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Assessment of different types of crowns used for restoration of maxillary anterior endodontically treated teeth

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Abstract
The present study was planned to evaluate the performance between different types of crowns and composite restoration. Those restorations were used for ETT in maxillary anterior teeth, after a glass-fibre post with composite resin core builds up.
The present study was planned in the Department of Conservative Dentistry and Endodontics, Buddha Institute of Dental Sciences and Hospital, Patna. The 20 cases of maxillary anterior endodontically treated teeth (ETT). The roots were restored with reinforced GFPs (Relaxy Fiber Post, 3M ESPE, Germany), and composite resin cores (Tertic-N-Ceramic, Ivoclar Vivadent, Lichenestine). The 50 ETTs were divided into four groups depend on the crown type or the final restoration.
Selection of the most suitable post and core systems is challenging and should be guided by knowledge of their indications, advantages and disadvantages, as well as the amount and quality of remaining tooth structure and aesthetic requirements. The data generated from the present findings concludes that E max and zirconia crowns have a higher success comparing to other groups. While PFM crowns and composite restorations were associated with colour changes and inflammation of the free gingiva.

Keywords: clinical, endodontically treated teeth, ETT, Follow-Up, glass fiber-reinforced posts, maxillary teeth

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 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].
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 [7]. 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.
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 [8]. 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 [9]. 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 [10].

A temporary filling material is applied between the visits [11]. Leaky temporary filling will allow the root canals to become reinfected by bacteria in the saliva (coronal microleakage). Khayat *et al*. showed that all root canals obturated with gutta-percha and root canal sealer using either lateral or vertical condensation were recontaminated in less than 30 days when exposed to saliva [12]. Therefore, maintaining a coronal seal throughout root canal therapy is very important for the success of the treatment [13].

Molars and premolars that have had root canal therapy should be protected with a crown that covers the cusps of the tooth. This is because the access made into the root canal system removes a significant amount of tooth structure. Molars and premolars are the primary teeth used in chewing and will almost certainly fracture in the future without cuspal coverage. Anterior teeth typically do not require full coverage restorations after a root canal procedure, unless there is extensive tooth loss from decay or for esthetics or unusual occlusion. Placement of a crown or cusp-protecting cast gold covering is recommended also because these have the best ability to seal the treated tooth. There is insufficient evidence to assess the effects of crowns compared to conventional fillings for the restoration of root-filled teeth, decision of restoration should rely on the clinical experience of the practitioner and the preference of the patients [14]. If the tooth is not perfectly sealed, the canal may leak, causing eventual failure. Also, many people believe once a tooth has had a root canal treatment it cannot further decay. This is not true, however: a tooth with a root canal treatment still has the ability to decay, and without proper home care and an adequate fluoride source the tooth structure can become severely decayed (often without the patient's knowledge since the nerve has been removed, leaving the tooth without any pain perception). Thus, non-restorable carious destruction is the main reason for extraction of teeth after root canal therapy, accounting for up to two-thirds of these extractions [15]. Therefore, it is very important to have regular X-rays taken of the root canal to ensure that the tooth is not having any problems that the patient would not be aware of.

Endodontic treatment may fail for many reasons: one common reason for failure is inadequate chemo mechanical debridement of the root canal. This may be due to poor endodontic access, missed anatomy or inadequate shaping of the canal, particularly in the apical third of the root canal, also due to the difficulty of reaching the accessory canals which are minute canals that extend in from the pulp to the periodontium in a random direction. They are mostly found in the apical third of the root [16]. Exposure of the obturation material to the oral environment may mean the gutta-percha is contaminated with oral bacteria. If complex and expensive restorative dentistry is contemplated then ideally the contaminated gutta percha would be replaced in a retreatment procedure to minimise the risk of failure. The type of bacteria found within a failed canal may differ from the normal infected tooth. Enterococcus faecalis and/or other facultative enteric bacteria or Pseudomonas sp. are found in this situation. Endodontic retreatment is technically demanding; it can be a time consuming procedure, as meticulous care is required by the dentist. Retreatment cases are typically referred to a specialist endodontist. Use of an operating microscope or other magnification may improve outcomes.

Endodontics encompasses the study (practice) of the basic and clinical sciences of normal dental pulp, the etiology, diagnosis, prevention, and treatment of diseases and injuries of the dental pulp along with associated periradicular conditions. Endodontics has evolved tremendously in the past decade and its applications have immensely improved the quality of dental treatment [17].

In clinical terms, endodontics involves either preserving part, or all of the dental pulp in health, or removing all of the pulp in irreversible disease. This includes teeth with irreversibly inflamed and infected pulpal tissue. Not only does endodontics involve treatment when a dental pulp is present, but also includes preserving teeth which have failed to respond to non-surgical endodontic treatment, or for teeth that have developed new lesions, e.g., when root canal re-treatment is required, or periradicular surgery [18].

