



Decision Making for Restoration of Teeth Following Root Canal Treatment: A Narrative Review

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Authors' contributions

This work was carried out in collaboration among all authors. Author CSC designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author JSD checked all drafts, Author MSY managed the literature searches. All authors read and approved the final manuscript.

Article Information

Editor(s):

(1) Dr. Armando Montesinos Flores, National Autonomous University of Mexico, Mexico.

Reviewers:

(1) Márió Gajdács, University of Szeged, Hungary.

(2) Aliaa Abdelmoniem Bedeir Eita, Alexandria University, Egypt.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/70122>

Mini-review Article

Received 12 April 2021

Accepted 18 June 2021

Published 23 June 2021

ABSTRACT

Objectives: The decision-making process is extremely important in the field of dentistry, including the field of endodontics, particularly in the selection of materials to be used for restoration. This review paper aims to summarize the factors to be taken into account before choosing a restoration for endodontically treated teeth, to review the different options of restorative materials, as well as to compare the conventional method of crowning endodontically treated teeth with the use of adhesive composite resins on these teeth.

Data: In order to find relevant articles, search terms including composite resin, partial crown, full crown, root canal therapy were used.

Sources: Sources were gathered from bibliographic databases including MEDLINE, National Centre for Biotechnology Information (NCBI), ResearchGate as well as ScienceDirect.

Study selection: Only articles that are 10 years old or newer were included in the study. In cases where there are insufficient articles that fit this criterion, the length of time was extended to 25 years old.

Articles must be published in the English Language.

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Conclusion: The selection of coronal restorations requires the consideration of a multitude of factors. A clinician must always weigh in the benefits and drawbacks of each type of restoration as well as taking into account aesthetics and patient satisfaction.

Keywords: decision making; endodontically treated teeth; endodontics; onlays; crowns; resins.

1. INTRODUCTION

Oral health and its maintenance are one of the most important factors that contributes to the overall health and physical wellbeing. The decision-making process and choice of materials for restoration to be used must be closely related to the vitality, functionality, and aesthetics of the tooth [1]. This decision-making process is the essence or core of everyday clinical practice in the field of dentistry. The process relies heavily on the application of theory-based knowledge, balancing the risks and benefits and the consideration of probabilities and various outcomes [2]. This is imperative in endodontics as procedures such as root canal therapy (RCT) often tend to further weaken tooth structure. For example, when removing excess tooth structure in order to ensure optimum entry to access cavities. Hence, great importance must be given not only to the root canal treatment itself but also the selection of the post RCT restoration, particularly the selection of an adequate coronal restoration [3]. Much debate still revolves around the selection of the coronal restoration for post RCT treatment. It was found that a full-coverage crown is better than a partial coverage restoration as the former provides better mechanical strength and support to the tooth.

2. OBJECTIVES

1. Review the factors taken into account when choosing a coronal restoration for a post-RCT tooth during the decision-making process.
2. Review different options and properties of coronal restorations.
3. Collate evidence regarding the benefits and drawbacks of using a full or partial crown as well as the potential benefits of using a partial crown/direct composite restoration instead of a full crown where appropriate.

3. METHODS

To retrieve relevant articles, search terms including “composite resin”, “partial crown”, “full crown”, and “root canal therapy” were used.

Sources were gathered from bibliographic databases including MEDLINE, National Centre for Biotechnology Information (NCBI), ResearchGate as well as ScienceDirect.

3.1 Inclusion Criteria

- Only articles that are 10 years old or newer have been included in the study. In cases where there are insufficient articles that fit this criterion, the length of time was extended to 25 years old.
- Articles must be published in the English Language.

4. RESULTS AND DISCUSSION

A total of 112 articles were retrieved from the database by imputing the keywords above accounting for the inclusion criteria. 70 articles with scopes other than coronal restoration for endodontically treated teeth were excluded. A total of 42 articles were included in the study.

