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Methyl Prednisolone with Iontophoresis in the Treatment of Dentine Hypersensitivity. An In-Vitro and In-Vivo Study

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Abstract: *Subjects fulfilling inclusion and exclusion criteria were evaluated for hypersensitivity and randomly divided into four groups: group A receiving 2% sodium fluoride, group B receiving 10% strontium chloride, group C receiving 0.125% methyl prednisolone and group D distilled water. All the reagents were applied through iontophoresis. The result was evaluated immediately, one week, three weeks and six weeks after the application of the reagent. SEM study was done on dentine specimens after application of above mentioned reagents through iontophoresis. After statistical analysis, it was found that comparison between groups A and B was statistically non-significant, groups A and C, groups A and D, groups B and C, groups B and D and groups C and D were significant. In SEM analysis maximum occlusion of tubules was seen in sodium fluoride group. It was concluded that single application of the above mentioned desensitizing reagents through iontophoresis proved to be better therapeutic reagents in comparison with distilled water.*

Key words: *Dentine hypersensitivity, iontophoresis, methyl prednisolone, sodium fluoride and strontium chloride.*

I. Introduction

Dentine hypersensitivity is one of the most painful and least predictably treated chronic conditions in dentistry. It is estimated that one in every seven people experience occasional pain due to dentine hypersensitivity, the incidence tends to peak around the third decade of life[1] with women showing more prevalence.[2] This condition generally involves the facial surfaces of teeth near the cervical margin[2], and is very common in upper premolars followed by upper first molars with the incisors being the least sensitive teeth[3] Despite its acute character, and because it is not spontaneous but rather stimulated, dentine hypersensitivity can be considered as a chronic pain condition.[4]

The rapid movement of fluid in dentinal tubules in response to certain stimuli was postulated many years ago to explain the sensitivity of dentine.[5] Considerable evidence has accumulated in support of this hydrodynamic theory and is considered the mechanism by which the pain associated with dentine hypersensitivity is produced. This theory postulates that rapid shifts, in either direction, of the fluids within the dentinal tubules, following stimulus application, result in activation of sensory nerves in the pulp/inner dentine region of the tooth.[6]

Currently there are many agents used to manage hypersensitivity. Various chemical compounds have been used for occlusion of open dentinal tubules.[7] Among these sodium fluoride has been largely used for these purpose. Topical fluoride applications create a barrier by precipitating calcium fluoride (CaF2) on the tooth surface, blocking patent dentinal tubules and, hence, reducing permeability and hypersensitivity.[8] Several studies have reported on effectiveness strontium chloride in managing dentinal hypersensitivity. Strontium deposits are produced by an exchange with calcium in dentin, resulting in recrystallization in form of strontium apatite complex. This type of precipitation is known to reduce the diameter of open tubules.[9] Anti-inflammatory agents such as corticosteroids have been proposed for use to manage dentine hypersensitivity.[7] When applied to dentin steroids increased peritubular mineralization. Steroid application to dentin increased peritubular dentin mineralization. Thus, the tubule lumen would be decreased, resulting in less dentin tubule fluid movement, reducing the dentinal sensitivity.[10]

Iontophoresis uses low amperage direct electrical current to introduce ions or ionized drugs into tissues. This procedure allows a concentrated application of drug in a desired localized area.[11]

The aim of the study was to evaluate the treatment strategies for dentinal hypersensitivity by using single application of various agents such as sodium fluoride, strontium chloride, methyl prednisolone and distilled water (control) clinically as well as under scanning electron microscope with iontophoresis.

II. Materials And Methods

1.1 In Vivo Study

Study Population: Sixtyfour patients in the age range of 20 to 55 years were selected from the outpatient Department Of Periodontology and Oral Implantology, Luxmi Bai Institute Of Dental Sciences And Hospital,

Patiala (Punjab). The study protocol was approved by the institutional review committee and informed consent forms signed.

