Introduction

One of the great challenges in endodontic treatment is the cleaning, shaping and disinfection of the root canal spaces. Filing and irrigation methods results in a clean canal surface even in the apical portion of the canal which is commonly considered the most difficult part of the canal to clean.

Root canal obturation in three dimensions is an essential component of root canal treatment which aims to prevent future bacterial contamination or recontamination of the canal space and periapical tissues. When the root canal spaces are not adequately cleaned and shaped before obturation, proper sealing will be jeopardized by the remaining tissue and debris. [(1)]

Endodontic instrumentation alone cannot achieve a sterile condition due to irregularities of the root canal system, for this reason antimicrobial materials are used during instrumentation as intracanal medication. Over the years, medicaments used for this purpose have changed from strong and toxic chemicals to more selective and effective medications such as calcium hydroxide, iodine potassium iodide and chlorhexidine have been tried with variable degrees of success.

Recently, Antibacterial efficacy of triple antibiotic paste has gained a lot of attention. It consists of Ciprofloxacin which has a broad antibacterial spectrum activity & acts against both gram positive & gram negative bacteria by inactivating enzymes & inhibiting cell division, Metronidazole which is effective against obligate anaerobes which are common in the deep dentin of infected root canals & acts by disrupting bacterial DNA and tetracycline which acts by inhibiting protein synthesis and inhibiting matrix metalloproteinase enzymes.

The intra-canal medication must be completely removed from the root canal walls prior to the final obturation in order to obtain the best interface possible between canal walls and the filling material.

It has been reported that chemical agents used during endodontic treatment might cause an alteration in the chemical and physical properties of dentin in terms of microhardness, and permeability [(2, 3)]. Also, changes in the mineral content of superficial dentin may adversely affect the sealing ability and adhesion of dental materials such as resin-based cements and resin based root canal sealers to dentin [(4)].

Review of Literature

Rationale for use of intracanal medications:

The basis of endodontic treatment depends on identifying and eliminating the causative factors in the development of apical periodontitis so that optimal healing can be achieved. The role of bacteria and their byproducts in the pathogenesis of apical periodontitis has been clearly established [(5)].

An improved prognosis has been shown for teeth after a negative culture has been obtained compared with teeth having a positive culture at the time of obturation [(6)]. Antibacterial intracanal medication has been advocated to eliminate remaining bacteria after canal instrumentation and irrigation.

Many medicaments have been used as intracanal dressings [(7)] and according to their chemical basis, generally fall into the following categories: phenolic compounds, iodine–potassium iodide, calcium hydroxide, antibiotics, and various combinations.

The most popular intracanal medicament in use currently is calcium hydroxide. Calcium Hydroxide is a substance that inhibits microbial growth in canals [(8)]. The antibacterial effect of $Ca(OH)_2$ is due to its alkaline pH (12 to 13).

It also dissolves necrotic tissue remnants and bacteria and their byproducts [(9)]. It can be placed as a dry powder, a powder mixed with a liquid such as water, saline, local anesthetic or glycerin, or a proprietary paste supplied in a syringe [(10)].

Amanda et al. [(11)] performed an evidence based analysis for the antibacterial effectiveness of intracanal medicaments used in the management of apical periodontitis (problem, intervention, comparison, outcome) strategy was developed to identify studies dealing with calcium hydroxide, phenolic derivatives, iodine–potassium iodide, chlorhexidine and formocresol.

They concluded that studies did not address issues of culture reversals or false positive and false negative cultures. The main component of antibacterial action appears to be associated with instrumentation and irrigation, although canals cannot be reliably rendered bacteria free. Calcium hydroxide remains the best medicament available to reduce residual microbial flora further.

Lele et al. [(12)] compared the antibacterial efficacy of formocresol, 2% gluteraldehyde and iodine potassium iodide by obtaining cultures of consecutive appointments in multiple visit pulpectomies in primary molars. Formocresol and 2% gluteraldehyde were more effective as intracanal medication and cause significant reduction in the count of aerobic and anaerobic microorganisms.

