant. GROUP 2 = 1% sodium hipochlorite as irrigant.

DISCUSSION

Anaerobic bacteria were identified in all the teeth selected with asymptomatic apical periodontitis. Thioglicolate for anaerobics (Difco) may not be the ideal transport medium but showed efficiency. Certainly, some bacteria were killed during the twelve hous between sample collection and laboratory analysis, but some anaerobies that are very sensitive and difficult to culture were identified such as *Fusobacterium nucleatum* and *Eubacterium histolyticum*. A qualitative reduction, about 50% of anaerobic bacteria in the root canals, was achieved when a nonantisseptic irrigant was used (saline solution - group 1), but bacteria were present in all teeth. This reduction was achieved after the use of the fourth instrument larger than the initial file. These findings are in agreement with those by BYSTRON and SUNDQVIST[1]. It is clear that we cannot get negative cultures at the end of the first appointment using a nonantiseptic irrigant. On the other hand, when 1% sodium hypoclorite was used as an irrigant solution (group 2), the qualitative reduction was more significant after the enlargement by the third instrument; however, no difference was observed between this and the fourth instrument. Sodium hypochlorite is the most popular irrigant and has been evaluated by many studies. CVEK et al.[4] reported that in half of the initially infected root canals, bacteria could be recovered. BYSTRON and SUNDQVIST[1] pointed to a low frequency (13%) after the first appointment, and OLGART[15], 34% frequency. In our study, 5 specimens showed no bacterial growth at the end of instrumentation, but this does not mean that desinfection was complete. Bacteria can remain in the dentinal tubules, between the lumen of the canal and the ligament and if no intracanal dressing is used, they grow and invade the lumen again in a few days. These differences are probably related to the bacteriological techniques used. The antimicrobial effect of 1% sodium hypochlorite is very clear when we compare the results of groups 1 and 2. In the second and third samples, the reduction of microorganisms seems to be well defined. Table 1 shows that the root canal flora is mixed. Bacillus and coccus, Gram-negative and Gram-positive were identified as being part of this flora. Tables 2 and 3 show that Gram-negative bacteria are more sensitive to instrumentation and to the antiseptic irrigant, and easily eliminated from the root canals. Gram-positive bacteria are more resistant and prevalent after root canal preparation. The cell wall of Gram-negative bacteria consists of two layers: the outer membrane and the peptidoglycan layer enclose a periplasmatic space, forming the cell envelope. The Gram-positive bacterial cell wall consists of one thick layer. This explains why Gram-positive bacteria are more resistant to root canal preparation and intracanal dressing[5,18,24]. The criteria adopted for determining how much the canal should be enlarged is very critical. It is not enough to eliminate bacteria from the root canal which emphazises the need for an antimicrobial intracanal dressing, completing the triad for root canal disinfection.

CONCLUSIONS

Root canal preparation using a non antisseptic irrigant contributed in reducing the number of anaerobic bacteria in infected root canals but did not eliminate it. Anaerobic bacteria were present in all teeth of this group.

When 1% sodium hypochlorite was used as an irrigant during root canal instrumentation, the qualitative reducion was more significant but did not eliminate all of them. The concept of enlarging the root canal three or four sizes larger than the initial file is not enough to eliminate bacteria from infected root canals. In our experiment *Peptostreptococcus prevoti and Clostridium histolyticum*, both Gram-positive anaerobic rods, were prevalent after the use of the fourth instrument and the use of an antimicrobial irrigant.

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ORAL MUCOSAL TATTOO INDUCED BY ENDODONTIC SEALERS

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The aim of this study was to analyze oral mucosal tattoo induced by the submucous injection of two different root canal sealers: N-Rickert, containing silver and Rickert-SP, not containing silver. Forty rabbits were used in this study, being sacrificed at intervals of 30, 90, 150, 210 and 270 days and submitted to clinical and histological analyses. The results were as follows: during the first 30 days, none of the sealers induced pigmentation. N-Rickert induced pigmentation in all animals after 90 days of observation, while Rickert-SP did not produce any tattoo in all groups observed. On the other hand, Rickert-SP sealer showed to be a lot more irritating to the tissues than N-Rickert.

Key Words: Sealers, tattoo, biocompatibility

INTRODUCTION

Some patients have been referred to the Oral Diagnosis Service of São Lucas Hospital, PUCRS, presenting black pigmented lesions with clinical aspects similar to amalgam tattoo. The radiograph showed only the presence of root canal filling. These teeth had not been submitted to apicoectomy with retrofilling, nor filled with silver cones. The presence of silver powder in some endodontic sealers, the potential of overfilling in some cases, and the possibility of reaching the submucous tissues in perforations, has led us to believe that exogenous pigmentation could occur from these sealers.

In 1938, CAHN[2] described a case of a patient with gingival pigmented lesion. A tooth with endodontic treatment and a root perforation could be seen in the area. The author considered the possibility of an irrigating solution containing silver being the cause of pigmentation. DAYAN et al.[3] reported two cases of pigmentation from AH-26 sealer. Although this sealer contains silver in its chemical composition, no relation with this fact was considered by the authors. SAVOLDI et al.[14] reported a clinical case of a patient with black gingival pigmentation following the overfilling of a lateral canal. The authors did not mention the chemical composition of the sealer, nor the possible causes of the tattoo.

The aim of this study is to evaluate the presence of pigmentation in rabbits induced by the submucous injection of two sealers, one containing silver and the other not, as well as the histological responses.

MATERIAL AND METHODS

In this study, 40 white New Zealand rabbit, were randomly divided into 5 groups of 8 each (groups I, II, III, IV and V). Following anesthesia, the sealers were prepared according to the manufacturer's instructions. The sealers used were N-Rickert (Veado D'Ouro, SP, Brazil), which contains 30% silver in its powder, and Rickert-SP (Inodon, RS, Brazil), with no silver in its chemical composition.

Once prepared, the sealer was tranfered to a syringe (Terumo Medical Co.), and approximately 0.1 ml of N-Rickert was injected into the submucous tissues of the right superior gingivo-labial sulcus. Rickert-SP was injected the same way into the left side.

After 30 days, the animals of group I were anesthetized to permit visual inspection by two observers, who registered the absence or presence of tattoo, and the diameter in mm. The animals were then killed, the tissue to be examined removed and taken for histological processing. The sections were examined by three observers, taking into consideration the presence or absence of granulation tissue, neutrophils, eosinophils, lymphocytes and plasma cells, macrophages and giant cells, perivascular deposit of sealer, abscess and fibroplasia. Analysis of variance and the Fischer test were used for statistical analysis.

The same procedure was used for groups II, III, IV and V, with the sacrifices at being intervals of 90, 150, 210, and 270 days, respectively.

RESULTS

Clinical Analysis

In Group I (30 days), no tattoo was visible in the oral mucosa of any of the rabbits. In groups II, III, IV and V, no discoloration could be seen in any of the animals on the left side, where Rickert-SP sealer was injected. N-Rickert induced discoloration in all specimens after 90 days (Figure 1). The size of the tattoo was larger in groups IV and V, but this was not statistically significant analysis of variance ($p = 0.01$). The sizes of the tattoos are shown in table I

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Table 1. Size of the tattoo in oral mucosa with the injection of N-Rickert sealer (mm)

ANIMAL	GROUP II	GROUP III	GROUP IV	GROUP V
1	0.1	0.3	0.1	0.1
2	0.1	0.3	0.4	0.4
3	0.1	0.3	0.4	0.2
4	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2
7	0.2	0.1	0.2	0.2
8	0.2	0.1	0.2	0.3

***Figure 1** - Gingival tattoo with the use of N-Rickert sealer - Group V - 270 days*

Histological Analysis

There was no grannulation tissue with the use of N-Rickert. Rickert-SP produced granulation tissue in 75% in group I, 35% in group II, and 12.5% in groups III, IV and V. The presence of neutrophils was evident in 12.5% of the specimens in groups I and II of N-Rickert sealer, while Rickert-SP produced these cells in 87.5% of the cases in group I, 50% in group II and 12.5% in groups III, IV and V. Eosinophils were evident in a great extent with Rickert-SP sealer, in groups I, II and III, with a percetage of 75, 100 and 50%, respectively (Figure 2). Groups IV and V showed a these cells in 12.5% of the cases each. N-Rickert produced a discrete presence of eosinophils in 12.5% of the specimens in groups I and II only.

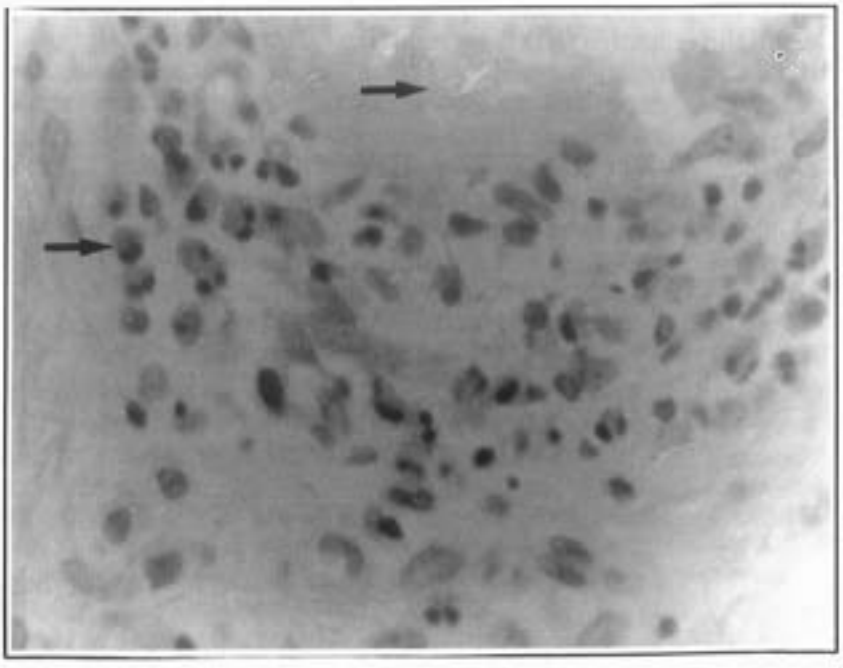

***Figure 2** - Presence of eosinophils with Rickert-SP sealer - 400X*

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Abscess with N-Rickert sealer was present in 12.5% in groups I and II. Rickert-SP had abscess formation in 62.5% of group I, 37.5% in group II, 25% in group III and 12.5% in group IV. Lymphocytes and plasma cells were present with Rickert-SP in 87.5% in group I, 75% in group II, 50% in group III, and 12.5% in groups IV and V. With N-Rickert sealer these cells were present in only12.5% in groups I and II. Fibroplasia could be identified in both groups of sealers. An overall analysis of the response of the tissues to the sealers showed the Rickert-SP sealer to be more irritating than N-Rickert, in all groups studied *(Figure 3)*.

***Figure 3** - N-Rickert sealer with fibroplasia and no inflammatory cells - 100X*

DISCUSSION

Oral pigmentation from endodontic sealers has been given very little attention in dental literature. Most publications are limited to describing a clinical case, sometimes showing the histological response, but not disscussing the possible causes for the discoloration. DAYAN et al.[3] and SAVOLDI et al.[14] mentioned the endodontic sealer as the probable cause, but did not consider the chemical composition of the material. In this study, the presence of silver was critical to the development of the gingival tattoo. ORBAN and WENTZ[9] considered this possibility without proving it. The 30% silver in the N-Rickert formula, must have contributed decisively to the occurrence of the tattoo.

The sealers used in this study were chosen because of the presence or absence of silver in the chemical composition. N-Rickert sealer, proposed by SAMPAIO[13], is very popular among endodontists in Brazil, being basically the Rickert formula with a corticosteroid. Rickert-SP is, according to the manufacturer, the Rickert formula without silver.

The use of polyethilene tubes for endodontic biologic studies has been widely used[1,5,8,10,16]. The material is in contact with the tissues only at the extremes of the tubes. This would prevent the sealers' dissolution. In this study, the objective was to create a condition similar to an overfilling with the sealer, which is very common in clinical practice.

The specimens in this study were sacrificed at periods not shorter than 30 days. The initial inflammatory response was not the object of this study, and has been reported by other authors[1,13].

Pigmentation occurred in this study between the 30th and the 90th day of contact of N-Rickert with the mucosa. This is in agreement with the study described by ELEY[4] using silver amalgam, in which the tattoo appeared after 60 days. The mechanism of pigmentation from endodontic sealer must be similar to the amalgam tattoo, which is, according to HARRISON et al.[6], a process of corrosion of the metallic compounds in contact with the tissue fluids.

Histological analysis showed significant differences in the responses to the sealers. N-Rickert did not stimulate the presence of granulation tissue in any of the groups studied, confirming the findings of HOLLAND et al.[8] and BOMBANA[1]. Rickert-SP sealer showed granulation tissue at variable degrees. This sealer also presented the presence of neutrophils, eosinophils, and abscess at higher degrees than N-Rickert, thus showing it to be a very irritating sealer.

According to SAMPAIO[13] the presence of delta-hydrocortisone in N-Rickert may have contributed to better tissue repair. Several studies[7,11,12,15] point to this corticosteroid as a moderator of the initial inflammatory response, thus inducing the repair.

Perivascular deposits of N-Rickert sealer could be seen after 150 days of the experiment, with a similar pattern to that observed with dental amalgam. ELEY[4] verified these deposits in the endothelium of blood vessels after 90 days of experiment with dental amalgam.

The ideal sealer has not yet been found. Besides having good biological characteristics and physical properties, the filling material should not cause

gingival discoloration when in contact with the periapical tissues.

CONCLUSIONS

1. N-Rickert sealer, when in contact with oral soft tissues, tattooed all specimens after 90 days of experiment. The largest tatoos were present between 210 and 270 days, although the differences were not statistically significant. Rickert-SP sealer did not cause any discoloration.

2. Both sealers caused various inflammatory reactions. Rickert-SP sealer was a lot more irritating to the tissues than N-Rickert sealer.

3. Endothelial deposits of N-Rickert sealer could be seen after 150 days of the experiment.

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COMPARISON OF TWO K-FILES USED IN A LINEAR FILING ACTION TO SHAPE SIMULATED ROOT CANALS

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A total of 80 simulated canals of various angles and positions of curvature were prepared by hand using either Mani K-Files or Kerr K-Files. Following orifice enlargement each file type was used to prepare 40 canals employing a linear filing motion and an anticurvature stepback technique. Pre- and post-operative images of the canals were taken with a video camera and stored and manipulated in a computer with image analysis software. The presence of canal aberrations and the amount of material removed as a result of preparation were determined from composite images of superimposed pre- and post-operative views. Overall, canal preparation was significantly quicker with Mani K-Files and was associated with fewer instrument failures. The incidence of aberrations was balanced with respect to instrument type. Canal shape had a significant influence on preparation time, canal blockage, apical extrusion, the width of zips and the incidence and width of danger zones. Under the conditions of this study, Mani K-Files were more effective than Kerr K-Files.

Key Words: Canal preparation, shaping, files, simulated canals

INTRODUCTION

Adequate preparation of the root canal system prior to obturation with an appropriate filling material is an important factor for success in root canal therapy[11,21]. For gutta-percha, the optimum shape is a continuously tapering and conical form with the smallest diameter at the apical limit of instrumentation[19]. In curved canals it is important that preparation does not straighten the canal unduly since this can result in an hour-glass shape, with canal transportation and irregularities such as zips and elbows, ledges and perforations, . These aberrations may compromise the long-term success of treatment by making cleaning less efficient and obturation more difficult.

A number of preparation techniques have been described which aim to provide the optimum shape at the end of preparation[1,8,9,11,14,15,17,18]. Unfortunately, evidence suggests that although modern techniques have led to an improvement in the final canal shape the ideal form is not achieved consistently[2,3,4,7,24].

The failure of many techniques to produce the correct shape has directed attention towards instrument design in an attempt to reduce the risk of canal irregularities. The ideal endodontic instrument should be flexible to allow negotiation of curved canals and be resistant to fracture and cut efficiently. Following standardisation[11] canal preparation was accomplished using carbon steel reamers. Subsequently, stainless steel was introduced and a filing action advocated rather than reaming. Unfortunately, steel is relatively inflexible and this property is thought to contribute to the development of canal irregularities during preparation[2,7]. The risk of developing irregularities is compounded as instrument diameter increases and as the root canal becomes more curved[3,4,7,22,24].

Attempts have been made to increase the flexibility and cutting efficiency of endodontic files by modifying their design. For example, files with a triangular cross section are associated with a superior cutting efficiency and improved flexibility when compared to a square shape[3,4,10,23]. Machined instruments are also less effective and less flexible than twisted instruments[5]. Despite these improvements the risk of developing canal irregularities still remains[2,3,4,7,12].

The aim of this study was to compare two stainless steel files used in a linear filing motion during the preparation and shaping of simulated root canals in resin blocks. The effect of file type and canal shape were determined by assessing development of canal irregularities and the amount and position of resin removed from the canal wall during preparation.

MATERIAL AND METHODS

CONSTRUCTION OF SIMULATED CANALS

A total of 80 simulated root canals in plastic blocks were constructed using a previously described technique[6]. Annealed silver points (size 20) used as templates to form the canals were precurved using a canal former prior to embedding in clear resin. Four canal shapes were fabricated, all with a radius of 16 mm:

- 20 degree curve, 8 mm from the canal orifice
- 20 degree curve, 12 mm from the canal orifice
- 40 degree curve, 8 mm from the canal orifice
- 40 degree curve, 12 mm from the canal orifice

INSTRUMENTS

The stainless steel instruments selected for study were Mani K-Files (Mani Inc, Tochigi-Ken, Japan) and Kerr K-Files (Kerr Corp, Romulus, MI, USA). Mani K-Files are square in cross-section up to size 40 and triangular in sizes 45 to 80, they have conical tips and rounded transitional angles. Kerr K-Files are square in

cross-section and have a sharp tip. Figures 1 and 2 are scanning electron photomicrographs of a Mani K-File whilst Figs. 3 and 4 are identical views of a Kerr K-File. Differences between the files in terms of rake angle, twists per millimetre and instrument tip configuration are clear.

PREPARATION OF SIMULATED CANALS

Canals were prepared by one operator using either Mani K-Files or Kerr K-Files. Ten canals of each shape were prepared with each file type, making a total of 40 canals for each file type and 80 canals in all. Each canal was prepared short of the actual end point to a length of 16 mm. During preparation, each resin block was placed in a holder to aid handling and to ensure that the process was carried out with purely tactile sensation, however, the direction of the curve of each canal was always known. Copious irrigation with water was used throughout and was introduced with a 27 gauge needle and a syringe. Irrigant was used between each instrument to a total volume of 50 ml for each canal. The preparations were identical for both file designs and were undertaken using a Stepdown technique with anticurvature filing as follows:

1. Radicular access was established with Hedstrom files and Gates Glidden burs (GG) up to the beginning of the curve. All files and burs were directed away from the inner side of the curve. Hedstrom files were used initially until a GG bur No.1 could be used. The No.2 GG bur was then introduced half the distance of the No.1 followed by a No.3 GG bur half the distance of the No.2. A size 10 file was used to recapitulate the canal at the full working length between burs.

2. The apical stop was prepared next. A precurved file the same size as the apical diameter of the canal was introduced and used in a linear filing (in/out) action while lateral force was applied against the canal walls. The same instrument was used repeatedly until it became loose at the full working length. This process was continued with further instruments until an apical stop of size 30 was achieved. Filing was directed towards the bulky aspect (safe zone) of the walls and away from the inner aspects (danger zone) of the canal curves. A ratio of three strokes on the bulky aspects to one on the inner aspect was adopted. A smaller size file was used to recapitulate and smooth the canal between increases in instrument size.

3. The remainder of the canal was prepared with a stepback technique. At first a file one size larger than the master apical file was introduced 1 mm short of the working length and used in an anticurvature action. The stepback procedure continued 2 mm short of the working distance with a file 2 sizes larger than the MAF and proceeded through to a size 60 instrument. Recapitulation with the MAF was performed between each step.

ASSESSMENT OF CANAL PREPARATION

Preparation time. The time taken to prepare each canal was recorded in minutes and seconds. It included only active instrumentation and not irrigation time or the time taken to change files.

Instrument fracture. Throughout the study a record was kept of the numbers and sizes of instruments that deformed or fractured during use.

Blockages. A record was kept of those canals which became blocked.

Apical extrusion. During preparation any debris extruding from the apical aspect of the canal was noted.

