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Smart Pediatric Dentistry

A Project Submitted to

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By

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Certification of the Supervisor

I certify that this project entitled Smart Pediatric Dentistry was prepared by the fifth-year student Mohammad Sadiq Kazem under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the bachelor's degree in Dentistry.

Lect. Heba N. Yessin

Date:

DEDICATION

I'd like to dedicate this project to my beloved **father** and to my beloved **mother** without both I would never make it to this point.

To all **my friends**, thank you for being always there for me with all you love and support.

ACKNOWLEDGEMENT

First, I thank "Allah" almighty for granting me the will and strength to accomplish this research and I pray that his blessings upon me may continue throughout my life.

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List of Abbreviations

Abbr.	Acronyms
ACP	Amorphous calcium phosphate
CPP-ACP	casein phosphopeptid-amorphous calcium phosphate
CCLAD	Computer- controlled local anesthetic delivery
°C	Celsius
ECC	Early childhood caries
GIC	Glass Ionomer Cement
HAP	Hydroxyapatite
IANB	Inferior alveolar nerve block
LA	Local anesthesia
MCPM	Monocalcium Phosphate Monohydrate
mm	Millimeter
NiTi	Nickle Titanium
PLS	polylysines
%	Percent
rpm	Revolution per minute
SEM	scanning electron microscopy
S-ECC	Severe early childhood caries
TENS	Transcutaneous Electrical Nerve Stimulation
TF	twisted file
VE	virtual environments
VR	Virtual reality

Introduction

Traditionally materials designed for long-term use in the mouth are thought to survive longer if they are “passive” and have no interaction with their environment. Materials such as amalgams, composites and cements are often judged on their ability to survive without reacting to the oral environment. Today the most promising technologies for life time efficiency and improved reliability include the use of “bio-active” smart materials (Shanthi *et al*., 2014).

A material is said to be "smart” if it can support the remaining tooth structure to the extent that cavity preparation can be carried out in the most conservative way. McCabe (2011) defined smart materials as "Materials that are able to be altered by stimuli and transform back into the original state after removing the stimuli". The stimuli can be derived from temperature, pH, moisture, stress, electricity, chemical or biomedical agents and magnetic fields. Due to the interesting behavior of smart materials, scientists have been encouraged to apply them in various fields, mostly in biomedical science and dentistry. A key feature of smart behavior includes an ability to return to the original state after the stimulus has been removed. Smart materials are highly responsive and have a great capacity to sense and respond to any environmental change. Hence these materials are also known as Responsive Materials (Bhatnagar *et al*., 2016).

A material is termed "smart" if it has the capacity to sense and respond to external stimuli in a useful and reversible way. These smart materials have found numerous applications in bio- medical fields and are termed bio smart. Materials, such as smart composites, smart ceramics, compomers, amorphous calcium phosphate-releasing pit and fissure sealants, as well as orthodontic shape memory alloys, smart impression material, smart suture, smart burs and others are examples of bio smart materials that have revolutionized bio-medical fields such as dentistry and orthopedics' (Dauda *et al*., 2021).

It is one of the challenging tasks to manufacture new multifunctional materials which possess intelligence at the material level. Material intelligence is classified in to three functions: sensing changes in environmental conditions, processing the sensed information and finally making judgment (actuating) by moving away from or to the stimulus (Mangaiyarkarasi and Manigandan., 2013).

Aim of study

The aim of this project is to outline smart pediatric dentistry and its application and highlight the smart dentistry types (smart material, smart instrument and smart devices). This project mentioned in detail about each of them and its application in pediatric dentistry.

Review of literature

1.Smart Material

There has been no single material in dentistry that fulfills all the requirements of an ideal material. While the search for an "ideal material" continues, a newer generation of materials has been introduced. The adjective "smart" implies that these materials can sense changes in their environments and then respond to these changes in predetermined manners traits that are also found in living organisms. These materials may be altered in a controlled fashion by stimulus such as stress, temperature, moisture, pH, and electric or magnetic field. Some of these are "bio-mimetic" in nature while others are "bio-responsive." These materials would potentially allow new and groundbreaking dental therapies with a significantly enhanced clinical outcome of the treatment procedures (Jain *et al*., 2017).

1.1 Smart Glass Ionomer Cement (GIC)

The smart behavior of GIC was first suggested by Davidson in 1998 When samples of restorative materials were heated to determine their values of coefficient of thermal expansion, for composite materials, expansion and contraction occurred in the expected way irrespective of dry or wet conditions. However, for glass-ionomers, in wet conditions, little or no change in dimension was observed when heating and cooling between 20°C and 50°C. In dry conditions, glass-ionomers showed a marked contraction when heated above 50°C (Davidson., 1998).

The smart behavior of glass-ionomers and related materials is closely linked to their water content and the way in which this can react to changes in the environment. On heating, increased fluid flow to the surface and rapid loss of water is the mechanism behind the observed contraction. This behavior is akin to that of human dentine where similar changes are seen as a result of flow of fluids in the dentinal tubules. Hence, the glass-ionomer materials can be said to be mimicking the behavior of human dentine through a type of smart behavior. Due to this smart behavior of GIC, it provides good marginal adaptation to the restorations (Nomoto *et al*., 2004).

The other aspect of the smart behavior of GIC is the fluoride release and recharge capacity. Normally, the fluoride release in products is seen as a high initial fluoride release followed by a gradual decrease over a period. The smart behavior of materials containing GIC salt phases is attributed to their property of getting “recharged” when the material is bathed in a high concentration of mouth rinse fluoride as may occur in toothpaste or mouth rinse.As shown in fig.1 (incorporates a “SmartGlass” filler) (Jain *et al*., 2017).

Fig.1 Smart GIC (Padmawar *et al*., 2016)

1.2 Smart Composites

It is a light-activated alkaline, nano filled glass restorative material. It releases calcium, fluoride, and hydroxyl ions when intraoral pH values drop below the critical pH of 5.5 and counteracts the demineralization of the tooth surface and aids in remineralization. The material can be adequately cured in bulk thicknesses of up to 4 mm. It is recommended for the restoration of class 1 and class 2 lesions in both primary and permanent teeth. Ex: Ariston pH control introduced by Ivoclar Vivadent (Shanthi *et al*., 2014).

Smart composites contain Amorphous Calcium Phosphate (ACP), as seen in fig.2, one of the most soluble of the biologically important calcium phosphates. The basic building block of tooth enamel is hydroxyapatite; it is also an inorganic component of dentin. In the case of carious attack, hydroxyapatite is removed from the tooth resulting in cavities or white spots. The carious attack is usually the result of exposure to low pH conditions (acid attack) either from bacteria, other biological organisms releasing acid, food (carbohydrate decomposition products). ACP at neutral or high pH remains ACP. When low pH values at or below 5.8 during a carious attack, ACP converts in to HAP (hydroxyapatite) and precipitates, thus replacing the HAP lost to the acid. when the pH level in the mouth drops below 5.8, these ions merge within seconds to form a gel. In less than 2 minutes, the gel becomes amorphous crystals, resulting in calcium and phosphate ions (Skrtic *et al*., 2003).