5. CHOOSING A CORONAL RESTORATION

The most efficient way to restore an endodontically treated tooth is still a controversial topic of heated debate to this day. It is imperative that dentists preserve as much sound hard tissues as possible as the loss of the coronal hard tissues of the tooth will result in compromises of the biochemical strength and overall longevity of the tooth. Besides, the choice of restoration must be appropriate so that it can sufficiently withstand occlusal forces during mastication, provide an adequate coronal seal in order to prevent future recontamination of sealed roots [4], be able to replace the destroyed dental tissue, restore normal coronal morphology and function and minimize the risk of the crown and/or root fracture [5]. Therefore, multiple factors must be considered when choosing a coronal restoration in order to fulfill the requirements above.

Studies by Zarow *et al.* and Faria *et al.* [6,7] reported that three of the most important factors that a dentist must take into account when choosing a restoration for endodontically treated teeth are the functional requirements, remaining tooth structure and the use of posts. In addition

to that, Spear Frank M, [8] also gave importance to secondary factors such as aesthetics and as well as value when choosing a restoration

5.1 Functional Requirements

The tooth position and placement in the arch must be considered when choosing a restoration due to the uneven distribution of occlusal forces within different positions of the arch, with the anterior regions and posterior regions exerting the least and most amount of force respectively [4]. This difference in forces is observed as the posterior teeth are closer to the temporomandibular joint [9]. According to Wan et al. [10] incisors and canines were less likely to fracture based on their location when compared to posterior teeth. Hence, the use of restorations with better strength as crowns should be considered on tooth areas bearing higher masticatory forces in order to prevent restoration fractures.

Additionally, anterior teeth are subjected to resist lateral and shearing forces whilst posterior teeth are more likely to be exposed to vertical forces. Therefore, a post may often be indicated in an anterior tooth with extensive coronal damage in order to provide adequate resistance to shearing forces and lateral forces experienced by the anterior teeth [11,12].

In addition to that, a clinician must also take into account any abnormalities in the patient's occlusion that may compromise the restoration to be used. A study by Zarow et al. [6] describes a classification that groups abnormal occlusion attrition into constricted path of closure, occlusal dysfunction and parafunction. Excessive occlusal wear is an important factor to take into account as it may indicate more destructive forces/ loads on the teeth which may lead to tooth fracture as well as restoration fracture such as crown or post-fracture [6,13] A study by Hidaka et al. [14] reported that a force of a tooth may be 10 times higher than the maximum biting forces when distributed within a balanced occlusion. Hence, understanding proper occlusal problems and planning appropriate and adequate reinforcements is one key to reduce failure.

5.2 Remaining Tooth Structure

Depending on the amount of tooth structure remaining, different treatment approaches can be considered. Nagasiri & Chitmongkolsuk, [15] reported that there is a direct relationship between the tooth structure and longevity of the tooth in the future. A dentist must take this into

account, as the remaining tooth structure influences fracture resistance which in turn dictates which type of restoration is needed. For example, in a situation where there is extensive coronal structure loss, a post and core along with a full-coverage crown would be needed to retain the permanent restoration whilst a tooth with minimal loss of tooth structure may require only a direct composite restoration in order to seal the access cavity [15,4,16].

In addition, marginal ridges and axial walls of the tooth must be taken into consideration when assessing structural integrity. The marginal ridges have been found to be important in the maintenance of tooth stiffness and limiting excessive cuspal deflection. A study showed that a 0.5 mm marginal ridge thickness significantly increased tooth fracture resistance when compared to a normal tooth [17]. Furthermore, in terms of axial walls, the larger the cavity preparation the thinner the axial walls. A study showed that an axial wall of less than 2 mm led to a reduction in tooth fracture resistance. A review by Abu-Awwad, [4] describes a classification for endodontically treated teeth. The authors grouped endodontically treated teeth into 3 categories as well as their interventions. Table 1 summarizes the authors' categories and restorations needed. In addition to that, Table 2 shows the restorations indicated in relation to the positional/functional requirements.