Canal aberrations. Commercial digitising image equipment (Seescan, Cambridge, UK) was customised and used to produce images of the simulated canals for comparison and evaluation. Two images of each canal were produced, the first prior to preparation, and the second at the end of preparation. The equipment allowed the two digitised images of each canal to be superimposed so that changes could be assessed. Comparisons were made between the pre-operative and post-operative images to determine the development of canal aberrations. Comparisons were also made between the images when evaluating the amount of resin lost during preparation.

A simple direct visual assessment was made of the presence or absence of the following canal irregularities:

1. *Apical zip:* irregular widening of the area at the end-point of the canal where resin had been largely removed from the outer aspect of the curve (Fig. 5)
2. *Elbow:* a narrow region of the canal associated with and coronal to a zip (Fig. 5)
3. *Danger zone:* excessive removal of resin from the inner aspect of the curve (Fig. 6)
4. *Coronal narrow:* a narrowing of the canal associated with and coronal to a danger zone (Fig. 6)
5. *Perforation:* a separate and distinct false canal towards the end-point of the canal which was not confluent with the original canal and which occurred along the outer aspect of the curve (Fig. 7).
6. *Ledge:* a distinct irregularity along the outer wall of the canal at or near the curve not substantial enough to be considered a perforation (Fig. 8).
7. *Shoulders:* a distinct step around the circumference of the canal.

Amount of resin removed. The amount of resin removed was determined both on the external and internal aspects of the curve and carried out perpendicular to the axis of the original canal. Measurements were made at the widest part of the zip (when present) and at the widest point of the danger zone (when present).

Transportation. the movement of the centre of the post-operative canal away from the centre of the pre-operative canal, was computed from the measurements of resin removed from the external and internal aspects of the curve at the zips and danger zones.

RECORDING, STORAGE AND ANALYSIS OF DATA

Data was recorded directly onto coding sheets and then keyed into and stored in a desktop computer. Following error and range checks, the data was analysed using MINITAB for Windows (Minitab Inc., State College, PA, USA), an interactive statistics package. A two-way analysis of variance (ANOVA) was used to evaluate the interaction of file type and canal shape

on loss of resin and preparation times. A Chi-square analysis was used to evaluate the effect of file type and canal shape on the number of aberrations, blockages and instrument fractures that occurred

RESULTS

Preparation time

The time taken to complete the preparation of the canals is shown in Table 1. Each combination of instrument and preset shape is represented by the means of 10 replicate specimens. Two-way analysis of variance indicated highly significant variation ($P<0.001$) in preparation time between instruments and between canal types. The interaction between instrument and canal type was also highly significant, meaning that differences in preparation time between instruments were strongly dependent on which shape of canal was involved.

Overall, the average time taken to prepare all the canals was shorter for the Mani K-File and longer for the Kerr K-File. For each position of curve (8 mm or 12 mm) 40° canals took longer to prepare than 20° canals. For each angle of curve (20° or 40°) 8 mm canals took longer to prepare than 12 mm canals.

INSTRUMENT FAILURE

In total, 16 instruments became permanently distorted during the preparation of the 80 specimens. Table 2 summarises how instrument failures varied with instrument type and canal shape. Overall, 5 Mani K-Files and 11 Kerr K-files failed but this differences was not statistically significant. For both instruments most failures occurred with size 30 instruments (8 out of 14) followed by sizes 25 (4) and 20 (3) but there were no significant differences between the instrument sizes.

Overall, 5 instruments deformed in the 20°, 8 mm canals, 6 in the 40°, 8 mm canals, 4 in the 20°, 12 mm canals and 1 in the 40°, 12 mm canals. There was no significant difference in instrument failure between the canal types.

CANAL BLOCKAGES

In total 15 specimens became blocked, 8 prepared by Mani K-Files and 7 by Kerr K-Files; the difference between files was not statistically significant.

The pattern of specimen blockage by canal shape is outlined in Table 3. There was a significant difference between the canal shapes in terms of the incidence of blockage ($P<0.05$) with most occurring in the 40°, 8 mm canals.

APICAL EXTRUSION

Extrusion of resin debris through the apical end of the canal occurred in 20 specimens, 10 in canals prepared by Mani K-Files and 10 in canals prepared by Kerr K-Files. The difference between instruments was not statistically significant.

The incidence of extrusion by canal shape is given in Table 4. Extrusion occurred most often through 20°, 8 mm canals (9) followed by 20° and 40°, 12 mm canals (8). The difference between canal shapes was statistically significant ($P<0.005$).

CANAL ABERRATIONS

Apical zips and elbows. Overall zips and elbows were found in 46 (58%) canals with each instrument creating 23. Table 5 highlights the incidence of zips and elbows by canal shape, ignoring instrument type. The differences between canal types was not statistically significant.

Table 6 describes the distance between the widest part of the zips and the end-point of preparation by canal type and instrument. The difference between instruments was statistically significant ($P<0.001$). The differences between the canal shapes was also significant ($P<0.05$); for each position of curve (8 or 12 mm) the distance was greater in the 40° canals whilst for each degree of curvature (20° or 40°) the distance was greater in the 8 mm canals.

Table 7 provides details of the distance of the elbows from the end-point of preparation. The differences between instruments and canal types were significant ($P<0.05$ and $P<0.001$ respectively); the distance of the elbows from the end-point was greater with the Mani K-Files whilst the effect of canal type followed the pattern seen with the zips.

Perforations. No perforations were found.

point of preparation. Overall, the differences between instruments ($P<$ *Danger zones*). Excessive removal of resin from the inner aspect of curves occurred in 18 (23%) canals, both instruments created 9. Danger zones were always associated with narrow regions placed more coronally and their incidence clearly reflected the pattern noted with the danger zones.

Table 8 highlights the incidence of danger zones in the various canal types. The majority of defects (14) were seen in 40°, 12 mm canals with the remainder (4) occurring in the 40°, 8 mm canals; no defects were seen in 20° canals. The differences between the canal types were statistically significant ($P<0.001$).

Table 9 provides details of the positions of the danger zones in relation to the end-0.01) and canal shapes ($P<0.001$) were significant. The positions of the coronal narrow regions (Table 10) demonstrated a similar pattern.

WIDTH MEASUREMENTS

Table 11 describes the mean total widths of canals at the zips for each canal shape. Analysis of variance confirmed that significant differences in the width of zips occurred between instruments ($P<0.05$) and canal types ($P<0.001$). Overall, zips were wider in 40° canals compared to 20° canals and in canals where the curve began 8 mm from the orifice compared to those where the curve began 12 mm from the orifice.

Table 12 demonstrates the mean width of resin removed from the outer aspect of the curve at the zips. Overall, significant differences were found between instruments ($P<0.01$) and canal types ($P<0.001$). Mani K-files removed significantly more resin than Kerr K-Files. More resin was removed in 40° canals compared to 20° canals and in canals where the curve began 8

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mm from the orifice compared to those where the curve began 12 mm from the orifice.

Table 13 describes the mean total widths of the danger zones. Overall, significant differences were found between instruments ($P<0.01$) and canal types ($P<0.01$). Mani K-files removed significantly more resin than Kerr K-Files and more resin was removed in 40°, 8 mm canals compared to 40°, 12 mm canals.

Table 14 demonstrates the mean width of resin removed from the inner aspect of the curve at the danger zones. Overall, significant differences were found between instruments ($P<0.01$) and canal shapes ($P<0.05$). Mani K-files removed significantly more resin than Kerr K-Files and more resin was removed in 40°, 8 mm canals compared to 40°, 12 mm canals.

TRANSPORTATION

Table 15 describes the amount of absolute transportation at the zips, that is, ignoring whether the direction of transportation was towards the inner or outer aspect of the curve. Two way analysis of variance confirmed that significant differences occurred between instruments ($P<0.01$) and canal shapes ($P<0.001$). Overall, transportation was greater with Mani-K-Files and less with Kerr K-Files. Transportation was greater in 40° canals and those which began 8 mm from the orifice.

Table 16 illustrates absolute transportation at the danger zones. Mani K-files removed significantly more ($P<0.05$) resin than Kerr K-Files but the trend for more resin to be removed in the 40°, 8 mm canals was not significant.

Table 1. Mean time (min) taken to prepare canals

	Canal shape				
Instrument	**20°, 8 mm**	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
Mani K-File	*10.3*	*13.0*	*7.3*	*10.8*	*10.3*
Kerr K-File	*10.9*	*14.4*	*10.4*	*10.6*	*11.6*
All	*10.6*	*13.7*	*8.9*	*10.7*	*11.0*

Table 2. Incidence of instrument failure by size

	Instrument size				
Instrument	**Size 15**	**Size 20**	**Size 25**	**Size 30**	**All**
Mani K-File	*1*	*0*	*1*	*3*	*5*
Kerr K-File	*0*	*3*	*3*	*5*	*11*

Table 3. Incidence of canal blockages by canal shape

	Canal shape				
	20°, 8 mm	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
All	*3*	*8*	*1*	*3*	*15*

Table 4. Incidence of apical extrusion by canal shape

	Canal shape				
	20°, 8 mm	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
All	*9*	*1*	*8*	*2*	*20*

Table 5. Incidence of zips and elbows by canal shape

	Canal shape				
	20°, 8 mm	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
All	*9*	*10*	*11*	*16*	*46*

Table 6. Mean distance (mm) of zips from end-point of preparation

	Canal shape				
Instrument	**20°, 8 mm**	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
Mani K-File	*0.54*	*1.48*	*0.47*	*0.63*	*0.67*
Kerr K-File	*0.33*	*0.42*	*0.26*	*0.35*	*0.36*
All 0.47	*0.74*	*0.39*	*0.47*	*0.51*	

Table 7. Mean distance (mm) of elbows from end-point of preparation

	Canal shape				
Instrument	**20°, 8 mm**	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
Mani K-File	*1.45*	*2.67*	*1.19*	*1.48*	*1.54*
Kerr K-File	*0.99*	*1.79*	*0.95*	*1.40*	*1.39*
All 1.29	*2.05*	*1.10*	*1.44*	*1.46*	

Table 8. Incidence of danger zones and coronal narrow zones by canal shape

	Canal shape				
	20°, 8 mm	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
All	*0*	*4*	*0*	*14*	*18*

Table 9. Mean distance (mm) of danger zones from end-point of preparation

	Canal shape		
Instrument	**40°, 8 mm**	**40°, 12 mm**	**All**
Mani K-File	*7.01*	*4.74*	*5.25*
Kerr K-File	*5.85*	*3.99*	*4.40*
All 6.43	*4.37*	*4.82*	

Table 10. Mean distance (mm) of coronal narrow regions from end-point of preparation

	Canal shape		
Instrument	**40°, 8 mm**	**40°, 12 mm**	**All**
Mani K-File	*8.86*	*5.87*	*6.53*
Kerr K-File	*7.33*	*5.40*	*5.83*
All 8.09	*5.63*	*6.18*	

Table 11. Mean total width (mm) of zips

	Canal shape				
Instrument	**20°, 8 mm**	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
Mani K-File	*0.49*	*0.61*	*0.40*	*0.55*	*0.50*
Kerr K-File	*0.42*	*0.59*	*0.42*	*0.49*	*0.50*
All 0.47	*0.60*	*0.41*	*0.52*	*0.50*	

Table 12. Mean width (mm) of resin removed from the outer aspect of the original canal at the zip

	Canal shape				
Instrument	**20°, 8 mm**	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
Mani K-File	*0.18*	*0.27*	*0.10*	*0.24*	*0.19*
Kerr K-File	*0.09*	*0.25*	*0.10*	*0.17*	*0.17*
All 0.15	*0.26*	*0.10*	*0.20*	*0.18*	

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Table 13. Mean total width (mm) of danger zone

	Canal shape		
Instrument	**40°, 8 mm**	**40°, 12 mm**	**All**
Mani K-File	*1.07*	*0.97*	*0.99*
Kerr K-File	*1.08*	*0.79*	*0.86*
All	*1.08*	*0.88*	*0.93*

Table 14. Mean width (mm) of resin removed from the inner aspect of the curve at the danger zone

	Canal shape		
Instrument	**40°, 8 mm**	**40°, 12 mm**	**All**
Mani K-File	*0.56*	*0.53*	*0.54*
Kerr K-File	*0.55*	*0.39*	*0.42*
All 0.55	*0.46*	*0.48*	

Table 15. Absolute transportation (mm) of canals at zips

	Canal shape				
Instrument	**20°, 8 mm**	**40°, 8 mm**	**20°, 12 mm**	**40°, 12 mm**	**All**
Mani K-File	*0.086*	*0.124*	*0.049*	*0.121*	*0.090*
Kerr K-File	*0.027*	*0.122*	*0.035*	*0.077*	*0.077*
All 0.067	*0.123*	*0.043*	*0.096*	*0.084*	

Table 16. Absolute transportation (mm) of canals at danger zones

	Canal shape		
Instrument	**40°, 8 mm**	**40°, 12 mm**	**All**
Mani K-File	*0.260*	*0.241*	*0.245*
Kerr K-File	*0.248*	*0.190*	*0.203*
All 0.254	*0.216*	*0.224*	

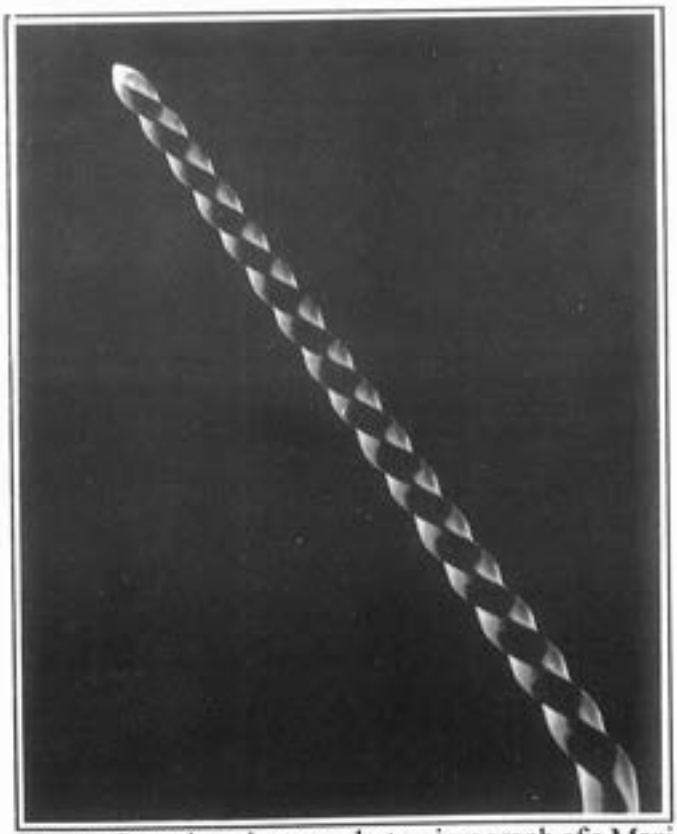

Fig. 1 - Scanning electron photomicrograph of a Mani K-File (original magnification x 20)

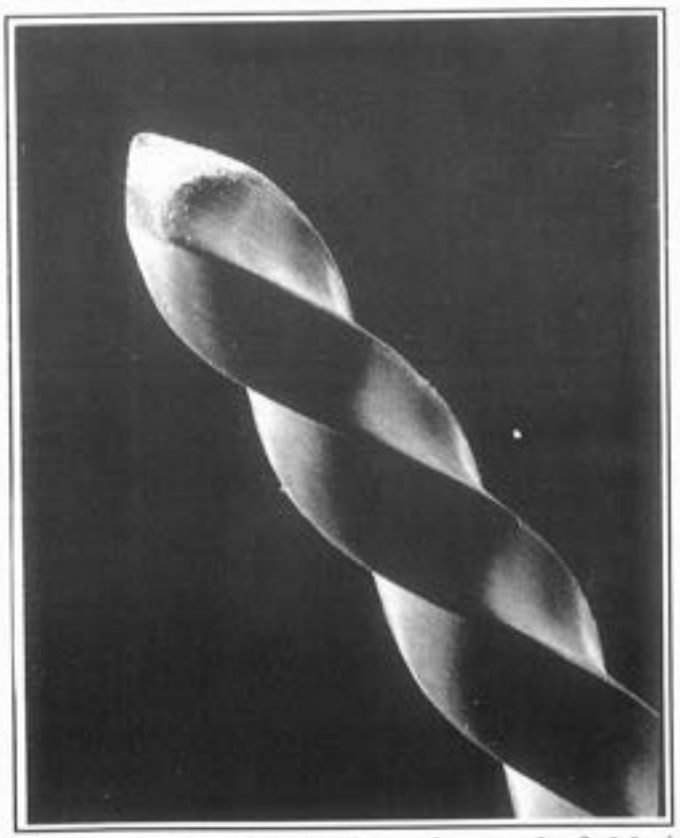

Fig. 2 - Scanning electron photomicrograph of a Mani K-File (original magnification x 120)

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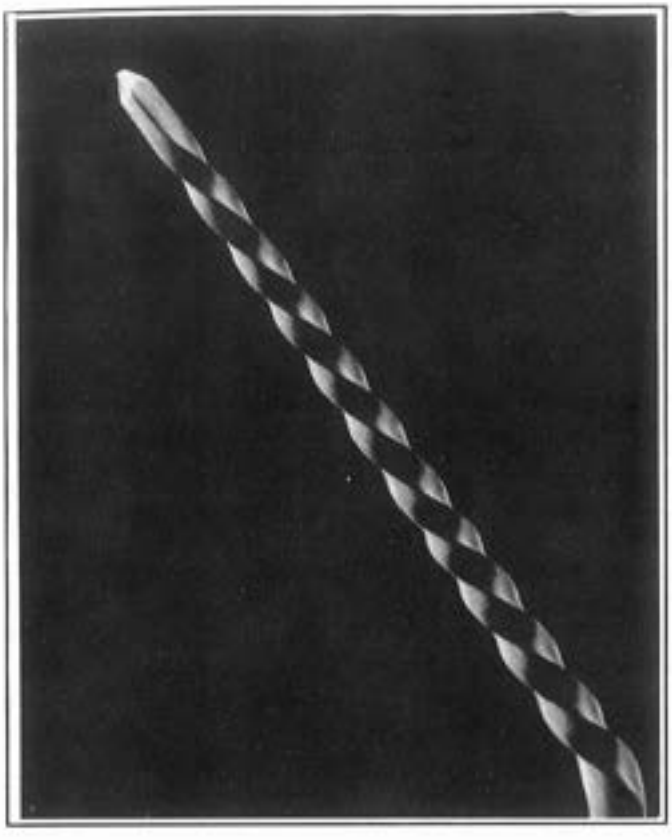

Fig. 3 - Scanning electron photomicrograph of a Kerr K-File (original magnification x 20)

Fig. 4- Scanning electron photomicrograph of a Kerr K-File (original magnification x 120)

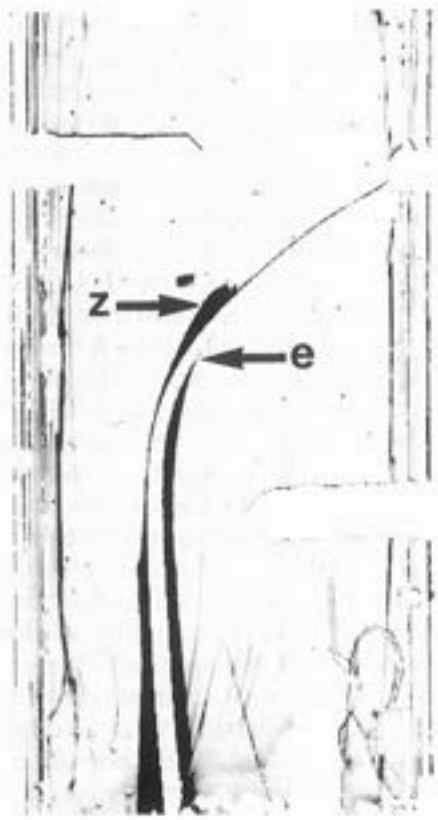

Fig. 5 - Composite photograph of a superimposed pre-operative (white region) and post-operative (black region) image of a simulated canal showing a zip (z) and elbow (e)

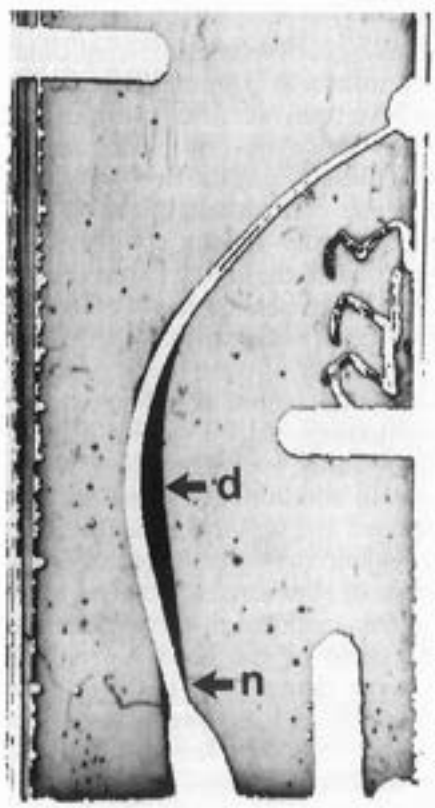

Fig. 6 - Composite photograph of a superimposed pre-operative and post-operative image of a simulated canal showing a danger zone (d) and region of coronal narrowing (n)