Screening Criteria: All the selected participants fulfilled the following criteria -patient with a history of dentinal hypersensitivity due to exposure of root surface by periodontal disease, the labial surfaces of the anterior teeth were selected, hypersensitivity due to abrasion, erosion and attrition. The patients who were excluded were - those who had chipped teeth, cracked tooth syndrome, and periodontal pockets, those who had pulpal response to caries or to restorative treatment, those whose hypersensitive area was not accessible, those who were taking anti-inflammatory drugs or were using desensitizing pastes or such other remedies.

Evaluation tests

The specific tooth was isolated by cotton rolls and subjected to tactile, air blast and cold water tests:

Tactile test: Dental explorer tip was kept perpendicular to the tooth while a sweeping motion was performed across its sensitive surface.

Air blast test: The nozzle tip of an air syringe was kept about 1 - 2 cm away from the isolated tooth and then a blast of air was directed on the tooth for one second.

Cold water test: A disposable syringe was filled with ice-cold water and the water was poured on the suspected isolated tooth surface drop by drop.

VRS (Verbal Rating Scale) was used to record scores:-

1. No significant discomfort or awareness of stimulus,
2. Discomfort, but no severe pain,
3. Severe pain during application of stimulus,
4. Severe pain during and after application of stimulus.

After the test, the teeth rated 2 or more for any of the two tests were selected for study. The 64 patients selected were randomly divided into four equal groups of 16 patients each.

Application of Agents

Group A. 2% sodium fluoride was prepared by adding distilled water to 2gm of sodium fluoride in powdered form to make it 100ml.

Group B. 10% strontium chloride was prepared by adding distilled water to 10gm of strontium in powered form to make it 100ml.

Group C. 0.125% methyl prednisolone was prepared by adding 7ml of distilled water to 1 ml of 1% of methyl prednisolone solution.

Group D. distilled water.

In each group the respective desensitizing agent was freshly prepared and applied to the hypersensitive teeth with the help of iontophoretic unit. Dosage of the current was 0.5mA for 2 minutes. Severity of sensitivity was assessed before application, immediately after application, after one week, after three weeks and after 6 weeks. The data was then statistically analysed.

1.2 In Vitro Study

Recently extracted thirty-two caries-free teeth were selected. Sectioning was done from cervical region of the buccal surface with a diamond disc at a low speed under water irrigation in mesiodistal diection. Enamel was removed from each sample to expose the underlying dentine. Sample size 5mm × 5mm was obtained. All the samples were rinsed and stored in phosphate buffer saline until use. 6% citric acid was applied for 2 minutes on the samples to expose dentinal tubules and simulate hypersensitive dentin. The samples were randomly assigned into four groups: group A: receiving 2% sodium fluoride, group B: receiving 10% strontium chloride, group C: receiving 0.125% methyl prednisolone and group D: receiving distilled water. Desensitizing agents were applied on to the samples for 2 minutes with iontophoretic unit delivering 0.5mA current. Specimens were dehydrated in an ascending concentration of ethanol solution in the following manner: 25% ethanol for 5 minutes, 50% ethanol for 5 minutes, 75% ethanol for 5 minutes, 95% ethanol for 5 minutes and 100% ethanol for 5 minutes. After dehydration in ethanol specimens were allowed to air dry for 2 minutes on filter paper. Dried samples were analyzed by SEM (Scanning Electron Microscope).

III. Results

The statistical analysis was performed using standard deviation, wilcoxon signed ranks test, mann-whitney test was used for comparison of two groups, and kruskal-wallis test. In the SEM study, results obtained were statistically analyzed using ANOVA test.

