Review Article

The concept of monobloc in Endodontic - A review

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Abstract:

The creation of a homogenous filling within the root canal has always been one of the most sought after objectives in the field of Endodontics. While conventional root canal filling materials have given predictable results, the pursuit of developing alternative sealers or techniques that bond simultaneously to canal wall dentin as well as filling materials has continued. Breakthroughs in dentin adhesive technology in the recent past have built a new generation of bondable root canal sealers and post systems. Thus arose the concept of monoblocs, with its purported advantages of simultaneously improving the seal and fracture resistance of the filled canals. The added advantages of reduced application steps and overall improvements in their user friendliness led to the aggressive marketing of materials claiming to achieve the 'monobloc effect'. On the other hand the credibility of this concept in practice has launched controversial discussions. This review attempts to throw light on the various dimensions of the concept of monoblocs as well as to scrutinize the potential of various root canal filling materials to create monoblocs.

Key Words: Monobloc, bonding, seal-ability, root reinforcement, modulus of elasticity, methacrylate based root canal sealers, fibre posts

Introduction:

The literal meaning of the word monobloc is 'Single unit'. It has been variously defined as either a forging or casting made in a single piece, rather than being fabricated from separate components. The introduction of the word 'monobloc' to dentistry can be traced back to 1902, in the field of orthodontics, by Dr. Pierre Robin. It was he who first united upper and lower acrylic removable appliances to treat certain syndromic patients. This appliance went on to emerge as the precursor of functional appliances used in orthodontics. In endodontics the term monobloc is used to signify a scenario where in the canal space is perfectly filled with a gap-free, solid mass that consists of different materials and interfaces with the purported advantages of simultaneously improving the seal and fracture resistance of the filled canals. This gap free solid mass filling may imply either a root canal obturating material or a post and core system. In fact this philosophy was first popularized in 1996 with the bonding of epoxy resin–based, carbon fiber–reinforced posts to root dentin as a mechanically homogeneous monoblock.[1]

Today, the concept of a monobloc has accomplished novel implications with break throughs in dentin adhesive technology as well as amassed a heightened interest in its application to Endodontics. In theory these monoblocs created by adhesive sealers and post systems have the potential to improve the quality of seal in roots and to reinforce teeth. However, the credibility of this concept in practice has launched controversial discussions.

Monoblocks created in root canal spaces are classified as primary monobloc, secondary monobloc, and tertiary monobloc depending on the number of interfaces present between the bonding substrate and the bulk material core.[2] This classification may be applied to root canal filling materials and Post and core systems. Current treatment protocols necessitate diseased pulps to be replaced by thoroughly sealing restorative materials in order to prevent reinfection. Additionally the rigidity of root canal treated teeth are often weakened by both endodontic instrumentation and restorative intervention. In such a crisis the sealing quality and the tooth strengthening potential of monoblocks assume significant value. In fact the afore mentioned qualities ultimately determine the long term prognosis of endodontic treatment.

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Sealability

Successful root canal treatment banks on the achievement and maintenance of a hermetic seal chemically and or micromechanically, along canal system. The prevention of microleakage including the passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material cannot be overemphasized. Purported reasons for microgaps and subsequent leakage include poor adhesion and wetting, polymerization shrinkage, thermal stresses, occlusal loading and water sorption. Lately increased efforts have been directed towards the development of bonded obturating materials. These endeavors have been inspired by demands to provide a more effective seal coronally and apically. Many a low viscosity methacrylate resin–based root canal sealers have been introduced with an intent of improving the degree of bonding or adhesion of root filling materials. Simultaneously, there has been a crop of new root filling material that claims to adhere to these methacrylate resins.

Till date four generations of methacrylate resin–based sealers (MBRS) have been introduced. The first generation MBRS contained poly [2-hydroxyethyl methacrylate] as major ingredient was marketed as Hydron. Second generation MBRS are hydrophilic and does not require etching to the adjunctive use of a dentin adhesive Eg; ENDOREZ. The third generation sealers involve the use of a self-etching primer and dual-cured resin composite Sealer Eg; RESILON/EPIPHANY. Lastly the fourth generation sealers, where in the etchant, primer and sealer were incorporated into an all-in-one self-etching, self-adhesive sealer Eg; METASEAL.

