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Post-Endodontic Restorative and Prosthetic Options - A Review

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Abstract:-

➢ ***Background-***

In the past, conventional wisdom in post-endodontic care dictated the application of full coverage restorations to all teeth. However, recently a shift towards minimally invasive dentistry has gained traction among the restorative dentists. This change has been driven by accumulating evidence revealing that full coverage restorations often result in significant loss of healthy tooth structure. Consequently, clinicians and researchers have advocated for more conservative approaches to restoring endodontically treated teeth. These alternatives encompass partial coverage restorations such as inlays, onlays, overlays, and even simpler resin composite cores. While the allure of this minimally invasive strategy is evident, there are cases where greater coverage is necessary. Various factors, including tooth type, occlusal load, number of missing teeth, remaining healthy tooth structure, and tooth position, must be carefully considered before selecting an appropriate post-endodontic restoration.

➢ ***Conclusion-***

The purpose of this review is to summarize the post-endodontic restorations, various new materials their indications depending on the remaining tooth structure and the teeth that needs to be restored. Light has been thrown on the recent advances in the prosthetic aspect in post-endodontic cases with minimally invasive dentistry in mind.

Keywords:- *Post Endodontic Restorations, Inlay, Overlay.*

I. INTRODUCTION

The success of endodontic treatment hinges on several critical steps, with post-endodontic restoration playing a vital role. However, the significance of post-endodontic restoration is often overlooked by both clinicians and patients.

Neglecting the post-endodontic restoration can lead to several complications. One of the most concerning risks is the passage of microorganisms and their by-products into the apical region of the root and surrounding alveolar bone. This can occur due to gaps or deficiencies in the restoration, allowing bacteria to infiltrate the root canal system and cause reinfection. Delayed failures in endodontic treatment may arise as a result of this microbial ingress, compromising the long-term success of the treatment. (1)

Therefore, clinicians must prioritize the quality of post-endodontic prostheses to ensure the integrity of the treatment outcome. This includes selecting appropriate restorative materials, achieving proper coronal seals, and ensuring a tight adaptation between the restoration and the tooth structure. By addressing these aspects comprehensively, clinicians can minimize the risk of microbial contamination and enhance the likelihood of long-term success in endodontic treatment.

The development of an exact treatment plan depends on taking into account the variations between teeth that have had endodontic therapy and teeth that are still vital.

As endodontically treated teeth lose a significant amount of their tooth structure, specific techniques are typically required to restore them. The modifications that accompany root canal therapy have an impact on the choice of particular materials and restoration techniques for teeth that have undergone endodontic treatment. (2)

➢ *The Following Factors Play a Vital Role in the Selection of the Line of Treatment*

- The quantity of remaining tooth structure that is still present.
- Physical alterations affecting the structure of teeth.
- The tooth's anatomical location.
- The tooth's aesthetic requirements
- The occlusal forces experienced by the tooth.
- The tooth's restorative requirements.

➢ *The Quantity of Remaining Tooth Structure that is Still Present.*

For a tooth that has undergone endodontic treatment, the amount of tooth structure lost can range from very little endodontic access preparation to severe damage that jeopardises the prognosis of the tooth. Since no restorative material can replace intact dentin, the amount of sound coronal tooth structure that remains is significantly more important for the long-term prognosis of the restored tooth than any other factor. (2). It has been demonstrated that tooth

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structure reduction in a mesio-occlusodistal (MOD) preparation reduces tooth stiffness by 60%, while endodontic operations only reduce it by 5%, mostly due to access opening. [2, 3]

➢ *Physical Alterations Affecting the Structure of Teeth.*

Endodontic procedures cause irreversible changes to the properties of dentin. In endodontically treated molars, changes in collagen crosslinking and dentin dehydration cause a 14% loss in strength and toughness. [4]

➢ *Alteration of Moisture Content.*

There is a clearly defined way that water and dentin matrix interact [5]. Water is thought to function as a plasticizer in hydrated dentin, maintaining the matrix's softness and pliability. Water-filled gaps divide the smaller microfibrils that make up the collagen fibrils of dentin collagen [5]. These interfibrillar gaps disappear with dehydration, and the fibrils' total diameter decreases.