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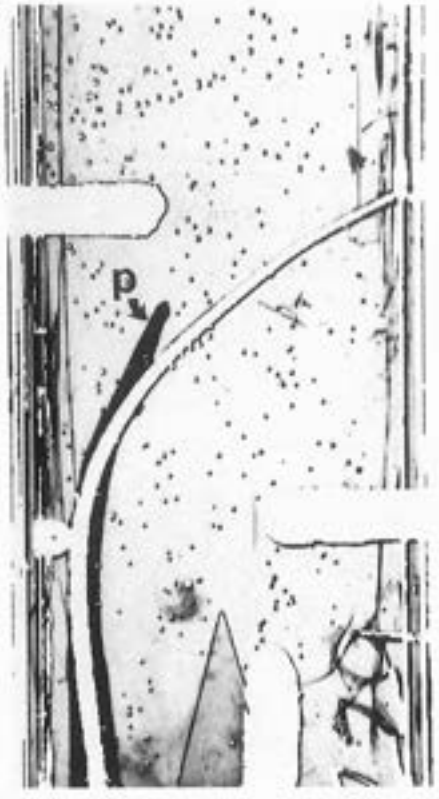

Fig. 7 - Composite photograph of a superimposed pre-operative and post-operative image of a simulated canal showing a perforation (p)

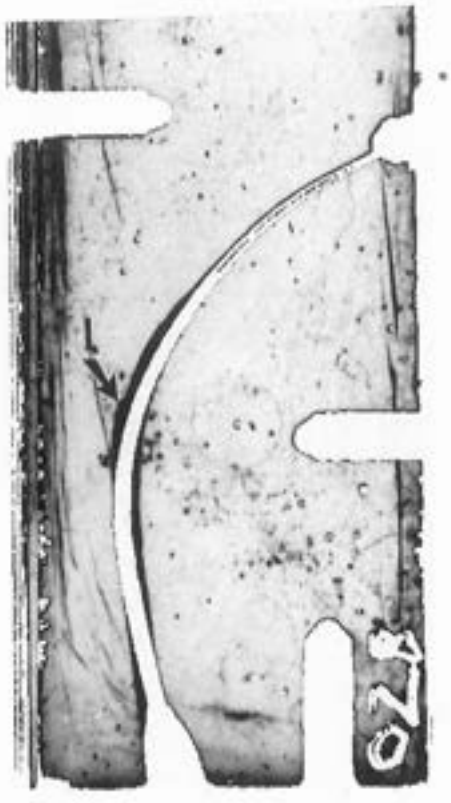

Fig. 8 - Composite photograph of a superimposed pre-operative and post-operative image of a simulated canal showing a ledge (l)

DISCUSSION

The advantages of using simulated canals in clear resin blocks to assess preparation procedures and instruments have been identified previously[2,3,4,7,13]. The purpose of this study was not to produce a definitive description of the action of the two file types but rather to provide a clear comparison of the effectiveness of the instruments under strictly controlled conditions *in vitro*. In particular, the ability to test the instruments using identical canal shapes removed a variable that is difficult to control using real teeth. However, a degree of caution should be exercised in the interpretation of the results and their extrapolation to the clinical situation.

During the study, each instrument was used in an identical way. In addition, the preparation procedure was standardised and was the same for each file type. There is no evidence to suggest that either file is better used in a linear or rotational action and so because of the square cross-sectional profiles of the instruments and the sharp tip of the Kerr K-File a stepback technique with filing was chosen. The orifice enlargement prior to hand preparation would have tended to improve access to the apical region and recuced the likelihood of zips and elbows.

The comparison of preparation times represents the efficiency of each instrument to enlarge the simulated canals. Speed itself is not the main criterion by which canal preparation should be judged, however, when taken together with other parameters it provides a useful indicator of instrument performance and efficiency. This study has highlighted a significant difference between the two files with, overall, Kerr K-Files taking longer. This finding may reflect the different designs of the instruments in terms of blade sharpness and tip configuration confounded by lack of flexibility. Indeed, subjectively, the Mani K-File appeared more flexible and user friendly.

A fractured or deformed instrument may prejudice the outcome of root canal treatment. In this study Kerr K-Files failed more often than Mani K-Files supporting the impression that the latter were more flexible. Of course, they may also be inherently stronger as a result of the steel from which they are made or because of their design, method of manufacture and quality control. Most failures occurred with size 30 instruments which was the size of the apical stop and presumably the size which suffered most stress.

More blockages occurred in 40° canals (11) compared to 20° (4) presumably as the greater curvature allowed less effective debridement because instrument manipulation was more constrained and irrigation procedures less effective resulting in more resin compacting apically. This contrasted with the results for apical extrusion where 20° canals (17) were affected more than 40° canals (3). Clearly, the less severely curved canals allowed greater debridement through more effective irrigation and less constrained instrument manipulation.

Most canal irregularities are thought to be caused by inflexible files straightening within the canal. Classically, this phenomenon produces an hour-glass

preparation[24]; the apical region is transported producing a zip on the outer aspect of the curve whilst excess preparation on the inner aspect of a curve causes a danger zone. Theoretically, aberrations would be expected to increase as canal curvature increases and as file flexibility decreases.

The results for zips and danger zones followed the expected pattern as far as canal type was concerned with 40° canals, particularly those where the curve began 12 mm from the orifice, being affected more often. However, differences between file types in terms of the incidence of aberrations were not apparent. It was expected that Mani K-Files with their greater flexibility and rounded tips would perform better than Kerr K-Files. Why the expected pattern did not occur cannot be determined with certainty but it may be related to the use of simulated canals rather than real canals and the fact that dentine is harder than resin; the softer resin may have predisposed to zip and danger zone formation to mask potential differences between instruments. Overall, the incidence of zips was high with over half the specimens affected. Previous reports have confirmed that the creation of zips is less apparent when files with triangular cross-sectional shapes are used[4] because they are inherently more flexible[10] and thus less likely to straighten. The effect of tip design is also critical, with those instruments with rounded transitional angles being less aggressive and less prone to create aberrations[4,16,20]. The Kerr K-File has a sharp tip lacking cutting flutes (Figs. 3 and 4) and has been shown previously to produce many zips when used in a linear filing motion[2,4]. As mentioned previously, the high incidence of zips noted with Mani K-Files was not expected as the instrument appeared more flexible and had a rounded tip (Figs. 1 and 2). On the other hand, they have a square cross-sectional profile which is inevitably less flexible than the triangular designs.

CONCLUSION

Under the conditions of this study, preparation of simulated canals with Mani K-files was more efficient than Kerr K-Files and was associated with fewer instrument failures. There was no difference between instruments in terms of the incidence of zips and danger zones. The Mani K-File removed more resin from the canals at the zips and danger zones.

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A COMPARISON OF THREE METHODS OF HAND AND AUTOMATED INSTRUMENTATION USING THE CFS AND M4 FOR PREPARATIONS OF CURVED AND NARROW SIMULATED ROOT CANALS

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One hundred and twenty-five (125) plastic blocks with simulated narrow and curved canals size ISO 15 with curvature of 50° - 70° were divided into 5 equal groups. Group I was prepared by hand instrumentation with ISO 15 - 30 Flex-O-Files. Group II was prepared cervically with CFS Master File 15, 20 to the level of curvature about 5mm short of the apex, the working length was then estabilished and the canal was prepared by hand instrumentation with 15 - 30 Flex-O-Files. The final flare was then made with the CFS to size Master File 25 - 30. Group III was similar to Group II except for using the M4 handpiece for automation. Group IV was prepared to the full working length 0.5mm short of the foramen with CFS. Group V was similar to Group IV except for using the M4 for automation. All 125 blocks were evaluated by a panel of 4 endodontists and rated for overall and specific quality. Time scores were also analyzed for all groups. The results were analysed for significance and the conclusions were that automated instruments (CFS and M4) can be used to start cervical preparation of narrow curved canals, size ISO 15, less which should stop 3 - 5mm short of the apex or the apical curvature level should be used. The apical curvature area and the rest of canal is then prepared with hand files to size ISO 15 - 30 to working length, followed by final flaring and finishing the preparation with automation to size 30.

This method was found to be superior to hand instrumentation or automated instrumentation alone, in terms of time and quality of performance.

The CFS and the Master (H) files demonstraded superior overall performance, cutting ability, efficiency (not single instrument fracture, speed of performance, better cleaning because os its built in water flow, and overall quality than the M4 Safety handpiece and the Safety Hedstrom files, which were also considerable slower. In cutting efficiency, the Safety files performed poorly in narrow curved canals and fractured easily.

Both automated sysetms, the CFS and M4 handpiece should not be used to the total working length of curved narrow canals, size 15 or less. However, if these canals are enlarged by hand instrumentation to size 25 - 30 then it is possible to use automated file sizes 25 - 30 safely.

Key words: Instrumentation, automated instrumentation

INTRODUCTION

During the past, the endodontic specialty has undergone a major philosophical and technological change in viewing automated root canal preparation.

To simplify the root preparation, as well as reduce the stress and operative time, many automated endodontic handpieces have been developed. The era of the "Gates-Glidden" and other orifice enlarging drills is firmly replaced with more

aggressive and efficient instrumentation that can potentially prepare the whole canal mechanically. The "fear and anxiety" traditionally associated with mechanical instrumentation has been tempered with improted automated handpiece/file design, materials, and manufacturing.

The majority of mechanized endodontic systems are based on a straight rotary action, whic is contradictory to hand instrumentation principles. In addition, selective removal of safe, thick dentinal walls cannot be achieved when an instrument is circumferentially cutting all walls at once. The inability to selectively file the desired dentin can lead to stripping. Mechanical rotary has been traditionally associated with ledging, zipping and instrument fracture. For these reasons, we selected two automated systems that are based on simulation of the basic, traditional human hand reaming and filing motions: the CFS[14] and the m4[15] Safety Handpiece.

The CFS has been evaluated by many studies. TRONSTAD and NIEMCZYK[13] used plastic blocks with simulated straight and curved canals to compare many automated systems and found the CFS fast and effective in all canal preparations, especially in narrow and curved canals and with no errors.

GOLDMAN et al. [7] found that CFS maintained the canal curvature better than hand instrumentation on extracted molar roots. It also kept the canal clean and free from blockage because of copious irrigation and the cleaning action of the H-File (withdrawal motion). Goldman found minimal 2/18 ledges 1/18 zip at the apical third; significantly less than with hand instrumentation (HI).

HAIKAL et al. [8] investigaded with the SEM, the CFS's ability to shape and clean canal walls from the smear layer compared to the H.I. and other sonic methods. The CFS compared favorably with H.I. and was superior to sonic instrumentation. However, it caused destruction of apical constriction and changied canal curvature (straightening the canal). (Table I).

CAMPOS et al.[3] found the CFS to cause zip formations and transportation on many levels. In addition, CFS caused more dentin removal from the furcal wall than H. I.

HÜLSMAN et al. [9], in comparing CFS with other automated systems, concluded that CFS is effective when used with small files (not larger than 15-20). If CFS is

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used with larger files at the apical curvature zone, it will cause deviation of the canal curvature leading to procedural errors. Other related studies are listed in Table I.

It is apparent from the above review that the CFS has received contradictory evaluations in terms of its performance at the narrow apical curvature level, especially when it is used in canls size ISO 15 or less. As to the performance of the CFS in the mid - and cervical level of the canal, most studies indicate favorable results except for Campos in 1990. Perhaps this is due to the technique of excessive flaring that was used with size 40, 45, 50 H files or because of circumferential filing (against furcal walls). This can be easily avoided if the CFS is forced mesially into the bulky canal walls.

Table I clearly indicates the lack standardization in using the CFS. This was quite evident in the sequence of filling, type of files used, size of files used, size of last file used, degree of canal curvature and type of teeth or models used. These differences in methodology may explain the differences in results. Another reason for variability in the results is the lack of universal definition of the criteria used in evaluations. Several terms we encountered include: apical discrepancy, zipped apex, zipped foramen (GOLDMAN)[7], transpositioning of the apex SEDELL [12], cervical height of contour transposition, apical transposition(CAMPOS)[3] and straightening of the apical part (HÜLSMAN)[9]. Are these terms used universally and in same manner by all studies? Perhaps not, especialy when different methodologies were used to evaluate these criteria; from radiographic comparisons of pre - and post - instrumentation to SEM evaluation.

The present authors did not locate any studies on the m4 Safety Handpiece. Apparently, it is manufactured for Kerr by an Austrian company. The authors found two references in the literature where a similar handpiece with endodontic contra angle, made by the same manufacture (Dental Work; Buermoos, Salzburg, Austria) was evaluated (O'CONNELL; BRAYTON, 1975[11] and HÜLSMAN, 1993[9]). In both studies, however, K - files were used. Here again, hand instrumentation was found superior to automated instrumentation in both studies.

Regardless of the methodology, the available literature on CFS indicates a trend against using the instrument in the narrow apical curvature zone, otherwise the CFS has many advantages over many other mechanical and automated systems. Furthermore, the literature is void of any study that investigates alternative methods of preparing the canal using the same automated system. Almost all studies on mechanical or automated instrumentation focused on comparing one device against another or against hand instrumentation. The question being investigated in this study deals with comparing two different root canal preparation methods using the same automated handpieces and files to pinpoint the advantages and disadvantages of each and to determine the factors leading to a specific result.

Table I: CFS-Canal Preparation Studies

Author	Sample	Control	Method of Study	Degree os Curvature	Method of CFS Usage	Final File Size	Results
TRONSTAD & NIEMCZYK [13]	40 Plastic Blocks		Speed of Performance	Straight and Curved		35	Favorable in narrow and curved canals. Twice as fast as other methods.
GOLDMAN et al.[7]	18 Curved Molar Roots	18 HI	Radiograph Tracing	19-53	Pathfind K Shape H Set 8K, 8H--thru size 20H	20	Maintained canal curvature loss of working length. Better than minor apical discrepancy 1/18HI. No apical blockage, ledge or zip.
HAIKEL & ALLEMANN	35 Premolar, Molar Curved	35 HI	SEM	20° - 60°	K Pathfind 15, then H to size 25; in - out motion	25	19/35 maintained curve; 14/35 maintained CDJ; 0,35 ledge. CFS as good as HI in cleaning ability, however it is not safe apecally.
SEDELL, **1989 não tem referência**	30 Premolars 30 Molars		Radiographs	20° - 30°	15-20 S. pulling and wiping motion		Apical discrepancies; did not maintain original canal or provide better shaping.
CAMPOS & DEL RIO [3]	12 Roots Section cervical; height of contour; apical level	12 Roots HI		20° - 30°	8K, 8H, 10K, 10H, 15K, 15H, 20K, 20H, 25H, 30H to WL, then stepback flare at 40 and 50 H. K up and down pumping; H upward sweeping	30	Transportation to the distal; dentin removed from furcal wall; zipping al all sections of the roots.
FUCHS et al. [6]	270 Ext. Teeth				No. 8K CFS, Penetrating Ability compared with 10K.		Statistical model; excellent automated ability using the #08 CFS versus 10 K.
HÜLSMANN [9]	15 Curved Canals	15 HI		31 - 35 Curvature	Circumferential filing at 15, 25, 35 ISO	10	Straightening of apical 1/3. 2 mm loss of working legth. 9/15 at 25; 7/15 at 35. CFS is safe when used in narrow curved canal with sizes smaller than 25 ISO. Hi superior.

PURPOSE

The purpose of this study was to investigate the time and quality of preparing simulated narrow curved canals prepared by CFS and M4 Safety Handpiece and using the three following methods:

. Total canal preparation hand instrumentation
. Total canal preparation with automated instrumentation CFS an M4
. Cervical canal preparation with automation CFS or M4 to size 20, followed by hand apical canal preparation to size 30, then completion with automation to size 30.

MATERIALS AND METHODS

The **Canal Finder System (CFS) Airmatic 900** used in this study was developed by GUY LEVY[10]. The hand piece design is based on a longitudinal movement that varies according to the resistance encountered within the canal. The mounted file will be either free to move forward to a maximum of 1.0mm if the file flutes meet no canal resistance or 0.3mm if there is minimal resistance encountered. The file will stop completely if high resistance is met to reduce the risk of perforation. Additionally, when the file meets minimal resistance, the file tip will move in a helicoid motions thus directing the file into the canal space. In effect, the file tip will move longitudinally until friction causes a helicoid motion thus maintaining its canal finding ability. This ensures that if the curve is not being negotiated, the file will not create its own canal.

The **CFS** uses specially designed Hedstrom type files (master files) which have increased cutting efficiency because of their 40 degre helical angle and the flute depth is more pronounced for better debridement. The file tip has been rounded and made inactive to reduce and/or prevent procedural errors. The first flute as a negative cutting angle for increased safety. (LEVY; ABOU-RASS)[10].

The **M4 Safety handpiece** (Kerr Corp, Orange, CA) has a "watch-winding" motion (30 degree oscillation) that lets the instrument glide along the walls of the canal. The handpiece is designed with an adaptable push button chuck for easy fit of almost any hand endodontic instrument. The M4's 4:1 gear ratio can function at full speed without undue torquing of the endodontic instrument.

The **Safety Hedstrom File** (Kerr Corp., Orange, CA) has an exclusive anti-perforation feature which flattens one side of the Hedstrom file for orientation towards the "Danger Zone" of the canal curve. The Safety Hedstroms' desing offers aggressive cutting while maintaining anti-perforating, anti-ledging action on the non-cutting
surface.

SIMULATED CANALS

One hundred twenty-five transparent plastic blocks with a standardized size 15 canal and severe curvature (50 - 70 degress) were used. The blocks were randomly divided into five froups of 25 each to correspond to the five different preparation techniques studied. Each canal was stained with dried methylene blue for better visualization, apical patency verified with a #10 K-File, numbered, and masked with tape to prevent visibility of the instrumentation process. A pre-instrumentation radiograph with a #15 K-File to within 0.5mm of the apex was taken for each model and the distances and angulations were standardized (Figures 1-5). The five different instrumentation methods were all performed using an anti-curvature technique[1] and are outlined as follows.

GROUP I: HAND INSTRUMENTATION (HI)

The canals were sequentially enlarged 4 file sizes froma #15 to a #30. Stainless steel Flexofiles were used in the hand instrumentation process with copious amounts of anesthetic solution to irrigate and flush the canal during the preparation using an anesthetic syringe and a 30 gauge short needle. Recapitulation using a #10 K-File was peformed between size increases and each file was used for 1 canal only. A final post-instrumentation radiograph with a #30 K-File in the canal was taken (Figure 6). This group served as a control. and will and will be abreviated as H.

GROUP II: THE AUTOMATED/HAND/ AUTOMATED WITH CFS

Preparation of the cervical and mid-root areas using the CFS Master File #15 and #20 was performed approximately 5.0mm short of the apex. After this, the working length was established with #15 Flex-O-File, then the apical third was sequentially prepared by hand instrumentation with the Flex-O Files to a size 30 within 0.5mm from the apex. The preparation was finalized by reinstrumenting the entire canal using the CFS (Master File) sizes 25 and 30 to working length with copious tap water irrigation and anesthesia flushing. Recapitulation was done using a #10 K-File between file sizes. This method has been used by the USC Advanced Endodontic Program since 1989. This method will be abbreviated Au-H-Au CFS.

GROUP III: THE AUTOMATED/HAND/ AUTOMATED WITH M4

Preparation of the cervical and mid-root areas using the M4/Safety Hedstroms size 15 and 20 was performed approximately 5.0mm short of the apex. The apical third was then sequencially prepared by hand toa size 30 within 0.5mm from the apex. The preparation was completed by reinstrumenting the entire canal with the M4/Safety Hadstroms sizes 25 and 30 to working length with copious anesthesia irrigation and flushing. Recapitulation was achieved with a #10 K-File between file size changes. This method will be abbreviated Au-H-Au M4.

GROUP IV: AUTOMATED INSTRUMENTATION WITH CFS

The preparation consisted of using the CFS Files (staninless steel) sequentially enlarging the size Master Files 15 canal to a size 30 within 0.5mm from the apex. Copious irrigation of tap water was employed through the CFS and anesthetic (30 ga.).

