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RESEARCH ARTICLE

FUNDAMENTAL CONCEPT OF MONOBLOCK IN ENDODONTICS

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Abstract

The advent of dentin adhesive technology in endodontics has made monoblock a well known concept in endodontics. However it has created many controversies on whether monoblock would reinforce the roots and provide a superior coronal seal.In this review, attempts have been made to understand monoblock in a broader aspect and understand how the monoblock concept can be applied to the materials used till date which rehabilitates the root canal space. The potential of currently available bondable materials to achieve mechanically homogeneous units with root dentin is then discussed in relation to the classical concept in which the term monoblock was first employed in restorative dentistry and subsequently in endodontics.

Introduction:-

Monoblock concept is defined as the creation of a solid, bonded, continuous material from one dentin wall of the canal to the other usually creating a mechanically homogenous unit with root dentin.(Andreasen JO et al.,2002). PRECISELY, THE WORD MONOBLOCK MEANS ‘A SINGLE COHESIVE UNIT’.The word Monoblock has been familiarized in dentistry since the era of introduction of adhesive technology in endodontics.

It was Dr. Pierre Robin in the year 1902 who introduced the concept of Monoblock in orthodontics where treatment of patients with syndrome was carried out with unified upper and lower removable acrylic appliances and later on this appliance was named after him.(Aptekar A,2006). However, in Endodontics it was Franklin R Tay who introduced the monoblock concept.(Benkel BH,1976)

With recent advancements in regenerative endodontics, regeneration of diseased pulp has become possible. But instances where regeneration is not possible, the pulp tissue has to be restored by some restorative material.(Bozeman TB,2006) (Camilleri J,2005)

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Root canal instrumentation and restorative procedures often renders the teeth fragile and weak and in such a dilemma, reinforcing potential and sealing ability of Monoblock's has paramount importance. (Carvalho RM, 1996) (Chirila TV,1993)Prognosis of endodontic treatment colossally relies on these qualities.

Failures in endodontically treated teeth are most commonly due to loss of structure and integrity of tooth. These failures are mainly due to fatigue stress caused by repeated physiological masticatory forces or parafunctional forces over a long period of time.So, in order to these forces the modulus of elasticity (MOE) of a material plays a crucial role. This is also one of the reasons why fibre post is gaining popularity. Fibre post allows flexure that is simultaneous with the remaining dentin causing favourable stress dissipation. This lowers the chances of incorrigible root damage.(Chouhan B)Also, the same MOE of adhesive composite cements with that of the fibre post and dentin reinforces the post system.

Additionally, long term use of calcium hydroxide in apexification leads to impromptu fractures after minor impacts or cervical root fractures. (Cormier CJ,2001) (Cozza P, 2004)

In regards to sealability, a successful endodontic treatment relies on achieving and maintaining a proper hermetic seal along the canal system. Some of the reasons for microleakage include thermal stresses, occlusal loading, water sorption, poor adhesion and wetting, polymerization shrinkage. With recent advances, many low viscosity methacrylate resin-based root canal sealers and bonded obturating materials have been developed promising better coronal and apical seal.

Subsequent to the introduction of methacrylate resin–based sealers (MBRS) until now, four generations have been introduced. The first-generation was commercialy available under the brand name Hydron MBRS. Its major composition was poly [2-hydroxyethyl methacrylate]. The second-generation MBRS was ENDOREZ which was hydrophilic. The third-generation sealers which were mainly RESILON/EPIPHANY. Lastly, METASEAL which is the fourth generation is all-in-one self-etching and adhesive sealer. (Cvek M,1992)In endodontically treated teeth where there is excessive loss of teeth structure, posts are used to reinforce and give strength to the teeth. Recently introduced fibre post require an adhesive resin cement for satisfactory seal. These adhesive resin cement bond to the tooth structure thereby reducing microleakage as compare to other cements. Therefore, Monoblock concept can be achieved by both MBRS and resin cement. But here high bond strength between the sealer or cement and dentin as well as between the cement or sealer and obturating material or post system is of utmost importance.

