Dental Treatment of Pediatric and Adolescent Patients

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Faculty

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Faculty Disclosure

Contributing faculty, Mark J. Szarejko, DDS, FAGD, has disclosed no relevant financial relationship with any product manufacturer or service provider mentioned.

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Director Disclosure

The director has disclosed no relevant financial relationship with any product manufacturer or service provider mentioned.

Audience

This course is designed for dental hygienists and assistants whose patient populations include children and/or adolescents. It may also be of interest to dentists with pediatric patients.

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Course Objective

Dental professionals are frequently involved in the care of pediatric and/or adolescent patients. The purpose of this course is to outline the oral health needs and problems unique to the pediatric and adolescent populations.

Learning Objectives

Upon completion of this course, you should be able to:

1. Outline the eruption sequence, anatomy, and morphology of deciduous teeth.
2. List the restorative options for deciduous and permanent teeth in children and adolescents.
3. Evaluate the preventive dentistry options that can benefit deciduous and permanent teeth.
4. Cite the major differences in the use of medications for dental treatment of children and adolescents compared to their adult counterparts.
5. Identify oral lesions that accompany common childhood and adolescent diseases.
6. Evaluate the common oral and maxillofacial signs of child and adolescent abuse.
7. Describe possible oral manifestations of eating disorders.

Sections marked with this symbol include evidence-based practice recommendations. The level of evidence and/or strength of recommendation, as provided by the evidence-based source, are also included so you may determine the validity or relevance of the information. These sections may be used in conjunction with the course material for better application to your daily practice.

INTRODUCTION

The goal of achieving and maintaining optimal oral health is one that should begin during childhood, continue during adolescence, and extend into the adult years. Teeth are essential throughout life for mastication, phonation, cosmetics, and support for the tissues that compose the facial form. Dental treatment of pediatric and adolescent dental patients must take into consideration their unique anatomical, physiologic, psychologic, maturational, and emotional differences and needs. This course will highlight these differences and options for preventive dentistry appropriate for this patient population, including a proactive means by which the risk of early childhood caries can be reduced. The need to adjust the dosage and/or frequency of administration of medications used in conjunction with dental treatment of pediatric and adolescent patients will be discussed. Oral lesions associated with common childhood diseases will be identified, as local outbreaks of infectious disease such as the measles and chickenpox still occur. The factors that are integral to the restoration of carious teeth and the oral and perioral signs of child abuse/domestic violence are discussed. Clinicians should consider the extent of their training with pediatric and adolescent patients before they are treated. If the complexity of the case, behavioral concerns, or patient management is beyond the clinician's ability, referral to a pedodontist should be made.

ERUPTION SEQUENCE

The first complete set of teeth to erupt in the oral cavity have been called deciduous, primary, baby, or milk teeth. The eruption of a tooth is a developmental process during which a tooth moves from its position within the alveolar bone through the overlying mucosa into the oral cavity until it achieves a fully erupted position, where it will attain occlusion against an opposing tooth. Most teeth follow this process, although some teeth, most often the third molars ("wisdom teeth"), become impacted as they encounter bony or other anatomical obstructions and never fully erupt. Surgical removal is usually required to relieve pain and to prevent pathology to the adjacent structures.

Infants are usually born completely edentulous (without teeth), but there are rare exceptions. Natal teeth are those that are present at birth, and neonatal teeth erupt within 30 days of birth [1]. These usually occur in the anterior mandible, particularly the early eruption of the mandibular deciduous incisors. Natal and neonatal teeth exhibit minimal root formation and may have a variable range of mobility. This can cause complications during breastfeeding, and sharp edges of the exposed teeth can even traumatize the oral mucosa of the infant. Although these are deciduous teeth, they must be cleaned gently with plain cotton gauze or a cotton swab, as they are subject to colonization by bacteria that can initiate the carious process. Consultation with a dentist or pedodontist can determine the best protocol by which this is accomplished. These teeth are extracted if the mobility presents a risk of aspiration, but this is rare.

The chronology of the eruption of the 20 deciduous teeth will vary widely among children. The mandibular central incisors are usually the first teeth to erupt at 6 to 10 months of age. The maxillary and mandibular second molars complete the sequence and usually appear at 23 to 33 months of age [2]. The lateral incisors, canines, and first molars erupt in the intervening interval. Genetics, systemic illness, and developmental problems are among the many factors that can delay the eruption of the deciduous teeth.

Unlike their permanent counterparts, deciduous teeth have no premolars. The permanent premolars replace the first and second deciduous molars and are the only permanent teeth to have less length in a mesial-to-distal (anterior-to-posterior) dimension than their deciduous predecessors. The permanent molars are the only permanent teeth that do not replace a pre-existing deciduous tooth.

The eruption sequence of permanent teeth can also vary. The mandibular central incisors and the mandibular and maxillary first molars are the first permanent teeth to erupt, usually at 6 to 7 years of age. The maxillary and mandibular second molars erupt between 12 and 13 years of age. The third molars are unpredictable but may appear at 17 to 21 years of age, the last teeth to fully erupt during adolescence [3]. Many genetic and physiologic factors can accelerate or extend these eruption patterns.

Teething pain can cause infants and toddlers to drool, become restless and irritable, and even develop a low-grade fever, with treatment designed to palliate symptoms. Caution should be exercised if over-the-counter topical anesthetic preparations are used, as even small doses of these drugs can be toxic to infants and toddlers if swallowed. Similarly, the use of any analgesic medication should be minimized to reflect the limited ability of the infant or toddler to metabolize these substances. Consultation with a pedodontist or pediatrician is advisable to determine a dosing schedule that is efficacious and safe.

ANATOMY AND MORPHOLOGY OF DECIDUOUS TEETH

The 20 deciduous teeth have pronounced differences in the anatomy of their crowns and roots and in the structure and amounts of enamel, dentin, and pulp chamber compared to those of the permanent teeth. These morphologic differences reflect the teeth's design to function for a limited period of time and to be aligned into maxillary and mandibular arches of small dimensions. These differences will also influence the progression of the carious process and the manner in which carious deciduous teeth are restored.

Proportionately, the relationship of the mesial-to-distal dimensions of the crowns of deciduous teeth to the occlusal to gingival dimension is greater than the same relationship among permanent teeth. The occlusal table of the deciduous molars, upon which grinding and crushing of food occurs, is more narrow compared with the wide occlusal tables of the permanent molars. Deciduous molars also feature a prominent bulge in the mesio-buccal area near the gingival crest, which can be conducive to the retention of bacterial plaque at the gingival level and which poses a greater risk of the development of caries [4].

