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Comparison of pH changes in root dentin following intracanal dressing with conventional calcium hydroxide powder, calcium hydroxide points and commercial calcium hydroxide paste

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Abstract

Background: comparison of antimicrobial efficacy of intracanal medicaments

Aim: To compare the changes in pH levels of root dentin after placement of intracanal dressing of Conventional Calcium Hydroxide Powder, Calcium Hydroxide Points and Commercial Calcium Hydroxide Paste

Method: In this in-vitro study, a total of 80 single rooted extracted teeth free of any caries and fractures were included. The teeth were decoronated to maintain a standard length of roots at 12-14mm. Biomechanical preparation of the canals was done till size #F2 with continuous irrigation. Following this the canals were dried with sterile paper points and the canals were filled with respective intracanal dressing of each group. The coronal access was then sealed with a layer of temporizing material. Each tooth was placed in separate plastic phial filled with 10ml of distilled water. The changes in pH of the storage medium were recorded over different time intervals using digital ph. meter.

Result: Results showed that all the experimental groups increased the pH of surrounding dentin, but the calcium hydroxide powder group recorded maximum increase in pH levels.

Conclusion: As the study was conducted on extracted tooth and the results may vary in-vivo, so the type of intracanal dressing to be placed in each case should be chosen wisely.

Keywords: Apex Cal, calcium hydroxide paste, calcium hydroxide points, calcium hydroxide powder, digital pH meter, Intracanal Dressing, pH level

Introduction

The primary goal of an endodontic root canal treatment is to create a sterile environment inside the root canal and around the peri – radicular tissues. Microbiotas create various micro – environments which include both host Défense system and infecting micro-biota.[1] Persistence of infecting bacteria in the tooth or surrounding areas, despite of chemo-mechanical preparation, will result in endodontic failure.[2] Hence, the extent of elimination of micro-organisms will determine the success rate of the treatment.

Intracanal medicaments eliminate the remaining bacteria in the canal and also prevent their proliferation between the appointments. When placed inside a canal, they act as a physicochemical barrier to prevent nutrient supply to the remaining bacteria.[3] The various intracanal medicaments used in dentistry are Calcium Hydroxide, Triple Antibiotic Paste, Double Antibiotic Paste, NSAIDs, Ledermix Paste, Dexamethasone, N2 paste, etc. [4] Despite of the various options available, the most trusted intra canal medicament used by most dentists is "Calcium Hydroxide". It was introduced by Hermann long back in 1920.

Calcium Hydroxide is an odorless powder having low solubility in water.[5] When placed inside the canal, it dissociates to release calcium and hydroxyl ions, raising its pH to 12.5.[6] The hydroxyl ions released, diffuse through the dentinal tubules and the apical foramen and reach the site of infection. This rise in pH provides alkaline environment that determines its antimicrobial nature.[7]

Since direct placement of powder in canal is a cumbersome act, so various vehicles are been used for its dispersal in canal. These vehicles are broadly classified into three categories as aqueous, viscous and oily. The aqueous vehicles tends to give an initial rapid ionic release, however, a viscous vehicle shows a gradual and continuous ionic liberation.[5] The oily vehicles being least soluble in water, release hydroxyl ions at a continuous low speed. Hence, they have limited application in endodontics.[6]

In today's modern dentistry, besides the basic powder form of calcium hydroxide, various other forms have been made available to be used as an intracanal medicament. They are available as preformed pastes, which are packed in tubes. These pastes can be directly placed in the canal as a medicament. They generally contain excess calcium hydroxide, beyond its solubility limit, to increase the thickness of the mixture.[8]

A relatively recent development of calcium hydroxide form available is calcium hydroxide points. They are designed to release hydroxyl ions from a gutta percha matrix. A passively fitting calcium hydroxide point can be placed in the canal as an intracanal dressing between appointments. The point should reach up to the working length such that moist air circulates freely around the calcium point.[5]

The aim of this In Vitro study was to compare the pH changes following intra canal placement of conventional calcium hydroxide paste i.e., $Ca\ (OH)_2$ + distilled water, commercial $Ca\ (OH)_2$ paste (Apex Cal) and calcium hydroxide gutta percha points over different time intervals from 2 hours to 14 days (2 hours, 24 hours, 48 hours, 7 days and 14 days). Thereby, to evaluate which of these products has a better alkalinizing potential over time to be used as an inter appointment intra canal dressing.