➢ *Position of Tooth and Occlusal Forces*

Teeth on the anterior region experience greater flexural and tensile forces than vertical compressive forces. The lingual and labial surfaces receive the majority of these stresses.

As a result, adding a post typically has no effect on preventing fractures [6]. Because they are positioned farther from the fulcrum line, anterior teeth have less force applied to them.

In posterior teeth, a full coverage restoration is typically recommended unless the tooth has an extremely conservative occlusal access opening and is not subjected to significant occlusal stresses, such as in a mandibular premolar where the occlusal table is narrow and not subjected to significant masticatory forces.

➢ *Restorative Requirement of Tooth*

The restoration's design is determined by the forces acting on the tooth and its restoration, as well as their direction. If the tooth is an anterior tooth, there won't be much masticatory force applied to the tooth and restoration. A posterior tooth will experience high compressive stresses, and if it is to serve as an abutment for a fixed or removable partial denture prosthesis, it will also experience additional horizontal or torque forces.

The goal of choosing the restoration materials is to offer the optimum resistance against fracture and caries leakage. [7]

The endodontic failure rate was actually only about 12% of patients. In addition, vertical root fractures caused 8.8% of teeth to fail. It is crucial to pay close attention to details when it comes to cuspal protection and coronal repair. There is a six-fold increased chance of failure for a molar tooth if a cuspal covering cast restoration is not placed on it. [8]

Minimally invasive dentistry has emerged as a prominent trend, particularly in restorative dentistry. Advancements in technology and materials have facilitated clinicians in practicing with minimal invasion of tooth structure. This shift toward minimally invasive approaches is driven by the desire to preserve as much natural tooth structure as possible while effectively restoring function and aesthetics.

This paper aims to review the various options available for post-endodontic restorations and to formulate clinical practice guidelines to assist clinicians in making informed decisions. By providing comprehensive guidance, the paper seeks to empower clinicians to choose the most appropriate restoration for endodontically treated teeth, considering factors such as longevity, aesthetics, biomechanical stability, and patient preferences.

- *Post-Endodontic Restorative Options*

✓ *Amalgam Restorations*

Amalgam has shown long-term success when utilized as a restorative material. Due to its aesthetic restrictions, amalgam has lost favour with certain professionals and patients in recent years. Patients are especially concerned about the amalgam's potential for metal ion toxicity. Contrary to popular belief, amalgam has a safe and successful clinical history and a high compressive strength, which makes it an excellent restorative material. [9]

Posts are rarely used for molar teeth unless there has been a considerable loss of tooth structure. Both in vitro and in vivo, a coronal-radicular core build-up with silver amalgam using the pulp chamber and potential 2 mm canal expansions, has shown to be highly successful. [10]. This is known as the Nayyar core technique in the classical sense. [11]

In a study on the long-term survival of extensive amalgam restorations that involved the rebuilding of cusps, the cumulative survival rate was 88% at 100 months. [12]

✓ *Composite Resin Restorations.*

Endodontically treated teeth having full coverage restorations (metal-ceramic crowns, onlays, and partial or full metal crowns) were compared with endodontically treated teeth without coronal coverage restorations. Coronal coverage crowns have failed to demonstrate a substantial rise in the success rate of endodontically treated anterior teeth. This result lends validity to the conservative restoration technique of using an etched resin restoration in the access opening of anterior teeth that are otherwise undamaged or have just minor restorations.

Only endodontically treated anterior teeth that require major form/color changes that cannot be achieved by bleaching, resin bonding, or porcelain laminate veneers, or that are structurally compromised by the presence of large and/or multiple coronal restorations, should have crowns placed on them.

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Scurria et al. [13] gathered information on the procedures performed by 654 general dentists carried out on teeth that had endodontic treatment from 30 insurance companies.

The idea that many anterior teeth are being adequately repaired without the use of a crown is supported by the data, which showed that 67% of endodontically treated anterior teeth were restored without a crown.