The main purpose of endodontic treatment (root canal therapy) is to remove the diseased pulp, clean and shape the root canal system, disinfect the contaminated root canals, and then obturate (fill) the root canal system to prevent re-infection and promote periradicular healing. The aim is to have radiographic evidence of healing, with no postoperative lesions present, and restored periradicular health if preoperative lesions were present. The main reason for dental pulpal problems has been related to bacterial contamination of the root canals. Therefore, significantly reducing the bacterial load within the root canal system, and

then filling the canals with an inert obturating material aid in preventing bacterial re-infection (see Gutta-percha#Dentistry) [19].

Endodontic therapy is not only performed when pain relief from an infected or inflamed pulp is required. It is also done to prevent adverse signs and symptoms from the surrounding sequelae and promote the healing and repair of the surrounding periradicular tissues. An example of which is if there is trauma to a front tooth which has caused it to be avulsed from the bony socket; endodontic treatment is required following re-implantation to preserve the aesthetics and function of the tooth, even though there may be no adverse symptoms of the dental pulp, or pain present at the time [20, 21].

Endodontists are specialist dentists with additional training, experience and formal qualifications in endodontic treatment, apicectomies, microsurgery, and dental emergency and trauma management. The use of magnification devices such as microscopes, and dental loupes have been widely accepted among endodontists and practitioners [22]; its use is believed to increase accuracy and visualization in the operating field however, a Cochrane review in 2015 found no evidence to determine whether there's a difference in the outcome of a procedure done by magnification devices or a conventional procedure done with no magnification [24]. Endodontic treatment is one of the most common procedures. If the dental pulp (containing nerves, arterioles, venules, lymphatic tissue, and fibrous tissue) becomes diseased or injured, endodontic treatment is required to save the tooth [25]. Endodontics is recognized as a specialty by many national dental organizations including the Dental Board of Australia, British General Dental Council, American Dental Association, Royal College of Dentists of Canada, Indian Dental Association, and Royal Australasian College of Dental Surgeons. The present study was planned to evaluate the performance between different types of crowns and composite restoration. Those restorations were used for ETT in maxillary anterior teeth, after a glass-fibre post with composite resin core builds up.

Methodology

The present study was planned in the Department of Conservative Dentistry and Endodontics, Buddha Institute of Dental Sciences and Hospital, Patna. The 20 cases of maxillary anterior endodontically treated teeth (ETT). The roots were restored with reinforced GFPs (Relaxy Fiber Post, 3M ESPE, Germany), and composite resin cores (Tertic-N-Ceramic, Ivoclar Vivadent, Lichenestine). The 50 ETTs were divided into four groups depend on the crown type or the final restoration:

- Group I consists of 5 ETT cases with GFP and composite restoration.
- Group II consists of 5 ETT cases with GFP and porcelain VITA VM (R) 9 (Vita Zahnfabric /Germany) fused to metal restoration.
- Group III consists of 5 ETT cases with GFP and e. max all ceramic (IPS e.max, Ivoclar/Vivadent) crowns.
- Group IV consists of 5 ETT cases with GFP and zirconia crowns, which consisted of a core's build up with Vita In-Ceram YZ Disc (Vita Zahnfabric/ Germany), and the porcelain build-up were done with porcelain VITA VM(R)9 (Vita Zahnfabric/Germany) crowns.

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.

Following was the inclusion and exclusion criteria for the present study

Inclusion Criteria: Cases of ETT at maxillary anterior teeth and restored with GFP then composite resin core build up. The quality of ETT should be RCT with no evidence of periapical pathology or root fracture. The periodontium was stable with no evidence of bleeding on probing and with a good bone support. All teeth should have enough ferrule and biological width, to allow the creation of the finish line on a sound tooth structure.

Exclusion Criteria: Teeth with pulpal and periapical pathosis and those that could be used or diagnosed to be used as an abutment for prostheses. Patients with absent from adequate posterior support and posterior vertical stops (absence of all molar teeth), or if there were any obvious occlusal interference or fremitus affecting the tooth to be restored

Results & Discussion

Preventing contamination of the root canal system between completion of endodontic treatment and restoration of the tooth should be a primary concern. Contamination is thought to be an important cause of future problems in endodontically treated teeth. Therefore, an immediate restoration should be placed, whenever possible. Delaying restorative treatment to assess the success of endodontic treatment is generally not in the best interest of the patient. Temporary restorations do not effectively prevent contamination for extended time periods.