The mean value for group A showed highest reduction in sensitivity immediately after application of the reagent i.e statistically highly significant. (**Figure 1)**. In group B highest reduction in sensitivity was observed immediately after application of the reagent i.e statistically highly significant and statistically significant at 3 weeks. (**Figure 2).**

In group C the mean value showed highest reduction in sensitivity immediately after application of the reagent i.e statistically highly significant. The result was also statistically highly significant when 6 weeks values were compared with the values of immediately after application of the reagent (**Figure 3)**. The mean value for group D reduced slightly 6 weeks after application. (**Figure 4). Figure 5** shows comparison of reduction in sensitivity using tactile, air blast and cold water tests between group A, B, C and D at different time intervals. **Figure 6**: bar diagram showing intergroup comparison of total and occluded tubules. **Figure 7:** SEM image of 2% sodium fluoride. **Figure 8:** SEM image of 10% strontium chloride. **Figure 9**: SEM image of 0.125% methyl prednisolone. **Figure 10**: SEM image of distilled water.

IV. Discussion

The term hypersensitive dentine implies a short, sharp pain arising from exposed dentin in response to stimuli typically thermal, evaporative, tactile, osmotic or chemical and which cannot be ascribed to any other form of dental defect or disease."[12]

In the present study, all the sixty-four patients, randomly divided into four groups completed the 6 weeks study. All the selected teeth were subjected to three different test stimuli: Tactile, Air Blast & Cold Water Test stimulus. The least disturbing stimulus (Tactile test) should be used first, with the most disturbing (Cold water test) used last so that one stimulus does not interfere with others. Each of these tests was performed with an interval of 5 minutes.[13] For all the stimuli, patient response was recorded on Verbal Rating Scale which is graded from 0 to 3.[14] The teeth rated 2 or more for any of the two tests were selected for the study.[15]

Severity of sensitivity was assessed immediately before application, immediately after application, one week after application, three weeks after application and six weeks after application.[16] As per Bartold's classification we have selected three different desensitizing agents, each having different mechanism of action. Sodium fluoride plugs the dentinal tubules, strontium chloride protein precipitant and corticosteroids having anti-inflammatory action and distilled water as control.

After the tests were performed, desensitizing agents were applied through iontophoresis for two minute and 0.5MA of current. Several hypothesis have been proposed by which iontophoresis produces desensitization of dentin. One mechanism proposed by Lefkowitz (1963)[17] involves the formation of reparative dentin following application of current to dentin, which results in dead tracts in primary dentin. A second possible explanation of iontophoresis is that the electrical current produces paresthesia by altering the sensory mechanisms of pain conduction. A third alternative explanation of iontophoretic desensitization is that iontophoresis act by influencing ionic motion by electric currents which may enhance ion uptake by the dentinal tubules and aid in achieving desensitization.[16]

Single application of all the three agents effectively reduced dentin hypersensitivity compared with the control reagent. Out of the four, excellent results were seen with 2% sodium fluoride and 10% strontium chloride (which were statistically insignificant when compared with each other). 0.125% methyl prednisolone depicted moderate reduction in sensitivity.

Single application of 2% sodium fluoride showed best results in 1 week and 3 weeks after application. This is so because maximum uptake of fluoride occurs in this time period. Sodium fluoride forms calcium fluoride there by occluding the dentinal tubules, or by increasing the amount of reparative dentin,[10] Kern et al in 1989 concluded that 2% sodium fluoride iontophoresis reduced sensitivity more than the 2% sodium fluoride used alone.[18] The crystal size of calcium fluoride is very small (approximately 0.05µm), and therefore a single application of sodium fluoride has less effect on dentin permeability. Furthermore, it has been shown that fluoride is lost fairly rapidly because these crystals are soluble in saliva.[19]

Single application of 10% strontium chloride showed best results immediately after application on day 0 and good results at 1 week, 3 weeks and 6 weeks after application. Strontium chloride is protein precipitating agent and its mechanism action is through organic precipitation and odontoblast denaturation forming a sealing film that prevents fluid movement and has an occlusive action.[20] Kun in 1976 found that topical application of concentrated strontium chloride on an abraded dentin surface produced a deposit of strontium that penetrated dentin to a depth of approximately 20 µ and extended into the dentinal tubules. Hodges and colleagues in 1946 showed that strontium adsorbs to calcified tissues. It has been suggested that strontium deposits are produced by

an exchange with calcium in the dentin resulting in recrystallization in the form of a strontium apatite complex.[21]