The material within the group is called by the acronym SMART (Self-etching, Mechanically strong, Adhesive, Remineralizing, Tooth mimicking) dental composite,as seen in fig.3. It differs from existenting commercial materials in the fact that it contains MCPM (Monocalcium Phosphate Monohydrate) as a remineralising agent and PLS (polylysines) as an antibacterial agent in addition to self-adhesion properties (Katsimpali and Aspasia, 2020).

Katsimpali and Aspasia (2020) develop novel SMART composites which will target the paediatric patient. They have antibacterial PLS and remineralising MCPM incorporated in them which could potentially address the bacterial microleakage problem of existing materials. They are self-etching and can be used as a bulk filling after soft caries removal. Good monomer conversion at depth and dimensional stability are essential for bulk filling and prevention of microleakage, and they concluded:-

1. Antibacterial PLS and remineralising MCPM do not have a significant effect on the delay time, reaction rate, half time and final monomer conversion of the SMART composites.

2. All SMART composite formulations tested had higher final monomer conversions than the commercial comparators.

3. The minimum curing time needed in order to achieve good final monomer conversion above the 50% cytotoxic limit is 20 seconds regardless of the thickness when having a maximum depth of 2mm.

4. The volume and mass change of SMART composites over long periods of time while submerged into water at a temperature of 37 °C imitating the oral cavity temperature do not exceed calculated shrinkage. This may be an indicator of lower fracture risk.

5. The volume change of SMART composites compensates for the calculated shrinkage following mathematical calculations.

6. The overshoot noted in the mass change of SMART composites indicates the release of composite components into the oral cavity.

7. The final SMART composite formulation (containing 8% MCPM and 4% PLS) demonstrates a significantly lower dye microleakage than the two commercial GICs.

8. SMART composites can be placed as a bulk filling without requiring etch or a bonding agent and provide an adequate seal.

Fig.2 smart composite (Padmawar *et al*., 2016)

1.3 Smart Ceramics

In 1995, at ETH Zurich (University in Switzerland) , the first “all ceramic teeth and bridge” was invented based on the process that enables the direct machining of ceramic teeth and bridges. The process involved machining a prefabricated ceramic blank made of zirconia ceramics with a nanocrystalline porous structure in the pre-sintered state, followed by sintering (the process of forming a solid mass of material through heat and pressure without melting to the point of liquefaction). The sintered material shrinks homogeneously in all spatial directions to its final dimensions. The material gains its high hardness, high strength, and toughness during the final sintering. The veneering of the high strength ceramic framework then adds the required esthetic and wear characteristics. The process has advantages of high accuracy in an easy, fast, and fully automated way , as seen in Fig.3. It then opened a new era of ceramics in dentistry. It showed superior characteristics with respect to esthetics demands, excellent biocompatibility, and absence of hypersensitivity reactions (Beuer *et al*., 2008).

In pediatric dentistry, they find use in making porcelain veneer restoration and full cast or porcelain fused to metal crown restoration. They also find use as smart bracket braces containing microchip capable of measuring the forces applied to the bracket/tooth line (Jain *et al*., 2017).

Fig.3 Smart Ceramics System (Little and david., 2012).

1.4 Casein phosphopeptid-amorphous calcium phosphate (CPP-ACP)

Dental caries is a bacterial biofilm induced acid demineralization of enamel or dentin, mediated by saliva. The disease of early childhood caries (ECC) is the presence of 1 or more decayed (non cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child 71 months of age or younger (Tinanoff and Baez., 2019).

In children younger than 3 years of age, any sign of smooth-surface caries is indicative of severe early childhood caries (S-ECC).It is a serious problem that progresses rapidly and often goes untreated. Current traumatic treatments may be replaced by safe and effective remineralization at very early stages especially a recent advancement in the phenomenon of remineralization known as the casein phosphopeptide-amorphous calcium phosphate (CPP-ACP).CPP-ACP is an acronym for a complex of casein phosphopeptides (CPP) and amorphous calcium phosphate (ACP). Caseins are the predominant phosphoproteins in bovine milk (El Mehdi *et al*., 2016)**.**

1.4.1 Mechanism of Action of CPP-ACP:

In 1991, the complex CPP-ACP, derived from a major protein found in milk called casein, was patented in the United States (Aimutis and William., 2004).

The complex is presented as an alternative remineralizing agent that is remarkably capable of stabilizing calcium phosphate, maintaining a state of supersaturation of these ions in the oral environment. In the past, the clinical use of calcium and phosphate ions for remineralization was relatively unsuccessful due to the low solubility of calcium phosphates, particularly in the presence of fluoride ions. To overcome these difficulties, a new calcium phosphate remineralization technology was developed based on casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), where CPP stabilizes high concentrations of calcium and phosphate ions, together with fluoride ions, at the tooth surface by binding to biofilm (Dorozhkin., 2016).

The ACP technology was introduced in the early 1990 and has demonstrated anticariogenic activity in laboratory, animal and human in situ experiments. Reynolds and colleagues (2009) reported that CPP-ACP binds readily to the surface of the tooth, as well as to the bacteria in the plaque surrounding the tooth. In this way, CPP-ACP deposits a high concentration of ACP near the tooth surface. Therefore, under acidic conditions, this localized CPP-ACP buffers the free calcium and phosphate ions, substantially increasing the level of calcium phosphate in plaque and maintaining a state of supersaturation that inhibits enamel demineralization and enhances remineralization. (Gurunathan, and Somasundaram., 2012).

1.4.2 Application of CPP-ACP in pediatric dentistry

1.4.2.1 Remineralization of White-Spot Lesions:

White-spot lesions are considered as a non- cavitated carious lesions extending up to the dentin- enamel junction. They can be arrested by using remineralizing agents. The casein phosphopeptides and amorphous calcium phosphate CPP-ACP is biologically active and able to release calcium and phosphate ions to maintain the supersaturated state, thus improving the remineralization process (El Mehdi *et al*., 2016).

1.4.2.2 Remineralization of Early Enamel Lesions of Primary Teeth:

Early childhood caries (ECC) is a major public health problem worldwide. It corresponds at any form of caries in infants and preschool children. It begins with white-spot lesions, and caries can progress rapidly, leading to complete destruction of the crown. Calcium and phosphate ions are more readily lost for children because they eat mainly soft and sweet foods, and due to lower mineralization of deciduous enamel. The disease usually develops very quickly and causes many childhood health problems, such as caries-related toothache and infection. Demineralization and remineralization are dynamic processes in caries initiation, progression, and reversal. Therefore, regulation of the demineralization-remineralization balance is a key to caries prevention and treatment (Zhang *et al*., 2011).

Reynolds *et al* (2009) have shown CPP-ACP to be effective in the remineralization of carious lesions. In their study, the use of CPP-ACP resulted in an increase in the remineralization of the dental enamel and dentin as observed under scanning electron microscopy (SEM).