Successful functioning of monoblock as homogenous cohesive unit requires two prerequisites. Firstly, constituents of the monoblock should bond strongly mutually with each other as well as to the medium that it is supposed to reinforce. Secondly, MOE of the monoblock and the MOE of the medium to which the monoblock bonds should be similar. (FIGURE 1)

With the quantum leap research and advancements in dentin adhesive technology, the monoblock concept has become extremely popular for its capability to reinforce the roots as well as better sealability. However, its credibility is still controversial and seeks need for more research. (Franklin R Tay,2007)

Monoblock's were classified as primary monobloc, secondary monobloc, and tertiary monobloc by Dr. Franklin Tay. This classification was done according to the number of interfaces between the bulk material core and bonding substrate.(FIGURE 2)

Primary Monoblock:
A primary monoblock has single interfacebetween the material and the root canal wall. Hydron, Mineral trioxide aggregate, Bio-gutta and Poly ethylene fibre pose core system are some of the examples of this group. Out of which Hydron sealer is a typical example of primary monoblock.

It was in the late half of seventies, Hydron Technologies (Pompano Beach, Florida, USA) commercially marketed Hydron which is a 2-hydroxylethyl methacrylate (HEMA) containing root filling material. (Gillespie WT,2006)
Simple to use, good adaptation to walls and non-irritating were some of the properties of these materials.

It was considered as one of the promising materials which would replace the existing sealer dependent vertical and lateral condensation obturation techniques. Hydron is introduced into the root canal in presence of the remaining

moisture. On Polymerization in presence of water, HEMA forms highly permeable and leachable soft hydrogels.But it was in the year 1980, clinical and laboratory findings demonstrated substantial leakages from Hydron-filled root canals. (Goldberg M,2006)

Also, studies reveal that endodontically treated teeth roots have more affinity to fracture. (Grandini S 2005)(Harpreet Singh 2015)(Islam I 2006)(Jensen, SD,2004)

This can be due to the fact that the amount of intact tooth structure which determines the strength of a root canal treated teeth. In order to reinforce the root, root filling material and that ofdentin should have similar modulus of elasticityi.e. 14,000 MPa.

The modulus of elasticity of Hydron ranges from 180 to 250 MPa. 27 With this clear comparison, it is obvious that the first monoblock Hydron employed in root canals could not reinforce the root canal due to lack of adequate strength and stiffness. (Khatavkar RA,2010)This considerable downside led to the advancements in development of secondary monoblocks.

Obturations done purely with MTA in cases of apexification is also regarded as a contemporary version of primary monoblock. Apexification done with MTA strengthens the immature tooth roots. Principal composition of MTA comprises of Portland cement as its primary composition along with bismuth oxide to impart radiopaqueness. (Koch.K,1994) (Koch.K,2006) Portland cement being aninorganic material, undergoes chemical shrinkage on hydration and this reduction in volume is nearly 0.1% and is mainly due to the cement and water interaction.Therefore, it can be assumed that setting of MTAs is accompanied with volumetric shrinkage.

MTA does not bond to dentin and therefore the volumetric shrinkage does not lead to shrinkage stress generation along the canal walls. The gaps are formed during the shrinkage phase which are eventually filled up by interfacial deposits. (Koch.K, 2006) (Lang H,2006) This leads to minimal resistance to friction of MTA when applied on to the root canal walls. It also enhances the MTA seal while repairing perforations or in cases of orthograde obturation.

Modulus of elasticity of MTA is approximately 15,000 MPa. As modulus of elasticity of MTA and dentin is similar, theoretically MTA should be able to strengthen the roots. But studies done on fracture resistance of MTA illustrated that MTA does grant any noticeable contribution to the strength of the root apart from stimulating cementogenesis in apexification and root end fillings. Thus, the numerous drawbacks of Hydron and MTA paved its way for introduction of secondary monoblocks. (FIGURE 3)

Secondary Monoblock:
Secondary monoblockhave two interfaces. The first interface is between the core material and cement. Second interface is between the cement and dentin. In case of gutta percha obturated root canals, two interfaces are present, one between the sealer and gutta percha points and between the canal walls and sealer.