5.3 Use of Posts

The primary purpose of a post is to retain a core in teeth with extensive coronal structure loss. In the past, some researchers believe that the use of a post may improve fracture resistance in endodontically treated teeth, but nowadays it is commonly known that the preparation of a post space may increase root fracture [7]. For anterior teeth with minimal tooth structure loss, the use of a post and core is not indicated as bonded restoration is normally sufficient to close the access cavity. However, anterior teeth in which a crown is to be placed, a post is normally indicated as the remaining tooth structure is quite thin after the crown preparation and hence, additional support to shearing forces must be provided to prevent fracture [11,12]. Anterior teeth are required to support flexural stresses unlike posterior teeth; hence rigidity is an important trait for the anteriors. As a result, posts may be used more often as they provides increased rigidity to the tooth [19,20].

Table 1. Categories of destruction and intervention

Destruction category	Features	Axial wall	Permanent restoration
Minimally destroyed	Occlusal cavity OR Mesio/disto occlusal cavity	Thick axial wall (≥ 2 mm)	intracoronary restoration OR Crown (areas with excessive loads)
Moderately destroyed	Mesio/disto occlusal cavity OR MOD cavity	Thin Axial wall (< 2 mm)	Adhesive retained restoration OR Crown
Severely destroyed	Cavity extending over MOD	-	Full crowns

Table 2. Summary of restoration of the root filled tooth

Tooth type	No previous restorations (for premolars and molars where the marginal ridges are intact)	Previously heavily restored (for premolars and molars where one or more marginal ridges lost)	Previously crowned (for premolars and molars where both marginal ridges lost)
Anteriors: Incisors Canines	Conventional composite in access cavity	Composite build up (or crown for canines)	Replace crown +/- post
Posteriors: Premolars Molars	conventional composite in access cavity OR Nayyar core amalgam restoration	Consider cuspal protection with onlay or crown (gold onlay where possible)	Replace crown & amalgam Nayyar core where possible

Note: adapted from Eliyas, Jalili and Martin [18]

On the other hand, molars normally do not require posts as their pulp chamber and canals usually provide adequate retention form for core buildup. They require a post only if the destruction of tooth structure is extensive [21]. Contrarily, premolars often require the posts because unlike molars they have relatively smaller pulp chambers, as well as a single root. Hence, premolars need adequate retention and resistance form [22,21].

5.4 Aesthetics

In addition to the factors above, a clinician must not disregard aesthetics when treating a patient. This is particularly important when dealing with cases involving the anterior teeth as these teeth are visible and contribute heavily to a patient's smile [23]. A correctly fabricated crown or bridge should blend in with the natural shade and structure of the patient's other teeth [24]. Ahmad, [24] also added that the good restoration should not stick out like a "sore thumb" and should integrate or mimic natural teeth in terms of appearance.

5.5 Value

Values involves weighing the monetary costs as well as the benefits of the treatment/restoration to the patients. However, value is not determined by the clinician but by the patients themselves. The dentist has a responsibility to fully inform the patients regarding the risk and rewards of the testament/restoration. In cases where the patient's request contradicts the best possible treatment, the dentist is only able to fully inform the patient about the costs as well as the risks of performing a chosen treatment/restoration. Therefore, ultimately it is up to the patient's alone when deciding the treatment/restoration [6]

6. TYPES OF CORONAL RESTORATIONS

6.1 Direct Restorations

6.1.1 Glass ionomer cement

Glass ionomer cement (GIC) has a long history within the field of dentistry. GIC has a vast application of uses in the field of endodontics

including sealing root canals, sealing and restoring the pulp chambers, and repairing perforation and root resorption defects. The success of this material is mainly due to its ability to strongly form a chemical bond with dentin which enhances the strength and stability of the tooth. Furthermore, a unique property of GIC is its ability to release fluoride into the oral cavity [24]. The fluoride imparts protection and an antimicrobial effect to combat root canal infection as well as enhances remineralization of enamel [25]. However, the main downside of GIC is its lower resistance to crack propagation when compared to a direct resin restoration. Therefore, they are contraindicated in stress-bearing areas such as posterior regions as well as on teeth with extensive loss of structure [26,27].