The roots of deciduous anterior teeth are more narrow in a mesial-to-distal direction compared to those of the anterior permanent teeth. The crown-to-root length ratio of deciduous molars is less than the same ratio in the permanent molars, as the roots of deciduous molars are longer in relation to the size of the crowns of these teeth. The apical anatomy of the deciduous molars can feature pronounced but slender curvatures that should be considered if the teeth must be extracted. The roots of the deciduous molars surround the crowns of the developing permanent maxillary and mandibular bicuspids. If an extraction is indicated for any of the deciduous molars, care must be taken to avoid damage to the crowns of their permanent successors. Deciduous molars with fully formed roots can be challenging

extractions. These slender and curved roots cannot withstand the degree of pressure utilized for the extractions of permanent molars and can fracture easily if excessive pressure is applied. Deciduous molar roots that fracture in the apical area may be difficult to locate and remove without damaging the permanent bicuspids.

When the roots of the deciduous teeth lose their normal means of attaching to the bone via the periodontal ligament and become fused directly to the bone, this is called ankylosis [5]. Although ankylosis can affect any deciduous tooth, the molars are most often involved. Ankylosis interferes with the normal process of deciduous root dissolution to allow for the normal sequence of shedding of the deciduous teeth and replacement by the permanent teeth. Ankylosed teeth have a dull sound when they are percussed with an instrument and a submerged appearance when adjacent non-ankylosed deciduous teeth are shed and the permanent successors erupt into their proper position. They can delay the eruption of their permanent successor and allow for the unintentional drifting of the adjacent teeth or hypereruption of the opposing tooth. These problems can lead to functional and cosmetic problems that require orthodontic correction. Ankylosed teeth can be difficult extractions because they are fused directly to the bone and excessive pressure can lead to fracture of the deciduous roots, the supporting alveolar bone, and the developing permanent tooth.

Clinicians should not consider the extraction of any deciduous tooth, especially the molars, an easy procedure. High-quality radiographs that show the tooth's root anatomy and its relation to the developing permanent tooth, the age and ability of the patient to withstand a surgical procedure, the surgical skills of the clinician, and the clinician's ability to establish rapport and treat pediatric patients should be considered before a surgical procedure is initiated. Referral to a pedodontist or oral surgeon should be considered if it is in the best interest of the patient.

The enamel and dentin layers of deciduous teeth are thinner than those on permanent teeth. The pulp chamber, which includes the nerve supply, blood vessels, and supporting tissue, is relatively large in deciduous teeth, with a larger pulp chamber-to-clinical crown ratio than in permanent teeth. Pointed extensions of the pulp chamber (called pulp horns) are common in deciduous teeth and are much closer to the external surface of the tooth compared to permanent teeth. Due to these anatomic differences, dental caries spread faster in deciduous teeth and pulpal involvement can occur quickly.

When a carious deciduous tooth will not be shed for a long time, it should be restored. Extension of decay into the pulp chamber will cause pain, necrosis, and local infection; infection can extend quickly between muscular planes to cause regional and even systemic involvement. Thus, carious lesions in deciduous teeth should be restored as quickly as possible to prevent odontogenic infections and tooth loss due to non-restorable caries. Even so, some parents may be reluctant to restore caries in primary teeth because they will ultimately be lost. Clear and complete parental education may help address this.

RESTORING CARIOUS DECIDUOUS AND PERMANENT TEETH IN PEDIATRIC PATIENTS

Dental caries are the most common childhood disease [6; 79]. Although tooth decay is usually managed with no untoward sequelae, complications from dental caries do occur, and if left untreated, caries can lead to meningoencephalitis, subdural empyema, and even death [7]. While this tragic circumstance is rare, it underscores the necessity to restore carious teeth whether they are deciduous or permanent.

Early childhood caries (ECC) are lesions that occur in deciduous teeth between birth and 71 months of age. Deciduous teeth that have been restored or extracted due to extensive caries are also included in this definition [8]. The restoration of carious deciduous teeth or permanent teeth with incompletely formed roots and larger pulp chambers requires different restorative techniques and materials than those used to treat the permanent teeth of adults.

There are numerous dental restorative materials available and several clinically acceptable techniques by which they can be placed. Clinicians should consider patient age, caries risk, ability to cooperate, the expected duration of retention of a carious tooth or the stage of development of a permanent tooth, and the costs involved before any restorative dentistry is begun. Every clinician should be well versed in state laws regarding the consent that is necessary to initiate any treatment for minors.

The prevention of dental caries remains the ideal approach. Teaching patients and their parents about the basic tenets of oral hygiene and motivating them to maintain periodic recall appointments are important parts of this preventive practice.

An initial clinical and radiographic examination will reveal the presence of caries and the risk of developing future caries. Statistics have shown that decay in the pits and fissures causes about 80% to 90% of all caries in the permanent posterior teeth and cause approximately 44% of all caries in deciduous teeth [9]. Pits and fissures are more plentiful and pronounced in the premolars and molars, although pits of varying sizes and depths are also common on the lingual aspects of the maxillary central and lateral incisors as well. These narrow invaginations in the enamel are areas in which bacterial plaque can congregate and into which toothbrush bristles may not reach.

Pit and fissure sealants may be placed to decrease the risk of caries in these areas. Studies have shown that the placement of a second-, third-, or fourth-generation resin-based material can decrease the caries incidence by 88% after two years and by 79% over a span of four years, although the quality of evidence is lower at this interval [10; 80]. Teeth with deeper pits and fissures and patients with poor oral hygiene will have a greater benefit from sealants than those with excellent oral hygiene or shallow pits and fissures. When recall appointments have been kept and oral hygiene has been maintained, sealants have an 80% to 90% retention rate after 10 years and a 65% retention rate after 20 years [11; 66; 80].

Several commercial resin-based sealant products are available. Before any sealants are set, the tooth should be cleaned and the surface etched with an acidic gel that causes the enamel surface to develop microscopic porosities into which the resin will flow. This is very technique-sensitive, as salivary contamination of the etched surface will preclude the development of an adequate bond strength and cause the sealant to detach. A thin layer of material is placed into the desired pit or fissure, with an ultraviolet light used to set the material. Occlusion should always be checked after sealants are placed, as any excess in the sealant height could cause a fracture of the sealant and/or traumatic occlusion of the teeth.