A direct composite restoration is preferred for anterior teeth with minimum to moderate restorations. When it can be challenging to light-cure composite, some clinicians prefer to use a glass-ionomer foundation or dual cure composite.

The composite can be applied directly over the gutta percha in the access cavity, which should preferably be down to the osseous level. In addition to offering a strong coronal seal, placing composite below the cementoenamel junction can reduce the tooth's susceptibility to fractures. [9]

This is a very useful technique for teeth that have suffered trauma in a young patient where the root canal walls are thin.

Composite resin restorations are rarely acceptable as definitive long-term restorations for posterior teeth. In cases where the access cavity is restricted to the occlusal surface alone, composite may be accepted as the final treatment. Composite resin is typically utilised to build up a core filling before the tooth being crowned. This can be accomplished with a dual-cure composite resin or a light-cure composite that is applied progressively.

✓ *Post And Core*

When restoring teeth that have undergone endodontic treatment, the placement of a post is typically advised if there is insufficient remaining tooth structure to support an amalgam or composite core.

When a tooth is restored with a post, core, and crown, the stress distribution pattern is noticeably different from when the tooth is left intact. During mastication, the "post–core–crown–tooth system" in a post–core repaired tooth bends or flexes as a single unit. The "flexing pattern" of a post-core repaired tooth differs from that of a typical undamaged tooth, and this variation may be the reason for periodontal bone loss in teeth with metal posts [14].

The appearance of stress concentration zones and the rise in tensile stresses generated inside the remaining tooth structure of a post-core restored tooth are the two fundamental distinctions between an intact tooth and a tooth repaired using the post-core technique.

Masticatory loads that are oriented away from the tooth's long axis have been found to dramatically increase the tensile strains and the severity of stress concentration.[15]

- *Custom Cast Post and Core*

Because of their extensive clinical track record of efficacy, cast metal posts were regarded as standard, with a high clinical success The issue of bonding the post with the core is resolved by custom cast posts. In the event of retreatment, they are also readily removed.

Nonetheless, they include laboratory procedures and call for more sitting time than other posts. As a result, they are not cost-effective. They are no longer in widespread usage since they are ineffective as compared to the alternative post systems. In addition, they have the drawback of the need for temporization, increasing the risk of root canal system contamination.

- *Prefabricated Post Systems*

For the past 20 years, prefabricated metal posts have been employed extensively. There are two types of prefabricated posts: active and passive. For most of the cases, passive forms are advised. Active posts must be used in some situations, typically involving small teeth with low retention. However, in the majority clinical scenarios, passive posts are typically selected as the active post have a higher potential to produce root fractures and difficulties in removal. [16]

- *Non-Rigid Post Systems*

Compared to rigid posts, non-rigid posts are intended to have physical characteristics that are closer to those of dentin. Glass, quartz, or carbon fibers embedded in a resin matrix make up their composition. Non-rigid posts in teeth with sound structural integrity flex with the tooth in response to functional forces, minimizing force transmission to the root and lowering the possibility of root fracture.

For compromised teeth with minimal tooth structure left above the tissue, non-rigid posts are not advised because the crown margin should engage at least 2 to 3 mm of the axial wall. A post will flex more under a load if it has the same modulus of elasticity as the root but a significantly thinner diameter.

Following flexure under occlusal stresses, the core may undergo micro-movements, the cement seal may be broken, and the core and crown may encounter microleakage.

Although preliminary post-failure is not clinically noticeable, it permits leaking that might cause caries or bacterial recontamination of the canal. [17].

✓ *Metal Ceramic Crowns*

When an anterior tooth that has undergone endodontic treatment needs to be crowned, metal-ceramic crowns are frequently recommended as the primary non-adhesive replacement for the anterior dentition. It is required to reduce the labial surface by about 1.8–2 mm. When prescribing such a repair, care should be used because this reduction could weaken the tooth tissue that is still present.

