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Recent Advances In Pediatric Endodontics

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Abstract
Dental caries is the most commonly occurring dental disease especially in children. The dental pulp is a fascinating tissue that has always attracted much attention within the dental profession. Pediatric endodontics deals with the management of pulpally involved teeth in children. Various methods and medicaments have been suggested for use in pediatric endodontics depending on pulpal status. This review article discusses the recent diagnostic procedures, treatment modalities and materials used in pediatric endodontics. This article is clinically relevant, as understanding of diagnostic methods, newer materials and treatment options is essential for effective endodontic diagnosis and treatment planning in children.

Key Words
MTA, Laser doppler Flowmetry, Pulp Oximetry

Introduction

Pediatric Endodontics deals with the treatment of pulp of deciduous and young, immature permanent teeth. The aim of Endodontics in case of primary teeth is to maintain function until exfoliation, or at least for as long as they are important for development of occlusion.[1] Endodontic treatment of immature permanent teeth intends to maintain continuing root development and to keep the tooth in functional condition.[2] Though there are reports of decline in prevalence of dental caries in the Western world, a large population exhibits rise in caries especially in children of developing countries. It is therefore important for all dental practitioners to be familiar with the endodontic techniques for maintaining and restoring the primary teeth.[3]

In this paper, we shall review the advances in the diagnostic procedures, treatment modalities and materials used in Pediatric Endodontics.

1.Pulse Oximetry-

The pulse oximetry is a non invasive method which is designed to measure the oxygen concentration of the blood and the pulse rate. The oximeter works on the principle that two wavelengths of light transmitted by a photoelectric diode detect oxygenated and deoxygenated hemoglobin as they pass through a body part to a receptor.

The principle of this technology is based on a modification of Beer's law, which relates the absorption of light by a solute, to its concentration and optical properties at a given light wavelength. It also depends on the absorbance characteristics of hemoglobin in the red and infra-red range. In the red region oxy-haemoglobin absorbs less light than de-oxyhaemoglobin and vice versa in the infrared region. Red light of approximately 660 nm. Infra-red light of approximately 850 nm.

A Silicon photo detector diode is placed on the opposing surfaces of the tooth which is connected to a microprocessor. The probe is placed on the labial surfaces of the tooth crown and the sensor on the palatal surface. Ideal placement of the probe is middle in the third of the crown.
A number of clinical studies have proved that the pulse oximetry is an effective and objective method of evaluating dental pulp vitality. It has been proved to be successful method in 70% of the clinical trials and further work is still in progress.

A study was conducted by Munshi A.K et al(2002) to compare the clinical effectiveness of the pulse oximeter over the conventional technique (electrical testing) of tooth vitality testing. The readings obtained from the pulse oximeter were correlated to vitality using a conventional electrical pulp vitality tester (Parkell Pulp Vitality Tester). It was concluded that pulse oximetry is an effective, objective method of evaluating dental pulp vitality especially in pediatric patients where patient co-operation and incomplete pulp innervation reduces the effectiveness and reliability of electric pulp testing methods.[4]

2. Laser doppler flowmetry-

Gazelius et al[5] first reported the ability of LDF to measure pulpal blood flow in humans and distinguished between vital and non-vital teeth. Later Olgart et al[6] and Wilder-Smith[7] considered it as a 'gold standard' in determining pulpal blood flow. LDF is a non-invasive electro-optical technique, which allows the semi-quantitative recording of pulpal blood flow. This technique measures blood flow in very small blood vessels of the microvasculature. It depends on the 'Doppler principle', which uses a beam of infrared (780 to 820nm) or near infrared light (632.8nm) that is directed into tissue by optical fibres, and the enamel prisms and dentine tubules guide this light to the pulp. As light enters the tissue, it is scattered by moving red blood cells and stationary tissue cells. Photons which interact with moving red blood cells are scattered and frequency is shifted according to the 'Doppler principle'. Photons that interact with the stationary tissue cells are scattered, but not 'Doppler shifted'. A portion of light is

returned to the photo detector and a signal is produced.[8] Currently available flowmeters display the signal on the screen, from which the clinician can interpret if the pulp is alive and healthy, or dead.[9] Limitations of using LDF are that it is too expensive and time consuming. The LDF is unable to quantify blood volume directly and is adversely affected by movement and saliva contamination.