Dental caries can develop despite the best preventive efforts of the patient and the dental staff. The most common materials used to restore deciduous teeth without pulpal involvement are dental amalgam and composite resins. The use of either material has advantages and disadvantages, and the material of choice should be based on the restorative needs of the patient.

DENTAL AMALGAM

Dental amalgam has been used as a restorative dental material since the late 19th century [12]. It has been popular due to its durability, ease of placement, and low cost compared to other dental restorative materials. However, there has been controversy about the safety of dental amalgam use because mercury is one of the composite elements, along with copper, tin, and silver. Patients and parents may have concerns related to the release of mercury during the placement of new amalgam restorations and the removal of deficient restorations, or the continuous release of small amounts of mercury from the material. Numerous studies and reports by the American Dental Association, the American Medical Association, the World Health Organization, the Fédération Dentaire International (FDI), and the U.S. Food and Drug Administration have affirmed the safety and efficacy of amalgam restorative material [14; 82].

Studies have shown that mercury off-gassed from dental amalgam (approximately 2–28 mcg per facet surface per day, with 80% absorbed by the lungs) accumulates in body tissues, particularly the kidneys and brain, with higher levels associated with a greater number of fillings; this represents the most prevalent source of mercury exposure for most individuals [65; 67; 68]. Evidence of debilitating systemic effects from these accumulations is lacking, but there is increasing awareness regarding the impact of cumulative mercury exposure, particularly on cognitive functioning. In 2008, both Norway and Sweden banned the use of amalgam as a dental restorative material [15]. In the United States, amalgam is still used, but some parents will not permit its use for their restorative needs or for those of their children. This debate is global in nature and will continue. Parents of minors who require restorative dentistry should always be presented with options for use of various restorative materials prior to initiation of the procedure.

The preparation of the tooth and placement of an amalgam restoration will depend on whether the carious lesion occurs in the deciduous tooth of a child, the permanent tooth of a child, or the permanent tooth of an adult. Amalgam does not have the capacity to self-adhere to enamel or dentin, and the form of the cavity may not be enough to retain the amalgam restorations. In these cases, auxiliary means of retention (i.e., small slots or grooves placed at the junction of the enamel and dentin) may be necessary. While this is not a problem in the permanent teeth of adults, careful placement is necessary to avoid pulpal involvement in children and adolescents.

A primary advantage of amalgam over composite resins is that it is not as technique-sensitive in its placement. If blood or saliva contaminates a tooth surface, the bond strength of a composite restoration will decrease, causing microleakage and ultimately failure. While a similar circumstance is not ideal for the placement of amalgam, the material is not dependent on a bonding process and contamination will not interfere with its setting.

Amalgam is durable under compressive strength, but its inclusion does not strengthen the tooth. It is a restorative material, not cosmetic, and its appearance will worsen over time as intra-oral oxidation reactions cause it to darken. Larger amalgam restorations can also impart a gray or black discoloration to the adjacent enamel.

In children and adolescents, preparation of the outline form for the restoration of deciduous posterior teeth is dependent on several factors. The point at which two adjacent teeth touch (i.e., the contact area) between deciduous molars is broader and flatter than the comparable contact area between permanent teeth, and this is an important consideration when placing class II restorations using amalgam or composite resin. Clinicians who are used to placing class II restorations in permanent teeth should be cognizant of these anatomic and restorative differences. A class II restoration that would provide an adequate interproximal contact in a permanent tooth will not span the contact area of adjacent deciduous molars, which can lead to food impaction and an increased risk of recurrent caries.

COMPOSITE RESIN

Composite resin material was first introduced as a choice for the restoration of class III (interproximal lesions in anterior teeth), class IV (carious lesions or traumatic fractures of anterior teeth that involve the interproximal surface and the incisal edges), and class V lesions of both deciduous and permanent teeth. Numerous composite resin materials have now been developed to restore class I and class II lesions in deciduous and permanent posterior teeth. Beyond the cosmetic benefit, the use of etchants and bonding agents allows a chemical and mechanical bond to develop and secure the composite resin to enamel and dentin. Thus, less tooth structure is removed compared to amalgam, which cannot bond to enamel or dentin and relies on the reduction of additional tooth structure and retentive grooves or slots for mechanical retention.

The primary considerations in the use of composite material for the restoration of posterior deciduous teeth are the additional time required in their placement, the additional cost, and the ability to isolate the tooth. As noted, the placement of composite resin restorations requires that the tooth be isolated from saliva and blood with a rubber dam. While this device provides excellent isolation, some patients will find it uncomfortable, feeling that it is confining and a barrier to communication with dental staff during the procedure. Children can be especially fearful of the rubber dam and may be uncooperative during its placement, which can jeopardize the successful placement of the restoration. Children may also become restless and uncooperative during the longer time required for the placement of composite restorations. If confronted with any of these situations, consider the placement of amalgam restorations in posterior deciduous or permanent teeth or referral to a pedodontist capable of sedating the patient for restorative procedures.

SILVER DIAMINE FLUORIDE

A relatively new product to the United States, 38% silver diamine fluoride (SDF) was approved by the FDA for use in the management of hypersensitivity, and one SDF product, Advantage Silver Arrest (Elevate Oral Care), was the first to be cleared as caries arrest treatment (off-label use) [69; 78]. SDF has been used around the world as an alternative to restorative dentistry (particularly in Japan) for more than eight decades in people of all ages. Because SDF is a newer product in the United States, a committee of researchers and clinicians at UCSF has developed a protocol for using topical 38% SDF for caries treatment at dental clinics. The authors of the protocol describe the mechanism of action of SDF [78]:

> Upon application of silver diamine fluoride to a decayed surface, the squamous layer of silver-protein conjugates forms, increasing resistance to acid dissolution and enzymatic digestion. Hydroxyapatite and fluoroapatite form on the exposed organic matrix, along with the presence of silver chloride and metallic silver. The treated lesion increases in mineral density and hardness while the lesion depth decreases. Meanwhile, silver diamine fluoride specifically inhibits the proteins that break down the exposed dentin organic matrix: matrix metalloproteinases; cathepsins; and bacterial collagenases. Silver ions act directly against bacteria in lesions by breaking membranes, denaturing proteins, and inhibiting DNA replication. Ionic silver deactivates nearly any macromolecule.

