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Review Article

Endo Crown-its Evolution and Overview

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Abstract

Endodontically treated teeth with severely damaged morphology provide a challenging task for the restorative dentist. Though heavily criticised for the invasive nature, such teeth are commonly restored with post and core preparations. Posts very often induce root fracture because of the mismatch in the flexural properties of the post and dentin and because of the overzealous internal tooth preparation. Research workers continued their efforts to find out a viable alternative to posts. Endo crowns provided an alternative which is less invasive than the post. The design of extension into the pulp chamber gives adequate retention to the endo crowns. The monobloc design, introduction of efficient adhesive resins, CAD/CAM fabrication technique and hybrid ceramics have refined the endo crowns and ensured long term prognosis.

Keywords: Endo Crown; Nayyar Core; Post and Core; Extensive Coronal Destruction; Coronal Rehabilitation; Molars; Mono Block Adhesive Restoration

Introduction

Loss of dental tissue can happen not only due to dental caries but also due to aggressive processes involved in the endodontic treatment. Restoring endodontically treated teeth with compromised structure was addressed with post and core preparation. Posts were not always recommended because of the possibility of root fractures caused mainly due to the biomechanical preparation. Lack of alternate methods forced dentists to continue with the treatment in the past. Nayyar core was practised as a substitute for some time but endo crowns which followed, received wide support in the context of the introduction of CAD/CAM and adhesive resins. This review narrates the evolution of endo crowns.

Post and core

Coronal portion of the tooth and its height is critical in providing retention to the restorative crown. If the coronal height of the tooth is limited, logically the clinician would make an attempt to obtain radicular retention and support. This idea was put into practice by Pierre Fauchard, the French physician (1700 AD) by inserting a wooden dowel into the root canal. Classic root canal treatment was not known in those times. Moisture in the canal would cause expansion of the wooden post and would enhance the retention. Occasionally the expansion would cause fracture of the root [1]. During the time of G V Black, metallic posts started appearing; a method by which crowns with porcelain facings were screwed to the root canal. Some clinicians of that time incorporated a tube into the root canal to allow drainage from the apex of the root [2,3].

Next in the evolution was Richmond crown which in its initial phase incorporated a threaded tube placed inside the root canal to which the crown was fitted by a screw (Figure 1). Later it was modified as a one piece dowel and crown. This design faced practical difficulties when it was used in abutment teeth especially with multiple unit fixed prosthesis. It was difficult to find a mutually parallel path of insertion and the post and core system was evolved as a solution. The endodontic treatment also started giving predictable results which compelled both clinicians and patients to avoid dental extractions and to opt for post and core system. Cast post and core with crowns cemented over it has remained popular for quite a long time. Once resins have become popular, metallic cores were replaced with bonded resin cores and metallic posts with fibre posts (Figure 2). Post and core systems received a nomenclature as foundation restorations [4-6].

Figure 1: Richmond crown exhumed from a burial ground in Germany.

Figure 2: Post and core.

Treatment with post or dowel received wide acceptance because of the retention it provided. In fact, the teeth which had undergone root canal treatment suffered a huge structural damage during the bio mechanical preparation and during the subsequent preparation for the placement of the post. Ikram., *et al.* have done a micro-CT assessment of the tooth tissue loss at different stages of preparation on a premolar tooth (Table 1). Nearly 17.5% tissue loss occurs when all the stages of tooth preparation are completed. In general, the tooth gets weakened leading to fracture and possibility of further intervention is completely negated [7,8].

Stages of tooth preparation	Volume of tooth material (mm^3)
Initial	462
Caries removal	428
Access cavity preparation	393
Root canal preparation	389.9
Preparation for fibre post	389.2
Preparation for cast post	381.3

Table 1: Loss of tooth material of premolar when subjected to root canal treatment [7].

Nayyar core

In an attempt to reduce the invasiveness of the posts, the Nayyar core (Coronal radicular dowel and core) was designed and originally it was prepared with amalgam. This was indicated in molars which have undergone sizeable removal of dentin and enamel. 2 to 4mm of gutta percha was removed from the orifices of the root canals. The canals were widened with Gates-Glidden drills to create space for the amalgam to be condensed. Amalgam was condensed into the canals along with the pulp chamber and the coronal portion of the tooth. The core portion thus developed was protected by a crown. With Nayyar Core, it would be difficult to relocate the canals if retreatment was necessitated. Entry of resins have replaced amalgam in the making of Nayyar core. Finite element stress analysis, however proved that post retained restorations distributed stress better. When hybrid ceramic resins were used for the fabrication of Nayyar cores, Von mises stress calculated were similar for both post and core and for Nayyar core [9,10]. Attempts have been made by clinicians to rebuild the crown portion along with the core by amalgam or by hybrid ceramics. Then they were known as Nayyar core crowns (Figure 3).