3. Transmitted laser light

Transmitted laser light[10] is similar to LDF, but LDF also records signals from non-pulpal origin. To overcome this disadvantage of LDF, in 1997 Sasano et al[11] tested pulpal blood flow using the same method as LDF, but instead used transmitted laser light, rather than backscattered light that is normally used in LDF. Conventional LDF probes comprise two glass graded index optical fibres, one transmitting and one receiving, with a core diameter of 100µm. When using transmitted laser light, a single probe is used, one fibre of which acts as the transmitter on the labial side of the tooth, the other held on the palatal side as the receiver. An advantage of transmitted laser light over LDF are that the blood flow signals do not include flow of non- pulpal origin. Output signals and blood flow changes were greater and could be easily monitored with less noise. The limitations are that it is still not possible to test in situ because of the position of the splint and the size of oral opening.

4. Dual wavelength spectrophotometry-

Dual wavelength spectrophotometry (DWLS) is a technique that was developed by Millikan[12] and improved by Wood and Geraci.[13] It is a method independent of pulsatile circulation. The presence of arterioles rather than arteries in the pulp and its rigid encapsulation by surrounding dentine and enamel makes it difficult to detect the pulse in the pulp space. The DWLS technique uses visible light and measures oxygenation changes in the capillary bed, rather than in the blood vessels. The light is filtered to a near infrared range (760 to 850nm) and guided to the tooth by fibre optics. This means that added eye protection is unnecessary for the patient and the operator. This test is non-invasive, does not rely on a subjective patient response and, therefore, yields objective results. The DWLS instrument is small and portable, relatively inexpensive and suitable for use in a private dental office. However, it detects only the presence of haemoglobin and not the circulation of blood.

5. Hughes-Probe Eye Camera:

Thermographic imaging is a non-invasive and a highly accurate method of measuring the surface temperature of the body. Surprisingly, there have been a very few reports concerning the usefulness of Thermographic imaging in assessing the surface temperature of teeth as an indicator of pulpal blood flow. The technique is accurate and allows comparison of different areas of tooth. A suitable device for infrared thermographic imaging is Hughes Probe eye thermal video system. This camera is capable of detecting temperature changes as low as 0.1?degree centigrade over a wide temperature range at a range of distances from the subject. Using this device, Pogrel et al showed that the temperature of upper incisors decreased from gingival margin to incur edge by approximately 2.5. Teeth with vital and non vital pulp were at the same temperature at rest, but after cooling with cold air, teeth with non vital pulp were slower to rewarm than vital teeth.

6. Photoplethysmography (optical detection of blood flow)-

Photoplethysmography has been suggested as a potential non-invasive method to detect vascularisation of the dental pulp. Experimentally it has been applied to the pulp in cats, dogs and adult humans.[14] The system includes a (5x3x1)mm light emitting diode (LED) powered by a 3V battery as the light source, with a peak output of 576nm, with a 36nm bandwidth at half the peak intensity. A silicon photodiode detector with a special range of 400 to 1100nm is used in a photovoltaic mode that requires no external power supply. The detector output is interfaced directly to an 8088-based computer. Polyethylene tubing is sealed into the coronal access and connected to syringe infusion pump. The pump is capable of producing desired flow rate solutions lengthwise through the tooth. The LED and detector are positioned on opposite sides of the tooth. This setup is housed in an optical carrier and on holders in an optical rail. As the number of blood cells increase, nearly all light passing through the pulp chamber is scattered by 1:1 solution/maximum limiting apparent absorbance. Due to the smaller size of the pulp chamber, a significant fraction of the detected light passes through the tooth, but bypasses the pulp chamber and, therefore, is not scattered by the blood cells. This non-pulpal light provides a constant background intensity that is independent of the relative concentration of blood cells in the pulp tissue. As the number of blood cells increases, nearly all light passing through the pulp chamber is scattered, thereby resulting in a maximum limiting apparent absorbance. The concept of measurement is to pass a selected band of light through the tooth, while continuously monitoring the intensity of the transmitted light. The advantages of the equipment used in this method is that signal contamination derived from periodontal blood flow does not occur. It has less signal noise (periodontal ligament blood flow) compared with LDF, due to the pathway of transmitted light. This method is still under research.