Another study suggests CPP- ACP can be expected to be effective in high-risk children who have not developed good oral hygiene habits. When used in combination with fluorides, CPP- ACP shows better results and lower caries scores than when used individually (Gupta and Nagpal, 2016).

Synergistic effects of CPP- ACP and fluoride have been reported in several studies. An in-situ study conducted by Srinivasan *et al*., (2010) compared the remineralizing potential of CPP-ACP and CPP-ACP with 900 ppm fluoride on enamel softened by cola drink. The study showed better results in CPP-ACP with 900 ppm fluoride and confirmed the synergistic effects of CPP-ACP with fluoride on remineralization of eroded enamel.

1.4.2.3 Prevention of white-spot lesions during orthodontic treatment:

The casein phosphopeptides and amorphous calcium phosphate (CPP-ACP) has been used to prevent demineralization during orthodontic treatment which can cause white-spot lesions at the tooth surface that can further develop into caries. The application of CPP-ACP resulted in a reduction in the demineralized areas, and this effect was more pronounced when CPP-ACP was combined with fluoride toothpaste (Wu *et al*., 2010).

<u>1.4.2.4 Prevention of enamel erosion caused by sports drink, soda or swimming pool water:</u>

Ramalingam *et al* (2005) conducted an in-vitro study to determine if the incorporation of CPP-ACP to a Powerade sports drink would eliminate enamel erosion. The authors concluded that there was significant reduction in the beverage’s erosivity without affecting the product’s taste.

<u>1.4.2.5 Prevention of caries in patients with xerostomia:</u>

In vivo studies in patients with xerostomia treated with CPP-ACP as mouth rinses show a lower rate of new caries lesions than for patients treated with 0.05% fluoride mouth rinses, although there were no significant differences between the groups after a control period for 12 months (Llena *et al*., 2009).

2. Smart instrument

2.1 Smart prep bur

A carious dentinal lesion consists of two distinct layers with different ultramicroscopic and chemical structures. The outer layer is contaminated with bacteria and the organic matrix is substantially degraded and cannot be remineralized requiring its removal and restoration. In contrast, the inner layer can be remineralized because of limited collagen degradation and should be preserved (Rabhakar and Kiran., 2009).

The traditional approach using mechanical rotary instruments is not fundamentally conservative because it often results in cavity preparations extending beyond the infected outer carious dentin layer into the non-infected or lightly infected inner carious dentin or into normal dentin. Carbide dental burs are designed to efficiently remove non-decalcified enamel and dentin but do not facilitate the differentiation between carious and normal dentin during cavity preparation. When this relatively aggressive procedure is combined with the dentist's goal to obtain an excavated surface that feels normal, inadvertent sacrifice of sound dentin is likely to occur (Vijay Kumar and Anil.,2012).

The Knoop Hardness value of caries-affected dentin is in the range between 10 to 40 kilograms/ square millimeter, while healthy dentin is within the range of 45 to 63 kg/mm2. The SmartPrep® (SS White, Lakeland, NJ, USA), as seen in fig.4 and fig.5, single-use, bur-like instrument is made of a medical-grade polymer with hardness less than that of healthy dentin. It is designed for the selective removal of carious dentin through the loss of its cutting efficiency upon reaching the caries-affected dentin (Allen and Salgado *et al*.,2005; Rabhakar and Kiran., 2009).

Polymer burs consist of cutting elements that cut softer dentin efficiently but are unable to cut normal dentin. The cutting blades will deflect and deform upon encountering normal or partially decalcified dentin, thereby enabling the reduction of cutting efficiency and alteration of the operator's tactile sensation. The bur blades are designed to primarily remove carious dentin by "plowing," during which carious dentin is first locally compressed by the blades then the compressed wall of softened carious dentin is pushed along the sounder dentin surface with rupture eventually occurring at this surface level and the loosened fragments are carried to the surface. In contrast, removal of normal dentin occurs due to chip formation by orthogonal cutting, during which the blade penetrates the dentin in a wedge like fashion, resulting in plastic deformation and shearing (Rabhakar and Kiran., 2009).

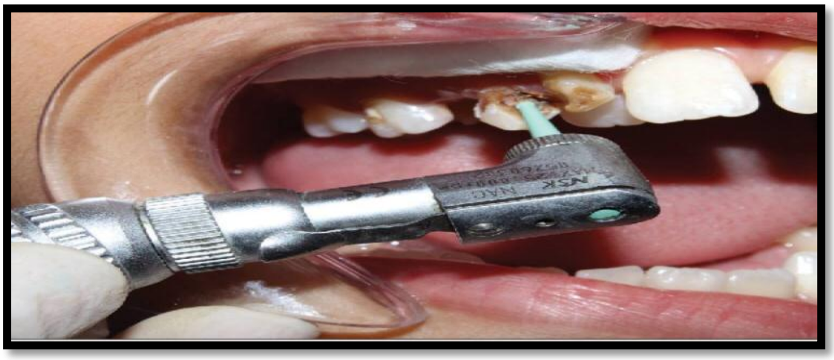

Fig.4 Caries excavation using SmartPrep bur (Baig and Arshia., 2016)

Fig.5 SmartPrep burs (Baig and Arshia., 2016)

2.2 NiTi Rotary instrument

These instruments are made of M-wire NiTi alloy and mounted on a dedicated handpiece and motor to operate the reciprocating rotation (Dagna and Poggio., 2014).

Rotary NiTi instruments create more rapid preparation and more centered smooth predetermined canal shapes, promoting a more uniform filling, minimize the risks of errors when compared to stainless steel instruments (Ramazani *et al*., 2016).

Presently some studies have assessed the ability of NiTi rotary endodontics in pulpectomy of deciduous teeth, in primary teeth, rotary instrumentation provided superior canal cleanliness, requiring less time for completion of canal preparation in comparison to manual instrumentation (Boyd., 2019).

Reciprocating systems seem to be applicable for preparation of curved canals in primary molars. Furthermore, the use of reciprocating motion was shown to decrease preparation time, simplifying the procedure, promoting patient cooperation with similar shaping ability in comparison with continuous rotation. All of these are desirable properties and particularly important considerations in pediatric patients (Wycoff and Berzins., 2012).

2.2.1 ProFile 0.04 system

It has a triple U-shaped cross-sectional design with flat radial lands, a non-cutting tip, and constant taper with a 20° helical angle and constant pitch,as seen in fig.6. The pulpectomy procedure began with a standard access and removal of coronal tissue. A NiTi ProFile 0.04 was chosen that approximates the canal size. It was inserted into the canal while rotating at a slow speed of 150–300 rpm till the calculated working length, as determined by pretreatment radiography (Chauhan *et al.*, 2019).