Figure 3: Nayyar core.

Endo crowns

An Endodontic crown or 'endo crown' is a single piece ceramic prosthesis indicated for the replacement of lost coronal portions of endodontically treated teeth, preferably molars (Figure 4). It is fabricated using CAD/CAM technology and bonded to the prepared tooth. This engages the pulp chamber which is prepared to relieve undercuts. The concept of endo crown was introduced by Pissis in 1909 in the name of mono block technique. The extension into the pulp chamber was primarily to enhance the micromechanical retention of the crown. Later in 1999 Bindl and Mormann introduced the term 'Endo crown' and described a CAD/CAM all ceramic crown which was fixed with an adhesive cement and utilized the micromechanical retention in addition to the macromechanical retention. Though started with glass ceramics, later pressable lithium di silicate, machinable composite resin and hybrid ceramics were introduced once sufficient research data was generated on polymer infiltrated ceramic network and resins with dispersed ceramic fillers (Vita Enamic, Lava Ultimate) [11,12].

Endocrowns - preparation technique

Endocrown is an all ceramic bonded restoration and it differs from conventional full coverage restorations. Full crowns get the retention from the axial walls which should have a minimum of 4mm occluso-gingival height. Endo crowns are indicated where adequate axial wall height is not obtained and hence as a compensatory retentive mechanism, endo crown is extended to the pulp

Figure 4: Endo crown.

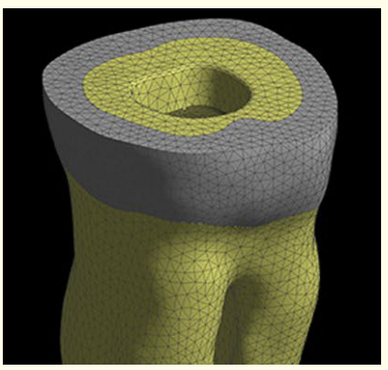

Figure 5: Design of butt joint preparation in endo crown.

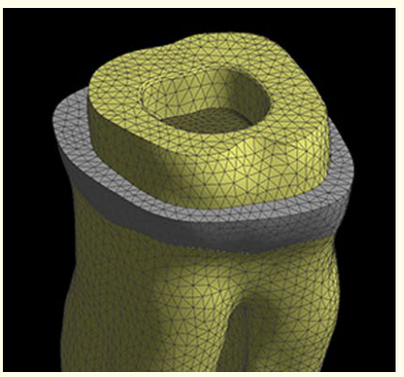

Figure 6: Design of axial wall preparation with ferrule.

chamber without involving the root canals. Floor of the pulp chamber has a saddle shape and it is retained during the tooth preparation. It may have an advantage of improving stability of the restoration. If the floor interferes with the scanning, the floor can be made flat with flowable composite resin. Undercuts if present and cannot be eliminated by reducing the dentin, flowable composite can be used for that purpose.

The first step in the preparation is giving occlusal restorative space of minimum 3mm. A circumferential butt margin of 1 to 1.2mm in width is then prepared. Enamel should be retained to the maximum to enhance bonding. A variation to this preparation is the making of a ferrule all round in the dentin to improve strength for the remaining tooth structure, when the crown is finally bonded. The ferrule increases the bonding surface and the retention of the endo crown will naturally increase. It is observed that milling may not provide such intricate designs, finally limiting the adaptation. Moreover, this is against the minimally invasive principles. The central cavity into the pulp chamber should have 5mm diameter and 5mm depth in the case of molars and 3mm diameter and 5mm depth in the case of premolars. Thickness of the ceramic endo crown in the occlusal region should be in the range of 6 to 7mm including the central pulp chamber extension. Increase in occlusal thickness increases the fracture resistance. The cervical margins are placed 1 to 2mm away from the gingival border; the more the better. It is desirable to make the access cavity wall and the pulp chamber continuous. The walls should have 5-7^0 occlusal divergence. Most of the clinicians follow the guidelines of Bindl and Mörmann in the tooth preparation for endo crowns. After evaluating a large number of samples (208) consisting of premolars and molars, they have observed adhesion failures mostly in premolars. In premolars the bonding surface availability is very limited when compared to that of molars and perhaps that can be attributed to the endo crown failures in premolars [13-21].