Teeth with significant loss of structure require posts in the interest of retaining the core. Since the currently favored fibre posts are passively retained into the root canal, an adhesive cement is important for a good seal. These cements may be categorized as Total-Etch Resin Cements, Self-Etch Resin Cements and Self-Adhesive Resin Cements. Due to their ability to bond to tooth structure, resin cements have the potential to exhibit less microleakage than other cements. Thus both MBRS and resin cements play a central role to achieve a monoblock, in that high bond strengths are imperative between the dentin and sealer/ cement, as well as between the sealer/cement and obturating material / post system.

Reinforcing roots

It is an established fact that root canal filled and treated teeth are more prone to biomechanical failure mainly due to loss of tooth structure and integrity.

Such clinical failures are primarily attributed to physiologic masticatory forces/parafunctional forces repeated over long periods referred to as fatigue stress. In the presence of these unavoidable forces, the modulus of elasticity (MOE) of materials replacing lost tooth structure gains paramount importance. In the biomechanical aspect restoration of root filled teeth with materials having similar MOE to dentin (i.e 14.0–18.6 GPa) can save remaining tooth structure. This justifies the current popularity of fibre posts. By virtue of allowing a slight flexure that is in unison with the remaining dentin there is a favorable dissipation of stresses acting on the tooth. This in turn reduces the likelihood of irreparable damage to the root.[3] Additionally, adhesive composite cements whose elastic modulus is in the same range of that of both the fibrepost and dentin contribute to the re-inforcing potential of the post system.

Primary monoblocs

Includes root filling materials that have one interface that extends circumferentially between the material and the root canal wall. Egs; Hydron, Mineral Trioxide Aggregate (MTA), Polyethylene fibre post-core systems.

In the late 1970s, a Poly HEMA containing root filling material (Hydron; Hydron Technologies) was marketed for en masse filling of roots. The material garnered significant interest as a potential successor for sealer-dependent lateral and vertical gutta-percha (GP) obturation. Its purported qualities included ease of use, nonirritating nature, adaptability to walls, and ability to calcify in the event of extrusion. However this material became obsolete in the 1980s in view of discrepancies between the manufacturer's claims and laboratory/clinical findings. Many of these lapses could be narrowed down to sub optimal polymerization of material in situ studies demonstrated, Hydron-filled root canals exhibited extensive leakages. Residual moisture within root canals notably hampered polymerization to form soft hydrogels that were extremely permeable and leachable. Manufacturer of Hydron did not infer that filling root canals with Hydron helps to strengthen roots and prevent root fractures. In any case the modulus of elasticity of porous poly (HEMA) hydrogels such as Hydron ranges from 180 to 250 MPa. On the contrary in order to reinforce roots, the modulus of elasticity of a root filling material would need to approximate that of dentin (i.e., 14,000 MPa).

MTA (Mineral Trioxide Aggregate)

MTA is a Calcium silicate based material that has been made available since 1998. Its ongoing use as an apexification material for orthograde obturation of immature teeth with open apices and reduced circumferential dentin thickness represents a primary monoblock essentially attempting to reinforce teeth. While the material is biocompatible and antimicrobial, on the downside retreatment is not possible in teeth obturated with MTA. All the same these alkaline biomaterials have gained wide acceptance in endodontic community owing to their good physico-chemical and biological properties. Ideally MTA is condensed into measured columns and carried into canals used carriers/syringes and plugged into place. On account of being hydrophilic it sets in the presence of residual moisture within the canal space. Over time it adheres to root dentine by forming a crystalline bond by biomineralization. The formation of interfacial apatite deposits is said to account for the good seal. With regard to its physical properties, the compressive elastic modulus of Portland cement increases after 14 days to 15,000 Mpa with a water powder ratio of 0.6. MTA is thus theoretically capable to strengthen roots. However a recent study which examined the fracture resistance of MTA when applied to immature sheep roots, reported no difference in teeth filled with saline versus those filled with MTA.[4]

Polyethylene fibre post-core systems

These systems makes use of ultra-high molecular weight braided polyethylene fibres coated with a dentine bonding agent to build-up endodontic posts and cores. Component woven fibres have a modulus of elasticity (MOE) similar to that of dentine. Moreover fibres adapt well to root canal hence significant canal enlargement is not necessary. Research has revealed that in clinical conditions, the MOE of polyethylene fibre reinforced material with an adhesive material like flowable composite has a MOE of 23GPa. This High modulus of elasticity and low flexural modulus of polyethylene fibre have a modifying effect on interfacial stresses developed along the resin dentin boundary. A study by Singh et al reported that cyclic loading reduced the retention of all posts but was lesser for the polyethylene posts compared to glass fibre posts.[5] Similarly data on leakage studies indicate resin-supported polyethylene fiber dowels and glass fiber dowels tested exhibited less microleakage compared to zirconia dowel systems.[6] However contradictory to the reinforcing effect of primary monobloc with polyethylene posts, a study by Jindal et al reported that endodontically treated teeth restored with glass fiber posts showed increased fracture strength and favorable mode of fracture as compared to poloethylene fibre posts.[7]