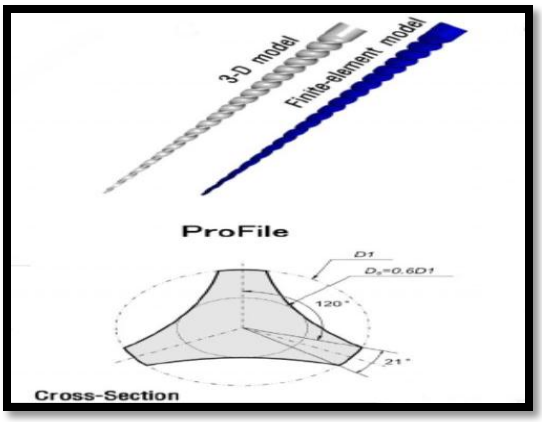

Fig.6 ProFile system (Kim *et al*., 2013)

2.2.2 ProTaper system

It has a convex triangular-shaped cross-sectional design with sharp cutting edges and no radial lands, noncutting tip, and variable taper with balanced helical angle and pitch to prevent “screwing in” effect ،as seen in fig.7 (Ruddle.,2005).

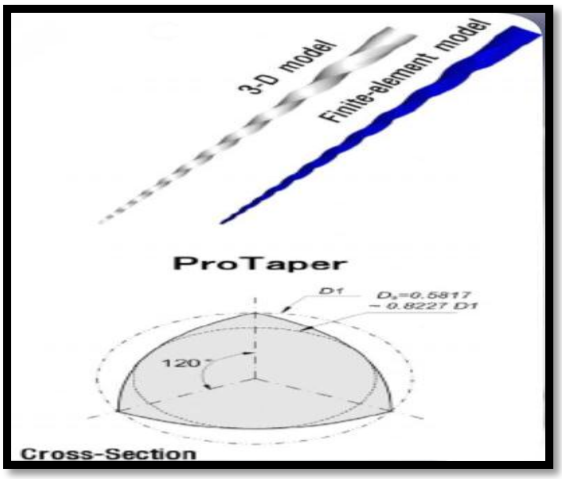

Fig.7 ProTaper system (Kim *et al*., 2013)

2.2.3 Flex-Master

These NiTi rotary files have a convex triangular-shaped cross-sectional design with sharp cutting edges and no radial lands, noncutting tip, fixed taper, and individual helical angles to prevent “screwing in” effect, as seen in fig.8 (Chauhan *et al*., 2019).

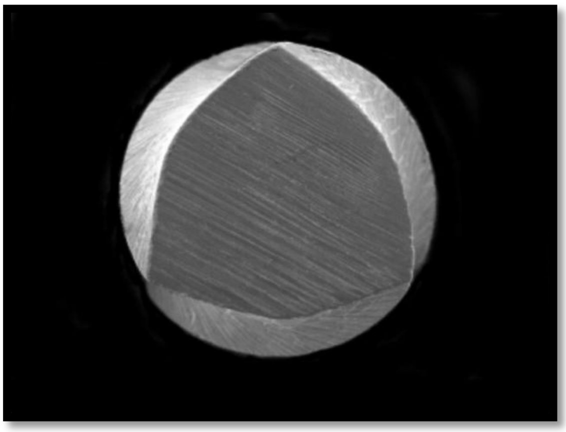

Fig.8 cross section of flex master file (Sonntag *et al*., 2005).

2.2.4 Hero files

These instruments are an example of second-generation rotary system. HERO stands for high elasticity in rotation. Recently a new root canal preparation instrument—HERO shapers—was designed with the same triple-helix cross-section. The key modification in this instrument is the introduction of the adapted pitch concept, as seen in fig.9 (Calas., 2005).

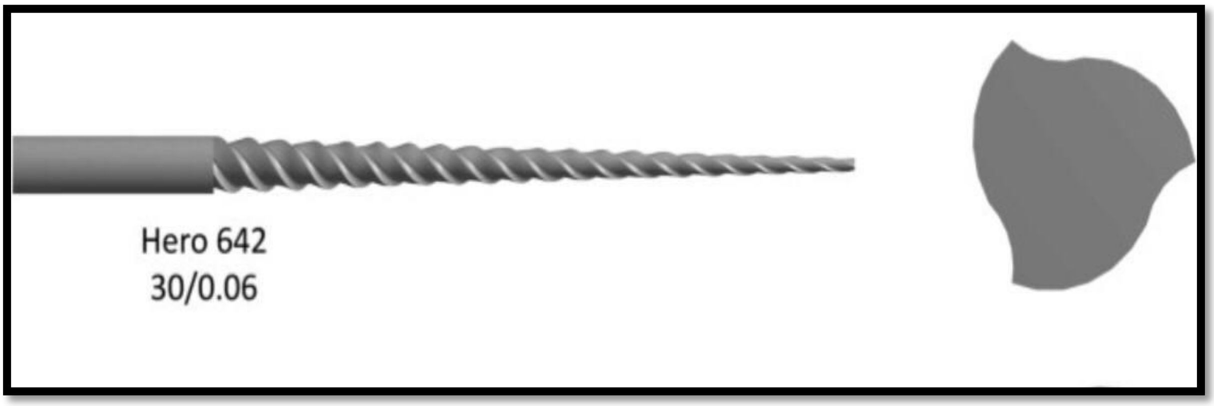

Fig.9 Hero file (Babacan *et al*., 2020)

2.2.5 Mtwo

It is a new generation of NiTi rotary instruments with an “italic S” cross-section with two cutting blades, noncutting tip, fixed taper, and variable pitch, as seen in fig.10 (Malagino *et al*., 2006).

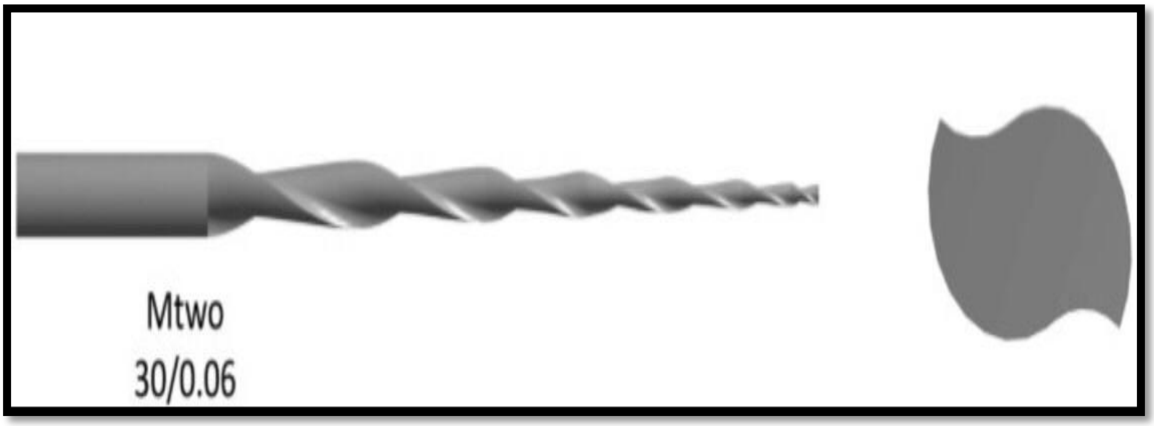

Fig.10 Mtwo file (Babacan *et al*., 2020)

2.2.6 K3

It has an asymmetrical design with a slightly positive rake angle for optimum cutting, three radial lands with peripheral blade relief, fixed taper, a noncutting tip, and variable pitch, as seen in fig.11 (Mounce., 2004).