Material and methods

The present in vitro study was conducted in the Department of Conservative Dentistry and Endodontics. A total of 80 extracted single rooted permanent teeth were selected for the study (Fig 1A). The teeth were

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collected from Department of Oral and Maxillofacial Surgery.

Teeth were washed with soft brush, under water to remove blood, saliva and soft tissue debris. The teeth were then stored in 10% formalin for 24 hours for disinfection and were finally stored in distilled water until used. The teeth were decoronated with a diamond maintaining a standard length of root at 12 – 14mm (figure 1B). The patency of all the roots was confirmed using a # 10 K file. The working length of the roots was determined using a # 15 K file. 1mm was then subtracted from the obtained length.

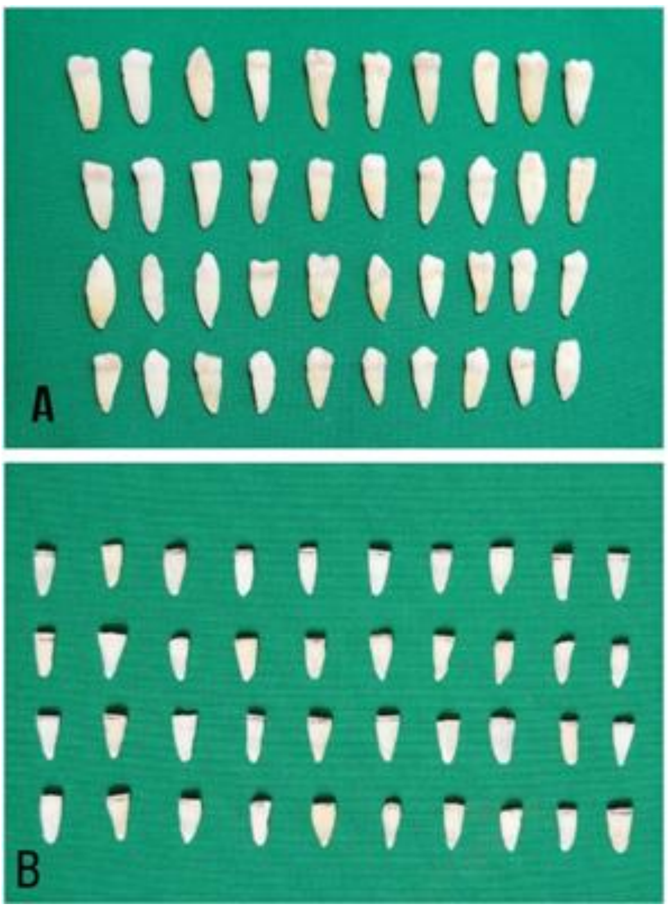

Fig 1:

A. Extracted human single rooted teeth

B. Decoronated sample of 12 – 14 mm

The canals of the teeth were prepared up to the estimated working length using NiTi Rotary instruments (Protaper Gold, Dentsply) up to size F2. During the biomechanical preparation, the canals were constantly irrigated with 5% sodium hypochlorite at every change of file, followed by a final rinse of 17% EDTA. Between various stages of study, the teeth were wrapped in sterilized cotton wool, which was saturated in isotonic distilled water.

The selected sample of 80 teeth was randomly divided into 4 groups.

Group 1: The canals of this group were dried with sterile paper points and were left empty to serve as a control group.

Group 2: Calcium hydroxide powder was mixed with distilled water using a cement spatula, maintaining P:L ratio of 1:2. The canals were dried using sterile paper points and the dressing was placed in the canals using lentulospirals (figure 2A).

Group 3: Commercial calcium hydroxide paste: Apex Cal (Ivoclar Vivadent) was used. The canals were dried using sterile paper points and the paste was placed into the canal, using the syringe delivery system provided by the manufacturer with the material (figure 2B).

