ORIGINAL ARTICLE

Comparison of Adhesion and Bond Strength of Gutta Percha and Polyurethane Materials with Root Dentin in Phosphate Buffer Saline Solution

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ABSTRACT:
Objective: To find out the adhesion and bond strength of composites of guttapercha with 10% hydroxyapatite (HA) and polyurethane (10% and 20% HA) immersed in phosphate buffer saline (PBS) solution with root dentin.
Materials and Methods: This descriptive cross-sectional study was carried out from June 2010 – August 2010 at the Department of Material Sciences, Queen Mary College of Engineering London, UK. Extracted human teeth were used for this study and in vitro root canal obturation was done. After filling the samples were immersed in Phosphate Buffer Saline (PBS) solution. Push out test and scanning electron microscopy (SEM) was done to find out the adhesion and bond strength of these materials.
Results: Guttapercha had maximum bond strength,where as guttapercha with 10% hydroxyapatite had minimum bond strength compared to other bioactive materials used. Polyurethane composite with 20% HA was next to guttapercha in terms of its bond strength followed by polyurethane with 10% HA.
Conclusion: Guttapercha obturating material proved to be the best obturating material but polyurethane (with 10% and 20% HA) also looked promising and it should be further tested and investigated for future use as choice of obturating material with enhanced properties.
Keywords:Gutta percha (GP), Polyurethane, Hydroxyapatite (HA), Phosphate buffer saline (PBS) solution, Push out test, Scanning electron microscopy (SEM)

INTRODUCTION:

Dental caries is the most common cause of pulpitis resulting in an intense, unbearable tooth pain in patients. In the past, grossly carious teeth were extracted by the dentists to relieve pain. But with passage of time, a vast improvement in the field of material science has taken place making it possible to save the tooth rather than extracting it. Root canal treatment (RCT) is one of the techniques practiced commonly in dentistry to save the tooth and keep it in a functional position in the oral cavity. The final filling of RCT is called obturation and biocompatible material used to fill the root canal is called an obturating material.The commercially available materials are although biocompatible but not bioactive. Their basic function is to fill the root canal and seal the apical foramen. The basic objectives of root canal obturating materials are to provide a clean canal, free of any bacteria or other debris, provide an apical seal to prevent any irritants entering or leaving the canal and to prevent recontamination due to oral micro-organisms.[1] Guttapercha is the most widely used obturating material for root canal treatment due to its biocompatibility with oral tissues. Guttapercha was introduced in UK in 1843 and since then it has been used as root canal filling material in endodontics.[1] Guttapercha alone does not adhere well with the root dentin. Different sealers are used for better adhesion and improved bonding. The effect of master cone taper on the bond strength and apical sealing ability of different root canal sealers has been investigated.[2] An in vitro comparison of inter radicular dentin bond strength of guttapercha and resilon was done in several studies and push out test results showed that resilon had higher value as compared to the gutta-percha obturating material.[3,4,5]
Polyurethane (PU) is a polymer. Several polymeric materials are in use in a wide range of applications in the field of medicine and dentistry. Polyurethanes are mostly thermosetting polymers and they are used to coat implant surface.[6] Polyurethane liners are in use to

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enhance the bonding of silicone based facial prosthesis like nasal prosthesis.[7] Polyurethane is under the spot light to be used in several medical applications such as cardiovascular (CVS) applications.

Hydroxyapatite is one of the most studied calcium phosphate in the field of bio-ceramics. It is a mineral content of bone and teeth and has excellent biocompatibility and excellent mechanical properties. It is the most common biomaterial in all the fields of health care industry. Its osteo-conduction and osteo-integration properties enhance the process of bone regeneration. In orthopedics and dentistry, hydroxyapatite (HA) is used in several applications due to its biocompatibility with human tissues.[8] Phosphate buffer saline solution constitutes calcium chloride and magnesium chloride and it mainly controls the pH of the system during study.