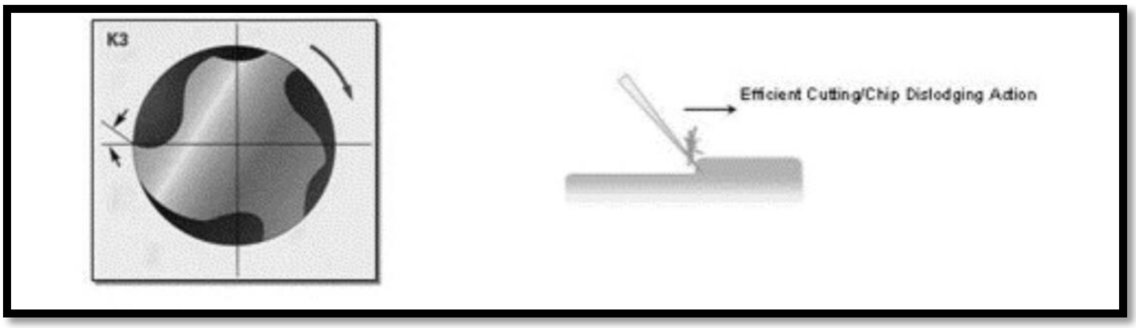

Fig.11 k3 file cross section (Mounce and Richard., 2004)

2.2.7 Light Speed (SybronEndo)

It has a triple U-shaped cross-sectional geometry with radial lands, a short cutting head and a long, noncutting, taperless shaft. The rotary Light Speed LSX instruments were used in the canal preparation to a size 50 for anteriors and to a size 40 for molars,as seen in fig.12 (Vieyra and Enriquez., 2014).

Fig.12 SybronEndo (Koch *et al*., 2002)

2.2.8 Twisted Files

In recent times, a completely different manufacturing process has evolved to introduce the third generation of NiTi rotary instruments: the twisted file (TF) with R-phase technology with three innovative methods of manufacturing viz. R-phase heat treatment, metal twisting, and special surface conditioning (deoxidation). These processes have shown to increase the instrument resistance, provide greater flexibility, and maintain the sharpness of the flutes (Fayyad and Elgendy., 2011).

The twisted file, as seen in fig.13, have better cutting efficiency over ProTaper rotary system. Hence these files can be efficiently incorporated into the contemporary pedodontic armamentarium (Prabhaker and Yavagal., 2014).

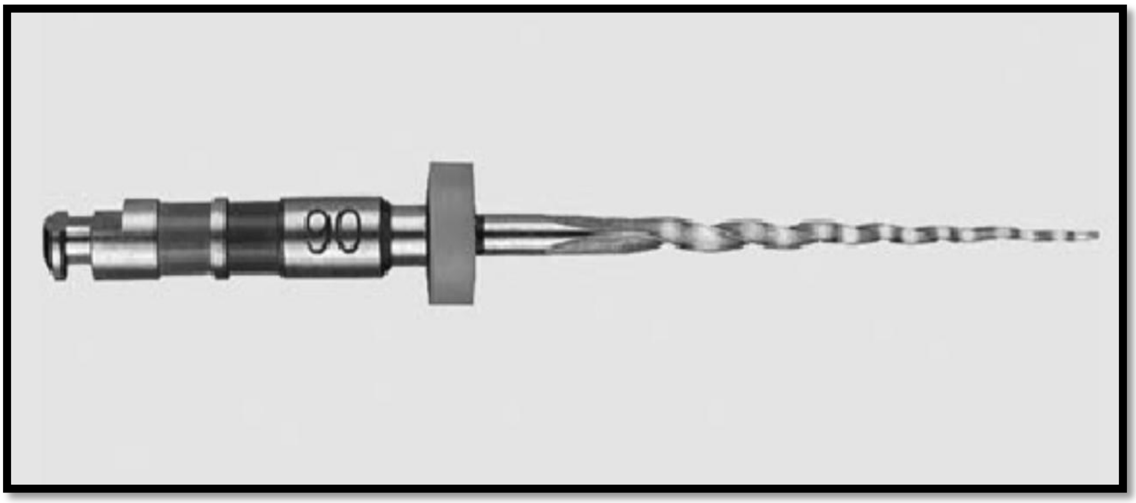

Fig.13 Twisted file (Gambarini *et al*., 2009)

2.2.9 Kedo-S

Kids Endodontic Shaper is the world's first rotary file exclusively for shaping primary teeth. It is invented by Dr. Ganesh Jeevanandan and came into existence in November 2016. It is a three-file system 16 mm in length—D1, E1, U, as seen in fig.14. D1 is specifically designed for molars with narrower canals. E1 is designed for molars with wider canals and U1 is designed for incisors. They are made functional at a speed of ≤250 rpm. This system claims to provide a safe and simple technique for shaping of primary root canals in the shortest time available. However, studies are yet to confirm its efficacy (Chauhan *et al*., 2019).