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needle) flushing was done after each file. Recapitulation with a #10 K-File was performed between file size increases and each file was used for 1 canal only. This method has been advocated originally by the manufacturer and is similar to the method used in many studies (Table 1). This group will be abbreviated Au-CFS.

GROUP V: AUTOMATED INSTRUMENTATION WITH THE M4/SAFETY HEDSTROM SYSTEM

The preparation consisted of using the M4/Safety Hedstrom Files (stainless steel) sequentially enlarging the size 15 canal to a size 30 within 0.5mm from the apex. Copious irrigation and flushing with anesthesia was used (30 ga. needle) and recapitulation using a hand #10 K-File was done between file increases. Each file was used for 1 canal only. This group will be abbreviated Au-M4.

One operator performed all the preparations in the groups and post-instrumentation radiographs with a #30 K-File in the canal were taken (Figures 7-10). The ***lenght of time*** required for each root canal preparation and ***procedural errors*** were recorded for each block.

DATA COLLECTION

After numbering all the prepared plastic blocks, a blind evaluation of blocks and radiographs was performed by four faculty endodontists. The data was recorded on an evaluation form as follows: (ABOU RASS, JASTRAB[2]; O"CONNELL & BRAYTON[11]).

Apical preparation Design: Measured by the presence of a defined apical stop and the apical third zone free from any procedural errors.

Smoothness: valuated by the lack of canal wall roughness.

Preparation an Flow: valuated by the continuous blending of all the canal walls to the apical third level, and the lack of an abrupt change in direction of the different sections of the canal.

Flare: valuated by the conical shape of the canal from the cervical zone to the apical third level.

The incidence of procedural errors such as ledge formation, blockage, perforation, instrument fracture, zipping of the apical curvature, loss of working length, and foramen transportation were also documented by the evaluators.

OVERALL QUALITY

The specific criteria and overall quality were rated by each endodontist as follows:

- Superior (no errors)
- Acceptable (1 error)
- Average (2 errors)
- Poor (3 or more errors)

RESULTS

Time required to complete the canal instrumentation

The student T-test was used for analysis of all results in this study. The time needed to prepare the canal in each group was recorded and ranged from 7.04 minutes to 18.65 minutes (Table 1). Hand instrumentation was the most time consuming.

The automated CFS was the fastest method at 7.04 minutes. The M4/Hand combination technique required 10.24 minutes while the Au-H-Au (CFS) method required 10.56 minutes (not statistically significant). The automated M4 required 12.66 min. with only 19 of the 25 blocks successfully prepared. The time differences between hand instrumentation and all od the automated techniques was statistically significant as well as the CFS with all other techniques.

Table 2. Average time required to complete the canal instrumentation.

Method	# of Canals	Average Time
HI	*25*	*18,65 Min.*
Au-H-Au (CFS)	*25*	*10.56 Min.*
Au-H-Au (M4)	*25*	*7.04 Min.*
Au-CFS	*25*	*10.24 Min.*
Au-M4	*19*	*12.66 Min.*

Number of Errors

Preparation debris through the apex or accumulated debris at the apical third was observed in all groups. Most of the errors regardless of the technique, were loss of working length and apical foramen transportation.

Hand Instrumentation tended to produce the fewest procedural errors which was mainly limited to loss of working length and apical transportation.

The Au-H-Au with CFS produced errors predominantly in the apical foramen transportation category.

The CFS created errors in loss of working length, ledging, and apical foramen transportation.

The Au-H-Au wit M4 produced significantly fewer procedural errors (apical transportation) than the **M4 Only** method which had six incidences of file breakage. Four of the six separations were size 20 files, one was a size 15, and the other was size 25. Once a file broke, this led to canal blockage and loss af working length. In addition to instrument fracture, the same procedural errors seen in the other instrumentation systems (i. e., loss of working length and apical transportation) were also observed with the **M4 Only.**

There was no statistical significance between **HI, Au/H/Au** whether or not CFS ou M4 was used. However, there was a significant increase in procedural errors between automated instrumentation only versus any method involving hand instrumentation (Table2).

Table 3. Number of errors by group.

Eval. No.	Hand	Au-H-Au (CFS)	Au-H-Au (M4)	CFS	M4
1	*27*	*32*	*35*	*43*	*47*
2	*23*	*30*	*26*	*36*	*39*
3	*16*	*26*	*23*	*56*	*34*
4	*33*	*34*	*22*	*47*	*43*
Average	*24.75*	*25.5*	*26.5*	*45.5*	*40.75*

Specific Quality Scores

The Specific Quality Scores are based on the A-score performance which is the highest evaluation rendered in each of the 4 examined categories. This study shows that any technique involving hand instrumentation, whether alone or in conjunction with automation, was always better than automated instrumentation only.

Table 3 shows the *percentage of superior A-scores* for all five groups on the specific criteria: **Apical Preparation Design, Smoothness** of the walls, **Preparation** and **Flow,** and **Flare.**

Table 4. specific Quality Superior A-Scores

Criteria.	Hand	Au-H-Au (CFS)	Au-H-Au (M4)	CFS	M4
Ap. Prep.	*34*	*23*	*21*	*19*	*15*
Smooth.	*54*	*54*	*33*	*26*	*24*
Prep/Flow	*47*	*62*	*29*	*24*	*18*
Flare 48	*48*	*59*	*32*	*24*	*16*
Overall Quality Scores					

Table 4 shows the results of the statistical analusis of the data on the 125 canals. The use of the CFS as an aid to hand instrumentation produced the best results on overall quality with the second fewest procedural errors. Hand instrumentation was second overall quality producing the least amount of procedural errors. The H/M4 method ranked third in both overall quality and amount of procedural errors. The CFS an M4 systems alone produced the greatest number of procedural errors and the fewest amount of superior scores.

Table 5. Overall Quality scores for each group.

Grade	Hand	Au-H-Au (CFS)	Au-H-Au (M4)	CFS	M4
A	*45.75*	*49.50*	*28.75*	*23.25*	*18.25*
B	*38.25*	*35.50*	*44.25*	*39.25*	*23.75*
C	*13.50*	*12.75*	*24.00*	*25.75*	*38.25*
D	*2.50*	*2.25*	*3.00*	*11.75*	*19.75*

DISCUSSION

The challenges encountered during the preparation of narrow, curved canals and the need to prevent procedural errors have led to the development of many endodontic preparation methods.

The stepback, stepdown, anticurvature, the balanced force,methods although they vary is sequence and details, their main goal is the preservation of original anatomy and improvement of canal preparation quality.

These methods have contributed greatly to improvement of hand instrumentation methods. Although it is time consuming, and occasionally stressful, it remains the standard by which all new preparation innovations are evaluated. In analyzing hand instrumentation, one finds some basic actions which are:

.**The Negotiation Action** (size 08 or 10 file): to evaluate the patency, size, curvature and direction of the canal.

.**The Shaping Action**: to maintain patency, enlarge and shape the canal

by applying lateral pressure upon file withdrawal.

.**The Cleaning Action**: to remove devris coronally during the file withdrawal motion.

Much of the superior quality and safety of hand instrumentation methods is dependent on the clinical tactile sense and ability to comply with the requirements of the three actions of hand instrumentation: negotiation, shaping and cleaning.

For mechanical instrumentation to be safe and effective it must therefore be designed to reproduce the above actions. Furthermore, due to the lack of tactile sensation, the automated file design becomes as critical as the design of the automated handpiece. The file design should be in synchronization and complete harmony with the handpiece motions otherwise

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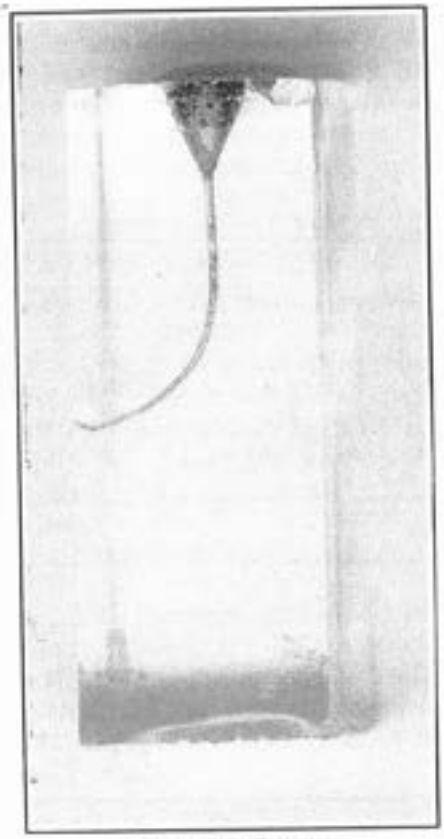
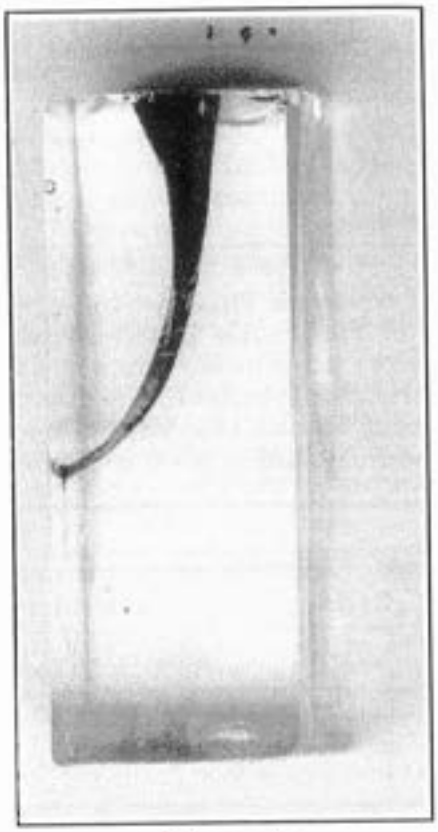
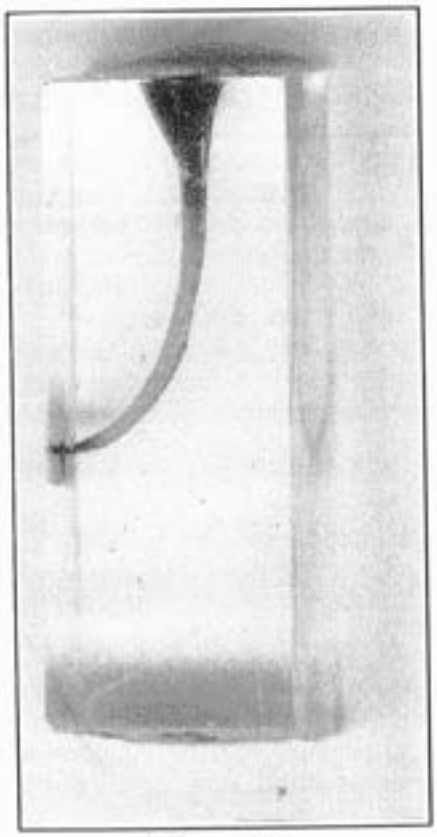


Control Group

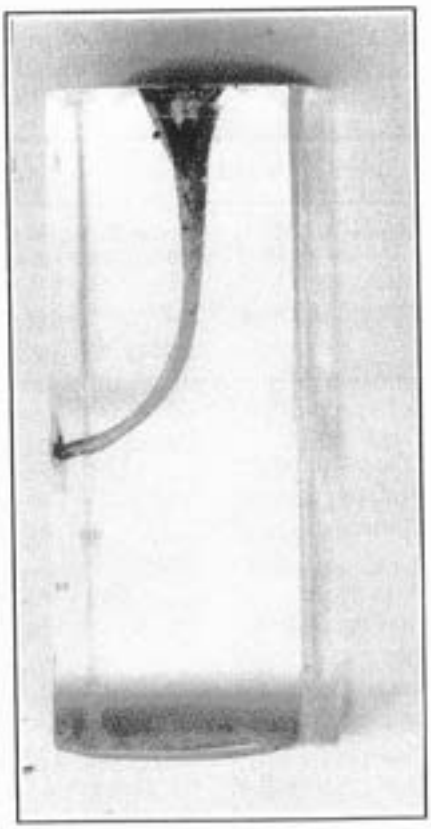
Group I



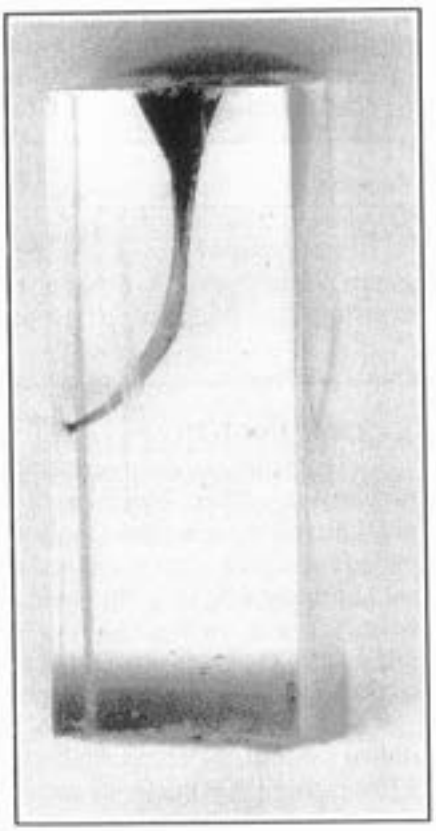
Group II



Group III



Group IV



Group V

Legend- *the simulated root canals prepared with the manual, CFS, M4 and combined techniques*

Group1 - Hand Instrumentation
Group2 - CFS + Manual
Group3 - M4 + Manual
Group4 - CFS
Group5 - M4

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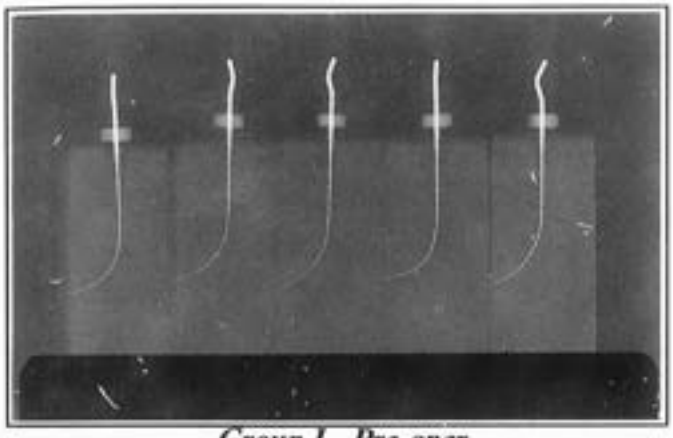
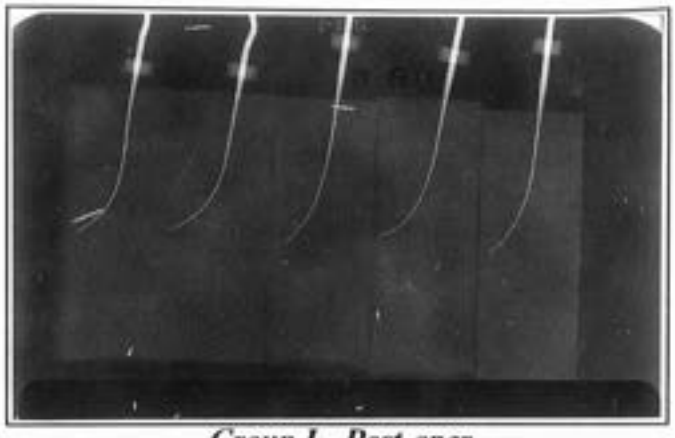
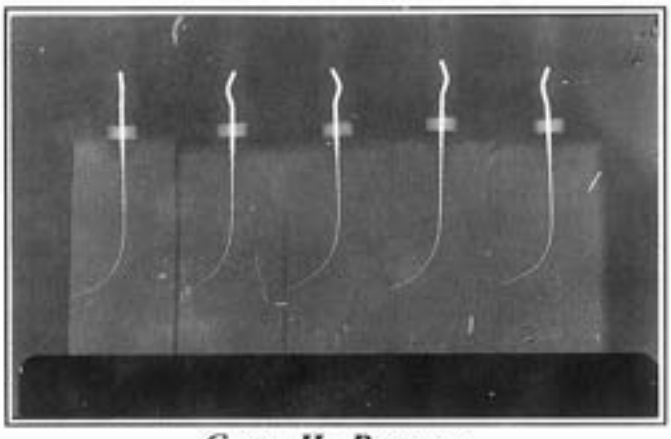


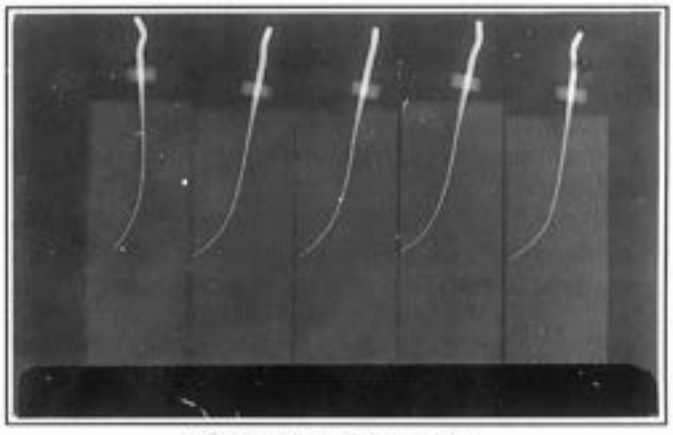
Group I - Pre-oper



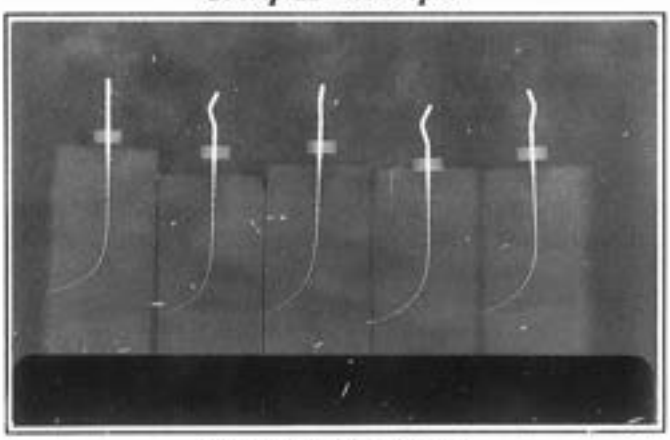
Group I - Post-oper



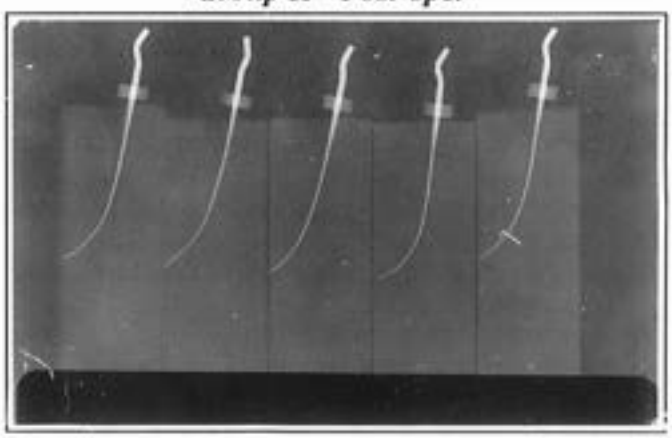
Group II - Pre-oper



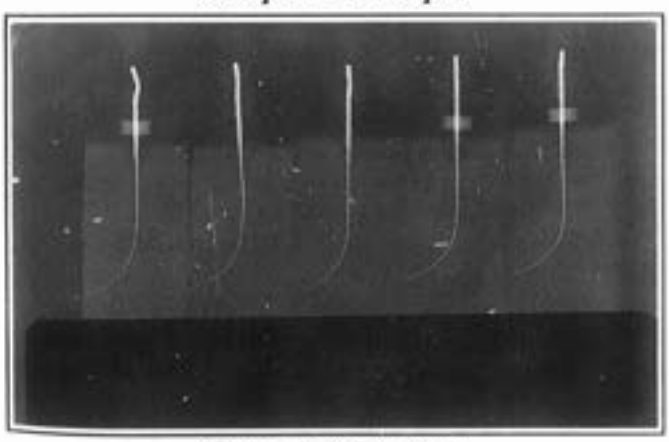
Group II - Post-oper



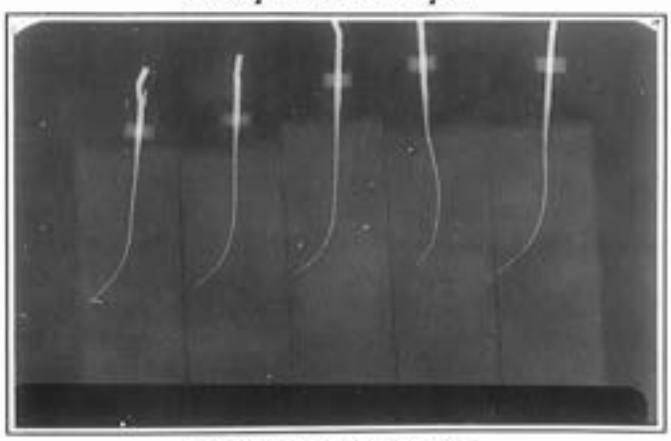
Group III - Pre-oper



Group III - Post-oper



Group IV- Pre-oper



Group IV- Post-oper

Legend- *the pre and post- operative x-rays*
Group1- Hand Instrum.
Group2-CFS+ Manual
Group3- M4 + Manual
Group4- CFS
Group5- M4

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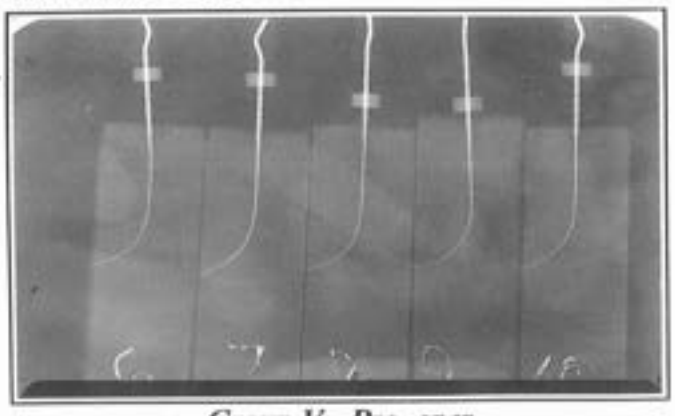
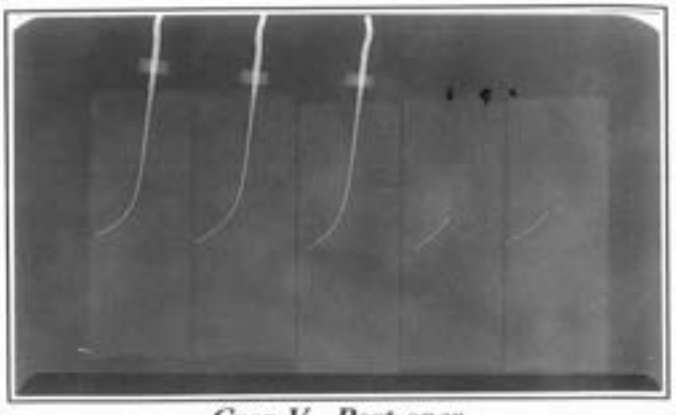


Group V - Pre -oper



Grop V - Post-oper

procedural errors will occur.