Shaul et al. [13] evaluated the antibacterial effect of iodine potassium iodide and calcium hydroxide on dentinal tubules infected with Enterococcus faecalis at different time intervals. Hollow cylinders of bovine root dentin (n=45) were divided into three equal groups filled with either IKI or $Ca(OH)_2$ and a positive control. After placing each medicament in the infected cylinders for time periods of 10 minutes, 48 hours and 7 days, microbiological samples were analyzed at the end of each period 400µm thick from each specimen were removed using dental burs of increasing diameters. Dentin powder was cultured on agar plates to quantitatively asses their infection, expressed in colony forming units. It was found that all the layers of the positive control group had a heavy bacterial infection. After 10 minutes, IKI reduced the amount of viable bacteria more efficiently than $Ca(OH)_2$, wheras at later time intervals $Ca(OH)_2$ showed the best results. They concluded that IKI has a more efficient antibacterial effect in the dentinal tubules for short periods of exposure but $Ca(OH)_2$ performs better after longer duration of exposure.

Soares et al. [14] evaluated the residual antibacterial activity of several calcium hydroxide pastes, placed in root canals of dogs teeth with induced chronic periapical lesions.

Root canals were instrumented with the Profile rotary system and filled with 4 pastes G1(n=16):$Ca(OH)_2$ paste + anesthetic solution; G2(n=20): Calen paste +camphorated p-monochlorophenol (CMCP); G3(n=18): Calen paste; and G4 (n=18): $Ca(OH)_2$ paste +2% chlorhexidine digluconate. After 21 days, the pastes were removed with size 60 k-files and placed on Petri plates with agar inoculated with Micrococcus luteus ATCC. Pastes that were not placed into root canals served as control. After pre-diffusion, incubation and optimization, the inhibition zones of bacterial growth were measured and analyzed. All pastes showed residual antibacterial activity. The control samples had larger halos ($p<0.05$). The mean residual antibacterial activity halos in G1, G2, G3, and G4 were 7.6;10.4;17.7 and 21.4mm, respectively. The zones of bacterial growth of G4 were significantly larger than those of G1 and G2 ($p<0.05$).

Siren et al. [15] studied the antibacterial effect of calcium hydroxide combined with chlorhexidine or iodine potassium iodide preparations in bovine dentine blocks. It was found that calcium hydroxide was unable to kill E.Faecalis in the dentin, calcium hydroxide combined with IKI or CHX effectively disinfected the dentine. It was concluded that the addition of CHX or IKI did not affect the alkalinity of the calcium hydroxide suspensions.

Mahdi et al. [16] compared the antimicrobial efficacy of six calcium hydroxide formulations (mixed with saline, lidocaine 2%, Iodine potassium iodide 2% and glycerin) on Enterococcus faecalis using agar diffusion test. Twelve culture plates were incubated with E.faecalis. Five cavities were made in each plate with 5mm diameter and 4 mm depth. Two plates were randomly considered for each calcium hydroxide formulation and filled completely with creamy mixture of tested materials. The plates were incubated at 37ºC for 48 hours. The diameter of inhibition zone around each well was recorded in millimetres and data were submitted to ANOVA and Tukey test. The results showed that all tested calcium hydroxide pastes had good antimicrobial activity. The antimicrobial activity of calcium hydroxide mixed with lidocaine, CHX 2% and IKI 2% were significantly greater than that of calcium hydroxide mixed with saline ($p<0.001$). No significant differences in the antimicrobial activity were found between the other groups ($p>0.01$).

Attia et al. [17] compared the antimicrobial effect of $Ca(OH)_2$ paste, CHX gel and Antibiotic-Corticosteroid paste against Streptococcus mutans, Enterococcus Faecalis and Candida albicans in root canal lumen and radicular dentin. Eighty four single rooted extracted human teeth with straight root canals were selected, decoronated leaving root segments of 15mm length.All canals were prepared up to size 40 master apical file under irrigation with sodium hypochlorite solution. Roots were sterilized, infected by mixed suspension of the three types isolated microorganisms and incubated at 37^{o}C for 14 days. The roots were divided into 4 equal groups according to the intra canal medication used. Each main group was further subdivided into 3 subgroups according to the isolated organism. The medicated roots were incubated for 7 days at 37^{o}C then irrigated to remove the medications. Two samples were taken from each canal, one from root canal lumen and the other from radicular dentin and cultured on three media selective for each tested microorganisms. The growing colonies were counted and recorded as colony forming units. Results showed that chlorhexidine gel showed the best effect against all tested microorganisms at both experimental sites, while Antibiotic –Corticosteroid paste was the worest one.

Siqueira et al. [(18)] evaluated the antibacterial activities of medicaments that acts by means of contact, and not by vapor release, against obligate and facultative anaerobic bacteria commonly found in endodontic infections. They used 0.12% chlorhexidine gel; 10% Metronidazole gel; calcium hydroxide plus distilled water, calcium hydroxide plus camphorated paramonochlorophenol; and calcium hydroxide plus glycerin.