A.PULP CAPPING MATERIALS-

1.Corticosteroids and Antibiotics-

Corticosteroids and/or antibiotics were suggested for direct pulp capping in the pretreatment phase and also to be mixed in with calcium hydroxide with the thought of reducing or preventing pulp inflammation. These agents included neomycin and hydrocortisone,[15] Cleocin,[16] cortisone,[17] Ledermix[18] (calcium hydroxide + prednisolone), penicillin, [19] and Keflin (cephalothin sodium).[20]

Oliveira MDF et al 2009[21] conducted a study to histologically evaluate the reaction of tooth pulp to treatment with calcium hydroxide in distilled water preceded by corticosteroid (Decadron) or corticosteroid/antibiotic (Otosporin) dressing. Calcium hydroxide solution was applied to exposed tooth pulp for 5 min or for 72 hr, using a sample of 120 molars of rats; and histological examination was performed 7, 14, 30 and 60 days after treatment. The results of the study showed that temporary dressings resulted in a milder inflammatory reaction during the early postoperative period. The tissue reaction and the quality of the barrier formed when the Otosporin temporary dressing was applied for 5 minute were similar in the experimental and the control groups at longer

postoperative periods. Temporary dressings of Decadron applied for 5 min or 72 h or Otosporin applied for 72 hr caused a slight retardation of the healing process of the tissue that was apparent 30 days after the intervention.

2. Polycarboxylate Cements-

These cements have also been suggested as a direct capping material. The material was shown to lack an antibacterial effect and did not stimulate calcific bridging in the pulps of monkey primary and permanent teeth.[22] Negm et al. placed calcium hydroxide and zinc oxide into a 42% aqueous polyacrylic acid and used this combination for direct pulp exposure in patients from 10 to 45 years of age. This mixture showed faster dentin bridging over the exposures in 88 to 91% of the patients when compared to Dycal as the control[23] suggesting that it can be a good pulp capping agent.

3.Inert Materials-

Inert materials such as isobutyl cyanoacrylate[24] and tricalcium phosphate ceramic[25] have also been investigated as direct pulp-capping materials. Although pulpal responses in the form of reduced inflammation and unpredictable dentin bridging were found, to date, none of these materials have been promoted to the dental profession as a viable technique.

At Istanbul University, dentists capped 44 pulps, half with tricalcium phosphate hydroxyapatite and half with Dycal (calcium hydroxide). At 60 days,none of the hydroxyapatite-capped pulps exhibited hard tissue bridging but instead had mild inflammation. Nearly all of the Dycal-capped pulps, however, were dentin bridged, with little or no inflammation.[26]

4.Collagen Fibers-

Collagen fibres are naturally occuring proteins found exclusively in the connective tissue. Collagen fibres are able to induce mineral formation and to orient hydroxyapatite crystals which form directly on or within collagen fibres of the mineralizing tissue, although the precise molecular mechanism involved has not been determined. They are formed both in vivo and in vitro.

Carmichael placed modified wet collagen sponges with reduced antigenicity in pulp-exposed teeth of young dogs.[27] They concluded that although the material was found to be relatively less irritating than calcium hydroxide, and with minimal dentin bridging in 8 weeks, collagen was not as effective in promoting a dentin bridge as was calcium hydroxide.