Biogutta

A recent addition to the category of primary monobloc is the Biogutta. This product contains bioactive glass of the 45S5 type incorporated into polyisoprene, the matrix polymer of gutta-percha. Manufacturers claim the material is self-adhesive with immediate sealing of the canal system. This has been attributed to the formation of Calcium Phosphate crystals on the material's surface in a wet environment. Preliminary studies report good push out bond strength to the canal dentin when compared with conventional gutta percha.[8]

Secondary monoblocs

These materials consists of two circumferential interfaces, one between cement and dentin and other between the cement and core material Egs Resilon based systems, Fibre re-inforced posts.
By definition, conventional root canal obturations may be regarded as secondary monoblock systems on account of the two interfaces (one between sealer and dentin, second between sealer and conventional guttapercha condensed into a homogenous mass). However the lack of sealer bond to dentin or guttapercha and the trivial values of modulus of elasticity that are 175–230 times lower than dentin are contrary to the fundamental concepts of the 'monobloc effect'.

Resilon

The concept of Monoblock was rekindled in 2004 with the advent of bondable root filling materials such as resilon. Resilon is a polycaprolactone based dimethacrylate resin which contains bioactive glasses. It is intended to be used along with a primer and a dual cure sealer such as Epiphany. While the material looks and handles like conventional guttapercha, unlike conventional guttapercha, resilon obturators bond to its associated sealer, Epiphany. In this technique the self-etch primers first applied to the level of the apex with a well-fitting paper point. This is followed by coating a small amount of the dual cure sealer over the canal walls. Lastly the root canal space is filled with Resilon Points and light cured for approximately 40 seconds. This is said to be the only bondable root filling material that works effectively with vertical condensation and lateral condensation techniques and is also available in the form of pellets for use with the Obturagun system.

Resilon offers a significant advantage over conventional guttapercha in that it shrinks only upto 0.5%. Unlike guttapercha, it is said to physically bond to the sealer by polymerization with no gaps at the interface due to shrinkage.

Furthermore immediate light curing of the coronal 2mm of the canal filling enhances the coronal seal. This was corroborated in one study where in Epiphany root canal filling system exhibited the least coronal leakage when compared to gutta-percha and AH 26 sealer as well as gutta-percha and AH plus sealer.[9] However the study by Bodrumlu & Tunga showed no differences in apical sealing ability between Resilon/Epiphany and gutta-percha/AH Plus groups.[10] In one study the authors evaluated the fracture resistance of endodontically treated teeth filled with either gutta-percha or Resilon and reported that filling canals with the new resin-based obturation material increased the in vitro resistance to fracture of endodontically treated single-canal extracted teeth when compared with standard gutta-percha techniques.[11]In contrast a study by Ulusoy et al showed that roots filled with AH26 + gutta-percha increased the fracture resistance of instrumented root canals compared with Resilon + Epiphany and Ketac-Endo Aplicap + gutta-percha.[12]

Fibre posts

First implied existence of a mechanically homogeneous monoblock was reported in 1996 with the bonding of epoxy resin– based, carbon fiber–reinforced posts to root dentin.[1] Carbon fibers are made to bond to epoxy resins by means of an oxidative process. The strongest carbon fibers have a tensile modulus 500 –1000 GPa which is 2.5 times that of steel. Authors claimed that carbon fiber posts, having an MOE similar to that of dentin, could achieve a tooth–post– core monoblock. Beneficial claims of the carbon fiber post–root dentin monoblock however could not be validated in independent in vitro and retrospective in vivo studies. The poor performance demonstrated by these systems has been reasoned based on several points. Firstly it was found that the carbon fibres are no longer surface active once the post is exposed by roughening during handling /with bur with resultant deterioration of bond to the epoxy resin matrix. Secondly while carbon fibers have a tensile modulus (500 –1000 GPa) that is 2.5–5 times as strong as that of steel, its stiffness of carbon fiber is lowered by presence of epoxy resin.