An agar diffusion test was used, and the zones of bacterial inhibition around each medicaments were recorded and compared. The results revealed that calcium hydroxide – CPMC paste was effective against all bacterial strains. Chlorhexidine was also inhibitory to all strains. Metonidazole also caused inhibition of growth of all obligate anaerobes calcium hydroxide mixed with distilled water or glycerin failed to show zones of bacterial inhibition.

Effect of standard intracanal medication on the bond strength of root canal sealer to dentin:

The medicaments for endodontic treatment are the clinical factors in influencing dentin bonding to the root canal sealers.

Ceci N et al. [19] evaluated the influence of calcium hydroxide paste used as intracanal medication on the bond strength of AH Plus (AH) and Epiphany sealers to root dentin. Sixty palatal canals were prepared in human maxillary first molars, using a rotary system. Half of the specimens received distilled water, and the other ones intracanal medication with $Ca(OH)_2$ for 14 days.The $Ca(OH)_2$ was removed and both groups were further divided into two subgroups, filled with either AH or EP. the test specimens were submitted to the micro push-out test at speed of 0.5 mm min Results were statistically analyzed with

ANOVA and Tukey's test Showing that The use of $Ca(OH)_2$ had statistically significant ($P< 0.05$) influence on AH only, increasing its bond strength from 19.7 ± 4.5 to23.8 ± 2.5 (mean ± SD in MPa). In both EP groups, with (1.8 ± 0.5 MPa) and without (1.5 ± 0.9 MPa) $Ca(OH)_2$, the bond strength values were statistically significantly lower than in either of the AH groups ($P< 0.05$).

João V et al. [20] evaluated the bond strength of Epiphany™ resin-based sealer to dentin walls after placement of calcium hydroxide dressings. Fifteen extracted single-rooted human teeth were instrumented using 2.5% NaOCl + EDTA as irrigants, The teeth were randomly assigned to 3 groups (n=5), according to the intracanal dressing: G1= $Ca(OH)_2$ + saline; G2= $Ca(OH)_2$+ 2% chlorhexidine gluconate (CHX) gel; and G3= saline (control). After 10 days of storage in 100% humidity at 37°C, the dressings were removed and the root canals were filled with Epiphany™ sealer. After additional 48 h of storage, the specimens were sectioned transversally into 2-mm-thick discs. Push-out tests were performed and the maximum loads at failure were recorded in MPa. One-way ANOVA and Newman-Keuls tests showed a statistically significant decrease in bond strength when a $Ca(OH)_2$ dressing was used before root canal filling with Epiphany™. (G1= 10.18 ± 1.99 and G2= 9.98 ± 2.97) compared to the control group (13.82 ± 3.9) ($p< 0.05$). It was concluded that the use of

$Ca(OH)_2$ as an intracanal dressing material affected the adhesion of Epiphany™ to the root canal walls, but even though the values were within the acceptable.

Manicka et al. [21] compared the effect of various endodontic irrigants and intracanal medicaments on push out bond strength to root canal dentin. Seven groups with seven samples each were treated with 0.2% chlorohexidine gluconate, 3% NaOCL and 3% hydrogen peroxide, isotonic saline. The medicaments used were calcium hydroxide and formcresol. C & B bond was used and the samples were subjected to push out tests. It was shown that calcium hydroxide and formocresol did not influence bond strength significantly whereas sodium hypochorite, hydrogen peroxide and their combination had a determental effect. Chlorohexidine had a positive effect and increase the bond strength values.

Joao et al. [22] evaluated the bond strength of different root canal sealers to dentin after different irrigation protocols. Forty extracted single rooted human teeth are used, one group irrigated with 2.5% NaOCL +17% EDTA and the other group irrigated with saline, each group is subdivided into four subgroups and filled with epiphany sealer, Endorez, AH26 and Grossman sealer, stored two weeks in 100% at 37ºC, all teeth were sectioned transversally into 2mm thick disc and push out test were performed at a cross head speed of 1mm /min using a universal testing machine. Results showed that epiphany sealer presented the higher bond strength values to dentin in both irrigating protocols, and the use of 2.5 % NaOCL and 17%EDTA increased the bond strength values for all the sealers.

