CHAPTER 1

A. BACKGROUND
BACKGROUND

Endodontic therapy mainly root canal therapy (RCT) as it is better known, has travelled a serpentine journey of evolution. With the gradual development of endodontic treatment, it is now possible to treat the infected tooth rather than to extract it.

In routine endodontic practice, a grossly decayed tooth (one having more than two thirds of crown structure missing) has to be effectively used to support a restoration. This brings about proper functioning of the tooth and improves esthetics providing psychological relief to the patient. Extra special techniques have to be taken into consideration when there is need to restore severely damaged teeth in order to obtain a good prognostic outcome. [1]

As a consequence of caries, fracture, wasting diseases such as erosion and abrasion, not being conservative in cavity preparation, or root canal therapy, there may be loss of enamel and/or dentin. These factors may compromise the structural integrity of the tooth. [2]

By using advanced techniques involved in post root canal therapy restorations such as post and core system, it is now possible to build up the lost tooth structure. The ‘post’ can be said to be that part which engages the root (radicular) dentin in order to achieve retention and the ‘core’ is the portion that forms the coronal portion of the crown. The post and core can be fabricated using metal. This is called a single cast restoration. The other option is to have a separate post with a core build up. [3]

Coronal restoration of root canal treated tooth presents a major concern in daily dental practice, for both practitioner and patient. [4]

According to Anusavice, [5] “mechanical properties are defined by the laws of mechanics, that is, the physical science that deals with energy and forces and their effects on bodies. These bodies are primarily static which are at rest and not those which are dynamic (in motion). Thus all mechanical properties are measures of the resistance of a material to deformation or fracture under an applied force.”

Cores are mainly retained by posts with or without bonding systems and at times with pins which promote retention and build up the tooth so that it can sustain a crown and bridge.
Looking back at the history of post and core systems in dentistry, one can find elaborate illustrations about how posts can be placed in the roots of teeth dating back around 250 years. In 1728, Pierre Fauchard used the term ‘tenons’ for posts, which were nothing but metallic posts fitted like screws in the roots of the teeth to support crown and bridge. It was in the 1800s, when wood was introduced in place of metal as the medium for making post and the crown. A wooden post would be attached to an artificial crown on one end and to the canal of the root on the other. This became quite popular for use among the dental fraternity. [6][7] It was common for these wooden posts to absorb moisture from the oral environment and cause fracture in the root due to expansion. Towards the end of 19th century, a scientist named Richmond Crown engineered a single unit post-retained crown to function as a bridge retainer. This crown also had porcelain facing for esthetic purpose. In the 1930s, one piece post crowns were replaced by what came to be known as ‘custom cast post and core’. [8]

Various classification systems of post and core have been proposed, the first classification is according to authors which is as follows: [8]

1. Richmond
2. Sharogorodski
3. Shiragodksi A Nankali
4. Ahmmedov
5. Davis
6. L V Illinois-Markasian
7. AI Kats
8. Kopeikin
9. Orton
10. V N Parshin
11. DN Sitrin [8]

The Nankali post and core classification was proposed by Dr Ali Nankali in 2003. It is the most commonly quoted classification which is used in conservative dentistry for classifying various types of post and cores. [7]
According to outlines of posts:

1. Parallel
2. Tapered
3. Serrated

According to surface of posts:

1. Simple (Straight)
2. Formed (Shaped)

According to method of production:

1. Cast Made
2. Pre Fabricated

Custom cast post and cores very well adjust in extremely tapered root canals or those with a cross section which is not circular and/or having irregular shape, and the roots having minimal remaining coronal tooth structure. 