The majority of research on mechanical or automated instrumentation shows unfavorable results when the mechanical action involves the apical curvature, the danger zone or the foramen; or when large size files are used. Hand instrumentation of these areas seems to be safer and more effective. Therefore, it is logical to combine HI with automated instrumentation, thus combining the safety of HI in the curvature of the apical zone with the speed and efficiency of automated instrumentation.

The results of this study confirmed once again that hand instrumentation, although requiring more time, produced the fewest errors than automated instrumentation. When HI was combined with automated instrumentation, the overall results were superior to HI alone (10.5m vs. 18.6m; 49.5 vs. 45.75 overall quality scores; and 198 vs. 163 specific quality scores). This is expected because of the documented poor performance of automation in the apical curvature zone.

Furthermore, the results indicate that once the apical third curvature is enlarged to size 25 - 30 by hand instrumentation, it is possible to use the CF with similar size files safely.

Automated instrumentation with CFS alone produced the best time scores of all groups (7.04 minutes). This group, however, received poor overall and specific quality scores and had many procedural errors such as loss of working length, ledge formation, and apical transportation. This is agreement with the results of CAMPOS[3], HÜLSMANN[9], HAIKEL[8], and SEDELL[12].

The M4 with safety Hedstrom files performed the worst in overall quality and superior specific scores. Furthermore, it was the only group where "safety file" fractures occured. In 6 blocks, all in the apical third and all were unretrievable. Four of the six were size 20, one was a size 15 and the last was a size 25. The high incidence of "Safety Hedstrom File" breakage is perhaps due to the contradiction in mechanics of the file design and handpiece movement as the handpieces rotate 30° from either side of the center. This motion is still considered rotational and Hedstrom files should not be rotated, especially in curved narrow canals. However, when the canal was enlarged by HI to size 30, the file movement became possible and safe. In this group the preparations also lacked smoothness, flow, and flare. When the M4 Safety handpiece was combined with hand instrumentation. No instrumente separation occurred and the preparation results were greatly improved. The M4/hand combination technique ranked third in overall quality procedural errors.

This study showed that hand instrumentation does not have to proceed automated instrumentation, and that preparation of the curved narrow canal can be significantly improved in terms of time and quality of performance if the narrow curved canal is prepared cervically with the CFS automation and apically by hand instrumentation.

Automated instrumentation alone is not recommended in narrow canals of size 15 or less total. Automated instrumentation of the canal can be performed if the apical canal curvature is enlarges first by hand instrumentation to size 25 or 30. Automated instruments should not be used in circumferential or rotary fashion. The anticurvature filing is recommended as it will guide the automated file to shape the safe, bulky areas of the roots selectively and directionally as needed. Clinically, this motion is usually mesial-bucco-lingual in most canals.

Circumferential filing or rotary filing should be avoided, especially in curved roots due to the dentin thickness ato the curvature sites. The clinician should guide the automated handpiece forcefully where needed and should not the canal curvature direct or dictate the path of any endodontic instruments, either mechanically or manually.

CONCLUSIONS

Based on the results of this study of standardized, simulated, narrow, curved canals in plastic blocks, the following conclusions are made:

.It is efficient and safe to begin with cervical preparation of the narrow curved canal with the CFS to the level of curvature to size Master File 15,20.

.The curved apical curvature is best prepared by hand instrumentation to the minimum size of Flex-O-File 30 prior to the use of any automation.

.The use of CFS or M4 to the working length to fully prepare the canal is not recommended.

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ACID ETCHING IN BLEACHED ENAMEL

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The purpose of this "*in vitro*" study was to evaluate the effect of a 10% carbamide peroxide bleaching agent (Opalescence) on the enamel surface of human teeth regarding the morphology of bleached enamel to acid etching. Five freshly extracted third molars were sectioned in quarters mesio-distally and then lingo-buccally. All surfaces except the enamel were sealed with nail varnish. From each tooth, one quarter (group 1) was treated for 12 hours with a bleaching agent and the other 12 hours with artificial saliva during 20 days (240 hours of bleaching treatment). Another quarter (group 2) was submitted to the same protocol but after bleaching treatment it remained in distilled water for 12 hours. The other two quarters were used as controls and one stayed all the time in artificial saliva (group 3) and the other (group 4) all the time in distilled water. All samples were then rinsed and acid etched for 15 seconds with 37% phosphoric acid. After the conditioning all the treated enamel surfaces were sputter-coated and examined under a scanning electron microscope for differences in surface morphology. When bleached enamel was acid etched the intercrystalline spaces were enlarged. Comparing saliva-treated enamel with water-treated enamel it is possible to see that these spaces are smaller when saliva is used, suggesting a mineralizing action in saliva. The pattern of enamel conditioning was the same as non bleachead enamel reported in the literature.

Key Words: Acid etching, vital tooth bleaching

INTRODUCTION

When prescribing home bleaching, dentists must warn their patients that eventually they will need to change their resin restorations, since the product, acting on these resins is able to bleach them[4,6,14], but not as intensely as the tooth, causing differences. Some authors trying to find out if bleaching products are able to modify resins, found that "*in vitro*" resins become rougher [4, 6, 14, 21] and stain in the oral environment.

Clinically, a resin composite, after short time in the mouth, will become rough due to tooth brushing[20] and other factors. If teeth with resin restorations, are submitted to nightguard vital bleaching, besides the roughness that is naturally found in the mouth an extra factor will be added. Dentists, when prescribing nightguard vital bleaching technique, know that when it is necessary to change the resin restorations, they must wait until the end of the treatment plus two or three additional weeks to achieve the best bonding between the restorative material and dental tissue. The reason why this happens is still not clear, and new investigations are necessary to find an explanation for this phenomenon.

REVIEW OF THE LITERATURE

TITLEY et al.[24], in 1988, analyzed the aspect of human premolar enamel submitted to bleaching treatment with 35% hydrogen peroxide and acid etching with 37% phosphoric acid. They found a higher porosity level the more time the enamel was left in contact with the bleaching agent, which was even more porous when the tooth was etched before the bleaching treatment.

In 1989, HAYWOOD and HEYMANN[11] introduced the use of a new bleaching technique called nightguard vital bleaching, using 10% carbamide peroxide (Proxigel). This product has an acid pH (5.3), and the authors wondered if this pH would be able to etch the enamel surface. In 1990, they published the results of a study[12] in which they analyzed the texture of the enamel and found that Proxigel did not produce etching patterns on tooth enamel surfaces. In 1991, the same authors[13] tested three different 10% carbamide peroxide gels (Proxigel, Gly-Oxide and White & Bright) and 1.5% hydrogen peroxide (Peroxyl), with distinct pHs and different oxygen liberation speeds. They found that the enamel had a normal aspect, and concluded that even low pH carbamide peroxide is not able to etch enamel.

TONG et al.[25] studied the loss of enamel, working with 30% hydrogen peroxide, they found that when treating enamel only with bleaching agents, no loss on enamel could be found; and when etching enamel with 37% phosphoric acid for 30 seconds there would be a loss in the enamel thickness, and this loss would not be increased when combining these techniques.

RUSE et al.[19], working with bovine enamel, 35% hydrogen peroxide and 37% phosphoric acid, examining the enamel composition when using only the bleaching agent found that nitrogen levels was increased, and when etching enamel, calcium and phosphorus levels decreased and carbon and nitrogen increased.

In 1988, TITLEY and TORNECK[23,24] concluded that when submitting tooth enamel to 35% hydrogen peroxide gel for one hour there was a loss in bond strength.

Two years later the same authors[26] found that the break up of the enamel-resin junction would occur in the interface between the material and tooth tissue.

CVITKO et al.[8] and STOWES et al.[22] studying different bleaching agents found that teeth that had been bleached had lower adhesion strength. In 1992, ADIBFAR[2] reported that the peroxide or a product related to it could stay on the enamel surface after bleaching treatment causing lower bond strength between resin and tooth enamel. BAUGHAN et al.[3] and MACHIDA et al.[16], found that bond strength did not change significantly, when using 10% carbamide peroxide. CULLEN et al.[7] worked with resins with different particles and found that resins without particles had lower bond strength.

In all these studies we can see that materials (bleaching, etching agents) and methods of investigation were diverse which may be the reason for so many different results.

When working with acid etching, GWINNET[10] compared the etching morphologic aspect, and found that there was no difference when using different times. CARTENSEN[5] recommended the use of 15 seconds of acid etching because the pattern produced in this time using 37% phosphoric acid was acceptable. In SEM we can very clearly see the effect of etching agents. The most common is pattern I, where the center of the prism is eroded. In pattern II, it is the opposite. And in pattern III, that is less common, we find pattern I and II mixed.

MATERIAL AND METHODS

The samples used in this study were unerupted third molars, extracted for orthodontic or prophylactic reasons. After extraction the teeth were fixed and selected with the use of a magnifying glass. Five teeth were selected and cut with a diamond disc from buccal to lingual and from medial to distal, with four sections produced, from each tooth, the root was removed. Each section of the same tooth was submitted to one of the following treatments : *Group 1 - Bleaching treatment + artificial saliva + acid etching.* In this group one section of the tooth remained for 12 hours in contact with the bleaching gel, and then was brushed with distilledwater and finally remained in contact with artificial saliva for the next 12 hours. The treatment lasted 20 days, with a total of 240 hours in contact with the bleaching gel. *Group 2 - Bleaching treatment + distilled water + acid etching.* The second section of the tooth was treated in the same way as group 1, the only difference was that instead of artificial saliva, distilled water was used. *Group 3 - Artificial saliva.* The third section remained contact with artificial saliva for 24 hours, and after this period was brushed with distilled water, and would be returned to saliva. This was done for 20 days. *Group 4 - Water.* The fourth section was treated in the same way as the third, but instead of using artificial saliva distilled water, was used.

The formula of artificial saliva used is the one presented in Bo Krasses book. The bleaching product used was 10% carbamide peroxide gel, Opalescence (Ultradent Products, Inc.).

Concluding the first part of the experiment, the teeth were brushed with distilled water and remained in sodium hypoclorite for 20 minutes, after wich they were submitted to ultrasonic procedure for 5 minutes. The sections were then stored in individual recipients with distilled water for 4 hours. All sections were equally etched with 37% phosphoric acid for 15 minutes and then washed and dried. The specimens were coated and analyzed by SEM and the photographs were taken with 1,000, 5,000 and 10,000 magnification.

RESULTS

Comparing the sections of the same tooth that were submitted to bleaching treatment, where one of them was part-time in water and part-time in bleaching gel and the other was part-time in artificial saliva and part-time also in bleaching gel, we can observe that the intercrystallin spaces became less evident on the one that was part-time in saliva.

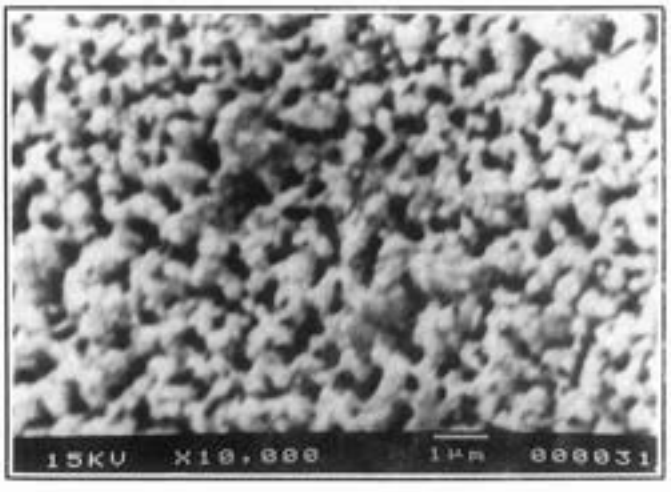

Figure 1 - "Prismless" enamel. Treated with gel and saliva and etched. Smaller intercrystallin spaces than in figure 2.

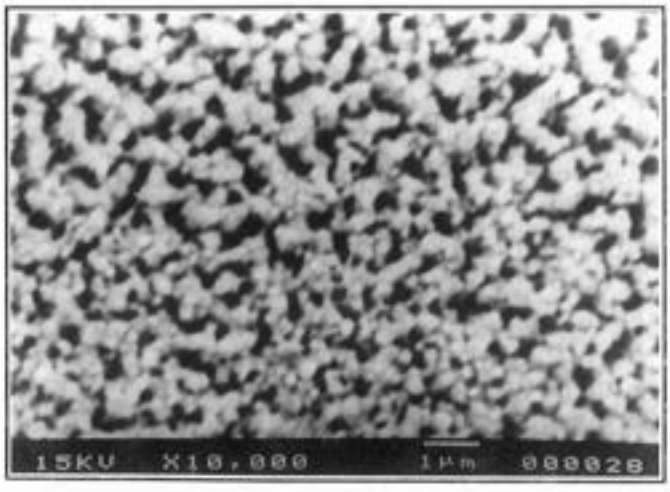

Figure 2 - "Prismless" enamel. Treated with gel and water, and etched. Larger intercrystallin spaces than in figure 1.

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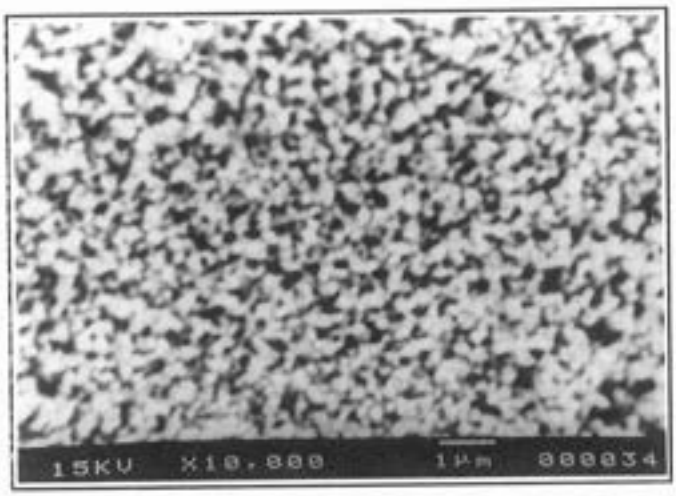

Figure 3 - "Prismless" enamel. Control thatremained in saliva and was etched. Smaller intercrystallin spaces than in figure 4.

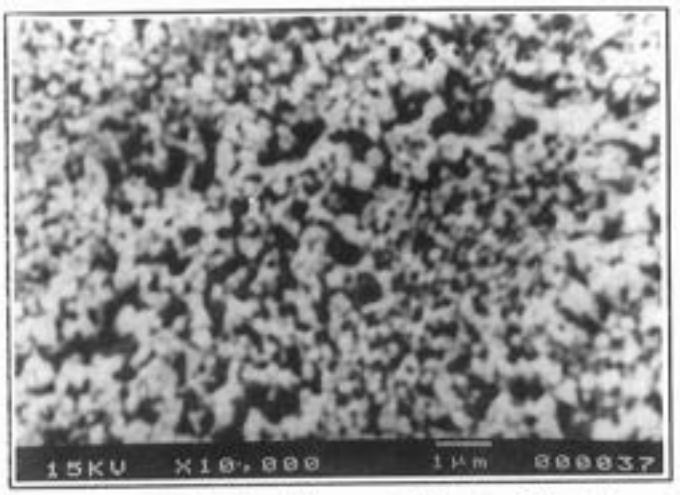

Figure 4 - "Prismless" enamel. Control that stayed in water and was etched. Larger intercrystallin spaces than in figure 3.

Similarly, comparing the sections (of the same tooth) that remained all the time in artificial saliva and the one that remained all the time in distilled water before the etching procedure, it was possible to see that the intercrystallin spaces were less evident in the section that remained in artificial saliva [Fig.3 (saliva)(photo 34) and figure 4 (water)(photo 37)]. Comparing the section that remained part-time in contact with the bleaching gel and part time in artificial saliva (figure 1) and the section that remained all the time only in artificial saliva (figure 3), the intercrystallin spaces are larger in the first case when the bleaching agent was used.

DISCUSSION

The scientific reason for recommending a time between the end of bleaching treatment and a resin restoration has not yet been found. In 1990, RUSE[19] found that after tooth bleaching with 35% hydrogen peroxide there would be only an increase of the nitrogen levels, and after an acid etching procedure there would be a low concentration of calcium and phosphorus levels and an increased concentration of carbon and nitrogen levels in the treated enamel. ADIBFAR et al.[2] worked with bovine enamel, 35% hydrogen peroxide and 37% phosphoric acid etching for one minute. The material was immersed in a solution to detect remaining hydrogen peroxide, and the results confirmed the presence of this material for a period of 7 days after the end of the bleaching treatment, which could interfere in the quality of adhesion.

The results of the present experiment with bleaching gel and artificial saliva on human teeth suggest that the bleaching process with carbamide peroxide acted in the intercrystallin spaces, since they were enlarged when compared with the control. With this information, it is suggested that the bleaching agent acted on the organic component of the enamel. Its action would be by opening, through the action of urea which is why it would increase nitrogen levels[19]. The oxidant agent would act on the staining structure changing or eliminating it. It also seems that saliva is able to reduce, in part, the intercrystallin spaces enlarged by the bleaching agent. Research that compares etching patterns in bleached and non bleached enamel and concludes that the patterns are the same[24] certainly are not observing the crystals and the intercrystallin spaces.

The loss of bonding strength after bleaching found clinically and well described in many studies[8, 22, 23, 24] can be related to a morphological factor, shown in this experiment and/or to the fact that some residue of the bleaching agent can stay in the enamel tissue[2].

CONCLUSIONS

With the methods and the products used in this "*in vitro*" study we can conclude that:

1 - Using 10% carbamide peroxide (Opalescence) on the enamel surface of unerupted permanent teeth, it is possible to produce *in vitro* larger intercrystalline spaces on the enamel surface.

2 - Comparing specimens treated with distilled water and specimens treated with artificial saliva it is possible to see that in the salive-treated ones the spaces between the crystals in the prismatic or "prismless" enamel are smaller, thus suggesting that saliva has a remineralizing action.