Yakup et al. [(23)] investigated the effects of calcium hydroxide $Ca(OH)_2$ and propolis intracanal medications on bond strength of AH Plus to root dentin. After chemomechanical instrumentation using Revo-S rotary system, three groups of root canal specimens were prepared: 10 root canals were left untreated as controls (G1), 10 received $Ca(OH)_2$ (G2), and another 10 received propolis intracanal medicaments (G3). Canals were obturated with AH Plus and gutta-percha. After bond strength evaluation using micro push-out test, data were analyzed using ANOVA and Tamhane test ($p=0.05$).At the coronal and middle thirds, there were no significant differences in bond strength among the three groups ($p<0.05$). At the apical third, G3 was significantly superior to G2 ($p<0.05$) and G1 ($P<0.05$), but there was no significant difference between G2 and G1 ($P<0.05$). They concluded that when AH Plus was used as the sealer in endodontic treatments, its combined use with propolis as an intracanal medicament seemed to result in favorable sealer-dentin interfacial bond strength.

Influence of standard intracanal medication on dentin mechanical and physical properties:

Semra et al. **[24]** evaluate Ca^{2+} & OH^{-} diffusion properties through root dentin by using different cacium hydroxide dressing materials. Twenty-eight single rooted teeth were instrumented & external defects were created on the root surface.

17% EDTA was used to eliminate the smear layer. All surfaces except the external defects were sealed and the teeth were placed in normal saline. Ca^{2+} Concentration & the pH in the saline were determined for 3 days as the control period. After removing the teeth from normal saline they were filled with: i) DT temporary dressing $Ca(OH)_2$, ii) $Ca(OH)_2$ powder and normal saline, iii) $Ca(OH)_2$ temp canal & iv) $Ca(OH)_2$ points. The teeth were then placed in normal saline & Ca^{2+} concentration & PH values were measured at 1, 3, 7, 14 & 28 days. Non setting $Ca(OH)_2$ pastes gradually released Ca, wheras this increase was abscent from $Ca(OH)_2$ points. None of the test materials induced a PH increase in the media during the observation periods. It was concluded that when $Ca(OH)_2$ pastes are applied to the root canal, Diffusion of Ca^{2+} without an increase in pH to the surrounding media occurs.

Koshy et al. [25] evaluated the long term effect of calcium hydroxide-glycerin combination on the microhardness of human radicular dentin. One hundred and fifty freshly extracted single rooted human premolars were decoronated at the cement-enamel junction and the root canals were instrumented with protaper rotary files. The teeth were then randomly divided into three groups with 50 teeth in each group, where group I & II had teeth with calcium hydroxide application for 30 and 90 days and group III had teeth with saline application for 90 days.The teeth in all groups were sectioned longitudinally into two equal slabs and then subjected to Vickers microhardness testing. Statistical analysis was performed with the aid of SPSS v 12.0 software and the data were analyzed using One-Way ANOVA and Tukey's HSD test showing that therewas a significant reduction ($p<0.001$) in the hardness values of specimens in group II as compared to group I and III.

Rosenberg et al. [26] studied the effect of calcium hydroxide root filling on microtensile fracture strength of teeth. 40 extracted human disease free permenant maxillary incisors were utilized, the teeth were hand and rotary instrumented and vertically compacted with United States Pharmacopenia calcium hydroxide. The teeth were stored in a moist environment for 7, 28, &84 days. The MTFs of the teeth was Measured using an Instron machine. Data were assessed statistically using an unpaired t-test. It was concluded that calcium hydroxide weakened the MTFs of the teeth by 13, 9 Mpa per 77 days.

Elgendy et al. [27] investigated the effect of Propolis on the fracture resistance of root dentin compared to Triple antibiotic paste and Chlorhexidine. The root canals of mandibular premolars (n=180) were instrumented and randomized into four groups; Group PRP, TAP, CHX and control group according to the medicament used. Teeth were incubated in 100% humidity at 37ºC for 3 days, one week and one month. After each period, teeth were subjected to a fracture resistance test. Two-way ANOVA and Tukey's post hoc pairwise test were used for statistical analysis.

Result showed no significant difference was found between groups after 3 days and one week, there was a significant decrease ($p<0.0001$) in fracture resistance after one month for both TAP and PRP while the decrease was not significant for CHX and the control group.

Glen et al. [28] studied the alteration of fracture resistance of human root dentin after exposure to intracanal calcium hydroxide. They utilized 102 freshly extracted single rooted human teeth divided into 3 groups (n=34), coronal access and endodontic instrumentation using stainless steel file and Profile GT rotary files were completed for each tooth.

The prepared root canal system of each tooth was filled with saline solution (group1), USP $Ca(OH)_2$, (group 2),