Volume-4, Issue-7, July-2015 • ISSN No 2277 - 8160

Research Paper | Medical Science

Peri-Cervical Dentin (PCD) : A New Paradigm for Endodontic Success

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ABSTRACT

This review discusses in detail about PCD and related factors which can affect the strength of the tooth.PCD is a new paradigm which can be used to arrive at a consensus regarding restorability and long term prognosis of the tooth .The treatment planning should integrate principles of Conservative Endodontic Cavity, minimally invasive endodontics,biomimetic endodontic shaping and biomimetic reinforcement and restoration to ensure that sufficient PCD is preserved and further reinforced as well.

KEYWORDS : Peri – Cervical dentin,Fracture. Resistance,root canal treatment,soffit

Introduction

The best strategy for a successful dental therapeutic procedure is to begin with the end in mind. Before initiating any dental treatment, the dentist should carefully examine the tooth for extent of caries and fracture. The tooth should also be evaluated for restorability, occlusal function, periodontal status, biological width and crown-to-root ratio. If these factors seem to be satisfactory, the tooth should be included in the treatment plan. Whenever possible, dentist should remove all existing restorations and caries before starting root canal treatment. This allows for even more accurate assessment of restorability and evaluation for fractures of the teeth.

A new clinical concept regarding the evaluation of the restorability of the teeth : The Endodontic-Endo-Restorative-Prosthodontic (EERP) continuum is gaining lot of popularity [1,2].This is a restoratively guided concept in which endodontics is simply a starting step to the restoration and preservation of the tooth, concurrent with a complete integration of endodontic preparation as part of an interconnected series of components involved.From crown to apex,an outside protective ring of fracture resistance and from inside to outside, a set of walls for prevention of microleakage is proposed [1,2,3]. Biomimetics and minimally invasive dentistry form the basis of this principle. Each component must additionally benefit,not affect the other components.This seems to be a logical concept to follow clinically for successful outcome of any restorative treatment.

Peri-Cervical Dentin (PCD)

In line with this new integrated concept for restorability of teeth, Pericervical dentin was a term first mentioned in the literature in 2008. Pericervical dentin as defined by Clark and Khademi (2008) is an area roughly 4 mm coronal to crestal bone and 4 mm apical to crestal bone. It acts as the neck of the tooth and transfers masticatory forces to the root and the bone. It is believed that strong and unaffected PCD scores above every other factor in the long term retention of the tooth. While the apex of the root can get affected, and the coronal third of the clinical crown removed and replaced restoratively, the dentin near the alveolar crest is not replaceable and is sacred [1-6]. PCD is important as it contributes to ferrule and prevents fracturing of the tooth. The literature search supports the fact that; long term retention of the tooth and resistance to fracturing are directly related to the amount of residual tooth structure.The more the residual dentin, the longer the tooth can be retained [7,8,9].

As far as the anterior teeth are concerned, the term Peri- Cingulum Dentin is specifically used in place of Peri-Cervical Dentin [1,3]. In the case of anterior teeth access, the research done by Magne P et al (1999) stated that palatal concavity that provides the incisor with its sharp incisal edge and cutting ability proved to be an area of stress concentration. This shortcoming can be compensated by specific areas that feature thick enamel such as the cingulum and the marginal ridges. When enamel is worn or removed from the facial surface, its replacement should be carried out by using materials with properties similar to enamel to restore the original biomechanical behavior of the tooth. Thus, the importance of the cingulum directly conflicts with traditional cingulum positioned endodontic access that is followed. There are heavy forces that are concentrated at the cingulum when the maxillary anterior teeth are functionally loaded in occlusion. These forces can cause structural breakdown of the teeth in the long run [10].

Effect of Endodontics on PCD

Root canal treatment leads to weakened tooth structure as a result of change in tooth internal structure, dehydration of PCD, Strains in PCD due to excessive pressure during obturation and changes in the physical and mechanical properties of PCD [11]. Regarding the loss of moisture in PCD,the effect is minimal and there is no significant loss in fracture resistance as evidenced by various researchers [12,13,14].The advancements in rotary root canal instruments over the last few years have led to greater root canal enlargements and increased taper. This leads to significant weakening of teeth due to excessive loss of PCD with variable taper instruments as reported in the literature especially in the cervical region of the tooth which is more prone to fracture [15 -18].

