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IN VITRO EVALUATION OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH WITH THE USE OF DIFFERENT ROOT CANAL SEALERS

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Abstract:
After endodontic treatment, teeth are structurally different from untreated vital teeth, so these teeth require specialized treatment. The toughness of an endodontically treated tooth is associated to the tooth structure left. In vertical root fracture, resection of the affected root or extraction of the tooth is mandatory. Hence, this is a serious concern as there is an unfavorable prognosis leading to endodontic failure. One major cause for tooth fracture is found to be endodontic treatment in many in vivo studies. Vital teeth are less prone to fracture than nonvital teeth. It is a well-known fact that loss of structural integrity associated with the access preparation results in increased cuspal deflection during function leading to a higher occurrence of fractures. It is difficult to establish whether the occurrence of fractures depends on change in dentin structure or missing tooth structure. If endodontically treated teeth are not restored immediately, there is bacterial contamination and coronal microleakage, and this can lead to retreatment or endodontic failure. Hence, bonded restorations must be used to avoid microleakage. Based on above findings the present study was planned to evaluate the In Vitro Evaluation of Fracture Resistance of Endodontically Treated Teeth with the Use of Different Root Canal Sealers.
The present study was planned in Department of Conservative Dentistry and Endodontics, Buddha Institute of Dental Science and Hospital, Patna, Bihar, India. For the in vitro study, 30 extracted maxillary central incisors from patients in the age group 30-55 years were obtained. After extraction, soft tissue and calculus were mechanically removed and teeth were stored in 5% sodium hypochlorite solution for 24 h to remove any remaining soft tissue. Certain teeth that had fracture lines, calcifications, surface irregularities were discarded, and a total of 20 teeth samples were obtained for the study. Although the sample size was small, it was sufficient to achieve a statistical difference. The teeth were sectioned at the cementoenamel junction using a diamond disc and water spray The sectioned teeth were taken, and a working length for each root was then established 1 mm short of the apical foramen using a No. 20 K-file. Further, the roots were divided randomly into four groups.
The data generated from present study concludes that increased the fracture toughness of the instrumented roots after obturation. Therefore the ability of these materials i.e., Resilon and Epiphany sealer, Gutta-percha and AH plus sealer, guttapercha and Endomethasone sealer to reinforce the Endodontically treated teeth looks very promising but further long-term clinical studies are necessary to collect evidence based data thus to be able to support the confident use of these materials in day to day practice.
Keywords: Fracture resistance, root canal sealers, Resilon, Epiphany, AH Plus Sealer, Endomethasone sealer, etc.

Introduction

Root canal treatment (also known as endodontic therapy, endodontic treatment, or root canal therapy) is a treatment sequence for the infected pulp of a tooth which results in the elimination of infection and the protection of the decontaminated tooth from future microbial invasion.[1] Root canals, and their associated pulp chamber, are the physical hollows within a tooth that are naturally inhabited by nerve tissue, blood vessels and other cellular entities. Together, these items constitute the dental pulp.[2]

Endodontic therapy involves the removal of these structures, the subsequent shaping, cleaning, and decontamination of the hollows with small files and irrigating solutions, and the obturation (filling) of the decontaminated canals. Filling of the cleaned and decontaminated canals is done with an inert filling such as gutta-percha and typically a Zinc oxide eugenol-based cement.[3] Epoxy resin is employed to bind gutta-percha in some root canal procedures.[4] Endodontics includes both primary and secondary endodontic treatments as well as periradicular

surgery which is generally used for teeth that still have potential for salvage.[5][6]

Before endodontic therapy is carried out, a correct diagnosis of the dental pulp and the surrounding periapical tissues is required. This allows the endodontist to choose the most appropriate treatment option, allowing preservation and longevity of the tooth and surrounding tissues. Treatment options for an irreversibly inflamed pulp (irreversible pulpitis) include either extraction of the tooth or removal of the pulp.