Restorative materials used for endo crowns

Ceramics were the first choice because endo crowns are to be bonded to the tooth. Endo crown fabrication started with reinforced ceramics. They could be bonded favourably and resisted retention challenges. However, Zirconia reinforced silica based ceramics when used for endo crowns, teeth were subjected to fractures extending to the roots and challenged the survival of the tooth. The fabrication technique got upgraded from pressing to CAD/CAM machining and lithium disilicate has become the material of choice for endo crowns. Machinable composite resins were introduced as an alternative to lithium disilicate but the latter resisted fracture better. One advantage with resins were the repairability in situ. Popular milling blocks available in the market are the following: Vitablocs MarkII (Vita Zahnfabrik), IPS Empress CAD (Ivoclar Vivadent), Paradigm MZ 100 - composite resin (3M ESPE).

Recently introduced hybrid materials combine both resins and ceramics and which could be milled. They are Enamic - a resin infused ceramic hybrid (Vita Zahnfabrik), Lava Ultimate Restorative - a nanoparticle and nanocluster-filled resin (3M ESPE) and Cerasmart – a nanoparticle-filled resin (GC Dental Products). Flexural strength of these materials are as follows: Cerasmart (219MPa), Lava Ultimate (178 MPa) and Enamic (137 MPa). Flexural modulus of these hybrid materials is: Cerasmart (7.9GPa), Lava Ultimate (10.8GPa) and Enamic (22.1 GPa). High flexural strength and low flexural modulus is a favourable combination that indicates the ability to withstand loading before fracturing. Cerasmart and Lava ultimate perform better in the case of flexibility. In contrast, ceramic materials are brittle because they exhibit relatively

high values in both flexural strength and flexural modulus (Modulus of elasticity 210 GPa). Flexural strength of dentine is 212 MPa and flexural modulus of dentine is calculated to be 17.5 GPa and the hybrid materials almost match with it [22,23].

Figure 7: Lava ultimate hybrid ceramic milling block.

Figure 8: Vita Enamic hybrid ceramic milling block.

Modified PEEK (Poly Ether Ether Ketone) that contains 20% inorganic ceramic particles (BioHPP, Bredent GmbH) can be used in the fabrication of endo crowns. Though it can be manipulated through injection moulding, the preferred process is CAD/CAM. The modulus of elasticity is 4 GPa and it behaves almost similar to bone. Modified PEEK is veneered with indirect light polymerised composite resin to obtain an acceptable tooth shade and surface finish [24].

Figure 9: Bio HPP blanks for milling.

Cementation of endo crowns

Resin cements are recommended for bonding endo crowns. Bonding procedures specified by the manufacturers should be meticulously followed to ensure long term service. The bonding should sustain the masticatory function for a reasonably long period of time. Panavia V5, Relyx ultimate and GC cement are the commonly used brands. Light curing or chemical curing cements can be used in endo crowns. If light curing is done, it would be better to opt for dual cure cements. LED lamps are preferred for curing. Resin cements have compressive/tensile strength ranging between 52-224 MPa and elastic modulus ranging from 11.8-16.5 GPa. Microleakage possibilities are comparatively low [25].

Discussion

Endodontically treated teeth which have undergone structural damage is always considered as a restorative challenge to the dentist. Use of post was once considered as a gold standard but that status did not have an unquestionable existence because of excessive removal of intra radicular dentin, possibility of off axis extension of the root canal, apical microleakage because of short apical plug and difficulties encountered in the retreatment and removal of the post. The practice of posts continued because of non-availability of alternate methods. Teeth restored with posts were not considered as solid abutments and their serviceability was questionable. A paradigm shift has occurred with the introduction of dentin adhesives and use of posts has become partially non acceptable. Though posts and cores could claim uniform stress distribution, many cases ended up with catastrophic root fractures. Adhesives along with the introduction of CAD/CAM made the way to endo crowns. Along with this a transition from macro mechanical retention to micromechanical retention also happened. The latter requires less aggressive tooth preparation and can be considered as conservative [26].