According to long-term studies, tooth caries are the primary reason why metal ceramic crowns fail [18]. Metal ceramic crowns placed on anterior teeth do not seem to have

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a different survival rate than crowns placed on posterior teeth, although anterior crowns may break more frequently and need repair. [19]

The non-aesthetic elements of the crown can be finished in metal with metal occlusal coverage, this enables a more conservative preparation in these areas and as a consequence preservation of valuable tooth structure.

✓ *All Ceramic Crowns*

All ceramic is a common dental treatment option for both anterior and posterior teeth. These restorations are now more widely available due to the development of materials with the strength to sustain functional pressures and aesthetic benefits.

All ceramic restorations have been made using a variety of techniques, including densely sintered alumina, glass infiltrated alumina, zirconia, glass ceramic, reinforced glass ceramic, and conventional or classic feldspathic porcelain.

Compared to metal-ceramic crowns, all-ceramic crowns provide the dentist with a better aesthetic outcome with frequently less tooth preparation. Certain all-ceramic crowns, including IPS eMax crowns, permit a labial preparation of 1 to 1.5 mm. It is imperative to ensure meticulous tooth preparation with well-rounded internal line angles to prevent the concentration of stress beneath the crown, which may result in the production of microcracks and the spread of fractures. It is possible to adhesively bond these crowns. [20]

- *Recent Trends in Post-Endodontic Prosthetic Options-*

✓ *Partial Coverage Restorations –*

In restorative dentistry, there are several types of indirect restorations, including inlays, onlays, and overlays. Each type has its characteristics and indications which are discussed below.

▪ *Inlays:*

Inlays are indirect restorations that are placed within the tooth's occlusal surface, without covering any cusps. They can be used to repair moderately sized cavities or areas of tooth damage. Inlays can have various configurations, such as mesio-occlusal, disto-occlusal, or mesio-occlusal-distal preparations. They are considered the least invasive type of indirect restoration for posterior teeth.

Ceramic inlays are an excellent choice to consider if you would prefer a less radical change to the appearance of your teeth during the design process. If a patient requires a class II restoration, in which both the buccal and lingual walls of the mouth are left unharmed, blend or composite rebuildings can be used instead of metal-projecting ones. They can also be used as a viable alternative in situations where the use of an immediate back composite rebuild would be impossible due to the extreme width of the isthmus in question. [21] **(Figure 1)**

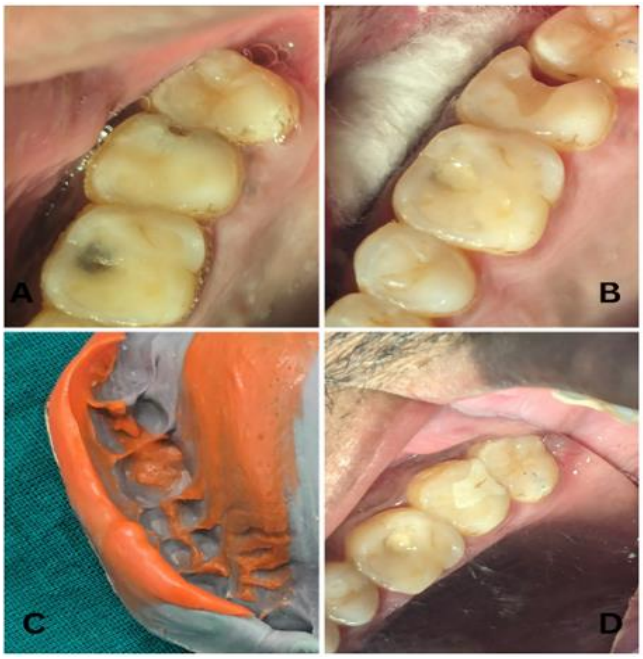

Fig 1 A, B: Inlay Cavity Preparation, C: C-Silicone Putty Impression, D: Ceramic Inlay Bonded in Place

▪ *Onlays:*

Onlays are restorations that cover one or more cusps of the tooth but do not extend to cover the entire occlusal surface. They are used when the damage to the tooth extends beyond what an inlay can effectively restore but still leaves a significant portion of the tooth structure intact. Onlays provide more coverage and support compared to inlays while preserving as much natural tooth structure as possible.