When immediate restoration is not possible, orifice barriers should be placed to help protect the root canal system from saliva contamination. Bonded materials such as composite resin or glass ionomer cements are excellent choices. A traditional temporary material such as IRM or Cavit can be used in the access opening. However, the practitioner should be aware that the temporary restoration does not protect the tooth against fracture. Sometimes endodontic treatment is performed through an existing crown. If the crown appears clinically acceptable, the access opening should be examined for dental caries.

Dental caries detector substances can assist in the evaluation, as can magnification. Absence of caries should be assured before the access opening is restored. If caries is present, the first choice is to remove the crown and remove the caries. If this is not practical, remove most of the caries and temporize the tooth as described above. The restorative dentist should then remove the crown and the remaining caries as soon as possible to minimize the chances of contamination of the root canal system.

The restoration of ETT with different post and core systems is a topic that is extensively studied and yet remains controversial from many perspectives [26, 28]. The main function of a post is to build up and securely retain a core for crown retention, but this post does not strengthen or reinforce ETT [30, 33]. The choice of appropriate post and core restorations is often complicated and should be guided by knowledge of their physical properties, indications, advantages and disadvantages, as well as the amount of coronal structure missing and aesthetic case need

Table 1: The Clinical results of ETT at the different time follow-up

Clinical Results	One Week	3 Months	6 Months	9 Months	12 Months
Movement of the crown margin under finger pressure					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	4	4
Fracture of the crown					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	5	5
Loss retention of the crown					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	3	3
Bonding at post-core/tooth interfaces					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	5	5
Periodontal status/ violation of biological Width					
Composite	5	5	5	5	5
PFM	5	5	5	4	4
e max	5	5	5	5	5
Zirconia	5	5	5	5	5
Aesthetic (color changes):					
Composite	5	5	5	3	3
PFM	5	5	5	4	4
e max	5	5	5	5	5
Zirconia	5	5	5	5	5
Recurrent caries at crown margin					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	5	5

Table 2: Radiographic Results of ETT at the Different Time Follow-Up

Clinical Results	One Week	3 Months	6 Months	9 Months	12 Months
Caries at cervical margin					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	4	4
Presence of periapical infection					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	4	4
Post fracture / root fracture					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	5	5
Loss of retention of post					
Composite	5	5	5	5	5
PFM	5	5	5	4	4
e max	5	5	5	5	5
Zirconia	5	5	4	5	5
Post adaptation in root canal					
Composite	5	5	5	5	5
PFM	5	5	5	5	5
e max	5	5	5	5	5
Zirconia	5	5	5	5	5

All endodontically treated maxillary premolars and most mandibular second premolars should receive cuspal coverage to protect the remaining cusps during occlusion. Goerig *et al.* [34] found that lateral excursive forces can shear the remaining cusp or cause vertical root fracture. He also concluded that the lower first premolars may be treated the same as anterior teeth; because of their canine-like shape, they are not subject to shearing forces on the lingual cusps.

When restoring an endodontically treated premolar, a decision regarding post placement is made based on the remaining coronal tooth structure, the functional requirements of the tooth, and an evaluation of the forces that acts on the tooth. If an endodontically treated premolar has increased functional stresses acting on the crown due to loss of the periodontuim and is to serve as an abutment for a removable partial denture a post may be indicated [35]. Conversely, if a premolar has a relatively short crown and functions more like a small molar, then a post is not indicated.

The bonding of a post to the tooth structure should improve the prognosis by increasing post retention [36]. and by reinforcing the tooth structure. This is due to stress distribution characteristics of the bonding materials. Mannocci *et al.* [37] reported that resin luting agents showed good adhesion to carbon fiber posts and glass fiber posts. The adhesion to Zirconia posts was found to be unsatisfactory; it was also observed that to improve retention, the carbon fiber post did not require any surface treatment as compared with the Zirconia post.

The limitations of this study should be noted and mentioned. The type of static loading test is used, which does not represent the intraoral condition. Teeth, intraorally, are subject to cyclic loading through mastication. This study design examined angle and force from a single direction, and this design is not necessarily representative of clinical conditions. Moreover, the oral cavity presents a different testing environment. For example, the presence of water, temperature changes and pH levels in the oral cavity may also considerably affect the results. The study also simulated maxillary central incisors, and therefore, the results can be applied only to that group of teeth. Therefore, further studies are required to simulate clinical conditions *in vivo*.

Conclusion

Selection of the most suitable post and core systems is challenging and should be guided by knowledge of their indications, advantages and disadvantages, as well as the amount and quality of remaining tooth structure and aesthetic requirements. The data generated from the present findings concludes that E max and zirconia crowns have a higher success comparing to other groups. While PFM crowns and composite restorations were associated with colour changes and inflammation of the free gingiva.

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