6.1.2 Amalgam

Dental amalgam generally is not used on the final restoration of endodontically treated teeth. This is mainly due to the property of amalgam, that prevents it from forming a strong bond to the tooth structure. Moreover, in order for amalgam to be retained in cavity preparation, retentive features must be present, but this normally involves the removal of sound tooth structure [26] leading to further weakening of the tooth. The most prevalent application of amalgam in endodontically treated teeth is as a core material. In some cases, amalgam can also be used as a direct crown restoration (Nayyar core crown). In this technique, a single piece of amalgam is condensed from the canal orifice all the way to the cuspal tip. This technique is indicated if further tooth preparation will lead to the weakening of the structure or the loss of tooth resistance forms. Amalgam can also be used in conjunction with composites as it has a similar elastic modulus to that of dentine and composite resin. Belli and Eraslan [26] reported that amalgam under composite may be beneficial in increasing resistance of root-filled premolars. An amalgam composite combination may be used in deep cavities [26].

6.1.3 Direct Composite Resin restoration

Restorations with composite resin is one of the more favorable choices for endodontically treated teeth as it preserves maximum sound tooth structure. In addition to having a tooth-colored appearance, this type of restoration also provides good resistance to tooth fracture as well as providing intra coronal reinforcements [28]. A study shows that composite resin restoration

using adhesive techniques is useful when restoring cavities with up to 3 surfaces. However, the main downside of this type of restoration includes polymerization shrinkage/stress as well as sensitivity to moisture exposure [29]. Hence, the clinician's techniques/skill, as well as the patients' cooperation, are vital in the use of composite resin.

6.2 Indirect Restorations

6.2.1 Adhesive onlays

An onlay is defined as a partial restoration that restores one or more cusps or the adjoining/entire occlusal surface of the tooth and is retained by mechanical or adhesive means. These adhesive onlays have the advantage of providing adequate cuspal coverage while retaining as much sound tooth structure as possible thus increasing the strength and stability of the tooth [4,30]. Many different types of materials are available for the manufacturing of onlays such as gold, ceramic materials as well as composite resins.

Gold onlays have the advantage of being an unreactive material and relatively high survivability and strength when compared to resin and ceramic onlays [18]. Furthermore, a review by Al Awwad, [4] reported a 5-year survival rate of 89%. However, due to their color, it might not be favorable for some patients especially if the filling lies in the aesthetic zone of the patient.

Ceramic onlays have a tooth-colored appearance making it a good aesthetic option similar to composite resin. It has a 5-year survival rate between 71-98.5%. However, when placed on non-vital teeth, posterior teeth, and those with parafunctional habits, ceramic onlays may experience higher failure rates [31].

Composite resin overlays are useful in providing a biological conservative and aesthetic option. Similar to Ceramic onlays, it has a higher failure rate of 21% when used on posterior teeth in parafunctional patients [4]. In addition to that, using composite resin is largely influenced by the size of the restoration as well as the operator's skill in building restorations.

6.2.2 Crowns

Dental crowns are indirect restorations that completely caps and encircles a tooth. Crowns

are used extensively as they provide the required cuspal protection and improved strength in endodontically treated teeth which are more likely to fracture. Unlike other types of restoration, placing a full crown involves the removal and destruction of sound tooth structure in order to provide adequate resistance and retention form of the crown to the tooth. There are many different materials for the manufacturing of dental crowns some of which include gold, porcelain fused to metal, and Ceramics.

