MONOBLOCK CONCEPT IN ENDODONTICS: A REVIEW

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Abstract:
Endodontic procedures like root canal treatment, post and core, etc., makes the root of the tooth brittle. This leads to the generation of monoblock concept in endodontics, which is directly related to the endodontic rehabilitation of weakend tooth structure. Monoblock concept can be achieved by using single-cone obturation technique of prepared root canal along with sealer, providing adhesion between the sealer and the dentinal tubules and, between the sealer and the obturating cones. However, some researchers focused that creation of monoblock is challenging in complex anatomical structure of root canal like fins, isthmuses, etc. This article reviewed the concept of "monoblock" and its various application to different endodontic materials used in root canal space rehabilitation.

Keywords: Monoblock, sealing ability, fibre post, modulus of elasticity

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Introduction

Prior to regenerative endodontics diseased pulp (due to caries, trauma or non-cavitated lesion) may be replaced by any form of restorative materials. Due to the brittleness of the root as weakened by endodontic and restorative instrumentation, the sealing quality and strengthening of tooth potential of endodontic replacement monoblocks become important concern.[1] Thus, the endodontic rehabilitation is very demanding procedure because the stress distribution depends on direction and magnitude of applied load therefore, it is multiaxial and also non-uniform. Therefore, it is desired necessity of treatment plan to restore reinforce the compromised tooth structure. [2]

Root canal treatment focuses on two phases: a) control of microbes (include preparation of root canal) and b) filling phase (include obturation of root canal and post endo restoration).[3] Most of the failure instances of treatment of pulpitis and apical periodontitis are due to the inappropriate mechanical debridement that leads to persistence of bacteria in the canals, poor obturation, inappropriate filling of root canal of the root canal.[4]

Figdor mention the principal functions of root canal filling are to (1) entomb bacteria remained within root canal (2) prevention of influxing of periapical tissue derived fluid that may feed the surviving bacteria, and (3) prevent coronal leakage of bacteria.[3]

Endodontic science has realized that to satisfy these challenges, there is the possibility of creating a true monobloc. Since last two decades root canal filling materials and techniques has dramatically advanced.[5]

Various techniques and different materials have been proposed till date with the aim to achieve the optimal properties mendatory for root canal filling. Also, many studies evaluated and compared the performance of obturation techniques; however, they have founded that no filling material or technique has fulfill ideal requirements.[6]

These researches for an ideal root canal filling material has given rise to the concept of endodontic monoblocks.[2]

Monoblock obturation concept obtained using single-cone technique associated with sealer, providing adhesion between the sealer and the dentinal tubules and also, between the sealer and the obturating cones.[6] However, the main purpose of adhesive root canal filling materials is the formation of fluid tight seal via creation of monoblock which provides strengthening to endodontically treated tooth.[7]

Some laboratory studies have shown that creation of monoblock root filling is a real challenge because of the heterogeneous composition of root dentin and it complex anatomy like fins, extensions and isthmuses; presence of sclerotic dentin in the apical third; and accumulation of large amount of hard tissue debris within the canal space.[8]

This review aimed to study vast concept of "monoblock" and its application to different materials used in root canal space rehabilitation.

Monoblock concept

Monoblock, literally implies "single unit". Dr. P. Robbin (1902) first to introduce 'Monobloc' in orthodontics by combining upper and lower acrylic removable appliances which was used for Class II division 1 malocclusion treatment. Later it was modified for treating the cases of sleep apnea.[1]

In endodontics, monoblock concept was introduced by Franklin R. Tay[9] and the nativity of this concept evolved from the development in dental adhesion field. 2 basic requirements for proper functioning of monoblock which require simultaneously to work as single unit are: a) material should have ability to bond effectively with each other and to the substrate and b) material which is used should be of similar elastic moduli to that of substrate. [2]

As the elastic moduli of any material increases, Von Mises stress decreases. Like, Panavia F (heavy filled resin cement) having elastic modulus approximately 18.3 GPa and zinc phosphate cement having elastic modulus approximately 9.3– 13.4 GPa show similar modulus of elasticity of dentin. Thus, when they used in root dentin, their Von Mises stress concentrations in the root dentin were lower because some stress redistributed to cement layer. However, zinc phosphate cement failed for cementation of posts as it has great modulus of elasticity and low bonding potential.