They are bonded restorations with supragingival borders and cuspal coverage to preserve tooth structure. Onlays do not cover the entire external structure and thus can simplify the tooth preparation, impression-making, cementation, finishing, and polishing processes. Biocompatible ceramic onlays are the material of choice in modern dentistry. Compared to resinous materials, ceramic offers physical and mechanical characteristics more similar to enamel and dentine, such as a higher modulus of elasticity, hardness, and coefficient of thermal expansion. Modern adhesives also provide superior bonding, even though proper tooth preparation should not be ignored. [22]

▪ *Overlays:*

Overlays are restorations that cover all the cusps and the entire occlusal surface of the tooth. Unlike onlays, overlays have margins placed high, sometimes coronal to the proximal contact areas. This type of restoration is indicated when extensive damage or loss of tooth structure requires full coverage of the occlusal surface while still preserving the natural proximal contact areas and adjacent teeth.

By selecting the appropriate type of indirect restoration based on the extent of tooth damage and the desired treatment outcome, clinicians can effectively restore function and aesthetics while maintaining as much natural tooth structure as possible**. (Figure 2)**

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Fig 2 Overlay Preparation, Etching with 37% H3PO4, and Bonding of E - Max Overlay Prosthesis with Dual Cure Resin Cement

✓ *Veneers*

Clinicians often face the dilemma of choosing between full coverage crowns and less invasive options like laminate or veneer restorations for endodontically-treated teeth where the aesthetics are to be enhanced. While full-coverage crowns may seem like a comprehensive solution, laminate veneers offer a less invasive alternative that preserves more natural tooth structure.

Laminate veneers involve minimal removal of tooth structure, making them a conservative option for restoring the appearance and function of endodontically-treated teeth. In cases where teeth are heavily discolored following endodontic treatment, internal bleaching before veneer application can further enhance esthetic outcomes.

By carefully weighing the benefits and drawbacks of different restoration options and considering the specific needs and conditions of each patient, clinicians can make informed decisions to achieve optimal outcomes while preserving tooth structure and promoting long-term oral health.

Indeed, veneer crowns offer a specific restorative option in dentistry, typically reserved for cases where aesthetics are of paramount importance and certain criteria are met as mentioned below:

- *Esthetics Priority:*

Veneer crowns are primarily indicated when achieving optimal aesthetic outcomes is the primary concern. This can include cases where there are cosmetic imperfections or abnormalities in the teeth that significantly affect the appearance of the smile.

- *Mixed Substrate:*

They are suitable for cases where there is a combination of enamel and dentin substrate, allowing for effective bonding and restoration of both tooth structures.

- *Minimal Parafunction:*

Veneer crowns are best suited for patients with minimal or no parafunctional habits, as these habits can exert excessive force on the restorations, increasing the risk of failure.

The preparation for veneer crowns aims to preserve as much remaining enamel as possible while still achieving the desired aesthetic outcome. This involves a conservative preparation design that minimizes tooth structure removal.

Common indications for veneer crowns include restoring peg-shaped lateral incisors or teeth with large proximal restorations and endodontic access.

However, there are situations where veneer crowns should be avoided or used cautiously:

- *Insufficient Enamel:*

Veneer crowns may not be appropriate if there is insufficient enamel remaining on the tooth surface to provide adequate support for bonding.

- *Parafunction:*

Patients with parafunctional habits, such as clenching or grinding, may be at higher risk of veneer crown failure due to the excessive forces exerted on the restorations.

- *Unsuitable Anatomy:*

Teeth with unsuitable anatomical presentations, such as severe malalignment or significant structural defects, may not be suitable candidates for veneer crowns.

- *Poor Dental Care:*

Patients with poor oral hygiene or inadequate dental care may experience increased risks of veneer crown failure due to issues such as recurrent decay or gum disease.

Additionally, risk factors for veneer crown failure include bonding onto pre-existing composite restorations, inexperienced operator placement, using veneers to restore teeth with large areas of exposed dentin, and insufficient tooth structure.