SDF may be used for caries preventative therapy in patients with salivary dysfunction secondary to aging, cancer treatment, methamphetamine abuse, polypharmacy, or Sjögren syndrome [78; 83]. SDF therapy is recommended for patients who have complications that preclude invasive restorative treatments. For children, indications for preventative therapy and treatment include extreme caries

risk (e.g., xerostomia, severe early childhood caries), treatment challenged by behavioral or medical management, and difficult-to-treat dental carious lesions based on access, isolation, and cleansability (e.g., recurrent caries at a crown margin, root caries in a furcation).

An advantage of SDF is that it can be quickly applied at a diagnostic visit; however, repeat applications are often performed at one- and three-month follow-up visits, and then at six-month semi-annual visits for two to three years [78]. Despite this, a single annual application of SDF is more effective for caries prevention than applying fluoride varnish two to four times per year or, if applied every year, than occlusal sealants [83].

For treatment of a carious lesion, the area is first thoroughly isolated using cotton or gauze; forced air may be used to ensure complete dryness, which improves efficacy. An applicator is used to place a small amount of SDF onto the lesion, where it is left for one to three minutes to soak into and react with the softened enamel and/or dentin; this timeframe is not critical but is a recommended caution for the first application. Uncooperative children have been successfully treated within only a few seconds SDF reaction time.

One disadvantage to SDF therapy is that the product permanently stains the lesion, but no other area, a dark grey color over time as the decay arrests; the color is similar to that of dental amalgam. Patients and/or parents should be informed of this effect [78]. Another disadvantage is that the treatment does not restore function of the tooth; fillings are recommended over SDF therapy if functional restoration is required. A consent form explaining these effects and limitations should be provided and signed by parents. The UCSF protocol and a sample consent form were published in the *Journal of the California Dental Association* and are available online at https://www.cda.org/Portals/0/journal/journal_012016.pdf [78].

CROWNS

Restorative materials such as amalgam and composite resin are not the materials of choice when an extensive amount of deciduous coronal tooth structure has been destroyed by caries. In adults, such teeth are restored with full crowns of cast gold, porcelain-fused-to-metal, or a variety of all-ceramic options. However, when deciduous teeth that will not be shed for several years have extensive coronal caries and occlusal function must be restored, preformed stainless steel crowns are the restoration of choice. These stainless steel crowns can also be used to restore grossly carious permanent molars and bicuspids in children and adolescents in whom the roots of the teeth are not completely formed and in which adult occlusion has not yet been completed. In patients for whom amalgam or composite restorations have fractured or who have developed recurrent caries, these crowns may be used. The silver color of stainless steel crowns makes them unaesthetic, and the extended time for the preparation of the tooth, the trial fitting and contouring of the crown, and cementation can be beyond a pediatric patient's ability to cooperate.

Anterior deciduous teeth with extensive coronal caries can be restored with anterior strip crowns. This technique features the use of a pre-formed cellulose acetate strip crown into which the appropriate shade of composite resin material is inserted and then placed onto the tooth [16]. The composite material is light cured, and then the cellulose acetate strip crown is removed. Because this is a bonding procedure, isolation from blood and saliva is mandatory. The restoration of deciduous anterior or posterior teeth with stainless steel crowns or anterior strip crowns is an exacting procedure and should be attempted only by clinicians who have been appropriately trained.

PULP CAPPING AND PULPECTOMY

Carious involvement of the pulp of deciduous and permanent teeth of children and adolescents pose another restorative challenge. Bacterial infiltration of the dental pulp initially presents with an inflammatory response that will culminate in the necrosis of the pulpal tissues. A localized abscess can form and evolve into cellulitis, which follows muscle and fascial planes and can ultimately lead to a disseminated systemic infection. In adults, carious involvement of the pulp of permanent teeth with fully formed roots is treated by root canal therapy or by extraction. While conventional root canal therapy cannot be performed on retained deciduous teeth or permanent teeth in which the roots are not completely formed, other procedures are available to treat pulpal tissue that has carious involvement.

Carious lesions that approach the pulp in a deciduous tooth can be treated by an indirect pulp capping technique. This procedure entails the removal of all of the carious dentin except the layer closest to the pulp. A medicament such as calcium hydroxide or zinc oxide-eugenol (ZOE) is then applied directly against this deepest layer of remaining caries. These compounds stimulate the pulp to produce reparative dentin beneath the carious lesion to stop the progression of caries and maintain pulpal vitality [17]. This technique can be done in one appointment, with amalgam or composite resin restoration placed over the layers of ZOE or calcium hydroxide. Another approach involves the placement of a temporary restoration over the ZOE or calcium hydroxide with a return visit in six to eight weeks to excavate any residual carious dentin and place the final restoration [18].

A direct pulp cap may be used when a carious lesion extends directly into the pulp of an otherwise healthy tooth without symptoms (e.g., pain, sensitivity to extremes of temperature). A material such as calcium hydroxide is applied directly to the area of pulpal exposure to stimulate reparative dentin [19]. This procedure usually has a poor prognosis in deciduous teeth, and if ineffective, a pulpotomy should be utilized.

A pulpotomy is a procedure in which the entire inflamed coronal pulp is removed while the pulpal tissue within the roots is left intact. Upon removal of all caries and the achievement of hemostasis within the pulp chamber, mineral trioxide aggregate (MTA), formocresol, or ferric sulfate is applied with either cotton pellets or a specific carrier directly to the pulpal tissue stumps until a clot forms. The tooth is subsequently restored with a base, such as intermediate restorative material (IRM). The ideal final restoration is a stainless steel crown for deciduous molars or an anterior strip crown for anterior teeth.

The treatment of extensively carious immature permanent teeth, for which root formation and closure are years away, also presents as a unique restorative challenge. Immature permanent teeth with carious lesions that approach the pulp but with no or minimal symptoms can be treated with the one- or two-step indirect pulp technique. If a stainless steel crown or an anterior strip crown is utilized for the immediate restoration, it must be replaced by a permanent crown after root formation is complete. If the removal of the carious lesion causes a small (pinpoint) exposure to the pulp, with symptoms of pain, the direct pulp cap technique can used for immature permanent teeth [20]. Direct pulp caps of immature permanent teeth have a much better prognosis when compared to those of deciduous teeth.

When an extensive carious lesion involves the pulp of immature vital (non-necrotic) permanent teeth, the therapeutic goals are to eliminate pain and to provide treatment that will allow for the complete development of the root, including apexogenesis. This can only occur if the radicular pulp is left in a healthy state. After the inflamed pulpal tissue is removed, a layer of calcium hydroxide or MTA is placed over remaining exposed pulpal tissue [21]. A base (e.g., IRM) and a composite resin restoration complete the coronal seal.