While, when Super bond C&B cement with modulus of elasticity of 1.8 GPa and glass ionomer cement with modulus of elasticity of 4.0 GPa used for cementation, high stress concentration occur in root dentin which is directly transferred to the root dentin because stress concentration within the cement layer is low. [1]

It signify a scenario where in root canal is perfectly obturated or comprise of post and core system with

a gap-free, solid mass composed of different materials and interfaces. This was first popularized in 1996 by bonding of epoxy resin– based, carbon fiber–reinforced posts to root dentin.[10]

In root canal treatment, monoblock units created by: a) adhesive root canal sealers, for example, EndoREZ in combination with bondable root filling material like Resilon or b) using adhesive post systems, having modulus of elasticity similar to dentine.[11]

The first mechanically created homogeneous monoblock in root canal space was introduced in 1996 with the bonding of epoxy resin-based, carbon fiber posts to root dentin**.** As carbon-fiber posts show similar modulus of elasticity as that of dentin, a tooth post-core monoblock form instead of heterogeneous materials. This helps in even distribution masticatory loads, thus, reduce stresses. [1]

Classification of monoblock

Sealers act as binding agents, which fills the space between root canal wall and obturating material, irregularities, also lateral as well as accessory canals**.**[12]

The bondable material used for formation of homogeneous units with root dentin is basically related to "monoblock" concept. This concept first used in restorative dentistry, and then in endodontics.

According to the number of interfaces present between bonding substrate and bulk material core

1. Primary monoblock: one interface present circumferentially between the material and the root canal wall.[1]

Common example of this would be obturation of root canals with gutta percha, without using the sealer.[9]

a) Hydron: It is 2- Hydroxyethyl methacrylate (HEMA) along with root canal filling material. This is the first monoblock used in root canals. Upon polymerization form hydrogel which is permeable and leachable. To reinforce the weaken tooth structure modulus of elasticity of root canal filling material should be close to dentin (14000 MPa), but the elastic moduli of hydron is approximately 180-125 MPa. Thus, it does not reinforce the weaken tooth structure due to its stiffness**.**[1]
b) Mineral Trioxide Aggregate: represents contemporary form of primary monoblock**.**[11]

Due to its better bioactive properties and superior physicochemical properties, it provides active seal against dentin. [13]

This material is composed of inorganic components (like Portland cement) which show chemical shrinkage after interacting with water. Due to shrinkage volumetric shrinkage takes place during setting. However, this does not cause the generation of shrinkage stresses as MTA not bond to dentin.[1] MTA form apatite deposits at the interface facilitating promising seal.[14] This seals helps to strengthen the roots of immature tooth and fills the gap induced during shrinkage phase. MTA may be able to strengthen the roots as its modulus of elasticity is approximately 14,000-18600 MPa (according to orientation and location of dentinal tubules). However, according to some studies it is not able to strengthen the roots as it does not bond to dentin.[1]

According to Mukut Seal et al (2016), for desired clinical success thickness of apical MTA barrier has significant role.[15]

c) When this classification of monoblock applied to post and core systems, then primary monoblock in root is created by polyethylene fibre post-core system like Ribbond**.** Primary necessity with this material is impregnation of polyethylene fibres with dual cure adhesive system. Thus, forming primary monoblock system.

The structure created with this impregnation has modulus of elasticity of approximately 23.6MPa (like flowable composite). There is only one interface present between fibre system and root canal.[11] Due to its high elastic modulus and low flexural modulus show modifying effect on interfacial stresses.

According to Singh et al, cyclic loading decreases the posts retention although was lesser for the polyethylene posts as compared to glass fibre posts. Also, leakage studies showed resin-supported polyethylene fiber dowels and glass fiber dowels exhibit less microleakage compared to zirconia dowel.