3 - The conditioning pattern, using the classification pattern, I, II, III, does is modified when using bleaching gel.

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COMPARATIVE STUDY OF CALCIFIED BRIDGE AFTER PULPOTOMY AND THE USE OF CALCIUM HYDROXIDE ASSOCIATED WITH DIFFERENT VEHICLES

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The calcified bridge after pulpotomy and the application of calcium hydroxide associated with saline, propylene glicol 400, and glycerin was studied. In nine premolars, diagnosed for extraction for orthodontic reasons, pulpotomy was performed and calcium hydroxide was applied. The above- mentioned were associated in the treatment of 3 pairs of teeth. The teeth were extracted and radiographed after 60 days. The dental bridges formed were analyzed from aprotect material and a dental pulp perspective, using a scanning electrom microscope. The calcified bridge surfaces showed agglutinates of calcospherites, existence of numerous circular and oval orifices and a smaller number of dentinal tubules.

Key Words: Pulpotomy, calcium hydroxide, Inflamed dental pulp

INTRODUCTION

Pulpotomy is a traditional procedure that is gaining support rapidly. Several studies have evaluated this therapeutic option in teeth with different clinical conditions: inflamed dental pulp, accidental pulp opening, traumatic, maintaining the vitality of immature teeth until full root development, normal pulp with anatomical inaccessible root canal[9-12]. Other research has analyzed the use of several materials for on the protection of the pulpal remnant, showing the biologically efficient proprieties of calcium hydroxide[7,8,14].

Calcium hydroxide has two essentials proprieties, resulting from its enzymatic action on bacteria or tissue enzymes, as alkaline phosphates, present in the calcified areas[2]. However, it is known that calcium hydroxide is a substance whose Physico-chemical proprieties are inadequate. Therefore, calcium hydroxide has been associated with other substances and vehicles that can improve its proprieties and consequently, benefit clinical use[4-13]. Many chemical substances have been used as vehicles with calcium hydroxide[3,4,11,13]. It is necessary to consider the probable interference that these associations can have on the morphologic characteristics of the calcified bridge. Many researchers using the optic microscope and some using the scanning electron microscope have evaluated the thickness and the morphology of the calcified bridge after pulpotomy with use of the calcium hydroxide paste[5,6,7,8,15,16].

The objective of this study is to evaluate, with the aid of scanning electron microscopy, the calcified bridge gain after pulpotomy in human teeth using calcium hydroxide associated with different vehicles: saline, propylene glycol 400 and glycerin.

MATERIAL AND METHODS

This study was performed on 9 clinically and radiographically intact premolars that were extracted for orthodontic reasons, in patients aged 11 to 15 years. After anesthesia and isolation, coronal opening was done with spherical diamond drills (# 1012-KGS), under water spray.

The coronal pulp was removed with sharp curettes (#11 & 12, Maillefer, Switzerland), and was washed with saline, dried with sterile cotton pellets and dressed with calcium hydroxide paste. For each group of 3 teeth, calcium hydroxide was associated with one of 3 vehicles: saline, propylene glycol 400, and glycerin. This paste was covered with cement with calcium hydroxide (Dycal, L.D. Caulk,USA), and cement with zinc oxide eugenol and amalgam.

After 60 days, the teeth were extracted and radiographed. They were then cut transversally at two levels, one coronal and the other apical to the calcified bridge. The segments were 2 to 3 mm thick. The coronal surface of each segment was washed in 10 ml 4-6% sodium hypochlorite to eliminate calcium hydroxide residue. It was then submerged 10 ml 4-6% sodium hypochlorite for 1 hour to eliminate organic material and to visualize the calcified bridge.

The samples were covered with gold to be observed in the JEOL USM-U3 scanning electron microscope. The surface of the pulp and the coronal aspect of 2 specimens of each vehicle were analyzed. Longitudinal sections of the remaining 3 specimes were cut buccal to lingual.

RESULTS AND DISCUSSION

The radiographs of all extracted teeth showed the presence of a complete calcified bridge of variable thickness. The bridge view was curved, with the surface concave to the coronal side and convex to the pulp side. This configuration is due to several reasons: the presence of a fine layer in the pulp tissue close to the dentinal walls as a result of the instruments

that were used and larger retraction of the central part after sectioning and cauterization because of the calcium hydroxide (Figure 1).

Analyzing the calcified bridge using the scanning electron microscope showed that the surfaces that were turned to the coronal direction had a calcified amorphous structure, and an absence orifices of (Figure 2a, 2b). These results are different from those found by GOLDBERG et al.[6], which showed crystals of different shapes, sizes, and distribution. These difference probably occur due to the removal of the calcium hydroxide particles from the calcified bridge surfaces with washing that was done in this study.

On the pulp view of the bridge, the surfaces were generally formed by agglutinates of calcospherites with an aspect similar to globular dentin, with a smaller number of dentinal tubules, and a great number of orifices, either oval or circular, with a diameter of 18 µm. This is in agreement with the description made by ULMANSKY et al.[16], which shows the presence of small holes. These holes, represent blood vessels that remain trapped during the calcification of the bridge[2,4,6,15] (Figure 3a, 3b, 3c).

In the study of the union area between the calcified bridge and the dentinal canal walls, the interface with perfect union and areas with absence of adhesion (Support) and with micro cavities dividing the calcified tissue (Figure 4a, 4b, 4c). GOLDBERG et al.(5) described the mechanism of union between the bridge and the circular dentine it happens from a fiber network that calcified with time. In this study, even though the period of observation was longer, these network were present. We can say that they came from: the presence of a blood clot, the presence of a fine layer of the pulp tissue fixed to the root canal wall or due to the irregula accommodation of the calcium hydroxide paste over the pulp remaining in the circular dentin.

It is important to note that these defects can allow the communication of the coronal area with the root canal. According to many authors the presence of these defects, considering that under certain clinical circunstances can allow the penetration of bacteria or its toxins, could affect the remaining vital pulp tissue and the pulpotomy as the final endodontic therapy[5,6,15]. However, in this study we observed the presence of orifices only in the pulp surface of the calcified bridge, but these were not found in the coronal surface. BERK and KRAKOW[1] and HOLLAND et al.[8] report that this porosity does not affect the pulpotomy or other traditional treatment. However, the presence of extensive cracks in the bridge junction with the canal wall, analyzed in this study, can allow the communication of the coronal area with the root canal, and compromised the remaining vital pulp. We must also consider that in any dentinal exposition the pulp tissue can be affected in the same way, with infiltration of bacterias and toxins. Furthermore, the coronal cavities have to be obliterated, and the sealing capacity depends on the applied filling system.

In this study saline was used, which is classified as a hydrosoluble vehicle, which allows a fast ionic dissolution of calcium hydroxide permitting better diffusion and consequently, better contact action of the calcium and hydroxyl ions with the tissue. Glycerin and propylene glycol 400 are classified as hydrosoluble and viscous. These substances are soluble in water in any proportion. The ionic dissolution of calcium hydroxide is slower because of its high molecular weight and the need to remove the water from the pulp tissues and the dentinal walls. However, significant variations in the thickness and in the morphology of the calcified bridge were not observed because of the physico-chemical characteristics of the vehicle associated with calcium hydroxide.

The results of this study confirm that the calcified bridge is not homogeneous, but has small orifices and cracks, and that the physico-chemical proprieties do not interfere in the formation of the calcified bridge.

Figure 1 - Radiographs of extractet teeth showing the presence of calcified bridge

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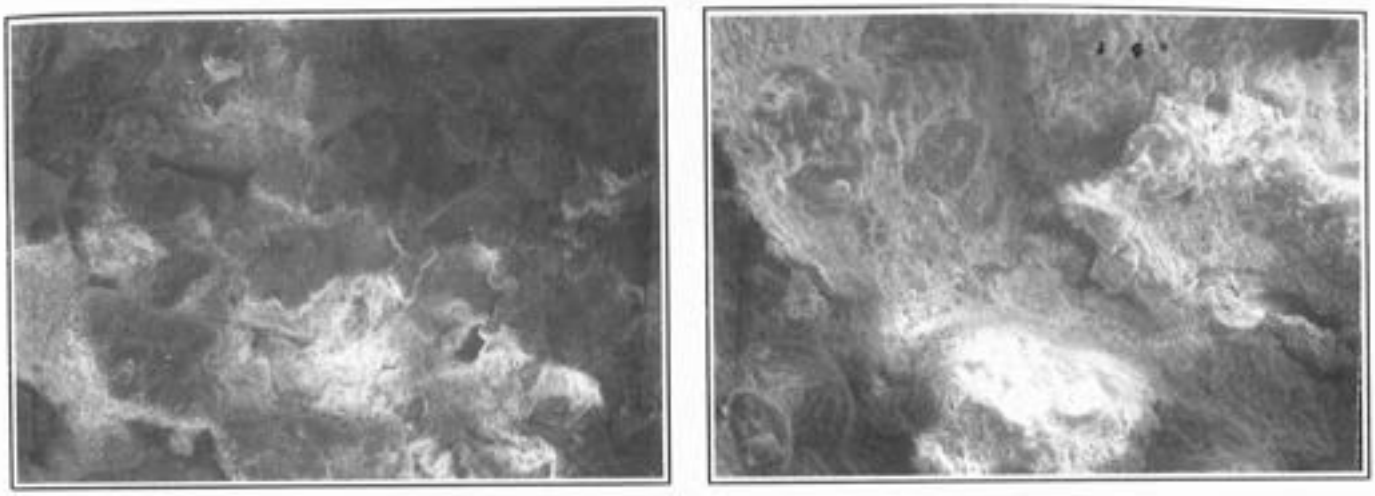
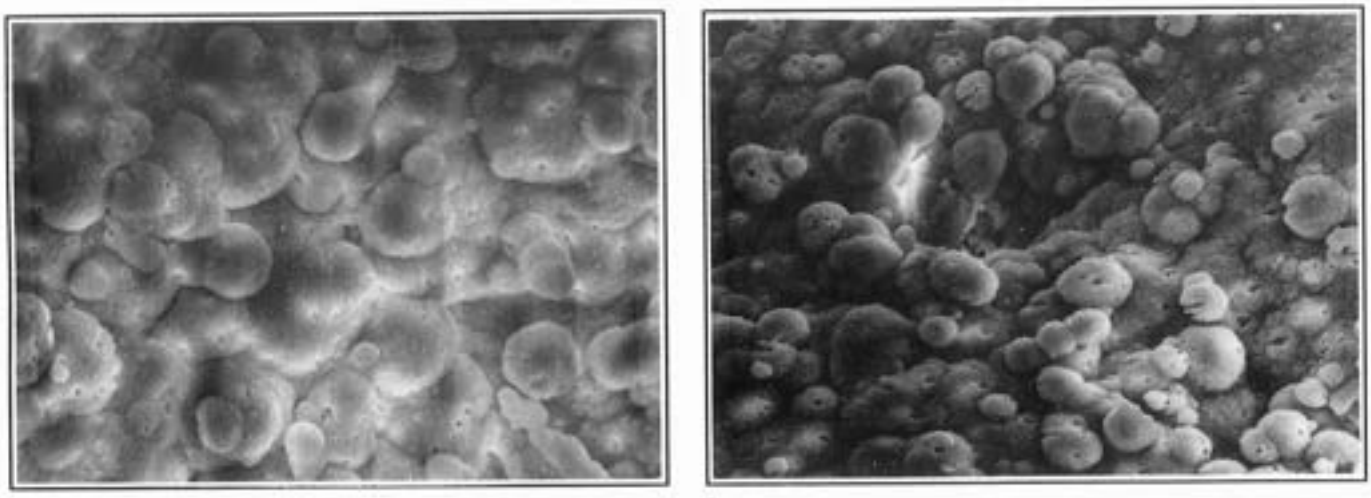


Figure 2a, 2b - SEM showing surfaces that were turned to the coronal direction



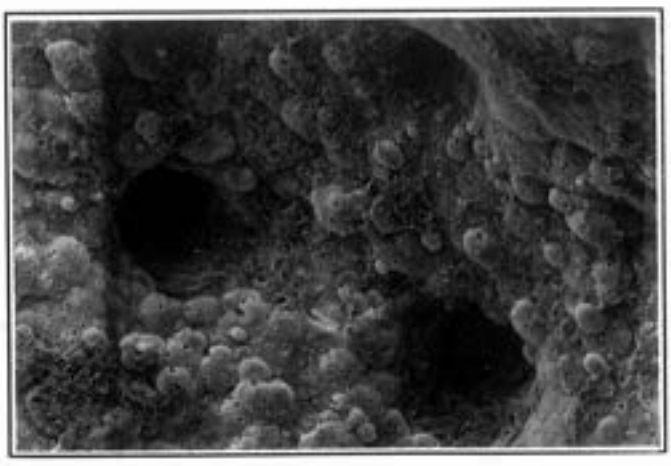


Figure 3a, 3b, 3c - SEM showing agglutinates of calcosferites

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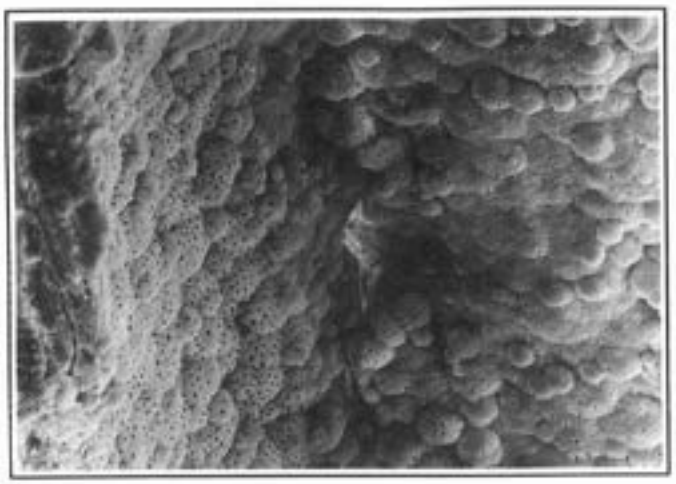

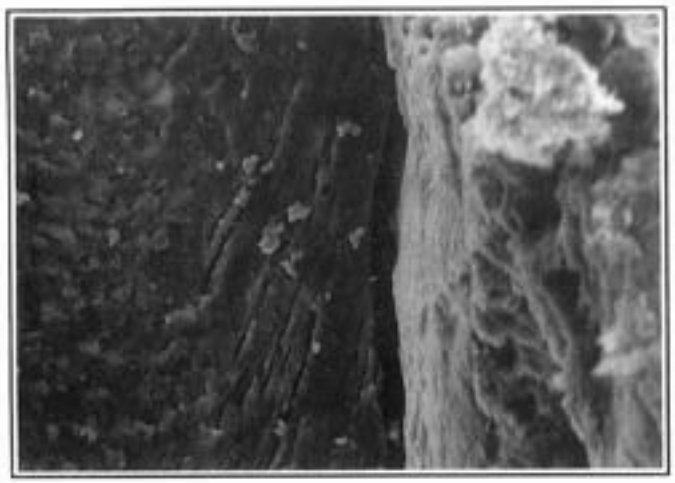

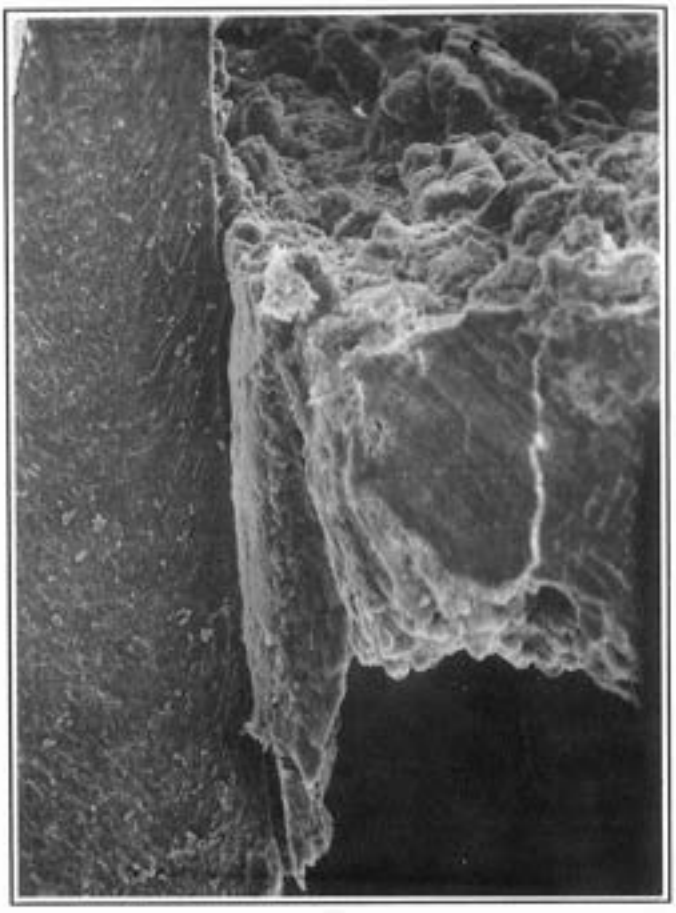

Figure 4a, 4b, 4c - SEM showing union area between the calcified bridge and the dentinal canal walls

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ANTIMICROBIAL ACTIVITY OF DRUGS USED IN PULP THERAPY OF DECIDUOUS TEETH

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The antimicrobial effectiveness of seven drugs used in pulp therapy of deciduous teeth - Guedes-Pinto, zinc oxide, calcium hydroxide and mixed pastes, formocresol, 1/5 formocresol and 2% glutaradehyde - was evaluated against *S. aureus, S. epidermidis, S. mutans, S. sanguis, E. faecalis* and *E. coli*, microorganisms that can be detected in infected root canals, and also against *B. subtilis*, a spore-forming bacteria which possesses recognized resistance to many chemical agents. The activity tests were carried out according to the disk diffusion method on Brain-Heart Infusion Agar supplemented with blood; the drugs were placed on filter paper disks and then on culture medium. Samples of the antimicrobial agents were assayed just after their preparation and 7, 14, 28, 60 and 90 days later; the agents were kept at 37°C throughout. After incubation at 37°C, the diameters of the inhibition zones were measured. The antimicrobial effect decreased with time depending on the drug used and on the bacterial strain tested. The data indicate that the zinc oxide paste had the strongest and 1/5 formocresol the weakest antimicrobial activity. The differences were all statistically significant except for 2% glutaraldehyde and formocresol, which were similar to each other.

Key words: Antimicrobial activity, pulp therapy, deciduous teeth.

INTRODUCTION

The maintenance of deciduous teeth in the dental arch up to their exfoliation has been one of the main targets of pediatric dentistry, because these teeth represent the fundamental basis for correct occlusion of the permanent dentition.

Nevertheless, it is known that the prevalence of caries in deciduous teeth is significant, and that the presence and activity of microorganisms in the pulp chambers and root canals play a decisive role in the development of pathological changes in tooth pulp, as has already beeen demonstrated concerning the permanent teeth[9,18,19]. Therefore, the success of pulp therapy is directly related to the antimicrobial potential of the materials used during treatment.

The antimicrobial effectiveness of materials used in pulp therapy of deciduous and permanent teeth have been established in many studies; however, their residual activity has not always been considered by researchers. Thus, several investigations have been carried out to study the antimicrobial activity of formocresol[4,15,25,26], providing information about its significant potential on pure and mixed cultures of microorganisms . Thomas et al.[21] studied the antimicrobial action of varying concentrations of formocresol in propylene glycol on gram positive and gram negative microorganisms. These studies indicated that this agent at as low as 10 to 20% possesses an irreversible effect against both groups of microorganisms.

Likewise, the antimicrobial effect of several glutaraldehyde solutions,(range, 0.045- 25%) was analyzed by HILL et al.[11] in relation to microorganisms commonly detected in carious deciduous teeth. They report that the minimum effective concentration of glutaraldehyde was 3.125%; in the same opportunity, the 0.75% formocresol was also effective.

Similar studies in relation to endodontic pastes and filling cements have also been developed, specially those carried out by GUEDES-PINTO et al.[10], and more recently by ESTRELA et al.[6-8]. In these experiments, the authors have established the spectrum of action of different materials on microorganisms that appear to be common inhabitants of the oral cavity, and also in relation to some facultative aerobic bacteria which, when not controlled in the infected root canal system, can complicate treatment sucess.

The purpose of this study was to evaluate the immediate and residual antimicrobial activity of pastes and liquids used during pulp therapy of deciduous teeth on pure cultures of microorganisms, which can be detected in infected root canals, and also against some that usually show resistance to chemical agents. The immediate effect was determined just following drugs manipulation and the residual action wasdetermined after 7, 14, 28, 60 and 90 days.