As discussed earlier, monoblock to work as a single unit it should fulfil two prerequisites i.e. Monoblock should bond strongly to the substrate it is intending to reinforce as well as between the constituents of the monoblock itself. The constituents of monoblock and the substrate should have a similar modulus of elasticity. Gutta percha points have modulus of elasticity 175- 230 times lower than that of dentin making it too plastic to strengthen the roots. Therefore, it was in the year 2004 the monoblock concept re-emerged as bondable root filling materials were introduced. These bondable filling materials were seen as substitute to gutta-percha for obturation. (Lang H,2006)

Root canal obturations inspite of poor bonding between sealers and dentin, may be considered as secondary monoblock systems. But it remains for a fact that it is not a homogenous single unit. (Lee KW,2002).

Resin-modified and conventional glass ionomer cements are alsoused as root canal sealers. (Lertchirakarn V,2003) (Lertchirakarn V,2002)They bond to root dentin but not to gutta-percha.Also as mentioned earlier modulus of elasticity of gutta percha is much lower than dentin making it incapable of reinforcing the roots after root canal treatment. (Li LL,2006) (Monticelli F) (Nakashima M,2005) (Raina R,1987).Till present,Resilonis the only bondable root filling material. Itis applied using a methacrylate-based sealer to self-etching primer treated root dentin. Interfaces present are first one between the primed dentin and sealer and second one between the sealer and Resilon. Therefore, resilon is considered as secondary monoblock.

The Resilon-based obturation systems are available in standardized points that correspond to endodontic instruments and in various tapers, i.e. 2, 4 or 6% and also available as nonstandardized points X-fine, fine-fine, medium-fine, fine, fine-medium, medium, medium-large and large sizes as well as pellets for use with thermoplasticized delivery system in the range of (105-150°C). Various techniques like single-cone method, cold lateral condensation and thermoplastic techniques can be employed to place this material in the canal, with the same instruments and devices that are used for gutta-percha condensation.

With the development of this material, a number of manufacturers have introduced newer Resilon-based obturation systems like:

- Pentron Clinical Technologies with its Epiphany™ system (http://www.pentron.com/).
- SybronEndo with RealSeal™ and its Elements™ Obturation unit (http://www.sybronendo.com/).
- Obtura Spartan with Resinate™ and its Obtura™ obturation system (http://www.obtura.com/).
- Discus Dental Endodontics with its SimpliFill™ filling system (http://www.discusdental.com/).
- Heraeus Kulzer which introduced its Next™ endodontic obturating system followed by InnoEndo™ endodontic obturating system (http://www.heraeus-kulzer-us.com/).

In the initial stage resilon-filled root canals prevented bacterial leakage(Reeh ES,1989) and improved the fracture resistance of endodontically treated teeth better than conventionally gutta-percha filled canals which led to formation of Resilon Monoblock System (RMS) (Sarkar NK, 2005) (Saunders WP, 1992). It consists of Epiphany primer and sealer system. It also has good fracture resistance and produce ideal root canals.(Shipper G, 2004)Root canals filled with resilon creates good seal coronally as well as apical but whether it produces better seal than gutta-percha and conventional sealer filled root canals is still questionable. (Shipper G, 2005) (Sophia T, 2014) (Stratton RK, 2006) (Stuart CH, 2006)

During polymerization conversion of double bonds to single bond create intrinsic volumetric shrinkage. This shrinkage debond the adhesive interfaces. (Tay FR, 2005)

This is where the “C-factor”comes into play.High C-factor hinders formation of perfect seal in Resilon-filled root canals owing to the polymerization stress of the resin. (Teixeira FB,2004)Furthermore, many studies indicate thatgutta-percha and resilon have similar potentiality in strengthening the roots. (Teixeira FB,2004)

Tertiary Monoblock:

Tertiary monoblocks have third interfacebetween the abutment material and bonding substrate. Examples of tertiary monoblock system includes Endorez, Fibre posts and external silane.The tertiary interface introduced in fiber posts coated with unpolymerized resin composite causes problems as gaps are formed between the fiber post and the resin coating during polymerization of the resin. (Teixeira FB,2006)These gaps will eventually lead to dislodging of the fiber post.

EndoRez is a proprietary resin coated conventional gutta percha. In EndoRez system, Clearfil Liner Bond 2V is used which is a self- ethching adhesive. This may be the reason for its good apical seal and high tensile bond to the dentin.(Watanabe T, 2004) (Williams C,2006) But inspite of these properties, it still faces some issues such as polymerization of adhesive and also that presence of adhesive does not help in creating a monoblock effect as canal consist of gutta percha point which is thermoplastic along with adhesive.