By carefully considering these indications and contraindications, clinicians can determine whether veneer crowns are the appropriate treatment option for their patients, ensuring long-term success and satisfaction with the restorations. [23] **(Figure 3)**

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Fig 3 Pre-Operative Intraoral Picture, Minimal Intra-Enamel Preparation for Ceramic Veneer, Bonding of Veneers in Place

✓ *Endocrowns*

Endocrowns have emerged as a promising prosthetic option for restoring endodontically treated teeth, particularly in cases where there is excessive loss of tooth structure or when traditional rehabilitation with posts and crowns is not feasible due to limited interproximal space or inadequate ceramic thickness. Here's an overview of the indications, contraindications, and advantages of endo crowns:

- *Indications:*

- Excessive loss of tooth structure with limited interproximal space, making traditional post and crown restoration impractical.
- Clinically low crowns, particularly in molars.
- 3.Cases with calcified or slender root canals.

- *Contraindications:*

- Pulp chamber depth less than 3mm.
- Uncertainty regarding successful adhesion.
- Negligible remaining tooth structure.

Endocrowns offer several advantages, including easy application, short clinical time, cost-effectiveness, minimal chair time, and improved aesthetics compared to traditional restorations. The retention of endo crowns relies on both macro mechanical retentions provided by the pulpal walls and micromechanical retention achieved through adhesive cementation.

The preparation for endocrown restoration typically involves the following steps, as suggested by Bindl and Mormann:

- Circumferential 1.0-1.2 mm depth butt margin.
- 5 mm depth for the first maxillary premolars, and a 5 mm diameter and depth for molars.
- The thickness of the ceramic occlusal portion of endocrowns usually ranges from 3-7 mm.

Although there are no strict guidelines for preparation, adhering to these general principles can help ensure proper fabrication and successful outcomes with endo crowns. [24] **(Figure 4)**

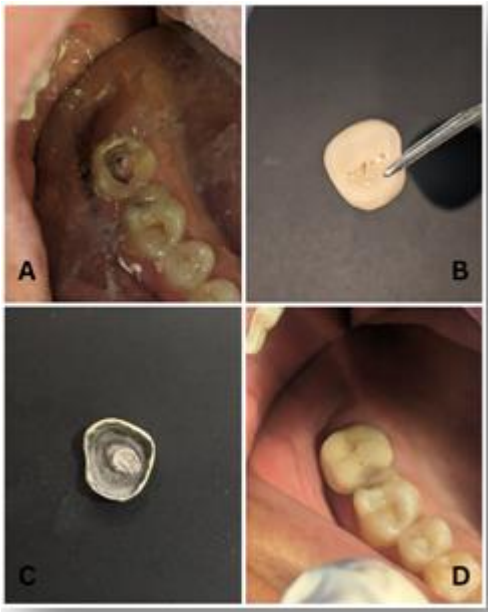

Fig 4 A- Cavity Preparation, B&C- Endocrown Prosthesis, D- Cemented Endocrown

- *Clinical Guidelines*

For anterior teeth experiencing typical functional load, it's essential to evaluate the remaining tooth structure. If only one proximal surface is affected, a resin-bonded composite restoration is adequate for filling the access cavity. However, if both proximal surfaces are involved, a veneer may be the preferred restoration. When the remaining tooth structure is between 1-4mm, a post and core restoration followed by a crown is recommended (Figure 5).

For posterior teeth with normal functional load and conservative access cavities, a resin-bonded restoration is sufficient. For teeth with larger cavities or lost proximal surfaces, indirect restorations such as inlays, onlays, or crowns are preferred. In cases of more severe tooth structure loss, post and core restorations are recommended (Figure 6). For teeth experiencing abnormal functional load or those intended to serve as abutments, full coverage restorations are advised.