There are two ways of making cast posts, either in the
patient’s mouth directly or in the laboratory indirectly. Custom cast posts and cores are cast in an alloy whose modulus of elasticity can be as high as ten times more to that of natural dentin. Stress concentrations can be created in the less rigid roots due to this possible clash in values. This results in failure due to separation of the post. Furthermore, fracture can occur when the occlusal forces which are transmitted through the metal core focus stress in particular areas of the root. Looking at the esthetic front, the ‘cast metallic post’ can cause discoloration and darkening of gingival tissues at cervical margins (marginal gingival) of the tooth.\(^{[10]}\)

Second type of post and core are the ‘prefabricated’ ones. Classification of prefabricated posts is according to their geometrical design (configuration and shape) and retention methods. They are named as active or passive due to technique of retention. Active posts hold the dentinal walls of the preparation when inserted and passive posts do not grip the dentin and totally depend on cements for their retention. According to the categorization, basic post shapes are tapered, smooth sided; tapered, serrated; and parallel threaded. Active or threaded have more retention properties than the passive posts, but the active posts produce high stress during placement. This makes the root more vulnerable to fracture from occlusal forces. Of all the passive prefabricated posts, parallel serrated posts are the most retentive and the tapered smooth posts have least retention.\(^{[7]}\)

Platinum, gold, palladium, brass, nickel-chromium (stainless steel), pure titanium, titanium alloys, and chromium alloys are some materials used to make prefabricated metal posts. Despite stainless steel being stronger, possibility for unfavorable tissue responses to nickel has encouraged utilization of titanium alloys. In addition, metal posts exhibit immoderate modulus of elasticity and high post corrosion contributing to root fractures due to which their use is of questionable virtue.\(^{[11]}\)

Nonmetallic prefabricated posts include fiber-reinforced resin posts and ceramic posts - zirconium oxide. Zirconium oxide posts have advantages of greater flexural strength, resistance to corrosion (unlike metallic posts) and biocompatibility. However, this material is not only hard to cut diamond bur in the oral cavity during treatment, but also difficult to remove from the canal in cases of re-root canal treatment. The fiber reinforced composite resin posts are favourable in ways more than one. They offer zero laboratory expenses, single appointment procedure, free from corrosion, minimal root fracture, no particular size of orifice, increased retention due to
increased surface area from irregularities on surface, conservation of tooth structure, and enhanced esthetics. [11]

Certain criteria have to be taken into consideration that affects the prognosis of root canal treated teeth. These are apical status, position of the tooth in the dental arch ie, anterior or posterior because each tooth receives different occlusal forces, number of adjoining teeth for support, occlusal contacts, bulk of hard tissue, residual thickness of dentinal wall, degradation of collagen and intermolecular cross linking of the root dentin, type of permanent coronal restoration and type of post (if required), core material being used and presence of a ferrule if necessary. [12]

Placement of a crown ferrule has been seen to be a significant factor in increasing the fracture resistance and clinical outcome of teeth having posts and cores. [13]

For the successful revival of a root canal treated tooth using the post retained system, we need to consider one particular structural design feature known as the ferrule effect. The completed preparation of the crown should have a ferrule. It envelopes the root canal teated tooth complex. A collar made by this ferrule preparation produces an antirotational factor to keep the crown stable. 1 to 2 mm preparation on the intact tooth structure is the general guideline. If the shoulder is made on the tooth substance, and axial preparation is done on the core build up, this will be an inadequate ferrule design. [14]

The principle formula for a root canal treated tooth requiring a post is as follows:

Minimum length of remaining tooth should equal to the sum of the biologic width (2.5mm), the ferrule length (2mm), the apical seal (4 mm), and the post length.

In teeth where a post is not required, the formula can be changed to sum of biologic width and ferrule length, or 4.5 mm of solid tooth above the bone. [15] Figure 2 diagrammatically represents the ferrule criteria and dimensions.
According to R.W Wassell (2002), a core can be defined as “that part of a preparation for an indirect restoration consisting of restorative material”. [16]

Core build-up materials are those materials which are used to rebuild the disfured tooth structure before preparation of the crown is done and stabilize the debilitated parts of the tooth. For this reason, it can be stated that core build up materials are the foundation of the preparation for an indirect restoration which consists of a restorative material. [17]