Gold crowns are known as the gold standard for comparison. This is attributed to their longevity of about 96% over 10 years with a low failure rate of 1.4% [29]

Porcelain fused to metal (PFM) crowns are metal crowns with a thin layer of ceramic coating its outer surface. In addition to their tooth-colored appearance, these crowns also have a good survival rate with a study by Behr et al [32] reporting an eight-year survival rate of 92.3% and 95.9% for anterior and posterior PFM crowns.

Similar to PFM crowns, Alumina, and zirconia-based crowns exhibit tooth-colored structure. However, when compared to PFM crowns, they exhibit a slightly lower 8-year survival rate of 83.9% and 92.8% for alumina and zirconia-based crowns respectively. Furthermore, comparisons between PFMs and ceramic crowns showed that PFMs are more durable than ceramic crowns with an 8-year survival rate of 62% and 48% respectively [33].

6.2.3 Endocrowns

An “Endocrown” is known as monolithic ceramic construction used to restore the severely damaged occlusal surface of an endodontically treated molar tooth. These crowns are anchored onto the pulp chamber thereby providing micromechanical retention whilst adhesive cementation would provide micromechanical retention [34]. In addition to that, endocrowns bear several advantages over conventionally full-coverage crowns including better mechanical performance, more economical costs as well as taking less clinical time to complete the procedure. However, endocrowns have a lower 5-year survival rate of 77.7% compared to that of conventional crowns at 98.3% [35]. In addition to that, the use of the endocrown is also relatively new hence some dentists may not be familiar with its use and application [36].

7. DIRECT (COMPOSITE RESIN) VS CROWNS

The conventional and traditional approach to the restoration of endodontically treated teeth was to put on a full-coverage crown. However, despite its high survival rate, there has been an ongoing debate whether it was really necessary to apply full coverage crowns especially to teeth without extensive tooth structure loss as the placement of a crown requires removal of sound tooth structure.

For anterior teeth, a full-coverage crown is normally not indicated unless there is extensive loss of coronal tooth structure. In a review article done by Tikku et al. [37] the authors reported that for anterior teeth, a full coronal coverage did not significantly improve the success of an endodontically treated tooth. Instead, they found that a resin restoration was sufficient in closing the access cavity in an otherwise intact anterior tooth. This finding was supported by Stavropoulou, McLean, McDonald, and King [38,39,40] Furthermore, Kane [22] reported that crowning an otherwise intact anterior tooth did not necessarily make it stronger.

In a systematic study by Suksaphar et al [41] on posterior teeth, it was found that the survival rate for a full-coverage crown and direct resin composition ranges from 94%–100% and 91.9%–100% respectively. The authors reported that for the posterior teeth the survival rates of these 2 types of restorations were not statistically significant and added that removing sound tooth structure in order to place a full crown may not be suitable for those with a minimum or moderate amount of tooth structure loss. Additionally, another similar study found that a posterior tooth with mild tooth structure loss treated with either a full-coverage crown or direct restorations have no significant differences and concluded that preparing sound tooth structure for a full-coverage crown may not be appropriate in the era of adhesive dentistry [30]. These findings were similarly seen in other studies [15,42]. Eliyas [18] reported that moderately destructed molars with intact marginal ridge can be restored using a direct composite or amalgam as well as composite or gold onlays where cuspal coverage is required. For a severely destructed molar with comprised marginal ridges, a full-coverage crown is indicated as adequate resistance must be provided in order to resist the vertical occlusal surfaces on the posterior teeth in order to prevent restoration fracture.

8. CONCLUSION

It is vital to have a thorough discussion with patients in order to determine the best course of action after endodontic treatment. In addition, clinicians must also be well versed in the properties, advantages, and disadvantages of material as well as their application in endodontics in order to determine and recommend the most applicable material for use in tooth restoration after a root canal treatment.

9. DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It's not applicable.

ETHICAL APPROVAL

It's not applicable.

ACKNOWLEDGEMENTS

The authors of this study do not have any financial affiliations with regards to the study/manuscript above. Additionally, the authors deny any conflicts of interest related to this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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