Other tertiary monoblock is ActiV GP. Here the gutta-percha cone surfacesare glazed with fillers of glass ionomer making the gutta percha stiffer. (Williams C ,2006) Now these stiffer gutta percha cones acts as both tapered filling cone as well as carrier cone itself. (Wu MK ,2004)The coronal seal of ActiV GP was evaluated and it was found that coronal seal of ActiV GP was not as good as conventional GP points. This may be dur to the coating of glass ionomer fillers around the GP point in ActiV GP. Hence it is unlikely that ActiV GP will reinforce the endodontically treated teeth.

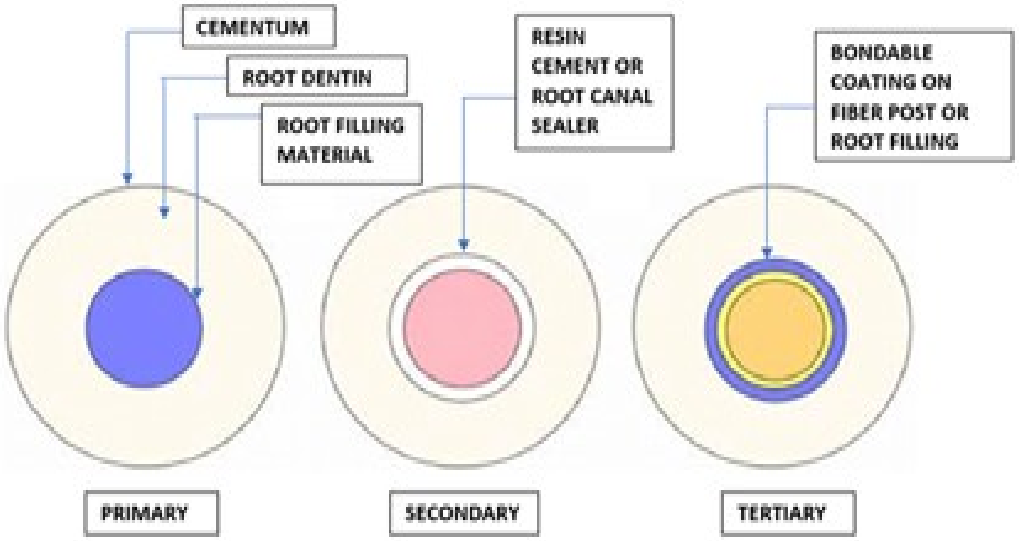


FIGURE 1: Cross-sectional illustration demonstrating the types of monoblocks.