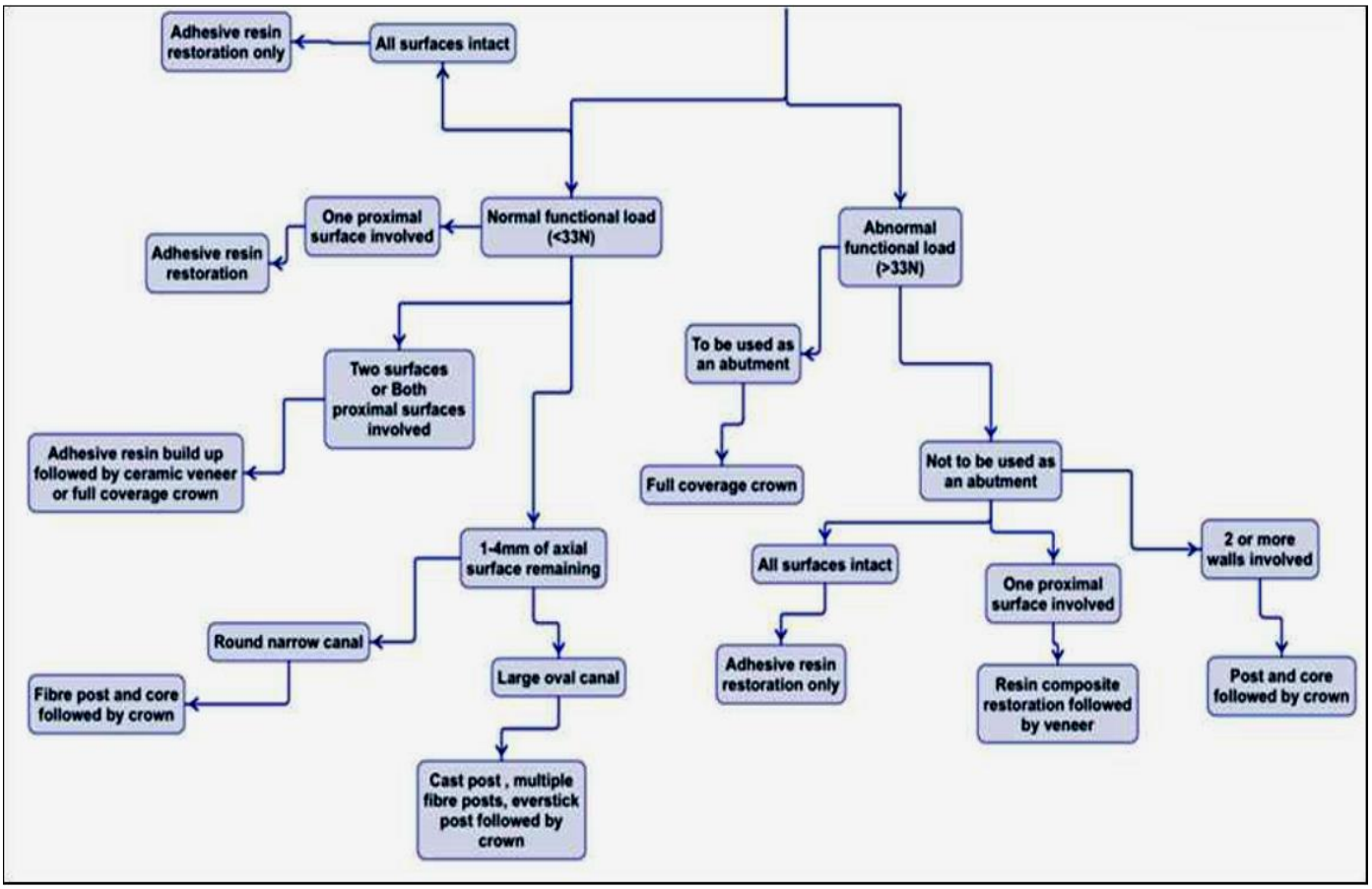

Fig 5 Clinical Guidelines for Choice of Post-Endodontic Prosthesis in Anterior Teeth [25]