Removing the infected/inflamed pulpal tissue enables the endodontist to help preserve the longevity and function of the tooth. The treatment option chosen involves taking into account the expected prognosis of the tooth, as well as the patient's wishes. A full history is required (which includes the patient's symptoms and medical history), along with a clinical examination (both inside and outside the mouth), and the use of diagnostic tests [7]

There have been a number of progressive iterations to the mechanical preparation of the root canal for endodontic therapy. The first, referred to as the standardized technique, was developed by Ingle in 1961, and had disadvantages such as the potential for loss of working length and inadvertent ledging, zipping or perforation.[8][9] Subsequent refinements have been numerous, and are usually described as techniques. These include the step-back, circumferential filing, incremental, anticurvature filing, step-down, double flare, crown-down-pressureless, balanced force, canal master, apical box, progressive enlargement, modified double flare, passive stepback, alternated rotary motions, and apical patency techniques.[10]

The step back technique, also known as telescopic or serial root canal preparation, is divided in two phases: in the first, the working length is established and then the apical part of the canal is delicately shaped since a size 25 K-file reaches the working length; in the second, the remaining canal is prepared with manual or rotating instrumentation.[11] This procedure, however, has some disadvantages, such as the potential for inadvertent apical transportation. Incorrect instrumentation length can occur, which can be addressed by the modified step back. Obstructing debris can be dealt with by the passive step back technique.[12] The crown down is a procedure in which the dentist prepares the canal beginning from the coronal part after exploring the patency of the whole canal with the master apical file.

There is a hybrid procedure combining step back and crown down: after the canal's patency check, the coronal third is prepared with hand or Gates Glidden drills, then the working length is determined and finally the apical portion is shaped using step back techniques. The double flare is a procedure introduced by Fava where the canal is explored using a small file. Then canal is prepared in crown down manner using K-files then follows a "step back" preparation with 1 mm increments with increasing file sizes. With early coronal enlargement, also described as "three times technique", apical canals are prepared after a working length assessment using an apex locator; then progressively enlarged with Gates Glidden drills (only coronal and middle third). For the eponymic third time the dentist "arrives at the apex" and, if necessary, prepares the foramen with a size 25 K-file; the last phase is divided in two refining passages: the first with a 1-mm staggered instrument, the second with 0.5-mm staggering.[citation needed] From the early nineties engine-driven instrumentation were gradually introduced including the ProFile system, the Greater Taper files, the ProTaper files, and other systems like Light Speed, Quantec, K-3 rotary, Real World Endo, and the Hero 642.

All of these procedures involve frequent irrigation and recapitulation with the master apical file, a small file that reaches the apical foramen.[13] High frequency ultrasound based techniques have also been described. These can be useful in particular for cases with complex anatomy, or for retained foreign body retrieval from a failed prior endodontic procedure.[14]

There are two slightly different anti-curvature techniques. In the balanced forces technique, the dentist inserts a file into the canal and rotates clockwise a quarter of a turn, engaging dentin, then rotates counter-clockwise half/ three-quarter of a revolution, applying pressure in an apical direction, shearing off tissue previously meshed. From the balanced forces stem two other techniques: the reverse balanced force (where GT instruments are rotated first anti-clockwise and then clockwise) and the gentler "feed and pull" where the instrument is rotated only a quarter of a revolution and moved coronally after an engagement, but not drawn out.

The standard filling material is gutta-percha, a natural polymer prepared from latex from the percha tree (Palaquium gutta). The standard endodontic technique involves inserting a gutta-percha cone (a "point") into the cleaned-out root canal along with a sealing cement. [15] Another technique uses melted or heat-softened gutta-percha which is then injected or pressed into the root canal passage(s). However, since gutta-percha shrinks as it cools, thermal techniques can be unreliable and sometimes a combination of techniques is used. Gutta-percha is radiopaque, allowing verification afterwards that the root canal passages have been completely filled and are without voids.

An alternative filling material was invented in the early 1950s by Angelo Sargenti. Filling material has undergone several formulations over the years (N2, N2 Universal, RC-2B, RC-2B White), but all contain paraformaldehyde. The paraformaldehyde, when placed into the root canal, forms formaldehyde, which penetrates and sterilizes the passage. The formaldehyde is then theoretically transformed into harmless water and carbon dioxide. According to some research, the outcome of this method is better than a root canal procedure performed with gutta-percha. There is, however, a lack of indisputable scientific studies according to the Swedish Council on Health Technology Assessment.

Root canal sealer used to fill the spaces between the gutta-percha and the walls of root canal and between the gutta-percha cones. In rare cases, the paste, like any other material, can be forced past the root tip into the surrounding bone. If this happens, the formaldehyde will immediately be transformed into a harmless substance. Blood normally contains 2 mg formaldehyde per liter and the body regulates this in seconds. The rest of an overfill will be gradually absorbed and the end result is normally good. In 1991, the ADA Council on Dental Therapeutics resolved that the treatment was "not recommended", and it is not taught in American dental schools. Scientific evidence in endodontic therapy was, and still is lacking. [16] Despite this lack of support, the Sargenti technique has advocates who believe N2 to be less expensive and at least as safe as gutta-percha. [17]

Pain control can be difficult to achieve at times because of anesthetic inactivation by the acidity of the abscess around the tooth apex. Sometimes the abscess can be drained, antibiotics prescribed, and the procedure reattempted when inflammation has been mitigated. The tooth can also be unroofed to allow drainage and help relieve pressure.