Clinically, the prognosis of an restoration which is indirect, is mainly dependent on the amount of tooth structure which is remaining (also responsible for the proper ferrule effect), but it has also been observed that the core build-up material being used plays a crucial role.
Cores provide retention and resistance form for crowns and behave as transitional restorations before crown preparation.\[18\]

A core can be thought of as a “build up”, which is instrumental in contributing to retention in the crown preparation and strength or it can thought of as a ‘filler’ which simply reshapes the preparation with the motive of eliminating undercuts.\[19\]

A core build-up material should possess superior mechanical properties for it to be called ideal. It should resist the stresses produced during function and be able to provide unbiased stress distributions of forces, reducing tensile and compressive failures.\[6\] For selection of core materials, strength is not the only criteria but of paramount importance. Stronger the core material, the better it will resist deformation and fracture, providing fair stress distributions, and reducing the probability of tensile and compressive failure. This will lead to higher stability and increase the likelihood of success in clinical situations. If other variables are deemed as equal, then the strongest core build-up material is the material of choice in clinics. \[18\]

The strength of a material can be expressed using compressive strength, tensile strength, flexural strength and shear strength, each of which is a measure of stress required to fracture a material. In the oral cavity, shear failure likely does not occur due to the following reasons:

1. brittle materials in tooth surfaces which are restored have predominantly rough curved surfaces

2. chamfers, bevels, or curvature changes of a bonded tooth surface would make shear failure of a bonded material next to impossible

3. the applied force should be located directly adjacent to the interface for shear failure to occur

4. tensile strength of brittle materials is typically below their shear strength values which makes tensile failure more common.\[5\]

Compressive strength is a critical indicator of favourable outcome. To withstand intra oral masticatory and para-functional forces, a high compressive strength is required. Due to oblique or transverse loading of their complex geometric forms, most dental restorations face tensile
stresses, hence tensile strength happens to be important. Flexural strength is considered sensitive to surface malformations and flaws such as cracks and voids which may have an effect on the fracture strength of brittle materials.

The ideal core build-up material should also be biocompatible, should be resistant to bacterial seepage, and should be dimensionally stable and insoluble in the presence of oral fluids such as saliva.

Selection of core materials is very much dependent on the requirements of the tooth being built up and individual operator processes.

Cast Gold has been used as a core build up material. It offers good strength. The luting agent used along with it provides resistance to leakage. Coefficient of thermal expansion of cast gold is very close to that of dentin and does not absorb water. It usually requires a notable degree of coronal destruction and a post for retention.

Amalgam has been in use as a build-up material for more than 165 years now. The Chinese are reported to have first used it. The use of a mixture was mentioned by a scientist Su Kung in the Material Medica in 659 AD. This mixture was Amalgam. Amalgam can replace approximately 75% of all restorative materials used in dentistry.

An amalgam is an alloy that contains mercury as one of the constituents. Amalgam restorations with pins have been thought to be the basic for cores in posterior vital teeth for almost half a century.

Composition of Amalgam Alloy currently in use is 40-70% silver, 12-30% tin and 12-24% copper. It may also include 0-4% indium, 0.5% palladium and up to 1% zinc. Zinc is responsible in preventing oxidation of other metals in the alloy incorporated during the manufacturing process and corrosion is also inhibited by Zinc. Admixed high copper amalgam containing indium reduces creep and increases strength. When it contains indium in concentration up to 10%, less mercury is required for mixing amalgam. Palladium reduces tarnish and corrosion.