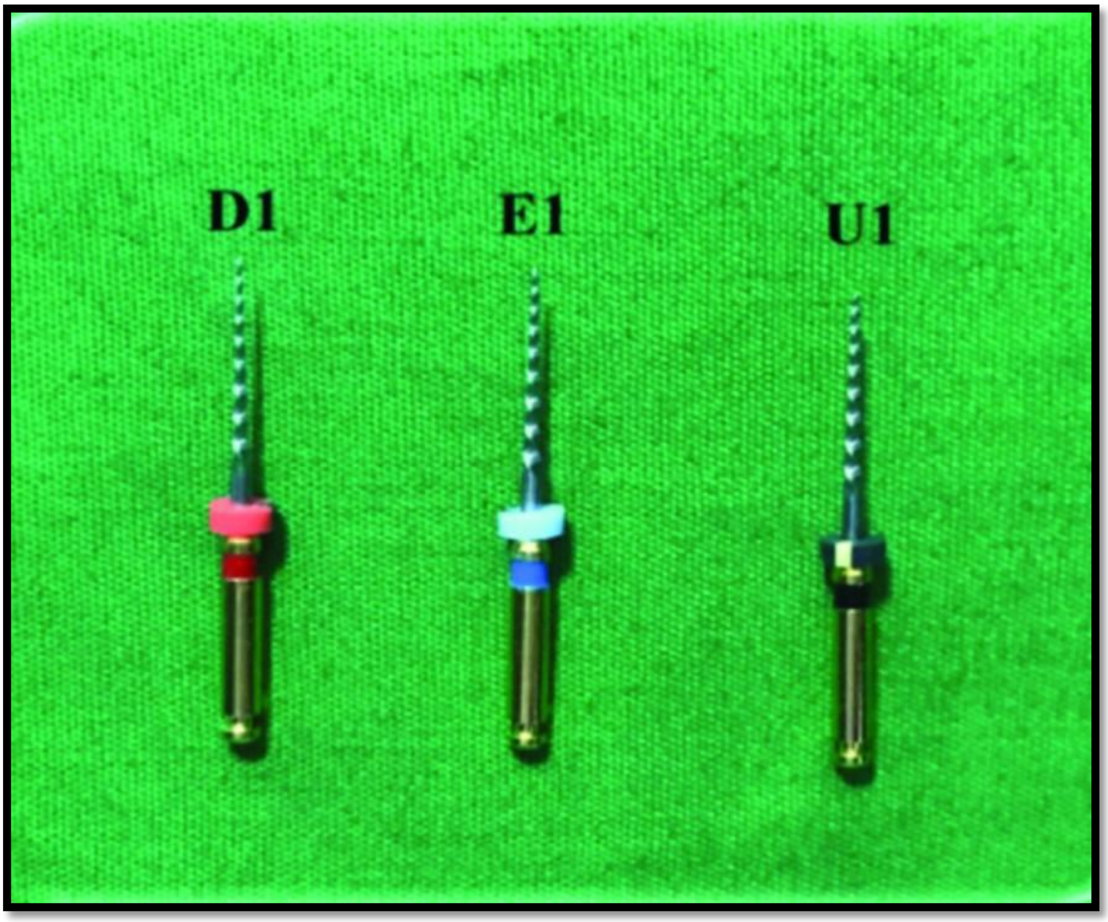

Fig.14 kedo-s files system (Jeevanandan and Ganesh., 2017)

3. Smart Devices

3.1 Recent Innovation In behavioral

3.1.1 Virtual reality distraction

In recent years, there has been an increase in behavioral research in VR and virtual world. By encouraging a patient to focus his or her attention on other thoughts, less attention is available for the pain. Virtual reality utilizes advanced technologies to create virtual environments (VE) that allow patients to be immersed in an interactive, simulated world. These advanced systems interact at many levels with the VE, stimulating sights, sounds, and motion to encourage immersion in the virtual world to enhance distraction from pain, as seen in fig.15 (Koticha *et al*., 2019).

Fig.15 Dental treatment with virtual reality distraction at the Department of Pediatric Dentistry (Veneva *et al*., 2018).

3.2 Recent Innovation in Surgery

3.2.1 Laser

Treating a pediatric patient with laser for oral and dental procedure is beneficial as it is less fearful to the child and better accepted by parents. When clinician uses the laser for surgical or pulpal procedure, children become more cooperative, and it also enhances the treatment outcome. It is used for caries prevention, early diagnosis, cavity restoration, management of traumatized teeth, and minor oral surgical procedure in child patients and seems to soon become the gold standard in pediatric dental practice (Galui *et al*., 2019).

A laser-assisted frenectomy can be done with Er: YAG laser in an attempt for diastema closure. Er: YAG laser is also used for surgical management of severe tongue tie or ankyloglossia in infants and children (Kotlow., 2004; Olivi *et al*., 2009).

CO2 laser is used for gingivectomy procedure. It is also used for surgical removal of soft- tissue tumor in the oral cavity. With the advent of diode laser, nowadays, clinicians prefer to reproduce gingival esthetics as a part of comprehensive orthodontic treatment. The advantage of using the laser in gingivectomy and gingival recontouring is that it provides a bloodless field and also sterilizes the wound by reducing the microbial load exposed to laser radiation, as seen in fig.16 (Galui and Pal., 2019).

Fig.16 Gingivectomy performed using diode laser (Shivaprasad *et al*., 2015)

3.3 Recent Innovation In Anesthesia

3.3.1. Transcutaneous Electrical Nerve Stimulation (TENS)

It is an electroanalgesia and used in simple restorations and periodontal procedures. Two mechanisms have been explained. One is that TENS stimulate the release of the body's endogenous opiates. The other is based on Melzack and Wall's gate control theory (Ranjana and Chopra., 2021).

Choudhari *et al*. (2017) compared the efficacy of Transcutaneous electrical nerve stimulation (TENS) and 20% benzocaine gel prior to inferior alveolar nerve block (IANB) injections in alleviating pain in children of 8–12 years of age. Author found application of TENS was more comfortable and significantly reduced pain. TENS is a safe, reliable, and practical alternative to be used in pediatric dentistry, as seen in fig.17**.**

Fig.17 Electronic dental anesthesia/transcutaneous electric nerve stimulation and its application during various minor dental procedures (Dhindsa *et al*., 2011).

3.3.2 Buzzy System:

Buzzy is a hand-held device that naturally and quickly minimizes sharp pain from needle sticks like IV starts, blood draws, finger pricks and immunizations, through a combination of vibration, ice and distraction methods (Ranjana and Chopra., 2021).

There is a study to evaluate the pain perception and comfort of patient during local anesthesia (LA) delivery using Buzzy system and conventional syringe and found that the external cold and vibration via

Buzzy® can reduce pain and anxiety during local anesthetic delivery for various dental procedures, as seen in fig.18 (Suohu *et al*., 2020).

Fig.18 Placement of Buzzy® Device before LA injection (Sahithi *et al*., 2021).

3.3.3 Computer - Controlled Local Anesthetic Delivery System

Many devices have been introduced that can inject local anesthetic into the tissues at a set speed. Collectively, these "painless anesthetic devices", are termed "computer- controlled local anesthetic delivery" (CCLAD) devices. CCLAD also collectively refers to devices that not only slow and maintain the injection speed, but also maintain a constant speed while considering the anatomical characteristics of the tissues being injected, as seen in fig.19 (Ranjana *et al*., 2021).

Fig.19 Computer controlled local anesthesia delivery system with dynamic pressure sensing (Veneva *et al*., 2018).

Conclusion

At the end of the treatment, the pressure on the child should be reduced, and he should have trust in the therapy, which will instill a positive attitude about dental care. Every pedodontist should be aware of novel materials and their applications in therapy. Smart dentistry which can intelligently select and execute certain functions in response to diverse local changes in the environment, promise enhanced dependability and long-term efficiency in dentistry, thereby greatly enhancing the quality of dental treatment.

References

A

Ahuja, K., Pannu, R., Pal, N., Aggarwal, N. and Berwal, V.,(2017). Biosmart Dentistry–A Revelation: A Review. Journal of Advanced Medical and Dental Sciences Research, 5(10), pp.15-18.

Aimutis, W.R., (2004). Bioactive properties of milk proteins with particular focus on anticariogenesis. The Journal of nutrition, 134(4), pp.989S-995S.

Allen, K.L., Salgado, T.L., Janal, M.N. and Thompson, V.P., (2005). Removing carious dentin using a polymer instrument without anesthesia versus a carbide bur with anesthesia. The Journal of the American Dental Association, 136(5), pp.643-651.