With single application of 0.125% methyl prednisolone, moderate results were obtained at day 0 immediately after application, 1 week and 3 weeks after application. Steroids are known to produce anti inflammatory effect.[19] When applied to dentin steroids increased peritubular mineralization. Thus, the tubule lumen would be decreased, resulting in less dentin tubule fluid movement, reducing the dentinal sensitivity.[10] The formation of dentin has been ascribed to medication with high doses of corticosteroids. Excessive formation of one like substances and disorganized odontoblasts in pulp chamber is seen in histological sections. The width of predentin zone could be approximately four times greater than in normal teeth and extensive formation of secondary dentin could be seen in some cases. Some studies have shown fibrosis of the entire dentin in histological sections.[22] Prednisolone reduces the permeability of the wall of the mast cells, preventing the escape of histamine and heparin, the enzymes responsible for inflammatory reaction. These results are in accordance with findings of Mosteller JH (1962).[23]

In case of distilled water desensitization moderate results were obtained in 1 week and 3 weeks. This was mainly due to electric current through iontophoresis which resulted in formation of secondary dentin and dead tracts in primary dentin.

In VITRO study total of 32 dentin specimens were obtained from extracted maxillary and mandibular teeth. The teeth used in this study were sectioned near the cementoenamel junction to obtain the experimental surface because the numbers of dentinal tubules are greater in this part of the crown.[24] All the samples were rinsed and stored in phosphate buffer saline until use.[25] To maximize permeability and to more closely simulate hypersensitive dentin, the dentin discs were acid-etched in 6% citric acid for 2 minutes to remove smear layer just prior to testing of various reagents.[26] After application of the respective agents with iontophoresis, specimens were dehydrated with graded series of ethanol (25%, 50%, 75%, 95% and 100%) and SEM analysis was performed.[27] Maximum occlusion of tubules was observed with sodium fluoride because of its tubule occluding mechanism of action. Whereas strontium chloride has protein precipitating and tubule occluding mechanism of action. In our study we have observed only tubule occlusion under Scanning electron microscope. Therefore less number occluded tubules are seen in case of strontium chloride as compared to sodium fluoride under Scanning electron microscope. Main action of methyl prednisolone is it acts as an anti-inflammatory agent. It also increases peritubular mineralization therefore lesser number of tubule occlusion is achieved with it when compared to sodium fluoride and strontium chloride. No tubule occlusion is achieved with distilled water.

V. Conclusion

The following conclusions can be drawn, when results of all the four desensitizing agents were compared Sodium fluoride showed the best results 1 week after application Strontium chloride retained its effects up till 6 weeks.

Methyl prednisolone is reasonably effective in reducing dentine hypersensitivity.

The effect of distilled water is mainly due to electric current in iontophoresis which forms secondary dentin. Since the clinical studies have proved the ability of the methyl prednisolone solution to reduce dentine hypersensitivity its routine use in dentistry may be indicated.

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FIGURE. 1

Showing Comparison of Reduction In Mean Scores Using Tactile Test, Air Blast Test And Cold Water Test Between Group A at Different Intervals.