MATERIAL AND METHOD

ENDODONTIC DRUGS

The following pastes were used Guedes-Pinto paste (0.30 g of iodoform[1], 0.25 g Rifocort[2] and 0.1 ml camphorated paramonochlorophenol[3]), zinc oxide paste (0.40 g zinc oxide[4], 0.15 g iodoform[a], plus Guedes-Pinto paste ingredients), Calcium Hydroxide paste (0.40 g of calcium hydroxide[5], 0.15 g iodoform[a], plus Guedes-Pinto paste ingredients) and mixed paste (0.20 g of zinc oxide[d], 0.20 g calcium hydroxide[e], 0.15 g iodoform[a], plus Guedes-Pinto paste ingredients). The liquids used were: formocresol[6], 1/5 formocresol[7] and

2% glutaraldehyde[8].

For paste preparation, the powders were mixed, the other ingredients were then added, and immediately incorporated on to sterile 5-mm filter paper disks. Cotton pellets were impregnated with one drop of the liquid agent. In the case of formocresol and 1/5 formocresol, excess was removed by pressing the cotton pellet on a filter paper, and then the cotton pellet was left on a second paper disk for 10 minutes. The cotton pellet saturated with glutaraldehyde was placed directly onto the paper disk remaining there for 5 minutes.

INDICATOR MICROORGANISMS

In this analysis, pure cultures of *Staphylococcus aureus, Staphylococcus epidermidis, Streptococcus mutans, Streptococcus sanguis, Enterococcus faecalis, Bacillus subtilis* and *Escherichia coli* were used.. The microorganisms were cultivated on Brain Heart Infusion Agar[9] (BHIA), and resuspended in reduced saline to give a final suspension of about 3 x 10^8 cells per ml, similar to that of tube #01 of the McFarland scale.

ACTIVITY TESTES

For immediate evaluation, the materials were tested just after their preparation, while for residual Evaluation the drugs using the previously prepared disks, were tested after their storage on Petri plates sealed with aluminum foil, for a period of 7, 14, 28, 60 and 90 days at 37°C.

The protocol for the standard assay has been described earlier[2] was as follows. The activity tests were carried out according to the disk diffusion method, spreading 0.1 ml of each microbial standard suspensions on the surface of BHIA, supplemented with 5% defibrinated sheep blood, followed by the application of the drugs impregnated paper disks on the culture medium. After incubation at 37°C, in aerobiosis or in presence of 5-10% CO_2, depending on the oxygen requirements of each microorganism, the diameters of the inhibition zones were measured.

Microorganism viability and disk sterility controls were done for each experiment. All assays were carried out in duplicate under aseptic technique.

STATISTICAL ANALYSIS

The data obtained were submitted to analysis of variance followed by multiple comparisons with the Duncan test (a = 0.05). The results of pastes and liquids were analyzed studied in two separate groups.

RESULTS

The data related to immediate and residual effects of the drugs tested are summarized in Table 1. The zinc oxide paste was the most effective against all microorganisms assayed throughout the experimental times, while the calcium hydroxide paste showed the weakest activity. Collectively, the results obtained with 2% glutaraldehyde, formocresol and 1/5 formocresol were not expressive; significant action was only detected just after impregnating the paper disks with the liquid. The drawings of this results are added to facilitate interpretation of the antimicrobial activity observed (Figure 1).

The behavior of microorganisms when exposed to the assayed pastes is shown in Table 2. In general, all microorganisms displayed some sensitivity to the pastes, but *S. mutans* appeared to be more sensitive and *E. faecalis* more resistant than the others. The microorganisms showed great resistance to the liquid drugs, especially after "0" time (data not shown).

The controls showed that indicator microorganisms were viable for each experiment and that the filter paper disks were maintained sterile during the assay period.

[1] K-Dent, Quimidrol, Joinville, SC, Brasil.
[2] Merrell Lepetit, Santo amaro, SP, Brasil.
[3] S. S. White, Rio de Janeiro, RJ, Brasil.
[4] S. S. White, Rio de Janeiro, RJ, Brasil.
[5] Iodontosul, Porto Alegre, RS, Brasil.
[6] Formocresolan, Inodon, Porto Alegre, RS, Brasil.
[7] Inodon, Porto Alegre, RS, Brasil.
[8] Glutaral, Inodon, Porto Alegre, RS, Brasil.
[9] Baltimore Biological Laboratories, Cockeysville, Maryland, USA.

Table 1. Mean diameter of inhibition zones in mm for pastes and liquids at all times(days)

		TIMES						
	DRUGS	**0**	**7**	**14**	**28**	**60**	**90**	**TOTAL**
PASTES	Zinc oxide	17.9a	16.1a	16.9a	16.1a	15.9a	15.2a	16.4a
	Guedes-Pinto	17.5a	15.7a	17.1a	16.0a	14.5a	13.9a	15.8b
	Mixed	15.3b	11.3b	8.7b	8.2b	7.9c	8.9c	10.1c
	Calcium hydroxide	15.3b	9.3b	8.1b	8.0b	8.1c	7.1d	9.3d
LIQUIDS	Glutaraldehyde	4.6a	0.0a	0.0a	0.0a	0.0a	0.0a	0.8a
	Formocresol	3.2b	0.0a	0.4a	0.0a	0.0a	0.0a	0.6a
	1/5 Formocresol	1.1c	0.0a	0.0a	0.0a	0.0a	0.0a	0.2b

Means followed by different letter, in the same column, are statistically different (Duncan test a = 0.05).

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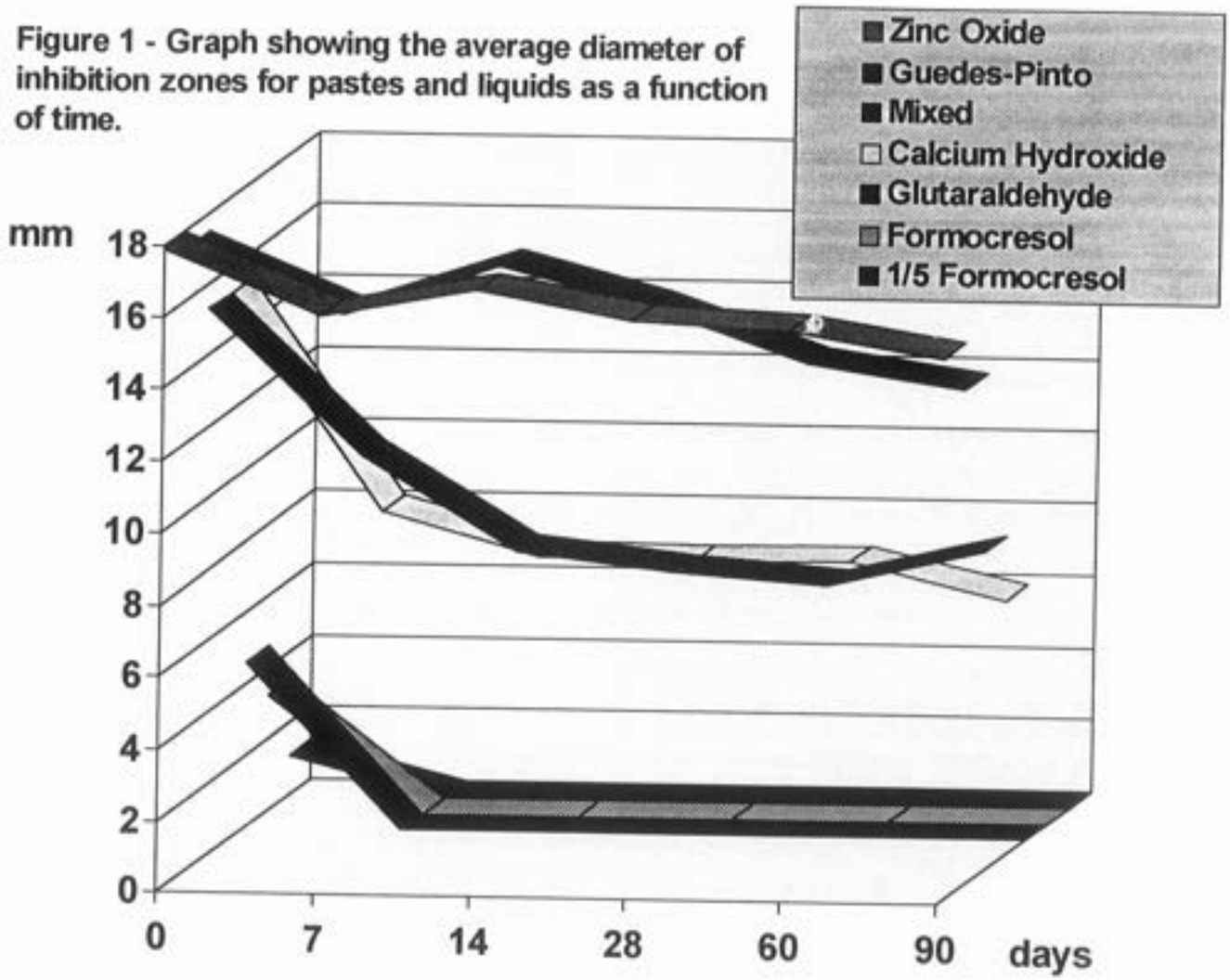
Table 2. Mean diameter of inhibition zones (mm) for pastes on pure cultures of microorganisms

Microorganisms	PASTES			
	Zinc Oxide	Guedes-Pinto	Mixed	Calcium Hydroxide
S. mutans	19.9 a	18.6 a	11.8 b	11.7 a
S. epidermidis	19.5 a	18.4 a	12.1 ab	10.8 b
E. coli	14.5 d	15.0 c	12.8 a	12.5 a
S. aureus	17.6 b	16.5 b	10.8 c	8.4 d
S. sanguis	16.3 c	15.1 c	9.2 d	9.6 c
B. subtilis	11.3 e	11.7 d	10.2 c	9.9 bc
E. faecalis	15.4 cd	15.3 c	3.5e	2.4 e

Means followed by different letters, in the same column, are statistically different (Dunacan test a = 0.05).

Figure 1 - Graph showing the average diameter of inhibition zones for pastes and liquids as a function of time.



DISCUSSION

In the model of study used, the antimicrobial agent would diffuse into the medium in a circle around the paper disks, expressing its antimicrobial potential. Activity is dependent on drug diffusibility and toxicity on the surface of the culture medium and against the indicator microorganism, respectively. According to DI FIORE[5], the medication diffusibility is a function of its chemical structure, the size of its molecules and the speed of its release from the matrix. Thus, large zones indicate more effective antimicrobial action or greater diffusibility of the medication, or both, while no zones point to antimicrobial ineffectiveness or lack of diffusion of the medication. The assay used is simple and reliable for testing the antimicrobial effect of endodontic materials and has been used by several investigators[1,2,6-8,10,16].

The data shon in Tables 1 and 2 are of particular interest, since they show that the drugs were active

against all the strains tested. Although no absolute correlation could be made, it does seem that the panel of microorganisms reflects, at least in part, the bacteriological conditions of carious lesions and infected root canal systems where the presence of a mixed culture is always significant[3,13,18,22,23].

The zinc oxide and Guedes-Pinto pastes appeared to be more effective, in comparison to mixed and calcium hydroxide pastes; however the mixed and calcium hydroxide pastes also preserved their activity after 90 days of the experiment. ESTRELA et al.[6] observed no effect of three filling cements with calcium hydroxide on Pseudomonas aeruginosa, Escherichia coli and Enterococcus faecalis; these results were related to the technical conditions used during evaluation, which could impair the ionic dissociation of calcium hydroxide and/or the hydroxyl ion diffusion on the surface of agar medium. However, it seems that release and diffusion of active principles occurred in the present study, because inhibition zones, in the (range, 15.3-7.1 mm) were observed with calcium hydroxide containing pastes, in relation to all microorganisms from 0 time until 90 days of the experiment.

The small effect of the calcium hydroxide-containing pastes observed in this study could be related to the fact that the pastes set in a coment-like manner just after preparation. PROSSER et al.[14] observed that materials that set are very complex and ions are unable to be released from hard strutuctures. TAMBURIC et al.[20] who reported that pastes with calcium hydroxide that set release less calcium and hydroxyl ions than those that do not set. Thus, over observations are consistent with results reported by several other investigators, DIFIORE et al.[5] pointed out that the setting property could be a factor to determine its release from the matrix, its diffusion on the surface of the medium and its action on microorganisms; moreover, the antimicrobial action of calcium hydroxide is dependent its ionic dissociation and action of hydroxyl ions on bacteria[6-8,12].

BARTELS[4], VERCO[24] and SEOW[15] reported that various concentrations of formocresol are effective against several microorganisms and, therefore, may be suitable for clinical use [21]. In our study report, the performance of liquid drugs was markedly lower than that of pastes, and 2% glutaraldehyde, formocresol and 1/5 formocresol did not to have residual effectiveness.

Collectively, the antimicrobial potential seems to decrease with time, since the sizes of inhibition zones were somewhat smaller after 90 days in comparison to those obtained on "0" day, but some variations have also be found. These discrepancies could be correlated to the amount of drugs used and/or to inherent technical factors [1,2].

The findings reported and discussed in this investigation may have significance in light of current interest in maintaining the deciduous teeth up to eruption of permanent teeth, which is important to oral health.

CONCLUSIONS

Based on the experimental conditions used, the pastes show a markedly higher antimicrobial effect than the liquids. The zinc oxide paste appears to have the best activity, followed by Guedes-Pinto, mixed and calcium hydroxide pastes, 2% glutaraldehyde, formocresol and 1/5 formocresol. The antimicrobial effectiveness decreases with time, being dependent on the drug used and on the bacterial strain tested.

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TREATMENT OF TEETH WITH INCOMPLETE ROOT FORMATION AND A HISTORY OF TRAUMA

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The authors describe 2 clinical cases of incomplete root formation associated with trauma, and discuss the role of scheduled periodic changes of intracanal medication in the process of dental apexification.

Key Words: Incomplete root formation, calcium hydroxide, dental trauma.

INTRODUCTION

The preservation of teeth with a history of trauma using periodic clinical examination and x-rays is of fundamental importance because several pathological alterations can be diagnosed during the period after trauma.

BAKLAND[3] reports the following sequelae from pulp trauma which can occur: 1, repair, which is the ideal reaction to an injury; 2, calcification, which can be considered both desirable and undesirable because generally calcification is an attempt of the pulp to respond in a positive manner to an injury; 3, necrosis; 4, reabsorption. These last two are definitely considered undesirable.

Physical trauma occurring with a fall, with or without dental fracture, can cause pulpar hemorrhaging resulting in disturbed nutrition of the cells, hyalinization of the pulp tissue, mineralization and excessive pigmentation of the teeth [2]. The pulp can heal completely or necrosis can occur depending on the intensity of the hemorrhaging and the stage of root development or the installation of infection [12].

Pulp necrosis occurs when the blood flow to the pulp tissue is interrupted, with a subsequent lack of oxygen. In the absence of bacteria, necrosis by coagulation presents a gradual degeneration of the tissues. If necrosis by coagulation has little effect on the periodontal ligament and on the alveolar bone, the tooth can remain completely asymptomatic.

According to ANDREASEN[1], the conservation of the traumatized tooth ought to always be the objective of the dentist. Besides seeking to maintain the tooth functionally in the alveola, therapy ought to prevent the development of pathologic alterations.

Our objective is to report two clinical cases in which there were later manifestations of dental trauma in the pulp of teeth with incomplete root formation.

CASE REPORT

Case 1

A thirteen year old female was seen at the clinic for routine examination. She reported that she had had a bicycle accident 5 years earlier but had not seen a dentist at that time because there was no apparent damage. A slight alteration in color to gray was observed and vitality pulp tests were negative. Percussion and palpation were normal.

Radiographic examination showed that the right maxillary central incisor had incomplete root formation with the parallel walls of the root canal showing that root formation was interrupted at the time of trauma.

Thus, access surgery and disinfection was carried out. In the treatment of a tooth with pulp necrosis, great care ought to be taken to avoid post-operative complications, principally "flare-up". Dakin's solution and hydrogen peroxide were used for disinfection.

A paste of calcium hydroxide with iodoform and propylenoglycol was then placed in the root canal using a lentulo. After 7 days, this calcium hydroxide paste was changed monthly for four months and then every 3 months for a period of 9 months, after which apexification was confirmed clinically and radiographically. Obturation was carried out with gutta-percha cones and Grossman cement.

Case 2

A forty year old female was seen at the clinic complaining of the presence of a fistula in the anterior maxillary region. She reported that she had fallen from a tree while playing when she was about 8 years of age and that she has then lost the left maxillary central incisor. The absence of this tooth was seen clinically and radiographically. Alteration of color of the right maxillary central incisor was observed with the presence of a fistula. The vitality test, palpation and percussion were all negative.

In order to identify the path of the fistula a gutta-percha cone was placed and x-ray examination revealed apical rarefaction and incomplete root formation in the right maxillary central incisor.

Dakin's solution was used for disinfection alternating with hydrogen peroxide. A calcium hydroxide, iodoform and propylenoglycol paste was placed in the interior of the canal using a lentulo and left for 7 days. Monthly changes of this paste were then carried out for four months, followed by trimestral changes for a period of 9 months when apexification was verified clinically and radiographically. As in case 1, obturation was carried out with gutta-percha cones and Grossman cement.

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Figure 1. A, Initial x-rayof case 1. B, X-ray showing incomplete root formation with parellel walls. C, Root canal filled with calcium hydroxide paste. D, X-ray 18 months after final obturation.

Figure 2. A, Initial X-ray of case 2. B, Incomplete root formation shown using gutta-percha cone. C, X-ray 3 years after final obturation

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DISCUSSION

Daily there is a greater number of individuals who are victims of different types of accidents which can cause often irreversible trauma to dental structures and to their support system, depending on the intensity and form of trauma[11].

Injuries which trauma can cause to the dental pulp, such as internal and external reabsorption, necrosis and calcification, have been reported by BAKLAND[3], showing the importance of preservation using periodic clinical and x-ray exams to detect the presence of these pathological alterations.

Endodontic treatment of teeth with incomplete root formation seeks to obtain physiological complementation of the radicular apex (apexigenesis) or apical closure by means of stimulation (apexification) which is the objective of this report.

Penetrating disinfection ought to be carried out with great care in the treatment of teeth with incomplete root formation with pulpar necrosis because the large lumen of the radicular canal and the thinness of the walls can cause the dental surgeon to fracture the root. In this case, filing ought to be done with only one file, of the greatest caliber, associated with a chemical solution to disinfect the radicular canal. The most important factors for apexification are canal cleaning, in other words removal of all necrotic tissue, and the temporary hermetic sealing of the tooth to avoid bacterial infiltration.

Diverse materials have been proposed to induce the apexification of nonvital permanent teeth. MORSE et al.[10] studied 5 treatment methods for teeth with incomplete root formation and pulpar necrosis and concluded that the success of therapy with apical tissue repair is due to the antibacterial action and the calcification-inducing action of calcium hydroxide.

The biological and bacteriological actions of calcium hydroxide, which was introduced in dentistry by HERMAN[6] in 1920, confirm its preference for intracanal use. Many different substances and vehicles have been combined with the objective of improving the antibacterial action, speed of liberation of calcium and hydroxyl ions, and interfering in the physicochemical properties[5,7,9].

Alkaline paste in combination with other substances or not has the objective of maintaining disinfection of the radicular canal and causing apex formation (apexification). Constant change of the medication maintains the state of disinfection until apexification.

In the cases reported here, the change of the medication in the first four months was carried out monthly and then every three months until a period of twelve months was completed. Change of the paste was initially carried out at shorter intervals due to the rapid reabsorption detected radiographically. The periods of apexification observed in these two cases is in agreement with the literature, which reports that in the absence of infection apexification occurs within 12 to 18 months[1,4,8,13].

The conservation of the traumatized dental element ought to be the objective of our attention, thus the necessity of periodic exams over a long period so that later pathologic alterations can be diagnosed. With this objective, the choice of adequate treatment is of fundamental importance so that the tooth can be maintained in the oral cavity carrying out its esthetic and functional purpose.

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MECHANICAL STIRRING OF SMEAR LAYER REMOVAL: INFLUENCE OF THE CHELATING AGENT (EDTA)*

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The purpose of this study was to evaluate under the scanning electron microscope, the influence of mechanical stirring of EDTA in the root canal interior on the smear layer removal. After root canal instrumentation, the samples were divided in to three groups with 10 specimens each. In group 1 EDTA remained still inside the root canal; in group 2 it was stirred using a #10 K-type file and in group 3, EDTA was stirred using #1 spiral lentulo (Maillefer) turning right with a high-speed of micromotor (Kavo). The best results were those obtained by means of mechanical stirring the EDTA solution when it was inside the root canals (group 3). The ANOVA test and the Student T test showed that there were significant differences between groups 1 and 3 ($p<0.01$) and between t groups 2 and 3 ($p<0.05$).