The orifice openers and gates glidden drills are the main instruments responsible for the loss of PCD. To further add on this effect is the use of greater taper files. Morever, the use of certain files such as Protaper induce dentinal cracks during preparation which can change the structure and stress bearing capacity of PCD. These micro cracks can lead to weakened PCD with reduced resistance to fracture [19-24]. Regarding the use of

some irrigants and medicaments which predominantly result in collagen depletion in PCD; this affects the elasticity of the dentine and predisposes to fracture during shearing forces. The effect of sodium hypochlorite was found to be dependent on time and concentration of sodium hypochlorite.Use of sodium hypochlorite (NaOCl), with concentrations over 2% has more deleterious effects.There is a synergistic effect of EDTA and NaOCl. MTAD and lasers are safe for effects on PCD [25-30].

The use of medicaments such as calcium hydroxide Ca(OH)2 dressing can decrease the flexural strength of PCD and microbial products can also degrade collagen [31-32]. The internal stresses created during lateral compaction obturation technique can also affect the fracture resistance of PCD [33].Some authors have even reported the deletirous effect of bleaching procedures on PCD,however,the use of antioxidants such as sodium ascorbate can reverse decreased fracture resistance [34,35]. Thus, it is clear that root canal treatment leads to a weakened PCD and therefore strategies for its reinforcement should always be planned in advance to compensate this decrease in fracture resistance.

The concept of pulp chamber Soffit [3,5,36,37]

Soffit is term used by architects for underside of a roof, at the corner of the roof and the wall. The same concept can be applied to the chamber of a molar tooth which is bounded by a roof, 4 walls, and a floor with small orifices that are arranged along the edges of the floor. One of the common clinical concept followed is that the entire roof of a pulp chamber needs removal during access preparation for root canal.

As per this concept of soffit, during endodontic access preparation, it is essential to maintain a small border amount of the chamber roof near the point where it curves at 90° and becomes the wall. This tiny "lip" or "cornice" as called by Clark and Khademi could be as small as 0.5 mm, or as large as 3.0 mm in cases where extra strength is needed, or when the anatomy of tooth allows for it

A curved explorer can be used to remove the pulp out of the soffit along with the flushing action of irrigants.Regarding soffit,there is always a tendency of dentist to maintain more soffit in one area and gouging in the other. It is suggested to leave a 360° small soffit than to compromise it with gouging or undermining and creating difficult clinical working conditions within the tooth compromising the strength of the tooth.Blind tunneling is another undesirable endodontic access approach and shape that creates a parallel sided access preparation destroying soffit when performed without advanced magnification, relying mainly on tactile sensation rather than on microscopic visualization and following the dentinal map and microscopic traces of residual pulp tissue.Typically performed with round bur, it is common in general and endodontic specialist practices. Buccal and Lingual gouging which is not easily seen in x-rays occurs in nearly every traditionally accessed case.

Similarly,as the size of the access cavitation is enlarged further internally, an inverse funnel results.The size of the access becomes wider as it progresses deeper into the tooth.It is a common occurrence when constricted cavosurface access opening size is paired with round bur use. It is exacerbated when advanced magnification is not used during tooth cutting for access preparation.Vital peri-cervical dentin is removed each time the bur enters the tooth compromising the strength of the tooth.

Concept of Three-dimensional ferrule (3DF) [1-5]

Three-dimensional ferrule has been described as axial wall dentin in all three dimensions covered by the axial wall of the crown or bridge abutment. It is an evaluation of the available dentin that buttresses the crown. The three essential components of 3DF are dentin height, dentin thickness, and TOC (total draw of the opposing buccal-lingual and mesial-distal walls). Research varies on the minimal vertical amount required ranging from 3–5 mm, but the range for absolute minimum dentin is from 1.5 - 2.5mm [8–23]. The clinician needs to realise that the restorative material, although necessary, does not count toward ferrules.