Group 4: Calcium hydroxide point (Roeko, Hygeine) of ISO size #25, were selected. One calcium hydroxide point was placed in each canal using tweezers (figure 2C). Excess of the points were cut with scissors. Finally a moist cotton plug was placed in the canal to facilitate the release of hydroxyl ions, from calcium hydroxide points.

Following the placement of intracanal dressing, the coronal orifice was sealed with 3 mm layer of interim restoration material (Orafil-G).

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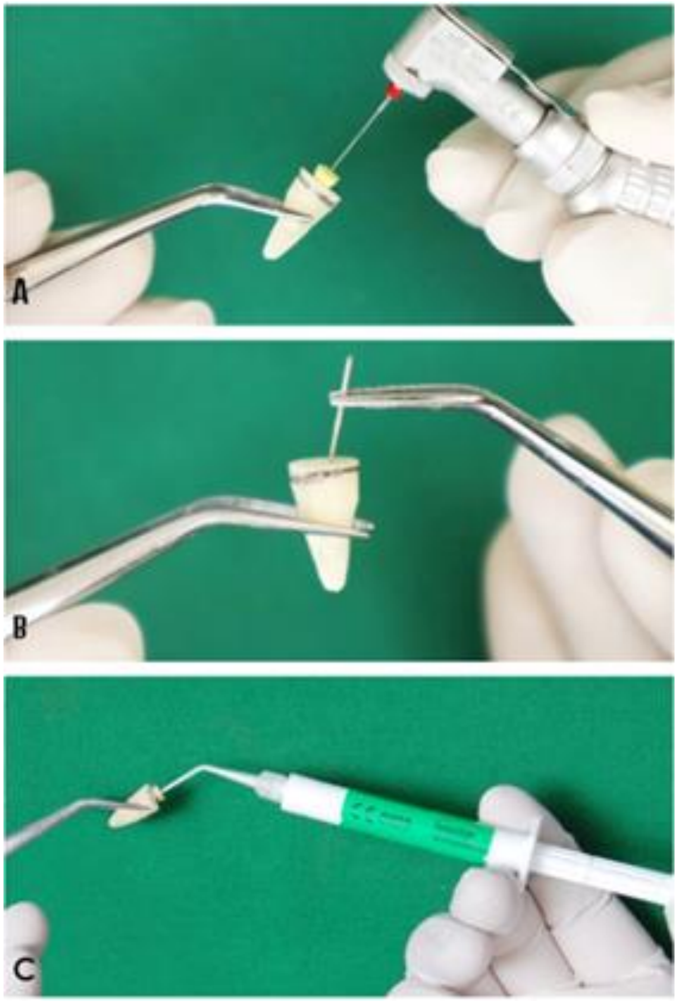

Figure 2: Placement of different calcium hydroxide formulations

A. Calcium hydroxide powder placement

B. Calcium hydroxide paste placement

C. Calcium hydroxide point placement

Each tooth was placed separately in air tight plastic phials (50ml) containing 10ml distilled water each as storage medium (figure 3). The changes in pH at various time intervals were recorded using Digital pH Meter. The readings were recorded at 2 hours, 24 hours, 48 hours, 7 days and 14 days after placement of respective intra-canal medicaments.

The distilled water in each plastic phial was shaken properly and the electrode of pH meter was cleaned efficiently before each reading was taken. After inserting the electrode in each phial, the readings were allowed to stabilize, before being noted down (figure 4). In between the stages, the samples were stored in the incubator.