According to Jindal et al, glass fiber post show higher fracture strength than polyethylene fiber posts.[10]

d) Biogutta: This is a self adhesive material, consists of polyisoprene matrix which is the matrix polymer of Gutta percha along with bioactive glass

(45S5 type) exhibiting self- adhesive property showing immediate sealability.[14, 10]

It forms crystals of calcium phosphate in wet condition over the surface of material.[10]

Drawbacks of primary monoblock: lack of sufficient strength and lack of stiffness.[9]

2. Secondary monoblock: These have two circumferential interfaces, one between the cement and dentin and other between the cement and the core material. Its common example is the use of sealer for obturation, where one interface is between Gutta Percha and sealer and second between the sealer and root canal wall.[9] Generally, root canal obturations, being indirect fillings of the root canal space created by cleaning and shaping, considered as secondary monoblock systems. But, conventional root canal sealers not bond strongly to dentin as well as gutta-percha. Glass ionomer and resin-modified glass ionomer cements bond to root dentin but they do not bond to gutta-percha, also gutta percha have elastic moduli lower than dentin (175-230 times lower). So they are not so stiff to reinforce root.

To-date, various bondable root filling materials available: [1]

a) Resilon: It is applied with methacrylate-based sealer to root dentin (self-etching primer treated). This is composed of two interfaces, between sealer and dentin and between sealer and Resilon.[9] In combination with Epipheny primer and sealer system, Resilon most commonly referred as Resilon Monoblock System (RMS). Its handling properties are similar to gutta-percha, therefore can be used with any obturation technique and shrink 0.5% only.[16,5] Some previous studies stated that Resilon show better results in terms of resistance to bacterial leakage and fracture resistance**.**

According to Medhat T. Elfaramawy (2017), Resilon/ Epipheny system show better fracture resistance than conventional gutta-percha with resin.[7]

Resilon bonds to sealer through polymerization process.[14] Usually all adhesive restorations responsible for development of interfacial stresses during polymerization because of intrinsic volumetric shrinkage occur while converting double bonds to single bonds. These high stresses can debond the adhesive interfaces and increases with increase of volume to surface area ratio. Thus, the "C-factor" of cavity is important factor, as in box-like class I cavity (C-factor is 5), there are 5 bonded walls and one (i.e. occlusal) unbonded wall where polymerization stress reduced by flow of resin**.** However, in root canals, C-factors may be over 1000 and polymerizing sealer will subjected to large polymerization stresses which are responsible for debonding and gapping. Therefore, due to higher C-factor in root canals may be the reason of not obtaining perfect seals with Resilon. Also the concentration of polymeric componenets like polycaprolactone and urethane dimethacrylates present in ratio of 10:1, which may not be good for adhesion. Some recent researches indicate that Resilon and gutta-percha were comparable in strengthening and reinforcement of immature roots. This may be because elastic moduli of Resilon is similar to that of gutta percha which represents that Resilon was also not stiff enough to reinforce the root. [1]

b) Prefabricated post systems: It bonds to root dentine with the help of resin cements. [11]
Even though Carbon fibers posts have similar elastic moduli as that of dentin it demonstrated poor performance. This may be due to the fact that as the carbon fibre roughened by bur they does not have active surface or because of reduced stiffness due to the presence of epoxy resin or may be due to the non bonding of epoxy resin to methacrylate resin sealer under normal temperature. Hence, they were replaced by quartz and glass fibres which form bond to methacrylates under normal temperatures. Also the epoxy resin embedded matrix replaced by highly cross-linked, methacrylate resin matrix showing the potential to bond to methacrylate-based resin.[10]

3. Tertiary monoblocks: three interfaces present in this; cement interface with the canal; 2nd interface with surface coating of the post itself (responsible for adhesion); 3rd interface with
coating and the post.[17]