Periodic radiographic assessment is necessary to evaluate the continuity of root formation and apexogenesis. Some teeth restored in this fashion may remain asymptomatic and exhibit no apical pathology, while others will require conventional root canal therapy after the root apex has completed its formation.

EXTRACTION

Caries in deciduous and immature permanent teeth may progress to the point that the tooth is no longer restorable and must be extracted. Although deciduous teeth are designed to be shed, they maintain an important role in occlusion and phonation. Unrestorable deciduous teeth should be extracted before causing drifting of adjacent teeth or creating an obstacle to the eruption of permanent teeth. A classic example of this occurs with the premature loss of deciduous second molars. Because the maxillary and mandibular permanent first molars erupt long before the anticipated exfoliation of the deciduous second molars, which are eventually replaced by the permanent second bicuspids, the premature loss of second deciduous molars allows the permanent first molars to drift mesially and create an obstacle to the eruption of the permanent second bicuspids. A space maintainer may be necessary to prevent this occurrence. The space maintainer is cemented onto the permanent first molar and is removed after the permanent second bicuspid has erupted to a position that will prevent mesial drift.

APEXIFICATION

Carious lesions that are left untreated will eventually cause necrosis of the coronal and radicular pulp. Necrotic (non-vital) immature permanent teeth present a unique challenge, as the non-vital radicular pulpal tissue cannot contribute to further development of the root and apexogenesis. In these cases, an apexification procedure is used. Conventional root canal therapy cannot be completed because the root of the immature permanent tooth has an open apex that cannot provide a definitive stop for obturation material. The apexification procedure is designed to create a definitive calcified stop in the apical region of the root, which would then allow gutta percha to be used to complete definitive root canal therapy. The initial appointment consists of the debridement and removal of the necrotic remnants of the pulpal tissue. A thick paste of calcium hydroxide is placed into the cleansed and debrided canal to stimulate the formation of the calcified stop in the apical region of the root. Whether calcium hydroxide is placed during the initial or second appointment, it is covered with a temporary filling material and left within the canal for approximately six months. If a calcified stop near the apical region of the tooth is confirmed by radiographs and is tactilely encountered by endodontic instruments such as files or reamers, conventional endodontic treatment can be completed [22]. If the stop is not encountered, the canal is retreated with calcium hydroxide paste. The complete loss of pulpal tissue in an immature permanent tooth precludes the continued thickening and developing of the root canal walls even if the apexification technique and subsequent endodontic therapy are successful [23]. This makes the tooth more susceptible to fractures of the crown or the root. A full-coverage crown can decrease, but not eliminate, the potential for coronal fractures. Patients should be reminded to minimize pressure to treated teeth and should be instructed to wear protective mouth guards during athletic activities.

Procedures such as pulpotomies of deciduous and immature permanent teeth and apexification should only be performed by clinicians who have had adequate training. Referral to a pedodontist or endodontist should be considered if the required clinical techniques are beyond the capabilities of the general practitioner.

PREVENTIVE DENTISTRY FOR CHILDREN AND ADOLESCENTS

Of course, the ultimate goal for each child and adolescent is avoidance of dental caries. Unfortunately, many patients in this age range have one or more carious lesions. Infants and children are dependent upon their parents/caregivers to brush and floss their teeth, to bring them to the dental office for exams and routine prophylaxis appointments, and to provide nutrition that is conducive to good oral and general health. There are general guidelines for the prevention of dental caries in children and adolescents that may be helpful for clinicians and parents/patients.

Oral problems that are diagnosed early can be treated conservatively and inexpensively. As such, the American Academy of Pediatric Dentistry has recommended an initial dental examination as early as the first tooth eruption and no later than 12 months, which would include a caries risk assessment, oral hygiene instructions for the parent(s), and a general assessment of the child's oral health [24].

SEALANTS

As discussed, the use and efficacy of pit and fissure sealants can decrease the risk of caries associated with anatomical features in deciduous and permanent teeth. Parents may be unaware of this preventive option, especially if sealants were never used for their own teeth. The benefits of this approach should be discussed with the parents, but it is important that they know that pit and fissure sealants are not a substitute for good oral hygiene. Parents should also understand that the cost of pit and fissure sealants is per tooth and that insurance company reimbursement is variable.

EVIDENCE-BASED PRACTICE RECOMMENDATION

The Scottish Intercollegiate Guidelines Network asserts that resin-based fissure sealants should be applied to the permanent molars of all children as early after eruption as possible.

(https://www.scottishdental.org/wp-content/uploads/2014/04/SIGN138.pdf. Last accessed January 19, 2023.)

Grade of Recommendation: A (At least one meta-analysis, systematic review, or randomized controlled trial rated as high quality and directly applicable to the target population; or a body of evidence consisting principally of studies rated as well-conducted, directly applicable to the target population, and demonstrating overall consistency of results)

FLUORIDE TREATMENT

Fluoride is the negatively charged ionic form of the element fluorine, and it is able to form stable bonds with positively charged ions, such as sodium and calcium, to promote remineralization of teeth. Virtually all water naturally contains fluoride, but usually at a concentration that is not sufficient to prevent tooth decay. The use of community water fluoridation began in late 1940s [25]. In 2010, the U.S. Department of Health and Human Services decreased the recommended optimal concentration of fluoride in drinking water for reduction of dental caries from 0.7–1.2 mg per liter of water to 0.7 mg per liter [30]. This change was the result of the widespread availability of fluoride-containing foods, water, beverages, toothpastes, and mouth rinses and to some degree was a response to concerns of overexposure to fluoride, which is neurotoxic at higher doses and can also cause dental and skeletal fluorosis [72]. This recommendation was finalized in 2015, with studies showing that 0.7 mg per liter of fluoride in drinking water maintained decreases of up to 35% of caries in children, while minimizing the risk of skeletal fluorosis [30; 81]. Fluoride is slightly more toxic than lead and slightly less toxic than arsenic and has a narrow therapeutic window

that can be difficult to control when all potential sources are considered [74]. Excessive ingestion of fluoride can cause fluorosis, a condition in which the enamel exhibits subtle changes (e.g., white spots) and potentially extensive areas of pitting and discoloration. Swallowed fluoridated toothpaste and drinking water are the primary sources of excessive fluoride intake and are considered the leading causes of fluorosis [71]. To prevent this, parents should receive instructions regarding toothbrushing technique and the amount of toothpaste that is appropriate for children to minimize the unnecessary ingestion of fluoride.