Thickness of PCD becomes more important close to the finish lines of the tooth preparation.The thickness of the remaining dentin (the wall thickness) between the external surface of the tooth at the finish line and the endodontic access is a more important parameter. Further, progressing apically downroot of the root canal treated tooth, the wall thickness can vary considerably and become thin in places,especially,if large coronal shaping or flaring was done.Thus, axially deep finish lines on root structure can be extremely damaging to 3DF.

The third component is the total occlusal convergence (TOC) or net taper. TOC is the total draw of the two opposing axial walls of the PCD of the prepared tooth to receive a fixed crown. A net taper or TOC of ten degrees requires 3 mm of vertical ferrule height; a TOC of 20 degrees requires 4 mm of vertical ferrule [24–37]. Deep chamfer marginal zones, common with modern all ceramic crowns, typically have a net taper of 50 degrees or more, and therefore many modern esthetic margins lose a millimeter or more of their original potential PCD of 3DF at the crown margins. In short, typical modern porcelain crown preparations have less 3DF than the all metal crown preparations.

Hence, the need for directed dentin conservation during endodontic access becomes even more crucial, and, at the same time, the volume of dentin removed in the axial direction should be questioned in the modern era of high-strength zirconia core crowns that actually allow minimal axio marginal reduction. In certain finish line designs, the degree of apical placement of the finish line can affect the ferrule quality because of loss of PCD.Slight axiomarginal reduction coupled with apically placed finish lines and a non zero degree emergence profile of the restoration can provide high 3DF.The concept of 3DF incorporates an interplay between all these factors as described above.

Concept of Directed Dentin Conservation and Banking of tooth structure [1-5,38]

Directed dentin conservation is a concept which stresses upon the conservation of PCD during root canal treatment and restorative procedures.By adopting the recent concepts of Conservative Endodontic Cavity and biomimetic obturation,it is possible to conserve dentin in a directed manner and thus the strength of the tooth is not compromised.

On a similar note,the approach of banking of tooth structure in restorative dentistry dictates that whenever possible, more tooth structure should be left in place than is needed for the procedure at hand. It may involve a less expedient, but more conservative, approach. This banked tooth structure may serve as a valuable future asset in the advent of unforeseen future trauma or disease coupled with the reality that a tooth will need to last for decades and potentially be restored and then re-restored in the patient's lifetime.

The Three Strikes Rule for long term prognosis evaluation [1,3]

In long term endodontically treated cases,the prognosis was found to be linked to following clinically controllable variables.The more the variables were involved,the more compromised was the prognosis.

(1) Excessive axial reduction for crown preparation

(2) Gouged or undermined endodontic access

(3) Large and arbitrarily round endodontic shape

All three of these factors related to loss of PCD are present,the loss of PCD is irreparable and the tooth is permanently compromised with poor prognosis.When the clinician is evaluating a case for possible treatment, it is far more advantageous to evaluate the restorative aspects of the case and amount of tooth structure left.Based on that criteria,concepts of directed dentin conservation,3DF and banking of tooth structure should be employed. Later on, the three strikes rule is used for final evaluation of prognosis of the case.

Clinical Implications of Peri-cervical Dentin

No man-made material or technique can compensate for tooth structure lost in key areas of the PCD. Access preparation is the key to endodontic success and should also be considered as the key to restorative success and to long-term retention of the tooth.

Conservative Endodontic Cavities (CEC) [39]

Based on this concept of preservation of PCD,krishan R et al (2014) have proposed Conservative Endodontic Cavities (CEC) for preservation of PCD in lines with the guidelines of Clark and Khademi.In their study, they assessed the impacts of CEC.Extracted human intact maxillary incisors, mandibular premolars, and molars were imaged with micro–computed tomographic imaging (20-µm resolution) and assigned to CEC or tradi-

tional endodontic cavity (TEC) groups . Minimal CECs were plotted on scanned images. Canals were prepared with WaveOne instruments using 1.25% sodium hypochlorite and post-treatment micro–computed tomographic images obtained. The proportion of the untouched canal wall (UCW) and the dentin volume removed (DVR) for each tooth type was analyzed.The mean proportion of UCW was significantly higher only in the distal canals of molars with CEC (57.2% ± 21.7%) compared with TEC (36.7% ± 17.2%).