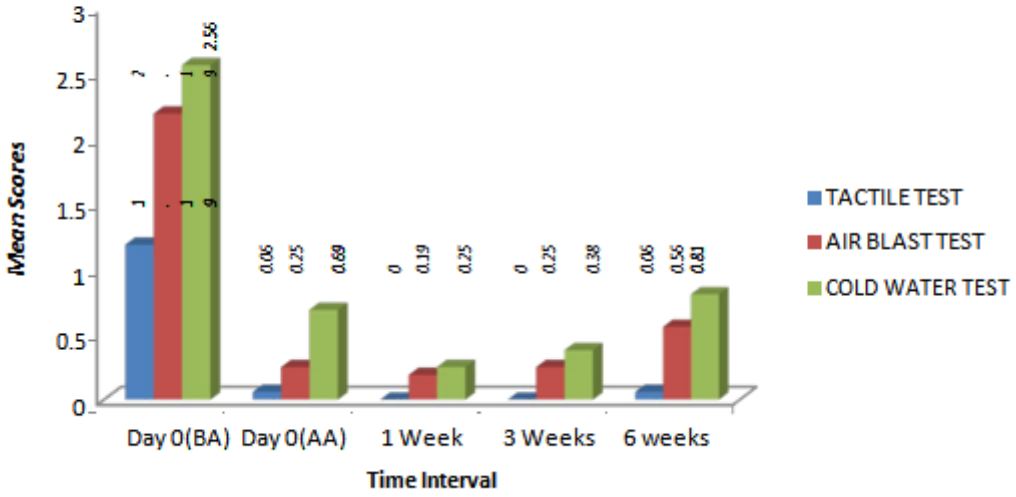


FIGURE. 2
Showing Comparison of Reduction In Mean Scores Using Tactile Test, Air Blast Test And Cold Water Test Between Group B at Different Intervals.

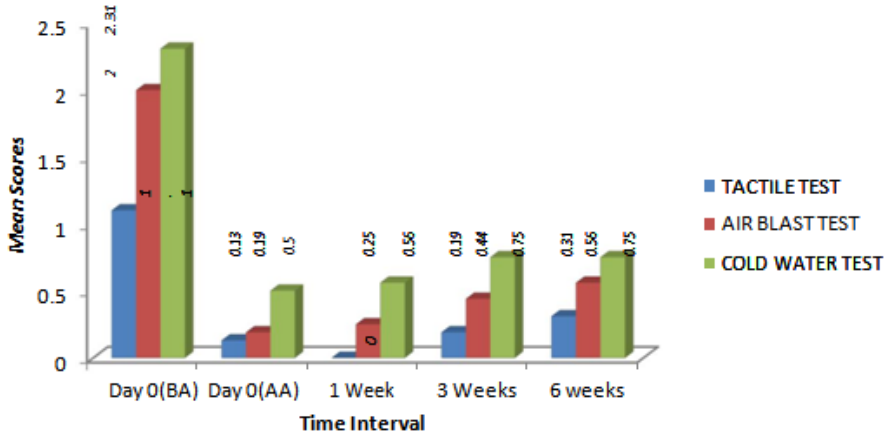


FIGURE. 3
Showing Comparison of Reduction In Mean Scores Using Tactile Test, Air Blast Test And Cold Water Test Between Group C at Different Intervals.