MATERIALS AND METHODS:

Present study was carried out at the Department of Material Sciences, Queen Mary University of London, UK. For this study, ten extracted human teeth were selected. They were of all types, incisor, canines, premolars and molars. Sound non-carious teeth with straight roots were selected. The teeth were properly cleaned of any debris including plaque and calculus with the help of manual scaler. All other materials, Guttapercha points, Polyurethane, Hydroxyapatite composite, extracted human teeth, hedstrom files #15 to #80 from Manni™ (Japan), Poly methyl methacrylate, Chloroforms, Dulbeco's Phosphate Buffer Saline solution from SIGMA ™, and Electron Microscope were used available from the lab of Material Science.

In vitro root canal treatment of teeth: An in vitro root canal therapy was done of the selected teeth using hedstrom files (H-files from Manni, Japan) #15-#80files. They were inserted step by step and whole canal was cleaned and prepared. After canal preparation, teeth were divided into different groups for filling with different obturating materials.

Filling of roots with Guttapercha: Guttapercha alone has a very poor bonding ability with root dentin. Thus a sealing agent, SealapexbYkerr ™, was applied to enhance the adhesion of guttapercha with root dentin. Homogenous mixture of Sealapex paste was prepared on glass slab and applied to the inner wall of the dentin. The bonding agent was set within 4-5 minutes. With the help of Obtura™ll (kerr dental, USA), which is a guttapercha heating obturating system, guttapercha was filled in the root canal. The temperature of Obtura was raised to 200°C and guttapercha was added from the top of gun (hand piece). It melts at this temperature and easily fills the root canal.Temperature changes to room temperature in just a few seconds after ejected from hand piece.Two teeth were obturated with guts percha and immersed in phosphate buffer saline solution. The samples were left in the incubator at 37°C for 7 days.

Mixing of hydroxyapatite with guttapercha points: Guttapercha points (1.5 gms) were taken and put in a glass beaker. The beaker was put in oven at 200°C for 15 minutes. Beaker was removed from oven. Guttaperchapoints became soft. A small amount of chloroform was added into the beaker and stirring was done to mix the softened Guttapercha points in chloroform. After mixing, pre ball milled hydroxyapatite of about 0.15gm (10% of weight of GP points) was added to the solution and mixed with stirrer.Mixture was left in the fume cupboard to allow chloroform to evaporate and guttapercha with 10% concentration of hydroxyapatite was left. When material acquired a semi viscous state, it was filled into the root canal. Two teeth were obturated with GP + 10% HA and immersed in phosphate buffer saline solution. The filled teeth were left in the incubator at 37°C for 7 days.

Obturation of root canal with polyurethane and 10% hydroxyapatite (PU + 10% HA) Composite material: Approximately 1.47gm of polyurethane with 10% HA was weighed and put in a clean glass beaker. The material was kept in a heat oven at 180°C for 15 minutes and it melted into semi viscous consistency. Beaker was removed from oven and with the help of a spreader, PU + 10% HA in semi viscous state was filled into the prepared teeth. Two teeth were filled with PU + 10% HA without sealer and immersed in phosphate buffer saline solution. The samples were left in the incubator at 37°C for 7 days.

Obturation of root canal with Polyurethane + 20% Hydroxyapatite (PU + 20% HA) Composite material: Approximately 1.5 gm of bioactive material (PU + 20% HA) was kept in a heat oven at 200°C for 12 minutes. After 15 minutes the material melts into semi viscous consistency. Then with the help of a spreader, PU + 20% HA in this semi viscous state was filled into the prepared teeth. Two teeth were filled with PU + 10% HA without sealer and immersed in phosphate buffer saline solution. The samples were left in the incubator at 37°C for 7days.