The mean DVR was significantly smaller for CEC than for TEC in incisors (16.09 ± 4.66 vs 23.24 ± 3.38 mm3), premolars (8.24 ± 1.64 vs 14.59 ± 4.85 mm3), and molars (33.37 ± 67.71 mm3). The mean load at fracture for CEC was significantly higher than for TEC in premolars (586.8 ± 116.9 vs 328.4 ± 56.7 N) and molars (1586.9 ± 196.8 vs 641.7 ± 62.0 N). In both tooth types, CEC did not differ significantly from the negative controls.Although CEC was associated with the risk of compromised canal instrumentation only in the molar distal canals, it conserved coronal dentin in the three tooth types and conveyed a benefit of increased fracture resistance in mandibular molars and premolars. This study is a stepping stone in line with the concept of minimal invasive Endodontics and clearly relates the strength of Endodontically treated tooth with the amount of remaining and conserved PCD.

CK burs [2,5]

Clark and Khademi have even introduced some new burs popularly known as CK burs.These burs are used once orifice are located.This bur is followed visually and slowly traced out in the canal.Given the size of these burs, explorers become even more pointless.The clinician uses these small CK burs in a low-speed latch or high-speed to trough around the periphery of the old pulp chamber. On comparing the CK endodontic access bur to the corresponding round bur,the tip size of these burs is less than half as wide as the corresponding round bur.

Biomimetic endodontic shaping (BES) [1,3]

The self adjusting files best serve the purpose for BES.These files have a lattice which adjusts to the root canal anatomy and thereafter leads to biomimetic root canal preparation. In an effort to preserve PCD, Clark and Khademi encourage the use of V-Taper rotary NiTi variable taper files due to their smaller diameter (<1 mm) mid-canal shaft size. The smaller mid-canal shaft size of these rotary files are thought to play an important role in avoiding the mid-root weakening of ovoid and smaller roots. The system is comprised of 3 NiTi files and an orifice opener is not included. Other NiTi rotary systems, such as the WaveOne, are available with regressing tapers from their tip. The WaveOne primary file, for instance, has an 8% taper in the last 3 mm but only a 5.5% taper in the coronal area. If a #10 file moves apically to length and is loose, then the Waveone primary should be the only rotary needed to complete cleaning and shaping using a reciprocating motion [40].

Reinforcement of PCD

Some authors have even suggested reinforcing PCD for efficient transmission of forces and preventing fracture of teeth under masticatory forces.Though the use of intracoronal restorations for reinforcement is not new, the focus is shifting towards the use of reinforcing intraorifice barriers for reinforcement.

This concept was first published by Nagas E et al (2010) who found promising results with the use of resin modified glass ionomers as reinforcing barriers [41].Later on, Aboobaker S et al (2015) also found a positive correlation between reinforcement and use of intraorifice barrier materials.They evaluated and compare the fracture resistance of roots obturated with guttapercha using bonded amalgam, GC Light cure GIC (resin modified glass ionomer cement) and Tetric N Flow (flowable hybrid composite) as different intra orifice barriers.Tetric N Flow and Fuji GC LC GIC can be used as intra-orifice barriers with good fracture resistance in endodontically treated teeth [43].

More recently, the role of newer adhesives such as nano-ionomer and silorane composites have been studied.In more recent studies,Arora V et al (2015) evaluated invitro the effect of post obturation materials on reinforcement of peri-cervical dentin to conclude that nRMGIC and silorane composite significantly reinforce PCD. Obturation also plays an important role in reinforcement of PCD [43].