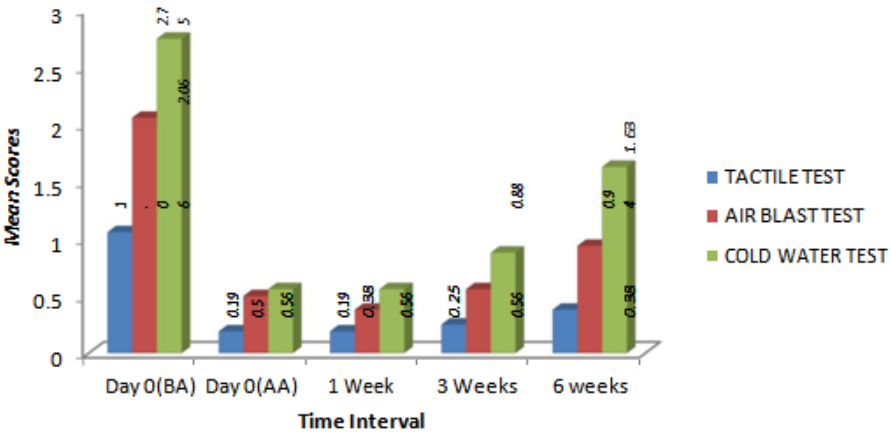
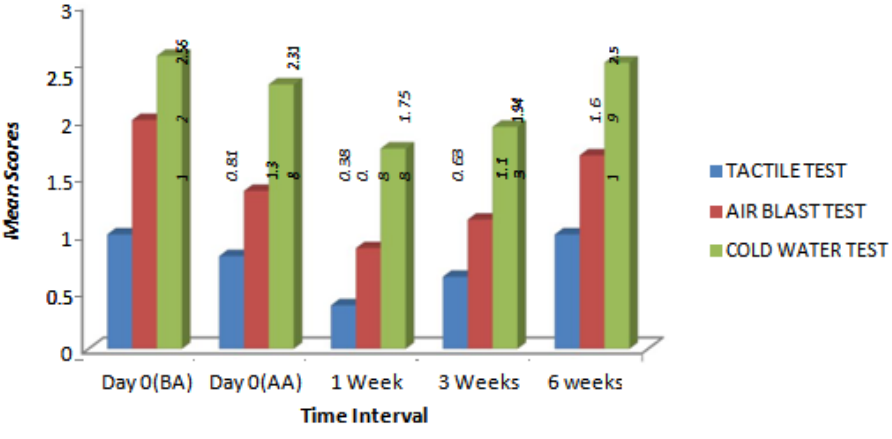
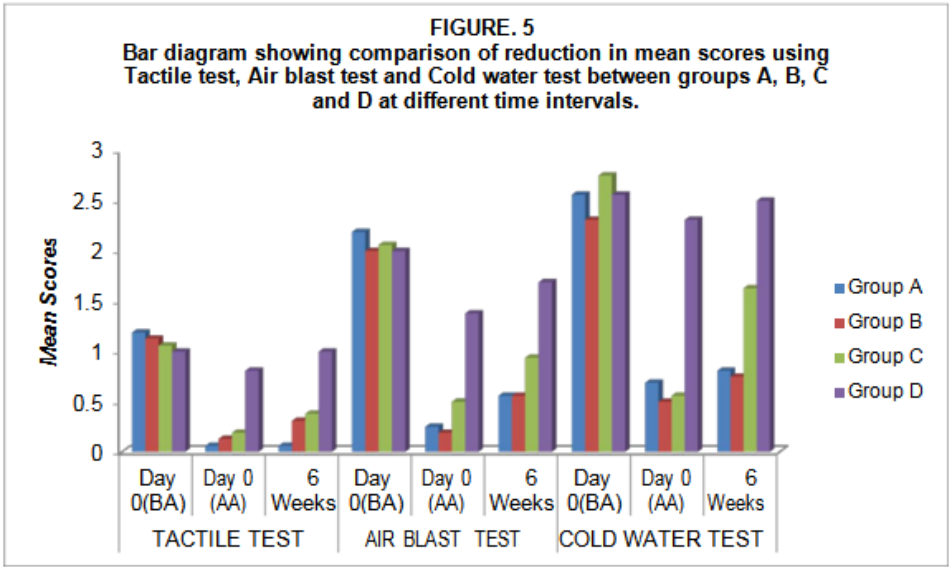


FIGURE. 4
Showing Comparison of Reduction In Mean Scores Using Tactile Test, Air Blast Test And Cold Water Test Between Group D at Different Intervals.