Fluoride's preventive effects are principally topical, rather than systemic, as was previously thought. Fluoride disrupts the activity of cariogenic bacteria (e.g., *Streptococcus mutans*) by decreasing its metabolism of carbohydrates in dental plaque, the action responsible for acidification of the oral environment that causes the demineralization [27]. Acid excreted by cariogenic bacteria stimulates the release of fluoride that is then incorporated into enamel that has undergone initial demineralization. However, mutated strains of *Streptococcus* bacteria resistant to fluoride are known to inhabit the oral cavity (and the environment) in response to fluoride exposure [70]. Fluoride is nonselective and also kills many species of beneficial bacteria.

Topical fluoride inhibits the demineralization of sound enamel and promotes the remineralization of damaged enamel, particularly in the context of dietary fluoride, calcium, and phosphorus deficiency [26]. Fluoride, calcium, and phosphate strengthen the crystal structure of enamel [28]. Beyond a topical effect, ingested fluoride will become incorporated into the enamel and dentin of unerupted teeth and thus increase their resistance to susceptible cariogenic bacteria [22]. New research indicates another important caries-preventing action of topical fluoride is to weaken the ability of bacteria to adhere to tooth enamel [73].

Fluoride concentrations in community water supplies in the United States are not standardized, and some communities have opted not to include fluoride in their water at all. The American Academy of Pediatric Dentistry recommends age-dependent fluoride supplementation only if the fluoride concentration in a child's water supply is less than 0.6 parts per million (ppm) [31]. No fluoride supplement is recommended for children from birth to 6 months, even if community water fluoridation is lacking. A 0.25-mg fluoride supplement is advised for children 6 months to 3 years of age if the fluoride concentration in available water is less than 0.3 ppm. Children 3 to 6 years of age should receive 0.50 mg fluoride if the water fluoride concentration is less than 0.3 ppm or 0.25 mg fluoride if the concentration range is 0.3–0.6 ppm. Children 6 to 16 years of age should receive 1 mg fluoride supplement if the fluoride concentration in the community water supply is less than 0.3 ppm or 0.50 mg if the fluoride concentration is 0.3–0.6 ppm [31]. The American Dental Association Council on Scientific Affairs encourages healthcare providers to evaluate all potential fluoride sources and to conduct a caries risk assessment before prescribing fluoride supplements [74]. Parents should consult with their pediatrician, pedodontist, or general dentist to determine if fluoride supplementation is required for their child.

Due to increasing research and public awareness of the neurotoxic effects of many chemicals, including fluoride, some parents will not want to administer fluoride supplement or fluoride toothpastes. These parents should be advised regarding proper nutritional intake of calcium, phosphorus, and vitamin D and the importance of regular tooth brushing and preventative dental visits [74].

An alternative to fluoride for enamel protection and tooth remineralization is calcium hydroxyapatite, a calcium and phosphorus (phosphate) mineral of which 70% to 80% of tooth and bone are composed.

Topical preparations containing hydroxyapatite have been shown to be as or more effective for remineralization, treating tooth hypersensitivity, and reversing carious lesions than fluoride and do not have the detriments of toxicity or tooth fluorosis [84]. Other effects of hydroxyapatite are absorption of oral pathogens and protection against stains and biofilm attachment. The most effective type of hydroxyapatite for topical use is the nanocrystal form (nanohydroxyapatite), which is readily available as toothpastes and rinses. Calcium hydroxyapatite is available as a nutritional supplement and is also included in some dental gels and varnishes.

DENTAL EXAMINATIONS AND PROPHYLAXIS APPOINTMENTS

As noted, children and adolescents are entirely dependent upon their parents or caregivers for access to dental care, and issues with transportation and financial stress may arise. However, regularly scheduled dental examinations can provide a means for oral hygiene instruction for children and their parents and can allow for identification of carious lesions early, when they can be restored by conservative and less expensive means. Beyond the cost-effectiveness of preventive pediatric dentistry, this approach reduces the suffering and morbidity associated with advanced dental problems.

Dental insurance coverage and family income may impact access to care. Families in need of financial assistance may be eligible for dental coverage under the Medicaid program. Unfortunately, the low reimbursement fee schedule for dental procedures precludes many general dentists and dental specialists from accepting patients under this program. The dental divisions of county health departments may provide another low-cost source of dental treatment for pediatric and adolescent patients. Some county and state dental societies also provide periodic pro bono services to those in need. Access to adequate dental care is essential for the appropriate development of children's oral and general health and for their ability to develop and maintain a healthy sense of self-esteem, making this a public health issue.

EVIDENCE-BASED PRACTICE RECOMMENDATION

The U.S. Preventive Services Task Force recommends that primary care clinicians apply fluoride varnish to the primary teeth of all infants and children starting at the age of primary tooth eruption.

(https://jamanetwork.com/journals/jama/fullarticle/2786823. Last accessed January 19, 2023.)

Strength of Recommendation: B (There is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial.)

MEDICATION USE IN PEDIATRIC AND ADOLESCENT DENTAL PATIENTS

Local anesthetics, analgesics, and antibiotics are used most often before, during, and after the dental treatment of pediatric and adolescent patients. As with any patient, a thorough medical history must be obtained and discussed with the patient and his or her parent or guardian prior to using any medication. Some states require written parental/guardian consent for any medication use in minor children. Medications used for dental purposes should be carefully selected and used to ensure they do not interact adversely with those prescribed to treat a systemic disease. If there are any medical issues that would cause a concern with a proposed dental treatment or the medications used, consultation with the patient's pediatrician or another physician is recommended.

Dental professionals who rarely treat or prescribe medications to pediatric and adolescent patients may give little thought to the profound differences in their ability to metabolize and excrete medications compared with adults. The dosage and frequency of administration may require significant adjustments. History of an adverse reaction to any medication should be discussed with the parent or guardian, as should the presence of pre-existing illness and other medication use. Age and weight should be considered before a medication is recommended

or prescribed. For example, a child who is 3 years of age and weighs 30 pounds is often categorized generally as "pediatric," as is an adolescent who is 17 years of age and weighs 200 pounds. But their ability to absorb, distribute, metabolize, and excrete medications will be vastly different. Given these issues, it is not possible to recommend a single dose of any analgesic, antibiotic, or local anesthetic for all pediatric patients. Consultation with a pediatrician is necessary if there is any concern about the type, dose, or frequency of administration of a given medication.