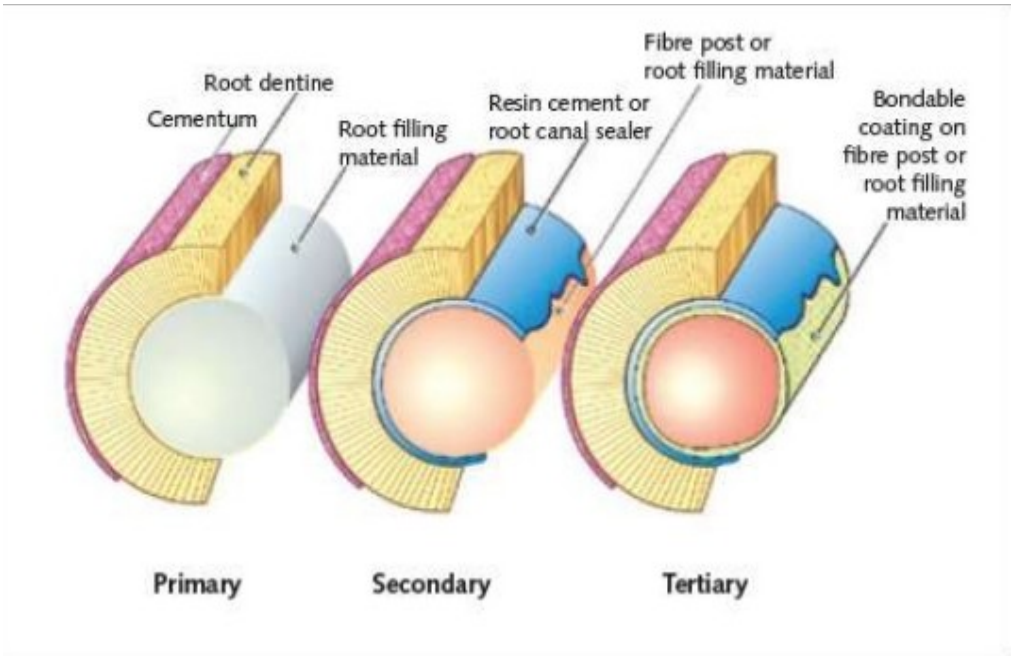
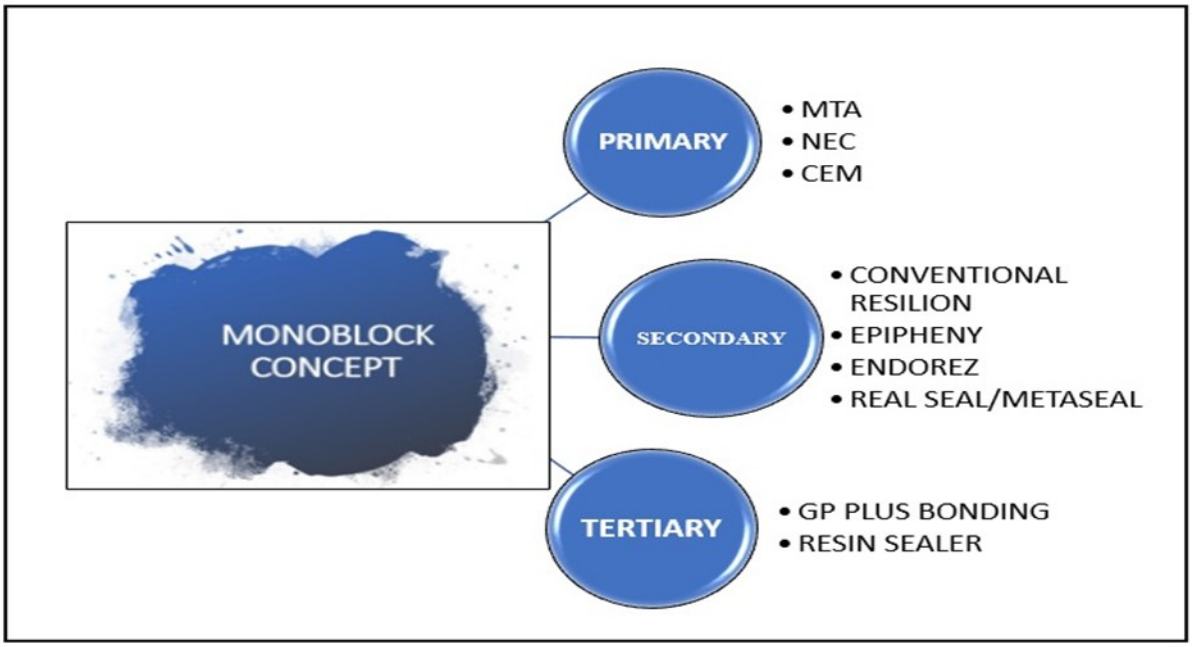


FIGURE 2: CLASSIFICATION OF MONOBLOCK.

FIGURE 3: EXAMPLES OF MONOBLOCK



Conclusion:-

The concept of monoblock seems simpler in literature but is quite challenging to achieve clinically. The prerequisites of achieving monoblock states that modulus of elasticity of dentin should approximate with that of the monoblock used. This will lead to lower stress generation. Secondary and tertiary monoblocks have higher magnitude of stresses than primary monoblock and the complexities associated with these shrinkage and stress generation becomes higher as we move from primary to tertiary monoblock.

Resilon creates better monoblock than MTA as pattern of distribution of stresses is similar to natural teeth. Polymerisation of resin causes shrinkage stresses causing gaps in the canal walls and due to the highly variable canal design, these stresses are almost unavoidable until nonshrinking resin are available. Only then the concept of monoblock can be seen as an ideal goal.

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