A root treated tooth may be eased from the occlusion as a measure to prevent tooth fracture prior to the cementation of a crown or similar restoration. Sometimes the dentist performs preliminary treatment of the tooth by removing all of the infected pulp of the tooth and applying a dressing and temporary filling to the tooth. This is called a pulpectomy. The dentist may also remove just the coronal portion of the dental pulp, which contains 90% of the nerve tissue, and leave intact the pulp in the canals. This procedure, called a "pulpotomy", tends to essentially eliminate all the pain. A pulpotomy may be a relatively definitive treatment for infected primary teeth. The pulpectomy and pulpotomy procedures aim to eliminate pain until the follow-up visit for finishing the root canal procedure. Further occurrences of pain could indicate the presence of continuing infection or retention of vital nerve tissue.

Some dentists may decide to temporarily fill the canal with calcium hydroxide paste in order to thoroughly sterilize the site. This strong base is left in place for a week or more to disinfect and reduce inflammation in surrounding tissue, requiring the patient to return for a second or third visit to complete the procedure. There appears to be no benefit from this multi-visit option, however, and single-visit procedures actually show better (though not statistically significant) patient outcomes than multi-visit ones. [18]

Root canal sealer is used along with Gutta Percha for obturation of root canals. Some root canal sealers can be complete sealers where no Gutta Percha is necessary. Endodontic sealers have varying base compositions, some may be Calcium Hydroxide, epoxide-amine resins, Barium Sulfate, Bismuth Oxychloride and Zinc Oxide. Endodontic sealers can be categorized as containing Eugenol or not containing Eugenol. The component Zinc Oxide Eugenol can be placed in the root canal cavity temporarily to reduce inflammation and sensitivity. Application of endodontic sealers can be via syringe, hand mix and premeasured capsules.

Endodontically treated teeth are widely considered to be more susceptible to fracture than vital teeth. The reasons most often reported have been the removal of tooth structure during endodontic treatment, dehydration of dentin after endodontic therapy, and

excessive pressure during obturation. These factors probably interact cumulatively to influence tooth loading and distribution of stresses, ultimately increasing the possibility of catastrophic failure. In addition to these factors, intracanal irrigants, medicaments and materials may also play parts in influencing the physical and mechanical properties of dentin, leading to fracture.

It would be advantageous if the root canal obturation, could decrease the incidence of root fractures. The type of root canal sealer may affect root fracture resistance and the pattern of root fracture. Gutta percha used in conjunction with root canal sealers may have been the best combination available to date and is seen as the gold standard of root canal fillings. Despite its many advantages and having achieved the status of a time-honored material, gutta percha still has its limitations like its inability to strengthen root as it does not bond to dentin. Growing interest in reinforcing the root canal system has led to the development of adhesive root canal sealers with the potential to increase fracture resistance. It is thought that adhesion and mechanical interlocking between the material and root canal dentin will strengthen the remaining tooth structure, and thus reduce fracture risk.

Gutta percha (GP) has been the filling material of choice for root canals for years. AH Plus is an epoxy resin-based sealer that is commonly used with GP. In recent years, a new resin-based obturation material, Resilon-Epiphany has been introduced. It is a dual curable thermoplastic synthetic resin material used with a self-etching primer to create a solid monoblock. GuttaFlow contains GP in particle form combined with a polydimethylsiloxane - based sealer.

After endodontic treatment, teeth are structurally different from untreated vital teeth, so these teeth require specialized treatment. The toughness of an endodontically treated tooth is associated to the tooth structure left. In vertical root fracture, resection of the affected root or extraction of the tooth is mandatory. Hence, this is a serious concern as there is an unfavorable prognosis leading to endodontic failure. One major cause for tooth fracture is found to be endodontic treatment in many in vivo studies. Vital teeth are less prone to fracture than nonvital teeth. It is a well-known fact that loss of structural integrity associated with the access preparation results in increased cuspal deflection during function leading to a higher occurrence of fractures. It is difficult to establish whether the occurrence of fractures depends on change in dentin structure or missing tooth structure. If endodontically treated teeth are not restored immediately, there is bacterial contamination and coronal microleakage, and this can lead to retreatment or endodontic failure. Hence, bonded restorations must be used to avoid microleakage. Based on above findings the present study was planned to evaluate the In Vitro Evaluation of Fracture Resistance of Endodontically Treated Teeth With the Use of Different Root Canal Sealers.