There are some advantages of dental amalgam as a restorative material such as it being strong in bulk section, it not being technique sensitive and it being sealed by corrosion products. The compressive strength of dental amalgam as per literature is 380 – 540 MPa, which develops
progressively after trituration but tensile (57 MPa) and flexural (114 MPa) strengths are much lower, making amalgam brittle. [23]

The well-known drawbacks of amalgam such as, lack of adhesiveness to the tooth structure, setting process being slow, mercury content and color, weak in thin sections, potential electrolytic action between metal crown and core are the several reasons why other materials were chosen for core build-up. [24, 16]

By the end of 1960’s, Glass IonomerCements(GICs) were introduced in conservative dentistry. In 1971, their use was first reported by Wilson and Kent. [25] Many properties of glass-ionomer cements such as adhesion to tooth structure, ease in placement, biocompatibility and fluoride release made it attractive for use in dental practice. The main problem in using glass-ionomer as a core material arose from low compressive (150 MPa) and tensile (15 MPa) strengths and the role of water in the setting reaction. In order to improve the physical properties of Glass Ionomer Cements, several modifications were done. One of the major developments in this direction was the addition of silver particles to Glass Ionomer Cement (Miracle Mix) which significantly increases its strength, however in vitro studies showed opposing results. [26] Glass Ionomer Cement with Resin are preferred by clinicians as materials for core build-up because they adhere to both enamel and dentin.

Composite resins are dental restorative materials that were developed simultaneously with GIC’s in 1960’s. Composite resins were used because of their convenience of a single visit core placement and preparation, no mercury controversy and strong dentin bond strengths (11−28 MPa) and esthetic appeal. [27]

Composite is equivalently strong as amalgam and recently it has been accepted as a core material of choice. But use of composite resins without dentin bonding agents poses a significant problem of microleakage which results in caries and pulpal problems. [28]

Compared to glass ionomers, composites proved to be superior with respect to their mechanical properties. Composite resins also have some drawbacks such as high technique sensitiveness, difficulties in distinguishing tooth from core during preparation and dentine bond rupture by polymerization contraction. [29]
Developments of dentin bonding systems and improvements in composites have led to the development of more conservative techniques that augments the opportunity to restore the mutilated tooth. Core build-up materials such as flow composite materials are the latest introductions in dentistry.

Fillers have been reported to improve the mechanical properties of bis-GMA-based dental resin. If the filler content is less, the mechanical properties of composite materials could be reduced. This allows flowability of the material and is a matter of concern. It hints that flowable materials having less filler content might be mechanically weaker than their equivalents having greater filler content. [3]

Present in – vitro study is being undertaken to evaluate the compressive strength, tensile strength and flexural strength of the following four commercially available direct core build up materials:

- Para Core (Coltene Whaledent, USA)
- Luxacore Z Dual (DMG – Dental Milestones Guaranteed, Germany)
- Fluorocore (Dentsply Caulk, USA)
- Multi Core (IvoclarVivadent)

Para Core is a dual cure, fiber reinforced and radiopaque core build up material. It exhibits a stackable, non slumpy consistency and is designed to cut similar to dentin and allows the bur to move smoothly between natural tooth structure and the material. Hence, it does not create troughs and grooves. Incorporation of glass particles grants strength to the material. Using Parabond adhesive along with Paracore provides excellent retention to enamel and dentin providing lasting restoration. Parabond is a composite cured self conditioning adhesive. [30]

Luxacore Z Dual can be automatically mixed and dispensed using intraoral tips. Its flow properties are considered ideal. It allows tooth substance and posts to be totally surrounded, while avoiding gaps or air pockets. It comes in a variety of shades. It has thorough and even distribution of nanoparticles throughout the resin matrix which results in the virtual elimination of particle agglomeration. The addition of Zirconium Oxide enhances the
compressive strength and dentin like cutting characteristics of radiopaque Luxacore. It is not too hard and cuts and trims just like dentin unlike other core or general restorative composites.

Fluoro Core composite build up material is dual cure and consists of two components namely base and catalyst. Both when mixed yield a core build up material which is a highly filled resin.

Multi Core composite is a dual curing core build up material consisting of two components – base and catalyst. It comes in four shades. It provides an optimum base for the reconstruction of both vital and non-vital teeth and in cases where most of the clinical crown missing.

These materials are being readily used in the modern day dentistry due to their desired properties which are required for maintaining the long life of the teeth.