Arora Vetal (2015) evaluated invitro the effect of adhesive obturation and post obturation monoblock systems on reinforcement of pericervical dentin (PCD).Samples restored with Activ GP and nRMGIC ;Realseal and silorane composite presented with higher mean fracture resistance values of respectively when compared to unrestored samples with tempoarary cement Adhesive obturation and post obturation monoblock systems significantly reinforce PCD [44].

PCD and Posts

The purpose of a post is to retain a core that is needed because of loss of coronal tooth structure.Post should be avoided when other anatomic features are available to retain the core. Molars may at times not require posts because a core can usually be retained by the pulp chamber anatomy and the canals [45].When a post is indicated, it should be placed in a distal canal in mandibular molars and the palatal canal in maxillary molars, because the other canals tend to be thinner and more curved. Multiple posts are seldom indicated. Anterior teeth with extensive loss of coronal tooth structure need a post as the pulp chamber and single canal are generally not adequate to retain a core. In addition, anterior teeth are subject to lateral and shearing forces during function, whereas posterior teeth are subject primarily to vertical forces.

Premolars require good clinical insight because of their transitional internal morphology. The remaining PCD will dictate whether a post is indicated to compensate for extensive loss of coronal tooth structure.The use of a post carries with it a risk of root fracture, particularly, if sound PCD is removed during preparation. Preparation of the post space leads to formation of cracks in PCD which after placement of post propogate further and can also lead to perforation apically or a lateral strip perforation in the fluted portion of the mid-root canal [22].

Some of the considerations in relation to posts and PCD are :

1. When a post is needed, remove little if any additional dentin beyond what is needed to perform the root canal treatment.

2. Use a post with modulus of elasticity same as that of PCD.

3.Since forces concentrate at the crest of bone during function, place the post to extend apical to the crest of the bone. The post should extend "into bone" at least as far as it protrudes "out of bone."

4. Use reinforcing adhesives to retain the post and reinforce the post space.

Future Insight

The future should focus on techniques to remove or just suction out pulp and necrotic material from the root canal followed by disinfection and obturation.This technique can save this critical component of tooth (PCD).

Another approach could be that the orifice enhancement should be used in place of orifice enlargement. The transition between the pulp space and the canal system in a young uncalcified tooth forms a natural "funnel" into the canal system.This makes finding the canal fairly easy and allows endodontic files to easily slide into the canal. It is one of the main reasons endodontic procedures are easier on young people. However, if the canal space is calcified, it is prudent to recreate the funnel mechanically. It will make easier for the rest of the procedure. This is a delicate area of PCD and must be done with the understanding that any dentin removal should be minimal and away from the furcation.The dentine is thin toward the furcation and robust toward the external surface in this region of the tooth.

When it comes to endodontic access and directed dentin conservation, each case must be titrated. Opportunistic access with soffit, creativity and a long view of the structural integrity of the dentin must be foremost in our minds.Reinforcement of tooth structure after root canal treatment should also be a part of the standard procedure.The time has come to integrate modern engineering to help design a strong root canal treated tooth that will withstand the forces of occlusion.

Conclusion

Practitioners performing endodontic treatment should follow these principles to ensure PCD is sufficiently preserved while performing the endodontics and restoration of the teeth:

- Preserve PCD during access preparation and coronal restoration.
- Avoid chemicals which degrade PCD.
- Use greater taper instruments with logic and caution to prevent unnecessary removal of PCD.
- Restore the tooth immediately after root canal treatment, if possible to avoid the unusual masticatory forces on PCD a weak tooth.
- Use reinforcing materials which chemically adhere and have modulus of elasticity same as that of PCD.
- Use posts only when necessary to retain a core build up with minimal sacrifice of PCD of post space preparation.
- Restore teeth in a way that allows for future retreatment of the root canal system without sacrificing PCD.

In the nut shell,the treatment planning should integrate principles of Conservative Endodontic Cavity, minimally invasive endodontics,biomimetic endodontic shaping and biomimetic reinforcement and restoration to ensure that sufficient PCD is preserved and further reinforced as well.

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