Lastly epoxy resin is not bondable to methacrylate based resin sealer under physiologic temperatures. Over the years, carbon fibers in this type of first-generation fiber post were replaced by quartz and glass fibres which were bondable to methacrylates under physiological temperatures. Additionally the epoxy resin embedding matrix was replaced with highly cross-linked, methacrylate resin matrices that have the potential to bond to methacrylate-based resin cements. Different modalities of surface treatments of these classes of posts are also available to improve the degree of bonding. Before cementation of posts, the obturating material is removed and post space preparation is done. Once appropriate etch and rinse protocols are carried out, canal walls are coated with a dual cure/self-cure primer. After priming, cement is applied to the canal and the post is cemented into place and cured.

Tertiary monoblocs

These systems involve the introduction of a third circumferential interface is introduced between the bonding substrate and the abutment material

Egs; Endorez, Fibre posts + external silane

Endorez

EndoREZ (Ultradent Products, South Jordan, UT) employs conventional gutta-percha cones coated with a proprietary resin coating to be used with a dual cured radiopaque methacrylate sealer. The self priming sealer is remarkably hydrophilic and does not require the adjunctive use of a dentin adhesive. Manufactures claim that the hydrophilic property makes it extremely compatible for use in the wet environment of the canal. In this system the mixed sealer is first syringed into canal by passive injection, using Navi tips followed by passive insertion of resin coated GP cones. While Studies show an effective penetration of dentinal tubules and adaptation to the walls, leakage & morphologic studies showed –that seal of the EndoRez system is mediocre.[13] This may be attributed to the polymerization shrinkage of sealer, weak bond of sealer to the prepolymerized coating on guttapercha and lack of free radicals for adequate bonding (due to removal of the oxygen inhibition layer during packing).Additionally inconsistencies in the resin coating have been observed in the form of uneven circumferential thickness or partial detachment. All the same while manufactures do not recommend the use of a primer both tensile bond strength and apical seal has been shown to improve by using a dual-cured self-etching primer/adhesive such as Clearfil Liner Bond 2V (Kuraray Medical Inc.).[14]

Activ GP

The ActiV GP (Brasseler USA), root filling system has been marketed as a monoblock system.

The important feature of this system is the incorporation of Silanated glass ionomer particles at percentage that does not affect the properties of GP. These stiffer GP cones -function both as a tapered filling cone as well as its own carrier core. The other advantage with this material is the capability of wet bonding to the root dentin via a glass-ionomer sealer. Its use involves the application of a hand file coated with Activ GP sealer to the working length followed by coating of a single active GP cone with sealer and its slow insertion into the canal. As this system is new, limited information is available. One study has reported that the apical seal of these systems to fluid filtration is comparable to GP and AH Plus. However being a single-cone technique, coronal leakage to fluid filtration was worse than GP and AH Plus.[15]

With regard to tooth reinforcement it is unrealistic to expect establishment of a mechanically homogenous unit within root canal with the systems such as the EndoRez system and Activ GP.[16] Since bulk of the material inside still consists of thermoplastic GP the modulus of elasticity continues to be far below the values of that of dentin.

Fibre posts with external silane

Conditioning of post is commonly done as a chairside procedure, which makes the treatment longer and also increases the risk of failure. Today fibre post conditioned with the latest coating technologies in an industrial process has been made available such as the DT Light®SL. The practitioner no longer needs to condition post as the post is pre-conditioned. These posts have an additional coating made of silane and silicate applied to the post. Furthermore in order to protect its activation before its use in dental practice, a protective layer made of MMA is also applied. Studies have reported improved adhesion superior bonding at the interface between prefabricated FRC posts and composite resin cores in preconditioned posts as opposed to those without silane coat.[17] However a study by Wrbas et al reported that while the type of composite had a significant effect on tensile bond strength, silanization of fibre post surfaces had no effect on core retention.[18]

Anatomic posts

Further improvement in post adaptation and retention has been attempted with what is known as the 'ANATOMIC POST'. These are translucent fibre posts that have been covered by a layer of light curing resin, which allows for individual anatomic shaping of post. These posts offer a better fit than prefabricated posts.

Additionally the precise fit leads to development of a thin uniform layer of cement ideal for post retention. In this technique the canal is first lubricated before applying a lining of composite material.