Key Words: Smear layer, irrigating solutions, chelating agent, EDTA

INTRODUCTION

During endodontic therapy, a layer of material composed of dentin, remnants of pulp tissue and odontoblastic processes and sometimes bacteria is always formed on the canal walls. This layer has been called the smear layer. It has an amorphous, irregular and granular appearance under the scanning electron microscope[13].

CAMERON[6] and MADER et al.[11], described the smear layer material in two parts: a superficial smear layer and the smear material packed into dentinal tubules. The extension of this material into dentinal tubules was calculated as extending up to 40 micrometers. It was also concluded that this tubular packing phenomenon of smear layer was due to the action of burs and endodontic instruments[5-11].

The advantages and disadvantages of the presence of smear layer, and whether it should be removed or not from the instrumented root canals are still controversial. The presence of the smear layer acts as a physical barrier interfering in dentinal permeability, adhesiveness and in the sealing efficiency of root canal obturation [8-10].

Several chemicals substances have been indicated for the removal of smear layer; however, EDTA and sodium hypochlorite are the most commonly used. The chelating agent acts on the inorganic component while sodium hypochlorite acts on the organic component of thesmear layer[4-14].

The efficacy of the irrigating solution is dependent not only on the chemical nature of the solution, but also on the quantity and temperature, contact time, depth of penetration of the irrigation needle, type and gauge of the needle, surface tension of the irrigating solution and age of the solution[9]. Liquid agitation in the root canal interior seems to contribute to a better removal on the smear layer[1-3].

The purpose of this study was to evaluate, under the scanning electron microscope, the influence of mechanical stirring of EDTA in the root canal interior on smear layer removal.

MATERIAL AND METHOD

Thirty freshly extracted, single-rooted maxillary anterior teeth were used. After preparation of the access cavities a #10 K-type file was inserted into each canal until it was visible at the apical foramen. One millimeter was subtracted from this length in order to establish the working length. All canals were then sequentially enlarged with K-type files to size 45 with 1% sodium hypochlorite. The patency was achieved using a # 25 K-type file.

The canals were then filled with 17% EDTA. The chelating agent was previously conditioned in empty anesthetic cartridges and injected the root canal interior a Carpule syringe and a 25-gauge needle. The time of permanence of EDTA in the root canal interior was 5 minutes.

The samples were divided in to three groups with 10 specimens each. In group 1 the EDTA remained still inside the root canal. In group 2 EDTA was stirred in the whole working length with a #10 k-type file for two minutes and then remained for 3 minutes. In group 3 EDTA was also stirred for the first 2 minutes, using a #1 spiral lentulo (Maillefer, Ballaigues, Switzerland) turning right with a high speed micromotor(Kavo, Santa Catarina, Brazil). The samples were then irrigated with 5 ml 1% sodium hypochlorite.

To facilitate their fracture, two parallel longitudinal grooves which did not penetrate the root canals were made on both external surfaces of the teeth. The coronal, middle and apical thirds of the canals were prepared and scanned under the scanning electron microscope (SEM; model Jeol USM-U3). Representative areas of each third were photographed.

The cleaning of the root canals walls was evaluated blindly by two investigators according to the rating system developed by Rome et al.[12]: 0 = no smear layer, dentinal tubules open, free of debris; 1 = moderate smear layer,

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outlines of dentinal tubules visible or partially filled with debris; and 2 = heavy smear layer, outlines of dentinal tubules obliterated. The data were analyzed using the ANOVA test and Student T test.

RESULTS

Group 1: The superficial smear layer was totally removed from all cervical thirds. However, in the middle third of four samples and in the apical third of five samples the smear layer was removed almost completely and some openings of the dentinal tubules were patent while and others were closed. A heavy smear layer was present in the apical third of one sample (Figure 1). Group 2: The superficial smear layer was totally removed from all cervical thirds. However, in the middle third of three samples and in the apical third of four samples the smear layer was removed almost completely and some openings of the dentinal tubules were patent while others were closed (Figure 2). Group 3: The superficial smear layer was totally removed from all cervical thirds and middle thirds. In the apical third of one sample the smear layer was removed almost completely and some openings of the dentinal tubules were patent while others were closed (Figure 3-5). Table 1 shows the mean scores for each group at various levels.

The ANOVA test and the Student T test showed that there was no significant difference ($p=0.05$) between groups 1 and 2. There were significant differences between groups 1 and 3 ($p<0.01$) and between groups 2 and 3 ($p<0.05$).

DISCUSSION AND CONCLUSION

The smear layer was removed in all groups from the cervical thirds independent of the mechanical stirring of EDTA in the root canal. In the middle third, 40% of group 1 samples and 30% of group 2 samples showed a moderate amount of smear layer with some dentinal tubules open and others closed. In group 3, the smear layer was removed from in the middle third in all samples.

In the apical third, 60% of group 1 and 40% of group 2 showed the presence of a smear layer; in group 3, the smear layer was found in only 10% of all samples.

The efficacy of the removal of the smear layer is decreased at the apical level. Similar results have been reported by other researchers[3-7]. The best results in removing the smear layer were those obtained by means of mechanical stirring of the EDTA when it was inside the root canals (Group 3).

Due to the small size of the root canal air bubbles frequently remain in its interior agent during it the filling with the chelating agent. The presence of these bubbles mainly in the middle third and in the apical third of the root canal blocked the contact of the chelating agent with the dentinal walls, making this way it difficult to remove the smear layer.

Mechanical stirring with K-type file contributes to the partial clearance of the air bubbles. Mechanical stirring with the spiral lentulo at a faster speed to agitate the chelating agent cleared the air bubbles better, allowing the chelating agent to come in contact with the root canal walls. The spiral lentulo creates shearing stress in the root canal interior which combined with the chemical action of EDTA removes the smear layer from dentinal walls more efficiently.

Table 1. Mean scores for smear layer at different levels

GROUP	Specimen	Apical third	Midle third	Cervical third
Group 1	1	2	1	0
	2	1	1	0
	3	1	0	0
	4	0	0	0
	5	1	1	0
	6	1	0	0
	7	0	0	0
	8	0	0	0
	9	1	1	0
	10	0	0	0
Group 2	1	1	0	0
	2	1	1	0
	3	0	0	0
	4	1	0	0
	5	0	1	0
	6	0	0	0
	7	1	1	0
	8	0	0	0
	9	0	0	0
	10	0	0	0
Group 3	1	0	0	0
	2	0	0	0
	3	1	0	0
	4	0	0	0
	5	0	0	0
	6	0	0	0
	7	0	0	0
	8	0	0	0
	9	0	0	0
	10	0	0	0

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Figure 1. Group 1: Apical Third, typical smear layer appearance. 1000x

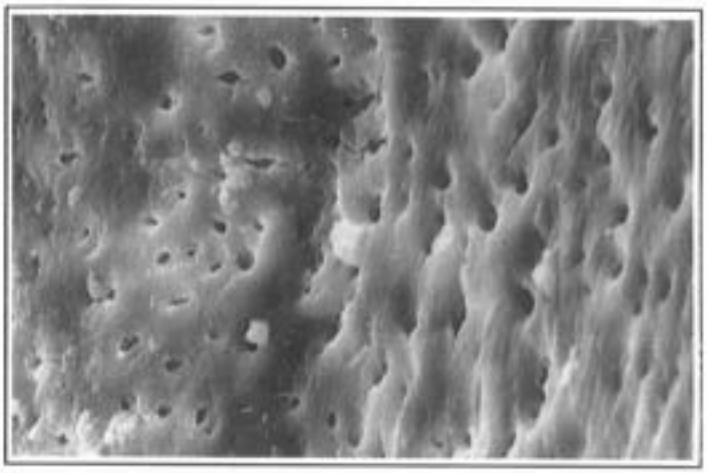

Figure 2. Group 2: Apical Third, some tubular openings are open and others are closed. 1000x

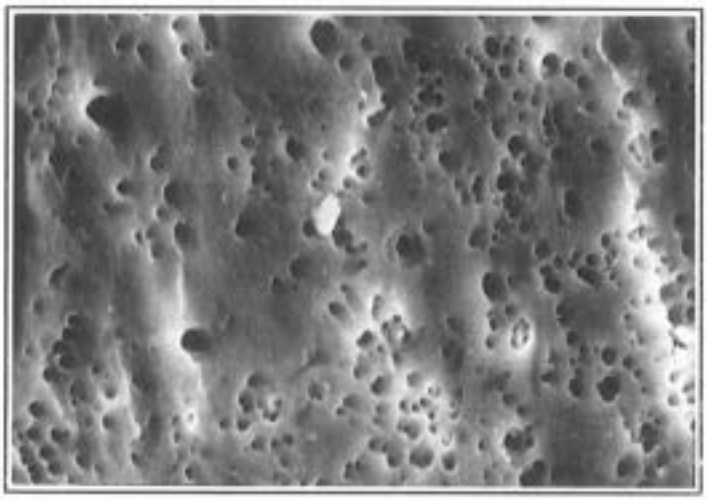

Figure 3. Group 3: Apical Third, superficial smear layer removed and patent dentinal tubule openings. 1000x.

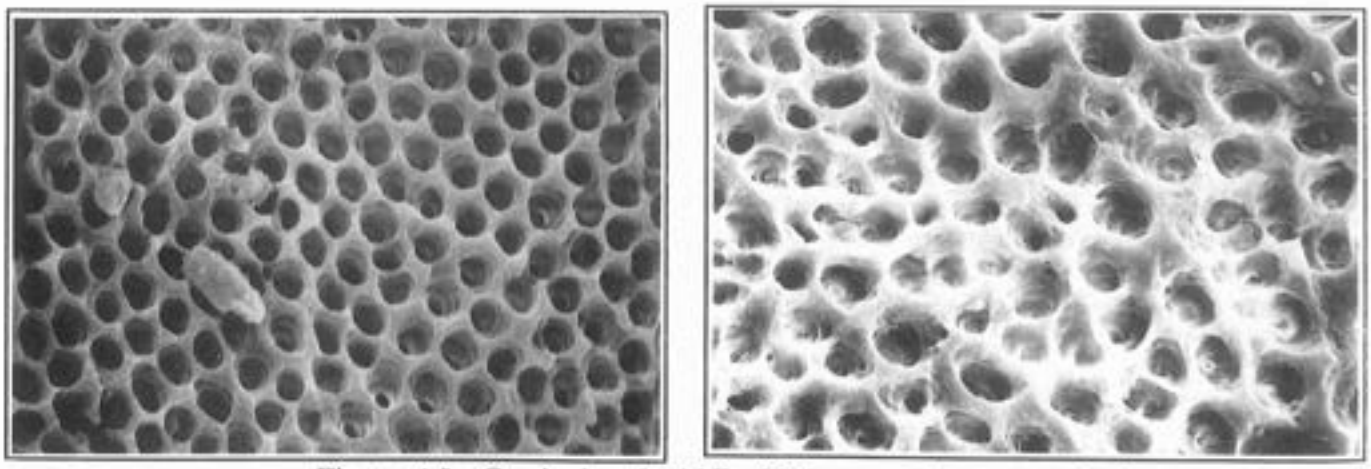

Figure 4,5: Cervical and middle third , smear layer completely removed. 1000x.

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RADIOGRAPHIC EVALUATION OF THE BEHAVIOR OF CHRONIC PERIAPICAL LESIONS OF ENDODONTICALLY TREATED TEETH

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Clinical and radiographic control after endodontic treatment is fundamental in assessing success therapy. The reduction of radiolucent area on radiographic examination has been interpreted as synonymous with repair in teeth with chronic periapical lesions. The goal of this study was to analyze radiographically the behavior of chronic periapical lesions of 102 anterior and premolar teeth treated by students from the undergraduate Dentistry Course of UFSC over a two-year period. Whether the behavior of the lesion might have been influenced by its size, and whether the absence of a restoration might explain the lack of repair was also investigated. Of 102 treatments performed, 86 showed significant reduction in the size of the lesion or in its disappearance; 12 of the lesions presented little reduction size, and 4 cases showed an increase in dimension. Restoration had been made on 57 teeth, whereas on 45 no restoration had been made. Analysis of data offered the following conclusions: a) chronic lesions of endodontically treated teeth had their sizes considerably reduced or disappeared in 84.31% of cases, with treatments being considered sucessful; b) no relationship was found to exist between lesion behavior and its size; c) the fact of the tooth having been restored or not did not apparently affect results.

Key words: Chronic periapical lesions, endodontic treatment / periapical healing

INTRODUCTION

Over the years dentists have been concerned with qualifying their endodontic procedures. This has been useful not only to confirm the adequacy of the techniques utilized but also to modify them in an effort to obtain better results. Search for success has been unabated.

Clinical and radiographic follow-up conducted after endodontic treatment is fundamentally important in evaluating therapeutic success. In spite of the limitations presented by radiographic examination, they have been the resource usually employed by clinicians and endodontists to compare dimensions of periapical lesions before and after treatment. Reduction or disappearance of radiolucent area — within given periods of time — has been interpreted as an indication of periapical tissue repair[8].

Lack of consenus exists as to the period of time an endodontically treated tooth should be followed-up, varying from 6 months to 4 years[8,10-12,15]. It is accepted that a lesion not presenting a reduction in size or maintaining its original dimension after one year has elapsed, at radiographic examination, will probably not present conditions to be repaired[15]. It is also suggested that follow-up should continue for a minimum of 2 to 3 years, starting at 6 months[7]. Other authors recommend a longer follow-up such as 8 to 10 years. The First International Convention of Endodontics, held in Philadelphia in 1953, studied the problem and recommended control for a 1 to 2-year period.

The rate of success obtained for endodontic treatments registered by several authors and evaluated through clinical and radiographic examinations varies between 53% and 94.5% for observation periods from 6 months to 25 years[1-3,5,10,12,13]. The lack of studies showing the outcome of endodontic treatment conducted by students from the undergraduate course of Endodontics at the UFSC motivated the authors to perform a radiographic evaluation of the behavior of chronic periapical lesions of endodontically treated teeth after a 2 year period. A study was also made comparing lesion size and behavior, and whether the examined teeth had undergone restorative procedures.

MATERIAL AND METHOD

A total of 228 patients were selected whose teeth had received endodontic treatment and presented chronic periapical lesions. Screening was made based on the patient files maintained by the undergraduate endodontic course of the UFSC. Only those cases where treatment had been performed 2 years before were selected. Letters and telephone calls were used to invite patients to return to the University. From those who presented themselves, a sample of 102 teeth was assembled, comprising incisors, canines and premolars from both arche. Postoperative periapical radiographs were taken, standardized as much as possible in relation to those already documented in patient files.

Using a slide projector, pre- and postoperative X-rays were exhibited at 5X magnification, being analyzed by 3 examiners (1 radiologist and 2 endodontists) and observations were recorded on a standard card. In an effort to avoid discrepancies in the analysis of radiographs examiners were request to document: a) whether a significant reduction, or disappearance of the lesion occurred; b) whether a slight reduction occurred in lesion dimension; c) whether an increase occurred in lesion size, or size remained constant. These observations permitted the classification of treatment results as successful, doubtful or failure, respectively.

Based on this information, a relationship was sought between lesion behavior and its dimensions. Clinical examination showed whether or not the teeth had been submitted to restorative procedures.

RESULTS

In 86 of the 102 teeth a significant reduction in size or even the disappearance of lesion was observed (Figures 1-4). In 12 teeth the lesions showed little reduction in size, and 4 of the teeth presented an increased dimension of radiolucent area. Final results were 84.31% successful, 11.76% doubtful and 3.92% failure (Table 1).

Of the examined teeth, 57 (55.88%) had been restored, and 45 (44.11%) remained restoration free. Chronic lesions presented radiographically different sizes for the various teeth analyzed.

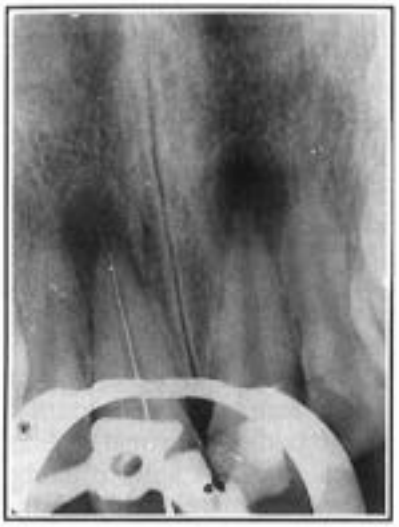

Figure 1. Preoperative radiograph showing the presence of chronic periapical lesion.

Figure 2. Two-year postoperative follow-up radiograph of the same tooth as in Figure 1, exhibiting periapical healing of lesion; this case was rated as successful.

Figure 3. Preoperative radiograph showing the presence of chronic periapical lesion.

Figure 4. Two-year postoperative follow-up radiograph of the same tooth as in Figure 3, exhibiting periapical healing of the lesion. This case was rated as successful.

Table 1. Periapical lesion behavior during the 2-year observation period.

LESION BEHAVIO	NUMBER OF TEETH(%)
SUCCESS (Significant reduction in lesion dimension or its disappearance)	**86(84,31%)**
DOUBTFUL (Slight reduction in size)	**12(11.76%)**
FAILURE (Increased or maintained dimensions)	**4(3,92%)**
TOTAL:	**102(100%)**

DISCUSSION

Reliability of the methods employed in the current study has already been proven in numerous other studies[1,3-6]. Radiographic interpretation conducted by 3 examiners permitted a larger margin of reliability of data. A 2-year postoperative period seemed to be an ideal one[3,10,12], since several authors believe failures usually to occur between 18 and 30 months [3,4,10,11].

Results obtained in this study are in agreement with those reported by other authors. BENDER AND SELTZER[3], in 1966, evaluating teeth presenting periapical lesions, obtained a 77% success rate after 2 years. BARBAKOW et al.[1], in 1980, analyzing 556 cases, found an 87.4% success rate. One year later, the same authors, registered 88% success in 192 cases. BYSTRÖM et al.[5], in 1987, studying 79 teeth submitted to endodontic treatment and presenting periapical lesions during a 2 to 5-year postoperative period, observed total repair to exist in 84.4% of cases. The same percent was obtained by SHAH[12],in 1988, in his analysis of 132 cases with periapical lesions during a period of 2 years or longer. In 1991, TRONSTAD[13], reported success of endodontic treatment to reach 90-95% with a 10-25% variation for those lesion cases. ROTH and ROTGANS[10], in 1994, obtained an 87% success rate for 107 teeth examined over a 5-year postoperative period.

The success reached in the present study can be attributed to various factors, including the use of an adequate technique with rigorous compliance to biological principles on which modern endodonticswas founded.

Samples obtained from a student clinic are rigorously standardized, minimizing the variables. Treatments were all conducted in at least 3 sessions, asepsis and antisepsis principles were the same, canal preparation technique, auxiliary chemical substances, filling technique and root canal sealers were all standardized. Also, the medication advised in pertinent cases was of standard quality. In the evaluation of endodontic treatment performed by general clinicians the number of variables is large, possibly affecting the results obtained[2]. Also responsible for results obtained in this study was the supervision by the faculty.

Cases classified as doubtful or failure, which numbered a little above 15%, could be explained by the presence of bacteria in the root canal system or periapical lesion having survived treatment and being able to continue the infectious process in periapical tissue[13]. A relationship between lesion behavior and its dimensions could not be established in the observed cases; there are indications that success of treatment does not depend on size of the periapical lesion[10,11]. During the 2-year follow-up period, total radiographic regression was observed to have occurred both for small and large lesions[10,12].

Of those teeth examined by the authors, only 55.88% had been restored, wich apparently had no influence on results, in spite of the greater importance attributed to coronal sealing. RAY et al.[9], in 1993, concluded the quality of coronal restoration was more important than the quality of root canal filling as it refers repair of periapical tissues. TROPE et al.[14], in 1995, evaluated *in vitro* the leakage of endotoxin in endodontically treated teeth without coronal sealing. They found the filled canal was not able to inhibit leakage of endotoxin in approximately 30% of the canals during 21 days.

There is no doubt that tooth restoration following endodontic treatment should always be performed in order to allow perfect functioning; however the lack of restoration did not affect results in this study.

CONCLUSIONS

1 - Chronic lesions of endodontically treated teeth had their sizes considerably reduced, or disappeared, in 84.31% of cases. Their treatment was considered successful.

2 - No relationship existed between lesion behavior and its dimension.

3 - The fact that only 55.88% of examined teeth had been restored did not apparently affect results.

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