ANALGESICS

Carious involvement of the pulp, localized infections, and trauma to the teeth or surrounding structures may all lead to the use of analgesics for pediatric patients. Acetaminophen is the most frequently used analgesic in this population for mild-to-moderate pain [33]. It is preferred over aspirin, which causes irritation to the gastric mucosa and may cause Reye syndrome. Acetaminophen has analgesic and antipyretic (fever-reducing) capabilities. It blocks the production of prostaglandins in the central nervous system and the generation of pain impulses peripherally [34]. Some younger children and adolescents may have difficulty swallowing tablets or capsules, and acetaminophen is available as a chewable tablet, elixir, or liquid.

An excess use of acetaminophen can lead to hepatic toxicity and even liver failure. The smallest dose for the shortest duration to provide adequate analgesia should be used. Acetaminophen may be combined with other over-the-counter medications (e.g., antihistamines) to provide relief from pain or symptoms of colds, influenza, or sinus congestion. These combinations increase the risk for hepatic toxicity. Parents should be aware that although acetaminophen is an over-the-counter medication, it can be dangerous if used inappropriately in children and adolescents.

Nonsteroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen and naproxen may also be used to relieve pain of odontogenic origin. NSAIDs have analgesic, antipyretic, and anti-inflammatory properties. The mechanism of action is twofold, as they decrease prostaglandin synthesis peripherally and decrease the accompanying inflammatory response. In the central nervous system, NSAIDs decrease the synthesis of prostaglandins in the critical pain processing regions and inhibit the ability for pain impulses to be transmitted or received.

The half-life of naproxen is 12 to 15 hours, which allows for it to be taken twice daily. The two- to four-hour half-life of ibuprofen requires that it be administered more frequently [35]. The gastrointestinal side effects that can occur with NSAIDs are decreased if they are taken with food; however, this practice will decrease their systemic absorption. To facilitate easier administration in the pediatric population, ibuprofen is available as infant drops, suspension, or chewable tablet, and naproxen is available as a suspension.

Patients who have experienced an aspirin-induced asthma attack should avoid the use of NSAIDs, as there is a high potential for cross-sensitivity [36]. This group of medications inhibits platelet aggregation and should not be used in patients with a bleeding disorder. NSAIDs are also contraindicated in patients who have gastrointestinal diseases such as inflammatory bowel disease or peptic ulcer.

Codeine, an opioid analgesic, is the most commonly prescribed medication for moderate-to-severe pain in pediatric patients [33]. It may be given alone, but it is usually given in combination with acetaminophen. The recommended pediatric dose of codeine is 0.5 to 1 mg/kg (maximum of 60 mg in adolescents) every four to six hours [33]. The maximum dose of acetaminophen with codeine is based on the acetaminophen dose. Respiratory depression is a serious complication; other common side effects include constipation, nausea, sedation, dizziness, and pruritus.

ANTIBIOTICS

Oral infections that develop from grossly carious teeth require prompt antibiotic treatment before definitive treatment is completed. The rise of resistant bacteria mandates that a conservative approach for the use of antibiotics is used. The extent of the infection, the immunocompetence of the patient, and the age of the patient should be considered before any antibiotic is prescribed. Dental infections contained within the pulpal or gingival tissues immediately adjacent to the tooth and fistulous tracts without signs of systemic involvement generally do not require antibiotic therapy; more extensive involvement and symptomatic presentations do [37]. Dental infections can advance rapidly among pediatric patients, especially younger children, and those who present with signs of systemic involvement should be referred to a pedodontist, oral surgeon, or an emergency department, as intravenous antibiotics and surgical drainage may be required.

Penicillin VK remains the empiric antibiotic of choice for the treatment of odontogenic infections [37]. It is effective against the gram-positive anaerobes commonly associated with these infections. Amoxicillin-clavulanate, a derivative of penicillin VK, is absorbed more rapidly and is more effective against gram-negative bacteria [38; 75]. Both medications are available in suspension formulations, with amoxicillin also available as a chewable tablet. Clindamycin is the alternative antibiotic of choice when a patient is allergic to penicillin VK or amoxicillin, but the development of pseudomembranous colitis is a potential risk when this agent is used. Consultation with the patient's pediatrician is recommended prior to prescribing this medication. Cephalosporins should be considered, particularly if the patient has had a previous course of penicillin or amoxicillin [37].

LOCAL ANESTHETICS

Adequate pain control during restorative or surgical procedures is essential for patient comfort and for the ability to complete the procedure. Many adults have fears or phobias about dental treatment that originate from the pain they experienced during a childhood dental procedure during which pain control was inadequate. Therefore, prevention of pain should be an utmost concern.

Supraperiosteal infiltration with a local anesthetic provides successful anesthesia for maxillary deciduous and permanent teeth. This technique is also successful for all mandibular deciduous teeth but decreases for mandibular molars, as bone density increases with age. An inferior alveolar nerve block (IANB) may be required to provide successful anesthesia for the deciduous mandibular molars in older children and will be required to successfully anesthetize permanent molars. The mandibular bicuspids may be anesthetized by an IANB or by infiltration of the mental nerve.

A topical anesthetic such as benzocaine (available in concentrations up to 20%) can be applied to the mucosa prior to the injection. The minimum required amount is placed on a cotton tip applicator, which is then spread on the isolated and dry mucosa. A staff member should remain with the patient to maintain isolation of the area and minimize swallowing of the topical anesthetic, which can cause nausea in some patients.

As with all medications, the choice of local anesthetic for a pediatric patient must consider the age, weight, medical history, and type and duration of the planned procedure. The margin of safety will be less in smaller, younger children. One can ascertain the safe limit for a pediatric patient by determining the dose (in mg) of a given local anesthetic per kilogram of body weight (mg/kg), which will establish the maximum cumulative dose per appointment.

If the maximum dose of lidocaine is 4.5 mg/kg for an entire appointment, a child who weighs approximately 16 kg should not receive more than two carpules of 2% lidocaine per appointment [39]. This is only a guide, as other factors (e.g., hepatic or renal impairment) can decrease a patient's ability to metabolize or excrete a local anesthetic.

Other local anesthetics, such as mepivacaine, prilocaine, and articaine, have established guidelines for the maximum allowable dose per appointment, also expressed as mg/kg. In general, the younger the age and the lower the weight of the pediatric patient, the lower the maximum allowable dose of local anesthetic. Clinicians should begin with these guidelines and use less if the medical history dictates or if a minimal amount of treatment is required.