Methodology:

The present study was planned in Department of Conservative Dentistry and Endodontics, Buddha Institute of Dental Science and Hospital, Patna, Bihar, India. For the in vitro study, 30 extracted maxillary central incisors from patients in the age group 30-55 years were obtained. After extraction, soft tissue and calculus were mechanically removed and teeth were stored in 5% sodium hypochlorite solution for 24 h to remove any remaining soft tissue. Certain teeth that had fracture lines, calcifications, surface irregularities were discarded, and a total of 20 teeth samples were obtained for the study. Although the sample size was small, it was sufficient to achieve a statistical difference. The teeth were sectioned at the cementoenamel junction using a diamond disc and water spray The sectioned teeth were taken, and a working length for each root was then established 1 mm short of the apical foramen using a No. 20 K-file. Further, the roots were divided randomly into four groups.

Group-A: Ten root canals were filled with Resilon and Epiphany sealer. The sealer was placed using Lentulo spiral filler. A master Resilon cone was placed into the root canal and with cold lateral compaction technique filled using accessory Resilon points. The excess was seared off with the help of plugger 1 mm below the canal opening and coronally cured for 40 seconds and canal opening was sealed with cavit.

Group-B: Ten root canals were filled using gutta-percha with AH plus sealer. The master cone was dipped in the sealer and placed in the canal and filled with gutta-percha of smaller sizes. Excess gutta-percha was seared off and condensed 1 mm below the canal opening with a plugger and the opening was sealed with cavit.

Group-C: Likewise here also ten numbers of root canals were filled using gutta-percha with Endomethasone sealer rest is similar as done in group II.

Group-D: Here ten root canals were left unrestored. Only the canal opening was sealed with cavit and was used as control group. Then cylindrical moulds of 20 mm in diameter and 20 mm in length were prepared using elastomeric impression material (Provil P – Soft, Heraeus – Kulzer, Domagen, Germany) and then self cure acrylic was placed in the mould and apical 6 mm of the root were embedded individually with 7 mm remaining exposed. The acrylic blocks including the specimen was placed on the lower plate of the machine (Universal Testing Machine, Instron), the upper plate of the machine included a round tip that had a diameter of 4 mm. This round tip contacted the coronal surface of the specimen and was subjected to slowly increasing vertical force of 1 mm per minute until the fracture occured and the values were recorded in Newtons.

All the patients were informed consents. The aim and the objective of the present study were conveyed to them. Approval of the institutional ethical committee was taken prior to conduct of this study.

Results & Discussion:

Reinforcing the remaining tooth structure is also one of the primary goals of endodontics and not just treating the diseased pulp. [18] There is also change in the mechanical properties of the tooth following endodontic treatment. There is some disagreement regarding the use of various nickel-titanium rotary files on root dentin. Some studies compared rotary with hand files and described that rotary files increased the risk for dentin cracks, craze lines and reduced resistance to root fracture. [19]

The materials put to use in root embedment in in vitro fracture resistance tests must combat the compressive and tangential forces, imitate bone and absorb masticatory loads. When periodontal ligament is simulated, the stresses produced are transferred all along the root surface. Furthermore, stress is not concentrated in one particular area. [20] The simulation of artificial periodontal ligament might have effect on fracture resistance as was proposed by Mandava et al. [21] Their study used silicone paste and polystyrene resin blocks for simulation of periodontal ligament and alveolar bone.