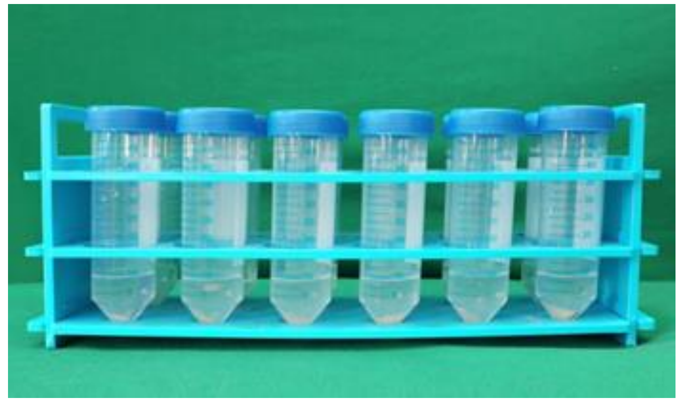

Figure 3: Samples stored in plastic phials containing deionized water

Figure 4: pH level monitored with Digital pH meter

Results

The readings obtained from the study were tabulated and were statistically evaluated using One Way ANOVA (Analysis of Variance) and t-test. Among the tested groups calcium hydroxide powder increased the pH levels to maximum and the calcium hydroxide points

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increased the pH levels minimally at all the specified time intervals (Table 1).

Table 1: Evaluation of changes in pH levels of samples in different groups with gradual time lapse

Groups	2 hours	24 hours	48 hours	7th day	14th day
1 – Empty	7.79±0.152	7.92±0.132	7.84±0.141	7.82±0.112	7.92±0.101
2 – Powder	9.01±0.152	9.25±0.696	9.26±0.774	9.92±0.933	10.49±1.007
3 – Paste	8.79±0.534	8.63±0.486	8.30±0.365	8.31±0.194	8.55±0.222
4 – Points	7.88±0.168	7.89±0.108	7.96±0.122	8.17±0.280	8.38±0.141
ANOVA test (F value)	45.719	45.143	43.076	69.358	94.283
p value	0.000*	0.000	0.000*	0.000*	0.000*

*: statistically significant

Discussion

The success of endodontic treatment is greatly influenced by the extent of the antibacterial environment achieved. Placement of intra-canal medicaments to achieve this sterile environment is an important step while performing endodontic treatment of an infected tooth. Calcium hydroxide has served as a gold standard intra-canal medicament among the various different forms available, since ages. Baran Wal R et al evaluated the biological properties of calcium hydroxide and stated that, when Ca $(OH)_2$ is placed in contact with bacterial cultures, it shows static action.[9]

Ca $(OH)_2$ as an intracanal medicament when comes in contact with the tissue fluid present in dentinal tubules and the periapical region, releases calcium and hydroxyl ions. The hydroxyl ions diffused into the acidic environment are highly active, oxidative free radicals, that tend to react with the bimolecular lipid layer of a bacterial cell.[10] Mohammadi Z et al studied the antimicrobial properties of calcium hydroxide and concluded that the bacterial damage caused by the alkaline environment of calcium hydroxide is irreversible.[11]

The present study was conducted due to the extensive use of different forms of calcium hydroxide by the dentists worldwide. Ca $(OH)_2$ powder has low solubility in water. This property proves beneficial as it permits slow and gradual release of calcium and hydroxyl ions for a longer period. The solubility of powder is often increased by mixing it with an aqueous media.[6]

Premixed commercially available Ca $(OH)_2$ paste Apex Cal (Ivoclar Vivadent) consists of calcium hydroxide, bismuth carbonate (radio-opaquer) and polyethylene glycol (PEG), glycerine and water as the medium. Glycerine due to its viscous nature releases the ions slowly over time.[12] However, PEG in the paste being hygroscopic in nature, allows absorption of water from the surrounding tissue, thus, increases the solubility of the dressing.[6]

In order to overcome the problem of removal, a new form of calcium hydroxide dressing was introduced in the form of gutta-percha impregnated calcium hydroxide points. As suggested by the manufacturer, a drop of sterile water is placed inside the canal besides the Ca $(OH)_2$ point to allow moisture saturation around the dressing and enable ion dissociation. However, thereafter the moisture inside the canal is often maintained by the fluid from dentinal tubules and the apical area.[13] The manufacture instructions suggest passive placement of one Ca $(OH)_2$ point smaller that the apical preparation in each canal.