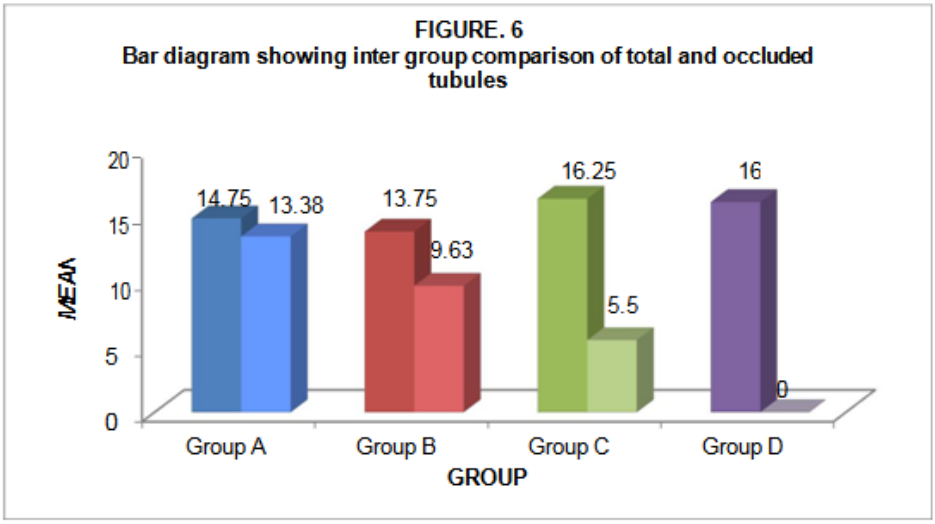


FIGURE 7: SEM image of 2% sodium fluoride

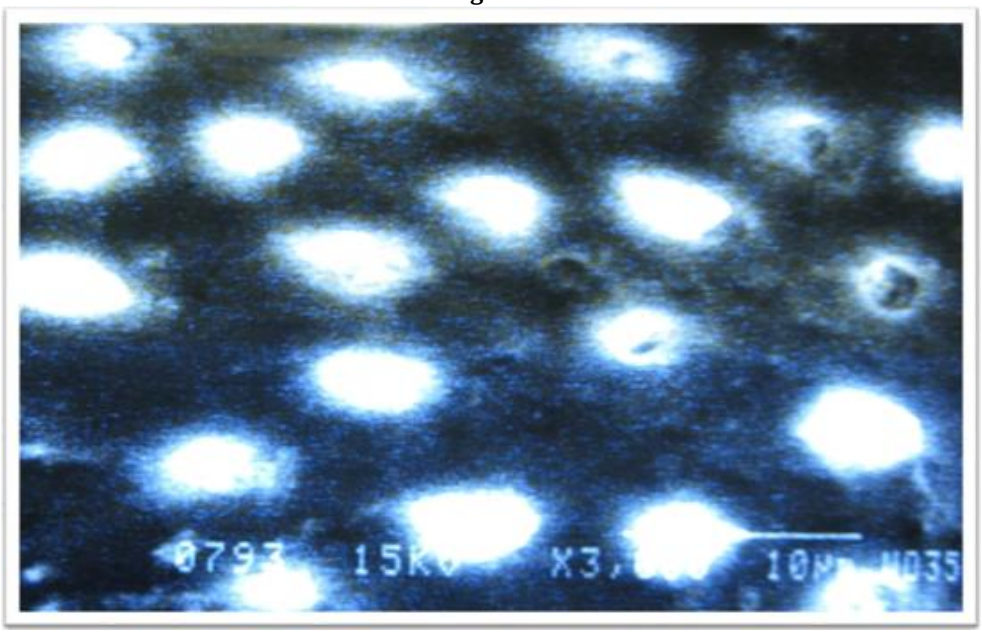


FIGURE 8: SEM image of 10% strontium chloride