In this study, mandibular premolars were preferred as they are fracture prone due to their crown size, anatomy, crown/root ratio, and function. Also because of their placement in the dental arch, they are exposed to both shear and compressive forces. [22]

Table 1:

Groups	Group	Sample size	Mean
Group A	Resilon with Epiphany Sealer	5	1004 - 1740 N
Group B	Gutta–percha with AH Plus sealer	5	946 - 1601 N
Group C	Gutta–percha with Endomethasonse sealer	5	665 – 1389 N
Group D	Control Group	5	461 – 719 N

In endodontically treated teeth, the root canal system is reinforced by obturating the root canal in order to increase the resistance of the tooth to compressive strength. [23] To provide a hermetic seal, the bonding of root canal sealer to the dentine is paramount in maintaining the integrity of the seal in a root canal filling. [24] Thus, a root canal sealer with the property of strengthening the tooth against root fracture would be of obvious value. Various research methodologies have developed materials which facilitate adhesion to the root canal system as it is thought that adhesion and mechanical interlocking may strengthen the remaining tooth structure thus reduce the risk of fracture. [23] Most commonly used root canal sealer is the zinc oxide-eugenol (ZOE) sealer (Kerr sealer-Rickert, California, USA) and has been used for several decades because of its satisfactory physicochemical properties. [25] However, leakage and recontamination of the root canal system due to eugenol or zinc oxide loss through continuous hydrolysis which causes post treatment complication. [26-27]

A study to evaluate the in vitro effect of various obturating materials on fracture resistance of root canal treated teeth revealed teeth obturated with AH Plus and gutta percha showed higher fracture resistance than those obturated with Resilon-Epiphany. [28]

A study to compare in vitro root fracture resistance following root canal filling with either Ketac-Endo or Roth's root canal sealer demonstrated that there were no significant differences between the groups in terms of force required to vertically fracture the roots. [29]

A study to compare vertical forces at fracture of endodontically treated mandibular incisors obturated with different types of root canal sealer revealed force at fracture of roots obturated with Ketac-Endo was significantly higher than those obturated with AH Plus and Tubliseal. [30]

A study to evaluate and compare the fracture resistance of endodontically treated teeth filled with gutta percha and Resilon showed that the Resilon group displayed higher mean fracture than the gutta percha. [31]

A study to compare to compare the fracture toughness of the instrumented roots after obturating it with Resilon Epiphany, AH Plus with gutta-percha and Endomethasone with gutta percha concluded that no statistical differences were found amongst the three experimental groups. [32]

A study to compare laterally condensed, vertically compacted thermoplasticized and cold free-flow GP obturations revealed that the cold free flow obturation technique showed the highest volume of obturation, followed by the vertically condensed thermoplasticised technique. The least volume of obturation was observed in cold lateral condensation tecnnique. [33]

Some studies have suggested that lateral condensation creates stresses in the root during obturation, which could lead to subsequent fracture. However, lateral condensation might not be a direct cause of vertical root fracture because dentin has sufficient elasticity to permit separation without complete [34] vertical root fracture. In several studies tests for fracture resistance were performed using the cyclic loading applying the force in different [35] directions in order to simulate the clinical conditions. However, in many studies it has been reported that applying the force vertically along the long axis of the tooth transmits the force uniformly (Chen et al 2000, Lindemurth et al 2002, Dias de souza et al 2002). In this present study a single “load to fracture” was applied vertically like other studies that evaluated the effect of root canal sealer on the fracture [36-37] resistance of root filled teeth.

Much of the fracture susceptibility of endodontically treated teeth is intrinsic to the root canal morphology, dentin thickness, canal shape, and size and curvature of the external root; [38] thus, special attention should be given for securing sufficient remaining dentin. However, enlargement of the coronal third of the root canal space is considered important to support root canal length measurement, debris removal, effective irrigation, and canal obturation. However, extensive use of rotary instruments during preparation of the root canal space by cutting the dentin to gain straight lines access weakens the root structure. Desiccation and dehydration of the dentin are also a few of the causes that may predispose to the weakening of tooth. Rundquist et al. (2006) stated that with increasing taper, root stresses decreased during root filling but tended to increase for masticatory loading, resulting fracture originating in the cervical portion. [39] Although bonded obturation materials might increase the fracture resistance of root-filled teeth, the current endodontic obturation systems are not suitable to obtain this goal. In the present study, the core material (gutta-percha) combined with the tested endodontic sealer (AH Plus) was not able to increase the root fracture resistance significantly in all the groups including the control group. Zandbiglari et al. (2006) also observed that roots get significantly weakened with the use of greater taper instruments and obturation with AH Plus sealer was not able to increase the fracture resistance. [40]

Conclusion:

The data generated from present study concludes that increased the fracture toughness of the instrumented roots after obturation. Therefore the ability of these materials i.e., Resilon and Epiphany sealer, Gutta-percha and AH plus sealer, guttapercha and Endomethasone sealer to reinforce the Endodontically treated teeth looks very promising but further long-term clinical studies are necessary to collect evidence based data thus to be able to support the confident use of these materials in day to day practice.

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