Mounting of obturated specimens in the mould and sample preparation for push out tests: Before experiments, the specimens were mounted on themould by using a conventional ice cube trays with the help ofself curing poly methyl meth Acrylate (PMMA). Dried roots were inserted in self cured PMMA separately in each block. The container with roots was put inside the fume cupboard, till all the residual monomer evaporated and started to set. When PMMA cooled down to room temperature, the moulds were taken out and put in respective containers. Extra PMMA was removed with cutter. Thin slices of each sample were cut with help of cooling diamond blade machine (Cuto1 Jean Wirtz, UK). Three slices of 4mm width were obtained from each root sample and put in their respective containers and kept in incubator at 37°C till the day of push out test.

Push out test and scanning electron microscopy: It was performed on INSTRON 5564(INSTRON™, USA).The load used for pushing out the material from the root was 100 N and speed of sharp knob was adjusted to 0.5 mm/min. The knob passed through the filling area and pushed the filling out of the sample. After it, sample was removed and saved for scanning electron microscopy

(SEM). Same procedure was repeated for all the slices of all samples.Allthe samples were mounted strongly on the round aluminium stubs with the help of conductive carbon cement and left in fume cupboard so that the carbon cement dries properly and adapts with aluminium stubs. Then dried samples were coated with carbon in BULZERS CED 030(BAL-TEC, Germany) equipment in lab. Now the scanning electron microscopic examination was done using FEI Inspect F microscope (USA) in the laboratory to visualize the amount of obturating material still attached to the root sample after push out test.

RESULTS:

Table 1 shows the mean push out strength values of the obturating materials in phosphate buffer saline solution. Three slices of all obturating materials in phosphate buffer saline solution were analysed for push out test and then the mean value for the bond strength in MPa was calculated. Table shows that guttapercha has the maximum bond strength value followed by polyurethane with 20% hydroxyapatite (HA).Where as GP+10% HA has least bond strength value.

Figure 1a shows the scanning electron microscopic examination of guttapercha in phosphate buffer saline solution. After push out test, it shows a smooth well adapted layer of guttapercha with root dentin after push out test. This shows a good bonding of GP obturating material with root dentin.

In Figure1b, Scanning electron microscopic exam of Guttapercha with 10% hydroxyapatite obturating material, it was hard to see any material attached with the root dentin. Reason behind this was that the carbon cementfilled the entire root canal space.

Similarly Push out test for Polyurethane with 10% hydroxyapatite (HA) was carried out on three slices of polyurethane with 10% hydroxyapatite filled specimens. Table 1a shows that the mean push out bond strength of this bioactive obturating material was 0.671MPa. Although this value is not as high as GP but it is still better than the composite of GP with similar concentration of HA.

In Figure 2a, On SEM, it was clear that some material was still attached with root dentin after it was forced out of canal. The material is attached at some point but gaps are also visible between the root surface and obturating material.In Figure 2b, the Scanning electron microscopic examination (SEM), shows that the material is almost covering the entire surface of root dentin indicating excellent adhesion after push out test. Figure 3 shows the push out bond strengths of all the materials used in the study.

Table: 1
The mean push out strength (MPa) values of the obturating materials in Phosphate Buffer Saline solution.

Obturating materials	Sample 1	Sample 2	Sample 3	Mean (mpa)
Guttapercha	0.882	0.871	0.891	0.881
GP + 10% HA	0.584	0.561	0.612	0.588
PU + 10% HA	0.684	0.659	0.671	0.671
PU + 20% HA	0.792	0.789	0.774	0.785

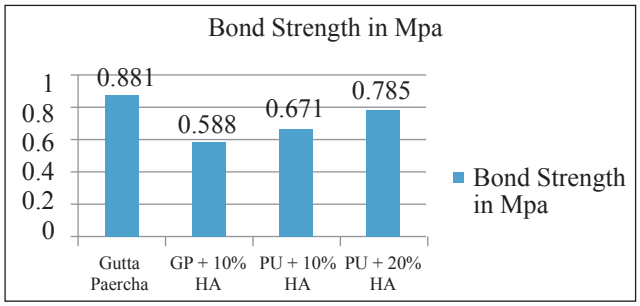
Figure: 1 a
The SEM of Guttapercha in Phosphate Buffer Saline Solution after push out test