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The placement of calcium hydroxide powder and paste was done using lentulospirals. Mohammadi Z et al has explained that the Ca $(OH)_2$ paste is thixotropic in nature, that is, the viscosity of the paste in the canal reduces, when agitated with a carrier instrument.[14] Bhalla VK and Chock Attu SJ in a review on delivery systems for Ca $(OH)_2$ placement stated that it is desirable to place a huge amount of Ca $(OH)_2$ slurry in the root canal system. This would help in achieving adequate ph levels and antimicrobial effect in the tissue.[15]

Fulzele P et al claimed that the direct contact of Ca $(OH)_2$ with the tissue initiated the formation of mineralized tissue at the affected site. But, this mineralization was observed from 7th day.[16] Hence, the present study was conducted as a time bound study observing the changes in pH for upto 2 weeks. Moreover, Garg AK et al stated that time played a vital role in effective and complete therapeutic action of calcium hydroxide, when placed as an intracanal dressing.[13]

The results obtained in the present study showed that the time factor display a definite effect on the variation in pH levels of different experimental groups. The initial pH of storage medium (deionized water) was recorded as 7.65. All the experimental groups recorded an increase in pH values with increasing time intervals.

The control group (group 1) despite having empty canals, showed a slight increase in ph levels over time. This could be because of the storage media in which the samples were kept before the experimental purpose. Babu VNS et al in his study quoted that the inherent hydroxyapatite crystals of the tooth tend to release some buffered ions into the storage medium (deionized water).[17]

The calcium hydroxide powder in the present study was mixed with distilled water (group 2) to form a homogenous paste. Hauman CHJ and Love RM proved that the calcium hydroxide powder has low solubility in water, which increased its bio-compatibility and bio-availability to the surrounding tissues.[18] This property of the calcium hydroxide powder is beneficial when used an intra-canal medicament, as it enhanced the slow and continuous release of hydroxyl ions, providing a maintained alkaline environment in the surrounding tissues.

The commercially available calcium hydroxide paste (group 3) used in the study contains polyethylene glycol (PEG) as one of its components. PEG as a vehicle is viscous in nature, hence, commands for a slow release of ions.[8] But, on the other hand, it is hygroscopic in nature, which tends to increase the solubility of calcium hydroxide.[19] This mixed nature of the PEG as one of the constituent is a possible reason for the instant rise in pH for the first 2 hours of the study, followed by reduced and slow release of ions for the remaining days of the study.

The matrix of calcium hydroxide points (group 4) consists of 52% calcium hydroxide and 42% gutta-percha.[13] Alagarsamy V et al stated that calcium hydroxide points had a comparatively lower diffusibility of ions than other forms of calcium hydroxide.[20] Holland R et al stated another possible reason that calcium hydroxide of the points reacted with carbon dioxide and was hence, available as calcium carbonate to the surrounding tissues.[21] This resulted in reduced availability of dispersed ions.

The results obtained in the present study may vary in the in vivo conditions. Variations might occur due to the fact that the natural dentin and the fluid in the dentinal tubules have a buffering action, which could alter the pH readings in the living conditions.[22] Some amount of hydroxyl ions released from the calcium hydroxide

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dressing are buffered and absorbed by the hydrate layer of hydroxyl-apetite crystals. So, more studies need to be done to come to definite conclusion that which forms of calcium better suits the periapical environment and heals the infected lesion to save the tooth.

Conclusion

The purpose of present study was to compare the pH changes in root dentin following intracanal dressing with conventional calcium hydroxide powder, commercial calcium hydroxide paste and calcium hydroxide points.

The readings obtained from the study concluded that:

1. All the experimental groups were capable enough to increase the pH of the storage medium to some extent.
2. Intergroup comparison of the experimental materials showed that the increase in pH levels was maximum for group 2 (calcium hydroxide powder) and minimal for group 4 (calcium hydroxide points).
3. Time dependent intra-group comparison of different forms of calcium hydroxide shows a continuous increase in pH for group 2 (calcium hydroxide powder).
4. However, the pH of Group 3 (calcium hydroxide paste) increased immediately for first 2 hours followed by a sudden decrease for next 48 hours. The pH then increases again till 14th day.
5. The pH of samples in Group 4 (calcium hydroxide points), showed a slow continuous increase of ph levels till 14th day.

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