The post is then adapted to the lubricated post space and photo activated to partially to polymerize the lining composite. The entire assembly is then removed from the canal and optimally polymerized outside of the patient's oral cavity to furnish an individualized/customized post. Efficacy of system not thoroughly investigated. In any case as the resin cement layer is significantly reduced theoretically it could imply a reduction in volumetric shrinkage. All the same there are uncertainties regarding the reduction of polymerization shrinkage in a low compliance environment such as the root canal. Furthermore gaps are known to exist between the post & relining composite which can later act as stress raisers resulting in adhesive failure.[19]

While the above mentioned root canal filling systems belonging to the category of tertiary monoblocs continue to be well received and accepted, the addition of the third interface is in conflict with the 'monobloc approach' to reinforce roots. A notable study in this regard is a finite element stress analysis conducted by Belli et al to investigate effect of interfaces on stress distribution. Here study findings suggested that stresses increased with the number of interfaces, with maximal values for tertiary systems Endorez and silane-coated posts.[20]

Problems with bonding in the root canal & strategies

Firstly bonding to root dentin is compromised by shrinkage stresses that occur along the root dentin- resin sealer interface that might result in debonding of the resin sealer/cement and subsequent leakage. The root canal as such presents a hazardous environment for adhesive bonding in view of its extremely high configuration or C factor which is the ratio of number of bonded to unbounded surfaces. Considering any ratio greater than 3:1 is unfavorable for bonding, it is the challenge to relieve the shrinkage stresses during polymerization created on the canal walls where the ratio might be 100:1. In view of the high probability for imperfect dentin bonding in root canals slow polymerization of the dual-curable sealers is advocated for relief of shrinkage stress via resin flow. Secondly it is critical to realize the effects of irrigation protocols on the bond strength. It is important to thoroughly flush the root canal after using sodium hypochlorite (NaOCl), because oxygen left behind from the NaOCl inhibits polymerization, by forming an oxygen-inhibited layer.

The latest bonding agents derive their adhesive properties from micromechanical interlocking by penetrating into dentinal tubules. While prolonged etching times may create a demineralized zone too deep for effective resin infiltration, simultaneously concerns exist regarding the self-etching potential of self-etching and self-adhesive sealers to hybridize intact radicular dentin. In this regard removal of smear layer as well as to preservation of the fibrillar collagen network can be best achieved by using 17% to 19% EDTA to reduce leakage and improve the seal of filled canals. Another limitation of dentin bonding is deterioration of the resin bond with time due to hydrolysis and plasticizing of the resin components resulting in degradation of their mechanical properties. Hydrolysis acts by breaking the covalent bonds within collagen fibrils and the resin polymers. This process is enhanced by matrix metalloproteinases (MMP's) and other enzymes released by bacteria as well as from the dentin itself. Degradation to occur. The detrimental effect of MMP's can be offset by using chlorhexidine as a final rinse in order to arrest degradation of the hybrid layer. Lastly the concept of moist bonding within the root canals lacks definitive guidelines. In fact most practioners believe that root canals need to be thoroughly dried after a final rinse. Thorough drying will create a hydrophobic environment while a hydrophilic material is being used. Proper moist conditions should be adhered to. A clinical technique to maintain moist dentin is to make sure that when excess water (or EDTA, saline or chlorhexidine) is removed with paper points, the last paper point shows at least 3 mm of moisture.[16]

Controversies & conclusion

The ambition of being able to bond a canal from the minor constriction to the canal orifice and up to the occlusal surface is doubtlessly a desirable objective and should be pursued. At present however the concept of monobloc is not without controversy. First and foremost currently available resin based root canal filling available have a modulus of elasticity far less compared to dentin.[17] Under these circumstances it seems highly unlikely that these materials contribute towards root reinforcement. Secondly the idea of monobloc is built on the assumption that improved bonding within the canals would lead to good sealing.[18] Yet it has already been proven that the good bond strengths of adhesive materials may not imply or equate with good sealing ability. Finally while designing a single unit root filling forms the cornerstone in achieving the 'monobloc effect' all root filling materials used today require additional interfaces.

Despite several drawbacks in this theory, it has been the subject of many discussions. It is said that the future of Endodontics is bonded. While review of the available data shows contradicting ex vivo and in vivo test results, the general opinion is that resin based materials are here to stay. What remains to be seen is whether these materials replace conventional materials or simply exist in parallel as an alternative choice.

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