5.Glass Ionomer(GI)/ Resin Modified Glass Ionomer (RMGI)-

In the mid 1980s the Resin modified glass ionomer were developed chiefly to overcome the problems of moisture sensitivity and low early mechanical strength of conventional glass ionomer cements and were widely advocated for indirect pulp therapy (T.Bozini et al, 2009).[28] Among the advantages are the anti-cariogenic acitivity, ability to remineralize dentin and stable physical characteristics, albeit with with low fracture resistance (Murray PE et al, 2006).[29] Although, some advantages of RMGI fulfil the criteria for the ideal pulp capping material, yet, information is scarce about the effects of RMGI on direct pulp capping. GI/RMGI is cytotoxic when in direct cell contact and the conventional formulations tend to be less toxic than the resin- modified formulations (TJ Hilton,2009)[30].

6. Hybridizing Bonding Agents-

Currently, hybridizing dentinal bonding agents (such as AmalgamBond or C & B MetaBond, Parkell Products, Farmingdale, N.Y.) represent the state of the art in mechanical adhesion to dentin with resultant microleakage control beneath restorations.[31],[32]

Miyakoshi et al. have shown the effectiveness of 4-META-MMA-TBB adhesives in obtaining an effective biologic seal.[31] Cox et al. demonstrated that pulps sealed with 4-META "showed reparative dentin deposition without pulp pathosis."[33]

7. Mineral trioxide aggregate (MTA)-

(Dentsply, Tulsa; Tulsa, Okla.) cement was developed at Loma Linda by Torabinejad for the purposes of root-end filling and furcation perforation repair. The material consists of tricalcium silicate, tricalcium aluminate, tricalcium oxide, and silicate oxide. It is a hydrophilic material that has a 3-hour setting time in the presence of moisture. Major MTA advantages include excellent sealing ability, good compressive strength (70 MPa) comparable to IRM, and good biocompatibility.

Fatou Leye Benoist 2012[34] assessed the effectiveness of mineral trioxide aggregate as an indirect pulp capping material in human molar and premolar teeth. They found a higher success rate with the MTA group relative to the Dycal group after 3 months, which was statistically significant.However, after 6 months no statistically significant difference was found in the dentin thickness between the two groups.

8. Enamel matrix derivatives-

(Enamel matrix proteins) like amelogenins from the pre-ameloblasts, are translocated during odontogenesis to differentiating odontoblasts in dental papilla, suggesting that amelogenins may be associated with odontoblast changes during development.[35] Enamel matrix derivative (EMD), obtained from embryonic enamel of amelogenin, was demonstrated in vitro, using a wound healing model, to be capable of stimulating periodontal ligament cell proliferation at earlier times (i.e., days one to three) compared to gingival fibroblasts and bone cells.[36]

Ishizaki et al (2003)[37], examined the histopathological response of dental pulp tissue to EMD used in pulpotomized teeth of mongrel dogs. The treated teeth histologically demonstrated an increase in tertiary dentin, suggesting that EMD exerts a considerable influence on odontoblasts and endothelial cells of capillaries in dental pulp tissue. These results imply that EMD used as pulp treatment material plays a role in the calcification of dental pulp tissue.

RECENT INNOVATIONS IN PULPOTOMY MATERIALS:

1.Mineral Trioxide Aggregate:

MTA is a new material currently being used in pulp therapy. It is a non- resobable material that has been used experimentally for a number of years and was approved for human usage by the ADA. Several in vitro and in vivo studies have shown that MTA prevents microleakage, is biocompatible and promotes regeneration of the original tissues when it is placed in contact with dental pulp. MTA is an ash coloured powder made primarily of fine hydrophilic particles of tricalcium aluminate, tricalcium silicate, silicate oxide, and tricalcium oxide. When the material is hydrated it becomes a colloid gel,it sets in approximately 3-4 hours, and bismuth oxide has been added for radiopacity.

The nearly normal pulpal architecture, intact and continous odontoblastic layer, and reparative dentin bridge formation, indicates the material's biocompatibility and regeneration ability (Agamy et al 2004).[38]

Cuisia et al. (2001) conducted a randomized, clinical trial compared MTA with Formacresol, but the randomization method was not reported. Only asymptomatic molars without clinical and/or radiographic evidence of pulp degeneration were included. Pulpotomies were performed in 60 molars by 1 pediatric dentist using a local anesthetic and restored with a stainless steel crown, but there was no mention of the use of a rubber dam. The results were assessed by 2 pediatric uncalibrated dental residents at 6-monthfollow-up; the clinical success rate was 93% for FC and 97% for MTA,whereas the radiographic success was 77% for FC and 93% for MTA.