Fiber posts consisting of external silicate coating or un-polymerized resin composite for relining purpose of too wide and irregular root canals in which conventional fiber post not fit accurately that are too wide or not perfectly round for the fitting of conventional fiber posts may function as tertiary monoblocks. In such conditions, post is placed within lubricated post space and photoactivated to partially polymerize the composite. It is also problematic that tertiary interface can be responsible for formation of gaps between the fiber post and the relining composite as they may work as stress raisers which can cause dislodgement of fiber post. [1]

a) Endorez: It involves conventional gutta-percha cones coated with resin and used with dual cured methacrylate sealer. This coating is formed primarily by reacting one of the isocyanate groups of diisocyanate with the hydroxyl group of a hydroxyl-terminated polybutadiene (bond with hydrophobic polyisoprene component of the gutta-percha cones). Secondarily, it involves grafting of hydrophilic methacrylate group to other isocyanate group, forming gutta-percha resin coating which is bondable to a hydrophilic, methacrylate-based dual-cured resin sealer. It does not require dentin adhesive and depends on the hydrophilic sealer penetration into the dentinal tubules as well as lateral canals followed by smear layer removal. Several studies indicate that seal of the EndoRez system is mediocre which may be due to polymerization shrinkage of methacrylate- based sealer. Another reason may be the weak bond between the sealer and the pre- polymerized coating (lacks free radicals for bonding due to removal of oxygen inhibition layer)**.**[1] Also, uneven circumferential thickness observed due to inconsistencies in the resin coating.[10]
b) ActiV GP: also uses conventional Gutta-percha cones whose surface is coated with glass-ionomer fillers. It is also helpful in formation of bond with root dentine via bioceramic glass-ionomer sealer, thus, forming 'Single-cone monoblock obturation'.[18] It requires less sealer because of involvement of precision-based system. This system is important for single cone technique because accuracy of cone fit minimizes the sealer amount and dimensional changes.[19]

As it is surface coated with glass ionomer fillers it is stiffer, thus can be transformed into gutta percha core/cone.
However, this material also show some disadvantages like coronal leakage was worse than gutta percha or AH Plus because of increased volume of glass ionomer sealer.[1]

c) Fibre posts consisting of additional silicon coating for example DT Light or ceramic posts which need silane coating like Cosmopost can be considered as tertiary monoblocks.[11]
d) Tenax Fibre post (Coltene) with specific resin coating on the surface when cured with dual cure resin ParaCore (Coltene) forms tertiary monoblock. It forms one interface between the fibre post and the resin coating and second between the resin coating and the luting cement; and the third between the luting cement and the root canal wall.[9]

Significance of Modulus of elasticity and sealing ability
Polymerization of resin leads to volumetric shrinkage due to which bond breaks from where ingress of micro-organism occurs. Along with it occlusal loading and water sorption also responsible.[10]

Configuration factor should be less than 3 for good bonding. But because of complex configuration of root canal it was more than 1000. This causes debonding at dentin-sealer interface**.**

Time is also considered as one of the factor in which bond strength depends. Because its deterioration is associated with time.

Root dentin in its apical one-third contains less dentinal tubules than coronal dentine. Hence, less resin tags form at apical one third. However, several studies found that the hybrid layer was responsible for favorable bond strength, not the resin tag. Therefore, because of presence of more intertubular dentin in radicular dentine it results in more hybrid layer formation.[14]

As root canal treated teeth are more prone to fatigue stress due to presence of masticatory and parafunctional loads, modulus of elasticity of material which replace lost tooth structure gaining popularity. With the fact that material having same MOE as that of root dentin may helps in saving the weakend tooth structure, fibre posts gaining popularity. Also, the adhesive composite cement with modulus of elasticity close to fibre post and dentin helps in reinforcing post system.[10]

Conclusion
As the efficiency of root canal sealer and root canal anatomy greatly influence the success rate of treatment. Therefore, various qualities of different root canal materials should be consider before using them. One such consideration is monoblock. Despite of various controversies related to monoblock concept, the future of endodontics should focus on development of newer materials for improving the interface between root dentin and obturating material with the goal of providing maximum sealability from minor constriction of root canal to occlusal surface.

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