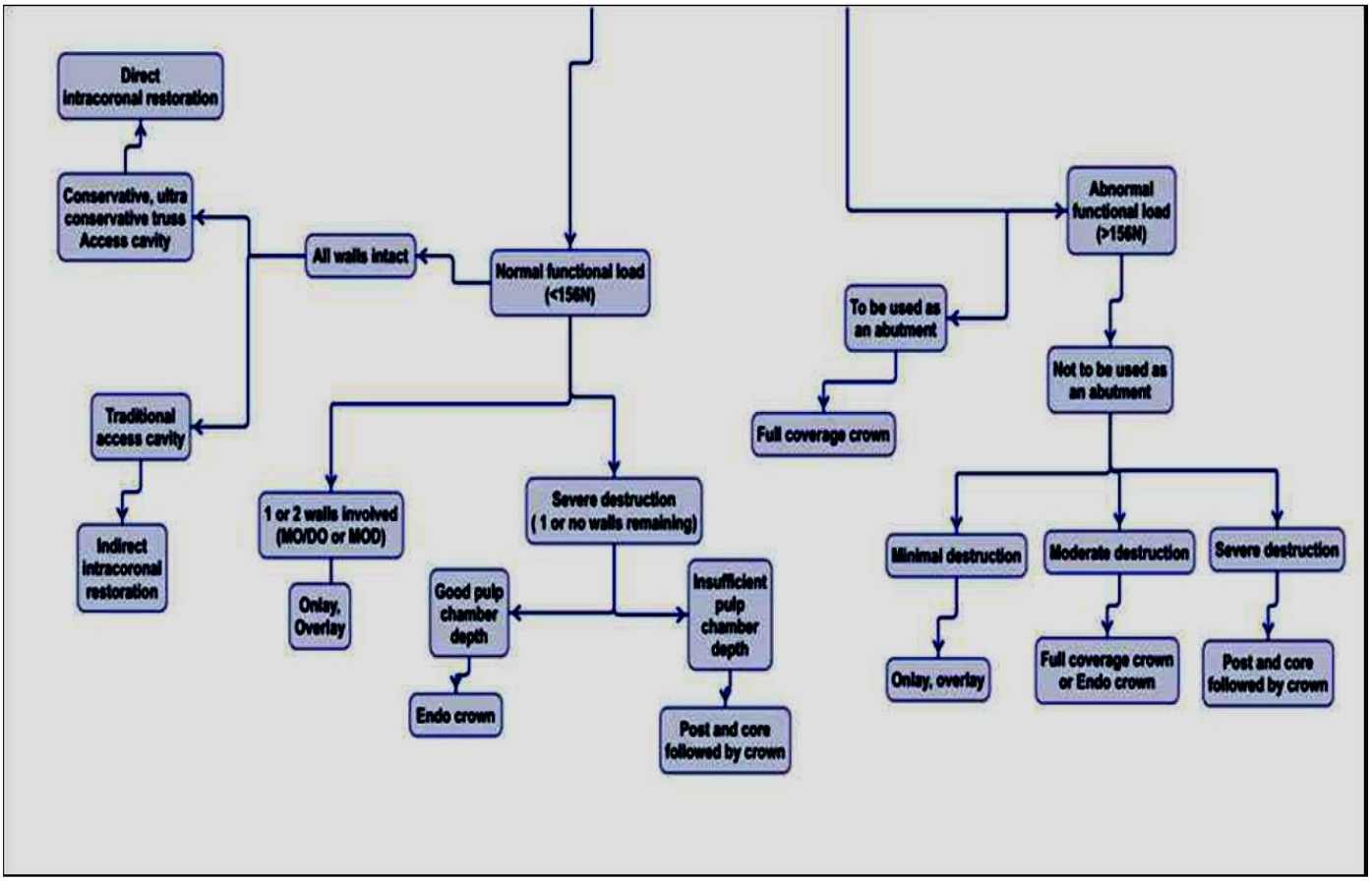

Fig 6 Clinical Guidelines for Choice of Post - Endodontic Prosthesis in Posterior Teeth [25]

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II. CONCLUSION

Post-endodontic restoration is crucial for the long-term survival and success of endodontic treatment. With the advent of newer materials and technologies, conservative approaches are increasingly recommended. Bonded restorations are preferred over non-bonded ones due to their superior performance and durability. However, more evidence regarding the long-term survival and effects of post-endodontic restorations is necessary to aid clinicians in making well-informed decisions.

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