Figure: 1b
The SEM of Guttapercha with 10% hydroxyapatite material after push out test

Figure: 2a
SEM Of Polyurethane with 10 hydroxyapatite (HA) after push out test

Figure: 2b
SEM of Polyurethane with 20% hydroxyapatite (HA) after push out test

Figure: 3
Push out bond strengths of all the materials used in the study



DISCUSSION:

The main objective behind this study was to do a comparative analysis among the bioactive obturating materials to find out an obturating material that has an improved adhesion and bond strength with the root dentin. Guttapercha (GP) is known, not to have good bond strength with the root dentin, because of this reason root canal sealers are used to improve sealing and bonding. Guttapercha with HA is supposed to bind well with the root dentin as HA is the main inorganic component of the tooth dentin. Polyurethane with 10% and 20% HA, seem promising and might prove to be a new addition in the family of obturating materials.

Push out test was carried out to find out the bond strength under compression and scanning electron microscopy (SEM) of the sample afterwards to find out the adhesion of the material with the root dentin wall. The solution used in this study was phosphate buffer saline (PBS). From the results of push out bond strength and scanning electron microscopic analysis of obturating materials, it is clear that guttapercha has the maximum bond strength (0.881)among all the materials used in this study. Although the mean bond strength was less than other studies but it is still excellent keeping in view the duration of the study as seen in other studies[5,8].

Unexpectedly GP with 10% HA has the least push out bond strength value. Polyurethane with 20% HA had the second highest mean push out test value (0.785MPa) followed by polyurethane with 10% HA (0.671MPa). On analyzing the bond strength values of Guttapercha with root dentin many reasons need to be considered. One may be the use of technique of obturating this material. The factor that helped GP in attaining maximum strength was the use of dentin bonding agent. This enhances the sealing as well as binding of GP for better prognosis of root canal therapy [2,9,10]. The combination of dentin bonding agent and obturating by thermofil obturating method had helped guttapercha to adhere well to the root dentin[11, 12].

The obturation technique can be one of the reasons for lowest bond strength of GP + 10% HA. Chloroform was used for softening of GP and its mixing with 10% HA. After obturation, chloroform got evaporated leaving voids and spaces between material and dentin[1]. During push out test, material showed least resistance. Another reason could be the low viscosity at time of filling this material as seen in other studies[13, 14].

Polyurethane with 10% hydroxyapatite also showed good results regarding bond strength with root dentin. Material showed better adhesion than GP with same consistency of HA. The SEM of polyurethane with 10% HA shows good adherence with root dentin even after the push out test was performed.The composite of polyurethane with 20% HA proved to be the best among all the bioactive materials used in this study. It was the only material that had the bond strength close to that of GP. The SEM also shows good adhesion of polyurethane with 20% HA. There was a lot of material still attached with the root dentin after push out test. This bioactive material looks promising[15,16,17]and it has excellent potential as a root canal obturating material [18,19,20,21,22]. Polyurethane showed excellent consistency when it was heated. It gave excellent working time at high temperature and its sticky consistency made it possible to adhere well with root dentin walls. It may be the reason which gave polyurethane better results than GP with 10% HA. SEM of polyurethane (10% and 20% HA) showed that the material is well adapted with the surrounding root dentin even after push out force. This study showed that the composites of polyurethane with 10% and 20% HA had ability to bind well with the root dentin and is coinciding with findings of other studies [23,24,25,26].

CONCLUSION:

Guttapercha obturating material proved to be the best obturating material but polyurethane with 20% HA proved to be promising and the only bioactive obturating material used in this study, the bond strength of which challenges that of guttapercha in PBS solution. It can be a good addition among the obturatingmaterials used in dentistry.These materials have a very bright future in the field of endodontics if their mechanical properties are improved.

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