Althaqafi, K.A., Satterthwaite, J. and Silikas, N., (2020). A review and current state of autonomic self-healing microcapsules-based dental resin composites. Dental Materials, 36(3), pp.329-342.

B

Baig, A.R., (2016). Smart Dentistry: Stepping into the Future. Saudi Journal of Oral and Dental Research, 1(2.2), pp.42-46.

Babacan, N., Caliskan, M., Alay, F. and Pehlivanli, N., (2020). Numerical Simulation of Cu-Al-Mn Endodontic Instruments under Bending and Torsional Conditions. Journal of Materials Engineering and Performance, 29(7), pp.4669-4676.

Badami, V. and Ahuja, B., (2014). Biosmart materials: Breaking new ground in dentistry. The Scientific World Journal.

Beuer, F., Schweiger, J. and Edelhoff, D., (2008). Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. British dental journal, 204(9), pp.505-511.

Bhatnagar, A., Wagh, S., Singh, B., Agarwal, R.R. and Khan, F.,(2016). Smart materials–A review. Annals of Dental Specialty Vol, 4(1), p.10.

Boyd, R.C., (2019). Basic endodontic therapy. Wiggs's Veterinary Dentistry: Principles and Practice, pp.311-334.

C

Calas, P.,(2005). HEROShapers®: the adapted pitch concept. Endodontic Topics, 10(1), pp.155-162.

Chauhan, A., Saini, S., Dua, P. and Mangla, R., (2019). Rotary endodontics in pediatric dentistry: Embracing the new alternative. International Journal of Clinical Pediatric Dentistry, 12(5), p.460.

Cochrane, N.J., Saranathan, S., Cai, F., Cross, K.J. and Reynolds, E.C., (2008). Enamel subsurface lesion remineralisation with casein phosphopeptide stabilised solutions of calcium, phosphate and fluoride. Caries research, 42(2), pp.88-97.

D

Dhindsa, A., Pandit, I.K., Srivastava, N. and Gugnani, N., (2011). Comparative evaluation of the effectiveness of electronic dental anesthesia with 2% lignocaine in various minor pediatric dental procedures: A clinical study. Contemporary clinical dentistry, 2(1), p.27.

Dagna, A., Poggio, C., Beltrami, R., Colombo, M., Chiesa, M. and Bianchi, S., (2014). Cyclic fatigue resistance of OneShape, Reciproc, and WaveOne: An in vitro comparative study. Journal of conservative dentistry: JCD, 17(3), p.250.

Dauda, K.T., Majebi, C.A., Ayoola, A.A., Agboola, O., Popoola, A.P.I., Fayomi, O.S.I., Banjo, S.O., Sojobi, J. and Ogunsanya, A.O., (2021). Biosmart Materials and Its Innovative Characteristics in Protective Composite Coating Application. In IOP Conference Series: Materials Science and Engineering (Vol. 1107, No. 1, p. 012216)

Dorozhkin, S.V., (2016). Calcium orthophosphates (CaPo4) and dentistry. Bioceramics Development and Applications, 6(2), p.96.

E

El Mehdi, H., Hind, R. and Hakima, C.,(2016). The benefits of casein phosphopeptid-amorphous calcium phosphate (CPP-ACP) in pediatric dentistry. Sch J Dent Sci, 3, pp.247-250.

F

Fayyad, D.M. and Elgendy, A.A.E., (2011). Cutting efficiency of twisted versus machined nickel-titanium endodontic files. Journal of endodontics, 37(8), pp.1143-1146.

G

Gambarini, G., Testarelli, L., Milana, V., Pecci, R., Bedini, R., Pongione, G., Gerosa, R. and De Luca, M., (2009). Angular deflection of rotary nickel titanium files: a comparative study. Annali dell'Istituto superiore di sanità, 45, pp.423-426.

Galui, S., Pal, S., Mahata, S., Saha, S. and Sarkar, S., (2019). Laser and its use in pediatric dentistry: A review of literature and a recent update. International Journal of Pedodontic Rehabilitation, 4(1), p.1.

Gupta, N., Nagpal, R. and Dhingra, C.,(2016). A review of casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) and enamel remineralization. Compendium of continuing education in dentistry, 37(1), pp.36-9.

Gupta, V., (2018). Smart materials in dentistry: A review. International Journal for Advance Research and Development, 3(6), pp.89-96.

Gurunathan, D., Somasundaram, S. and Kumar, S.A., (2012). Casein phosphopeptide- amorphous calcium phosphate: a remineralizing agent of enamel. Australian dental journal, 57(4), pp.404-408.

H

Huyang, G., Debertin, A.E. and Sun, J., (2016). Design and development of self-healing dental composites. Materials & design, 94, pp.295-302.

J

Jeevanandan, G., (2017). Kedo-S paediatric rotary files for root canal preparation in primary teeth–Case report. Journal of clinical and diagnostic research: JCDR, 11(3), p.ZR03.

Jain, P., Kaul, R., Saha, S. and Sarkar, S., (2017). Smart materials-making pediatric dentistry bio-smart. International Journal of Pedodontic Rehabilitation, 2(2), p.55.

K

Katsimpali, A., (2020). Dimentional stability and microleakage of SMART dental composites in primary teeth (Doctoral dissertation, UCL (University College London)).

Kumar, G., Rehman, F. and Chaturvedy, V., (2017). Soft tissue applications of Er, Cr: YSGG laser in pediatric dentistry. International journal of clinical pediatric dentistry, 10(2), p.188.

Kim, H.C., Sung, S.Y., Ha, J.H., Solomonov, M., Lee, J.M., Lee, C.J. and Kim, B.M., (2013). Stress generation during self-adjusting file movement: minimally invasive instrumentation. Journal of endodontics, 39(12), pp.1572-1575.

Koch, K. and Brave, D., (2002). Real world endo: design features of rotary files and how they affect clinical performance. Oral health, 92(2), pp.39-49.

Koticha, P., Katge, F., Shetty, S. and Patil, D.P., (2019). Effectiveness of virtual reality eyeglasses as a distraction aid to reduce anxiety among 6–10-year-old children undergoing dental extraction procedure. International Journal of Clinical Pediatric Dentistry, 12(4), p.297.

Kotlow, L.A., (2004). Lasers in pediatric dentistry. Dental Clinics, 48(4), pp.889-922.

L

Little, D.A., (2012). A smart ceramics system for expanded indications. Inside Dent, 8(12), pp.1-4.

Lendlein, A. and Langer, R., (2002). Biodegradable, elastic shape-memory polymers for potential biomedical applications. Science, 296(5573), pp.1673-1676.

Llena, C., Forner, L. and Baca, P., (2009). Anticariogenicity of casein phosphopeptide-amorphous calcium phosphate: a review of the literature. J Contemp Dent Pract, 10(3), pp.1-9.

M

Madrid-Troconis, C.C. and Perez-Puello, S.D.C., (2019). Casein phosphopeptide-amorphous calcium phosphate nanocomplex (CPP-ACP) in dentistry: state of the art. Revista Facultad de Odontología Universidad de Antioquia, 30(2), pp.248-262.