2. BONE MORPHOGENIC PROTEINS:

Bone morphogenetic proteins have been proposed as potential capping agents in direct pulp-capping and pulpotomy techniques. Bone morphogenetic proteins 2 to 8 belong to TGF-β, that are signaling proteins that regulate cell differentiation. Bone morphogenetic proteins 2 and 4 have been implicated in odontoblastic differentiation. Nakashima demonstrated dentin bridging in dog tooth coronal pulp amputation when the remaining tissue was capped with BMP-2 and BMP-4, along with recombinant human dentin matrix. After a 2-month time interval, tubular dentin and osteodentin were found histologically in response to both BMP types.

With the aim to observe painful reactions and signs of clinical and radiographic pathological alterations in human deciduous teeth,as well as to histologically examine pulp tissue after the use of recombinant human BMP-2 in a collagen scaffold.

Antonio Lucindo Bengtson et al 2008[39] conducted a study and found that after 12 months, there were 100% clinical and radiographic success, with no detectable abnormalities. On the histological sections, areas of inflammation, pulp nerosis and internal reabsorption,as well as the formation of tissue resembling osteodentin in the radicular portion,were observed. It was concluded from their study that the absence of symptomatology and clinical and radiographic alterations suggested that rhBMP-2 is a material with inductive properties that should be further investigated for use as an alternative to pulpotomy treatment.

3. LASERS:

Application of laser irradiation in vital pulp therapy has been proposed as another alternative to pharmacotherapeutic techniques Adrian[40] reported that irradiation of the buccal tooth surface with the neodymium: yttrium-aluminum-garnet (Nd:YAG) laser produced less pulp damage than the ruby laser with less histologic evidence of coagulation and focal necrosis. Shoji et al.[41] histologically studied the carbon-dioxide laser in the pulpotomy procedure. They noted that the least amount of pulp tissue injury occurred with defocused irradiation with lower power settings and shorter application. More tissue destruction occurred in the defocused mode with higher irradiation power settings.

Recent Advances In Pulpectomy.

Orascope: With help of orascope we can look inside the canal with help of a camera eye in Fiberoptic lens less than 2mm in diameter. Orascope can be used in Visualisation of complex anatomy cases, In Locating root fractures, Root end surgery, Locating canals and in removal of separated instruments.

Over the years, several brands have dominated the discussion, the ideas, and the market. This discussion will however, focus on the rotary NiTi instruments which are already in use or those which have future scope in Pediatric endodontics. These systems are:

1.Profile Rotary system:

The Profile system was introduced by Dr Wm. Ben Johnson in 1994. The Profile first was sold as a series of 29 hand instruments in #0.02 taper, but it soon became available in #0.04 and #0.06 conicity.These profile instruments made by Tulsa Dental (Tulsa,Okahoma) were one of the first NiTi instruments in the market. In 1994, the first product of the Pro series 29 stainless steel and NiTi hand instruments with a 0.02 taper was marketed. Further developments included increasing taper, including Profile series 29, 0.04 taper, 0.06 taper rotary instruments and orifice shapers. They are designed for continous rotation at 150-350 rpm in a contra angle and are eminently suitable for use with the crown down technique.

2. The Protaper System:

The system was developed by a group of well respected endodontists (Prof.Pierre Machtou, Dr Clifford Ruddle, and Prof. Jhon West) in cooperation with Dentsply/Mallefer. A unique feature of Protaper instruments is that, each one has changing percentage tapers over the length of its cutting blades.