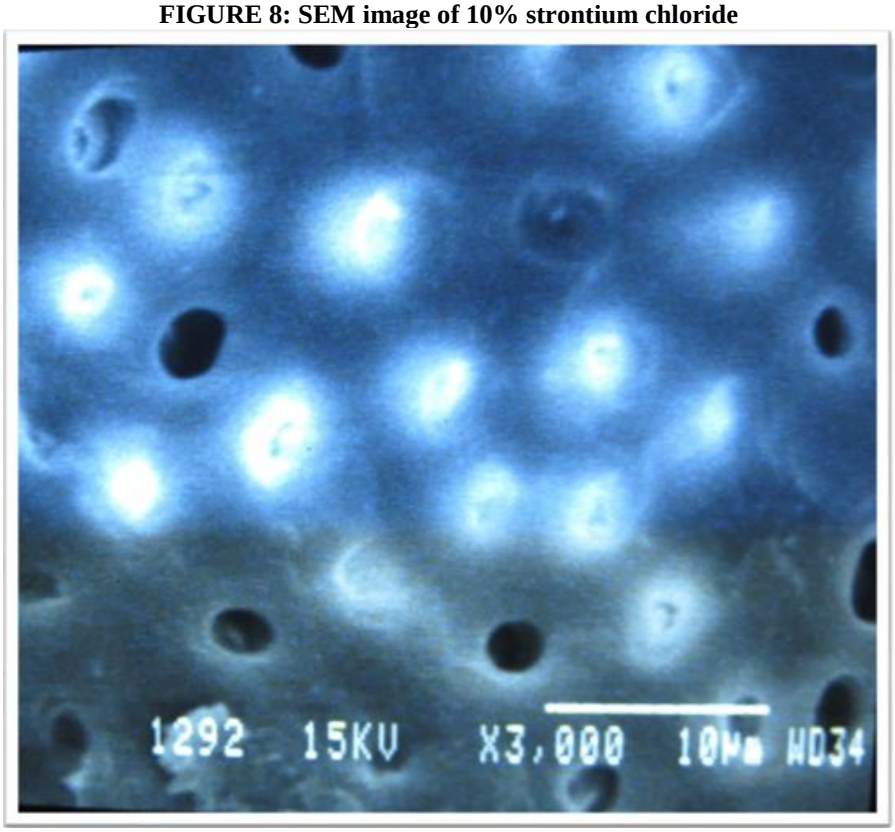


FIGURE 9: SEM image of 0.125% methylprednisolone

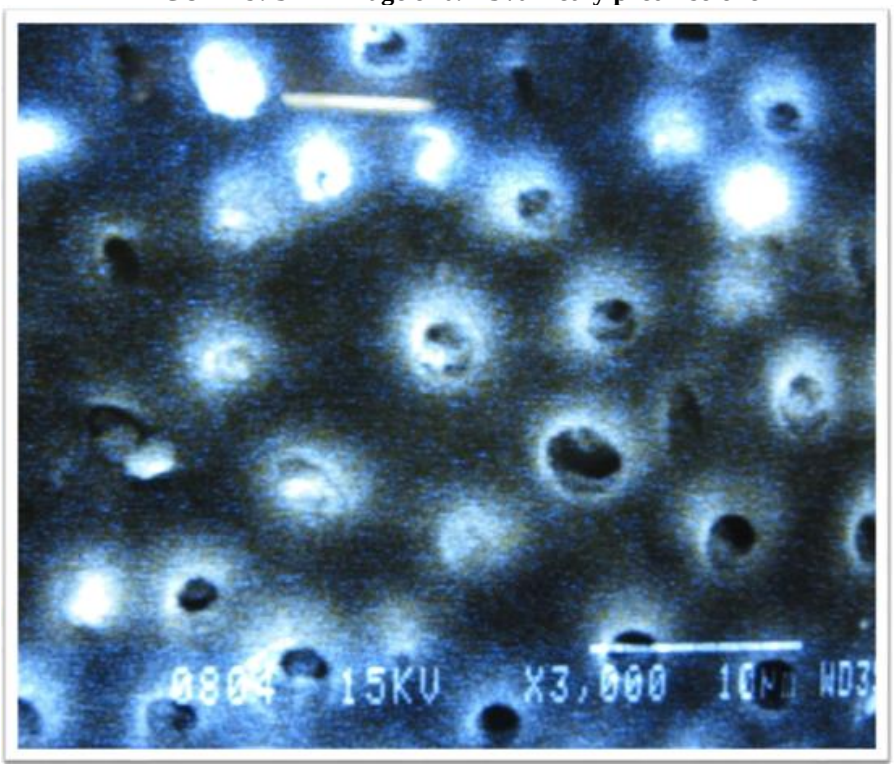


FIGURE 10: SEM image of distilled water