Malagino, V.A., Grande, N.M., Plotino, G. and Somma, F., (2006). The Mtwo NiTi rotary system for root canal preparation. Roots, 3, pp.59-62.

Mangaiyarkarasi, S.P., Manigandan, T., Sivagami, S., Vijayakumar, R. and Chowdary, N., (2013). Biosmart Dentistry.

Moezizadeh, Maryam, and Azar Alimi. "The effect of casein phosphopeptide-amorphous calcium phosphate paste and sodium fluoride mouthwash on the prevention of dentine erosion: An in vitro study." Journal of Conservative Dentistry: JCD 17, no. 3 (2014): 244.

Mounce, R.E., (2004). The K3 rotary nickel–titanium file system. Dental Clinics, 48(1), pp.137-157.

N

Nomoto, R., Komoriyama, M., McCabe, J.F. and Hirano, S., (2004). Effect of mixing method on the porosity of encapsulated glass ionomer cement. Dental Materials, 20(10), pp.972-978.

O

Olivi, G., Genovese, M.D. and Caprioglio, C., (2009). Evidence-based dentistry on laser paediatric dentistry: review and outlook. European Journal of Paediatric Dentistry, 10(1), p.29.

P

Padmawar, N., Pawar, N., Joshi, S., Mopagar, V., Pendyala, G. and Vadvadgi, V., (2016). Biosmart Dental Materials: A New Era in Dentistry. Int J Oral health med res, 3(1), pp.171-176.

Pinto-Sinai, G., Brewster, J. and Roberts, H., (2018). Linear coefficient of thermal expansion evaluation of glass ionomer and resin-modified glass ionomer restorative materials. Operative Dentistry, 43(5), pp.E266-E272.

Prabhakar, A. and Kiran, N.K., (2009). Clinical evaluation of polyamide polymer burs for selective carious dentin removal. J Contemp Dent Pract, 10(4), pp.26-34.

Prabhakar, A.R., Yavagal, C. and Vallu, R.K., (2014). Twisted vs Protaper files in contemporary pediatric endodontics. International Journal of Clinical Pediatric Dentistry, 7(2), p.93.

R

Ramalingam, L., Messer, L.B. and Reynolds, E.C., (2005). Adding casein phosphopeptide-amorphous calcium phosphate to sports drinks to eliminate in vitro erosion. Pediatric dentistry, 27(1), pp.61-67.

Ramazani, N., Mohammadi, A., Amirabadi, F., Ramazani, M. and Ehsani, F., (2016). In vitro investigation of the cleaning efficacy, shaping ability, preparation time and file deformation of continuous rotary, reciprocating rotary and manual instrumentations in primary molars. Journal of Dental Research, Dental Clinics, Dental Prospects, 10(1), p.49.

Ranjana, B.S., Chopra, K., Burman, A., Parmar, B.S., Surana, P. and Pandya, R.K., (2021). Recent innovation in field of pediatric dentistry. Journal of Advanced Medical and Dental Sciences Research, 9(6), pp.41-45.

Reynolds, E.C., (2009). Casein phosphopeptide-amorphous calcium phosphate: the scientific evidence. Advances in dental research, 21(1), pp.25-29.

Ruddle, C.J., (2005). The ProTaper technique: Shaping the future of endodontics. Endod Topics, 10, pp.213-6.

S

Skrtic, D., Antonucci, J.M. and Eanes, E.D., (2003). Amorphous calcium phosphate-based bioactive polymeric composites for mineralized tissue regeneration. Journal of research of the National Institute of Standards and Technology, 108(3), p.167.

Sahithi, V., Saikiran, K.V., Nunna, M., Elicherla, S.R., Challa, R.R. and Nuvvula, S., (2021). Comparative evaluation of efficacy of external vibrating device and counterstimulation on child's dental anxiety and pain perception during local anesthetic administration: a clinical trial. Journal of Dental Anesthesia and Pain Medicine, 21(4), p.345.

Shivaprasad, B.M., Rakesh, M.P. and Prabhu, S.S., (2015). Esthetic Correction of Gummy Smile by Gingivectomy using Dioda Laser. Journal of Health Sciences & Research, 6(1), pp.17-21.

Shanthi, M., Sekhar, E.S., Ankireddy, S., Shah, S.G., Bhaskar, V., Chawla, S., Venkataraghavan, K., Choudhary, P., Ganesh, M., Trivedi, K. and Eswara, K., (2014). Smart materials in dentistry: Think smart!. Journal of Pediatric Dentistry/Jan-Apr, 2(1).

Suohu, T., Sharma, S., Marwah, N. and Mishra, P., (2020). A comparative evaluation of pain perception and comfort of a patient using conventional syringe and Buzzy system. International Journal of Clinical Pediatric Dentistry, 13(1), p.27.

Sonntag, D., (2005). FlexMaster: a universal system. Endodontic Topics, 10(1), pp.183-186.

T

Tinanoff, N., Baez, R.J., Diaz Guillory, C., Donly, K.J., Feldens, C.A., McGrath, C., Phantumvanit, P., Pitts, N.B., Seow, W.K., Sharkov, N. and Songpaisan, Y., (2019). Early childhood caries epidemiology, aetiology, risk assessment, societal burden, management, education, and policy: Global perspective. International journal of paediatric dentistry, 29(3), pp.238-248.

V

Veneva, E.R. and Belcheva, A.B., (2018). Local anesthesia in pediatric patients–a review of current and alternative methods, devices and techniques. Folia Medica, 60(3), pp.381-388.

Vieyra, J.P. and Enriquez, F.J.J., (2014). Instrumentation time efficiency of rotary and hand instrumentation performed on vital and necrotic human primary teeth: A randomized clinical trial. Dentistry, 4(4), p.1.

Vijay Kumar, S., Anil, C., Aseem Prakash, T., Promila, V. and Rakesh Kumar, Y., (2012). A comparative evaluation of dentin caries removal with polymer bur and conventional burs—An in vitro study. Open Journal of Stomatology.

W

Wu, G., Liu, X. and Hou, Y.,(2010). Analysis of the effect of CPP-ACP tooth mousse on enamel remineralization by circularly polarized images. The Angle Orthodontist, 80(5), pp.933-938.

Wycoff, R.C. and Berzins, D.W., (2012). An in vitro comparison of torsional stress properties of three different rotary nickel-titanium files with a similar cross-sectional design. Journal of Endodontics, 38(8), pp.1118-1120.

Y

Yip, H.K. and Smales, R.J., (2000). Review of competency-based education in dentistry. British dental journal, 189(6), pp.324-326.

Z

Zhang, Q., Zou, J., Yang, R. and Zhou, X., (2011). Remineralization effects of casein phosphopeptide- amorphous calcium phosphate crème on artificial early enamel lesions of primary teeth. International journal of Paediatric dentistry, 21(5), pp.374-381.