Endo crowns become a natural choice when there is excessive loss of coronal structure; to be precise, half the height is lost along with limitation of inter occlusal space. After tooth preparation, if the axial wall height is less than 4mm, conventional full coverage restorations cannot be planned. Short or curved roots, narrow root canal which cannot receive a dowel, calcification of the root canal which cannot be tackled to place a post are all considered as indications for endo crowns.

If the peripheral wall can have 2mm supra gingival height and width of 1 - 2mm, a successful butt joint can be designed and the endo crown prepared can have good prognosis. Pulp chamber with minimum 3mm depth is also an indication for endo crown. All round presence of enamel ensures good bonding of the crown and that too favours the fabrication of endo crowns [27-30].

Adhesive failure, periodontal disease and fracture are considered as factors that fail the endo crowns. Endo crowns are always indicated for molars because of the dimensional advantage and the potential to withstand the masticatory load. Premolars, canines and incisors receive maximum non axial load and the chances of adhesive failures are more. Fracture resistance evaluations also do not support endo crowns in premolars and anterior teeth. On premolars, 95% of traditional crowns survive for an observation period of ten year while only 75% of endo crowns survive.

Rayyan., *et al.* have compared the fracture resistance of Endo crowns, Nayyar core and post and core preparations in incisors, premolars and molars. In incisors the fracture resistance for post and core, Nayyar core and endo crowns were as follows: 321, 208 and 118 Newtons. For premolars, the values were 329, 345 and 292

N and for molars 384, 603 and 801 N. The values clearly indicate that for anterior teeth post and core remains as a good treatment option. For premolars Nayyar core gives highest values, though not statistically significant. For molars, endo crowns provided the highest fracture resistance values of the series [26].

Materials

Machinable composite resins, nano ceramic resins (Lava ultimate and Enamic) and lithium disilicate are popularly used in the fabrication of endo crowns. No one material can claim superiority over the other. All these materials can successfully withstand masticatory load when it is applied axially. But non axial forces are resisted better by lithium disilicate. These materials can improve the fracture resistance of the tooth, once they are used in endo crown restorations. Endo crowns fail more by debonding than by fracture. Lithium disilicate is thus preferred to other materials because it has high adhesion values [30].

Preparation design

Endo crown is a ceramic (monolithic) restoration bonded to the remaining structure of the endodontically treated tooth. This is extended to the pulp chamber by more than 3mm in depth to ensure retention and stability. It will not involve root canals as in the case of post and core or Nayyar core. Traditional full coverage restorations gain success depending on the parallelism of axial walls and their minimum height of 4mm. Endo crown indicated teeth will have only 2mm height and which will be converted as a butt joint. The enamel present in the wall should be retained to the maximum to obtain effective bonding surface other than dentin. Lateral walls of the pulp chamber are prepared with 6^0 to 12^0 occlusal divergence to balance the stress at the adhesive interface [31,32].

Conclusions

Endo treated molar teeth with structural deficiencies can be successfully restored with endo crowns. With the available evidence, in premolars, endo crowns cannot be considered as a primary option. Nayyar core will be better suited for premolars to resist fracture. In the anterior teeth, post and core will continue to be a successful restorative method. There is ample scope for research in the design of tooth preparation and restorative materials which can withstand load and bond better with dentine. In short it can be stated that endo crowns can be considered as a useful restorative treatment with reasonably good predictable prognosis.

Author Contributions

Conceptualization –K.Chandrasekharan Nair, Pradeep Dathan; Clinical report – Lekshmy A R, Aswathy S Kumar,; Review of articles – K.Chandrasekharan Nair, Lekshmy A R, Pradeep Dathan, Aswathy S Kumar; Initial draft preparation – Lekshmy A R , Aswathy S Kumar,; Review and editing – K.Chandrasekharan Nair; Supervision – Pradeep Dathan, K. Chandrasekharan Nair.

All authors have read and agreed to the published version of the manuscript.

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Figure credits

Figure 1. Richmond crown- https://www.researchgate.net/publication/226566282_Localisation_of_a_Mass_Grave_from_the_Nazi_Era_A_Case_Study

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Figures 5, 6- FEA figures - Zheng et al. BMC Oral Health (2022) 22:30
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Figures 7, 8, 9 - Catalogues