Protaper instruments also have convex, triangular cross sections, a changing helical angle and pitch over their cutting blades and a non-cutting, modified guiding tip. The ProTaper system is comprised of three shaping files for the crown-down preparation(Sx,S1,S2) and five finishing files (F1,F2,F3,F4,F5). These may be hand or may be rotary. Three shaping files are characterized by increasing tapers over the whole length of their cutting blades, allowing for a controlled cutting performance in special sections of the instrumented root canal. The finishing files are dominated by different diameters, #20, #25, #30 and a fixed taper over 3mm to finish apical preparation.

3. FLEX MASTER:

Flex Master(FM) nickel-titanium (Ni-Ti files (VDW,Munich,Germany) have been used in Europe successfully for sometime. The cutting blades of FM instruments have no radial lands to completion of the crowndown phase using files with increasing diameters(green sequence).

Flex Master instrument fractures occur only occasionally during preparation. A comparison with results of studies of other NiTi systems shows that the safety and reliability of FM instruments are good. For FM instruments, the 'Endo IT professional'low torque controlled motor with instrument individualized torque is available. Curved root canals can be prepared without difficulty with FM NiTi instruments by both experienced practitioners and by novices.

4.MTWO:

It has S-shaped cross section and there are 4 instruments for all types of root canals. Mtwo is available in 0.04,0.05,0.06 taper. The advantages of Mtwo includes its ability of simultaneous shaping the canal that is, every instrument shapes the whole length of the canal to the apex, no building of ledges, less no. Of files, outstanding cutting efficiency, optimal shaping for all obturation techniques.

Obturation of the root Canal

1.Triple Antibiotic Paste:

3-Mix-MP is an effective and long-lasting cavity treatment, utilizing three antibiotics: metronidazole, minocycline and ciprofloxacin.The antibiotics are mixed with macrogol (M) and propylene glycol (P). Metronidazole is the first choice because of its wide bactericidal spectrum against anaerobes.

Ciprofloxacin is a broad-spectrum anti-infective agent active against aerobic gram-negative organisms. Minocycline is a long acting antibiotic active against both gram-negative and gram-positive organisms. The MP liquid is an excellent vehicle to carry the 3-Mix into the entire dentin and through the dentinal tubules to kill all the bacteria in lesions. The enteric coating of metronidazole, cipro? oxacin, and minocycline are removed. The tablets were pulverized using a mortar and pestle. The powdered antibiotics were stored and sealed in airtight containers separately from moisture and light. The same amount of each drug powder (1 : 1 : 1) is mixed together. After that, the mixed drugs are combined with macrogol and propylene glycol (MP) to form an ointment.

N-Loera Velasco et al(2012)[42] conducted a study to evaluate in vitro the antimicrobial efficacy of a modified 3-mix paste and to compare it with an iodoform paste (Ultrapex) against anaerobic microorganisms isolated from root canals of infected or necrotic primary teeth. . A total of 21 microbial samples (15 polymicrobial and 6 monomicrobial) were obtained, from which 19 different strains were identified. Modified 3-mix paste showed an excellent antimicrobial effect against most of both kinds of microbial samples, although some of them exhibited resistance; on the other hand, Ultrapex showed only minimal antimicrobial ability (null or low categories). Clostridium ramosum exhibited the most resistance to both materials. Thus, the authors concluded that the bactericidal effect of the modified 3-mix paste was superior to Ultrapex, with a statistically significant difference, against anaerobic microorganisms isolated from infected root canals of primary teeth.

2.Colla Cote

It is a soft, white, pliable, biocompatible sponge obtained from bovine collagen. It can be applied to moist or bleeding canals. It is an absorbable collagen barrier which prevents or diminishes extravasation of root canal filling material during primary molar pulpectomies. Apart from its use in endodontic therapy it also provides a scaffold for bone growth and so it can be applied on wounds.

Summary and Conclusion

Preservation of the primary tooth whose pulp has been endangered by deep carious lesions or trauma is a major issue of concern in children. The premature loss of primary teeth may reduce arch length required for the succeeding tooth and hence, predisposes crowding, rotation and impaction of the permanent teeth. Therefore, the main goal of endodontic therapy for primary teeth is to maintain an intact dental arch, a healthy periodontium, and the vitality of the dental pulp when possible.

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