The vasoconstrictor epinephrine is added to local anesthetics to prolong the duration of anesthesia and to aid in hemostasis in surgical cases. Preservatives such as sodium bisulfite or sodium metabisulfite are also added to local anesthetics that contain epinephrine in order to prolong their shelf life. Patients with allergies to sulfite compounds could develop an allergic reaction if a local anesthetic with epinephrine is used. For these patients, alternative anesthetics, such as mepivacaine plain, are reasonable alternatives.

The use of local anesthetics carries with it the responsibility of heightened safety. Before any local anesthetic is used, the dentist and staff should be fully trained in cardiopulmonary resuscitation for pediatric patients. Equipment and medications necessary in the event of a medical emergency should be easily accessible and all staff members should be trained in their appropriate use. Periodic emergency drills will define the role each staff member should assume during a medical emergency. Clinicians who infrequently use local anesthetics for pediatric patients should be cognizant of the differences in the safe maximum allowable dose of a given anesthetic among different patient populations.

ORAL AND MAXILLOFACIAL LESIONS

HERPES SIMPLEX

Several systemic diseases that affect children and adolescents can present with oral and facial lesions. But the most common cause of oral ulcerations in children is an initial infection with herpes simplex virus-1 (HSV-1). Primary herpetic gingivostomatitis (PHG) usually occurs after 6 months of age and has the highest incidence between 12 and 18 months of age [16]. In children with PHG, the gingival tissues appear red and edematous, with small vesicular lesions and ulcerations on the oral mucosa. Patients will have pain, malaise, and headache and may be febrile. Liquid nutritional supplements and a soft, bland diet may be necessary during this period. Healing occurs spontaneously within 7 to 14 days with no residual scarring from the herpetic lesions. Although this initial attack will resolve, it is not cured. The virus will migrate to a regional nerve ganglion and can become reactivated in the future as recurrent herpes labialis. These recurrent lesions usually occur at the mucocutaneous junction of skin and lips, and unlike PHG, the oral mucosa and gingival tissues are typically uninvolved. Lesions of recurrent attacks heal in 10 to 14 days without scarring. Pediatric patients who are immunocompromised can have a more aggressive course of HSV-1 infection and a protracted healing period. Antiviral medications such as acyclovir can accelerate the healing time. Acyclovir is available as a cream, capsule, tablet, or suspension, with the dosage and frequency of administration adjusted according to the patient's age, weight, and medical history.

MEASLES

Many of the systemic viral diseases that were once common among young children and adolescents, such as measles, mumps, and chickenpox, have been significantly reduced in the United States through the use of effective vaccines. The combined vaccine for measles, mumps, and rubella (MMR) was developed in the late 1960s [41]. In 1995, a chickenpox (varicella) vaccine was introduced, and by 2005, a combination vaccine for all four diseases (MMRV) was introduced [42]. In the 1990s, a study was published implicating the MMR vaccine with the development of autism [43]. Although the basis of this work was later declared fraudulent, many parents refused to have their children vaccinated on the basis of this initial report, which resulted in small increases in the incidence of these diseases [44].

The Centers for Disease Control and Prevention (CDC) has documented several outbreaks of measles in the last decade among unvaccinated groups (e.g., the Amish, orthodox Jewish communities, children of the anti-vaccination movement); one such incidence was the 2015 Disney California theme parks outbreak, which infected at least 125 individuals, most of whom had not been vaccinated due to personal beliefs; others had unknown vaccine status, were undervaccinated, or were too young to have received the vaccine series [76]. Since then, a major increase in the number of cases in the United States has been noted. In the first 10 months of 2019, 1,261 cases of measles in 31 states were reported (compared with a total of 1,958 total cases between 2010 and 2018), 75% of which were in New York. This represents the largest number of cases since 1992 and the second highest number since measles was considered eliminated in the United States in 2000. Of these patients, 89% were either unvaccinated or their vaccination status was unknown [77]. During 2020–2022, there were an additional 180 cases. Travel to or from a foreign country where the disease is endemic can also instigate the spread of measles among unvaccinated persons [76].

The measles virus causes cutaneous, red, maculopapular lesions. Oral manifestations of measles include grayish-white macules surrounded by an erythematous halo, known as Koplik spots. These lesions precede the eruption of the cutaneous lesions [45].

CHICKENPOX

Chickenpox, also known as varicella, is caused by the varicella zoster virus (VZV). This disease is usually seen in children and features lesions that originate on the trunk then spread throughout the body. The oral lesions are white to grayish-white vesicles with an erythematous border involving the tongue, buccal mucosa, gingiva, palate, and oropharynx. They can cause varying degrees of pain, which can complicate eating, swallowing, and maintaining oral hygiene [46]. Nutrition and hydration should be maintained via liquid nutritional supplements, if necessary.

After the primary varicella infection ends, the VZV is transported to the dorsal spinal ganglia and can remain dormant for decades, emerging later as herpes zoster virus, also known as shingles. However, shingles is much more common in older adults, and a vaccine is available for persons 50 years of age and older [47].

MUMPS

The MMR/MMRV vaccines have also been instrumental in significantly decreasing the incidence of mumps. When it does develop, mumps involves the major salivary glands. In particular, the parotid glands' inflammatory response to the mumps virus (known as parotitis) presents as bilateral swelling of variable severity. Children 10 years of age and younger are most commonly affected; however, a larger outbreak in 2006 involved 6,584 college students in multiple states, an outbreak of 3,000 high school students occurred in New York in 2009–2010, and nearly 20,000 cases occurred in 2015–2019 in a variety of settings, including households, schools, universities, athletics teams and facilities, church groups, workplaces, and large parties and events. Since the end of 2019, cases of

mumps have declined (likely due to coronavirus preventative measures), but hundreds of cases per year continue to be reported [48]. Rarely, more serious complications such as temporary or permanent deafness, encephalitis, or meningitis, may occur. In some cases, mumps will present as unilateral involvement and swelling of the parotid gland, which can be mistaken for a local odontogenic infection.

HAND, FOOT, AND MOUTH DISEASE

Hand, foot, and mouth disease is usually caused by coxsackievirus A16, although other coxsackievirus genotypes can serve as etiologic agents [32]. The disease primarily affects children during the summer and early fall. It usually begins with fever, loss of appetite, fatigue, and sore throat, followed within one or two days by oral sores.

The oral lesions of hand, foot, and mouth disease feature vesicles that quickly rupture to form shallow ulcerations encircled by an erythematous halo. Any area of the oral mucosa can be affected, but lesions occur most often on the palate, tongue, and buccal mucosa. The lesions can be difficult to distinguish from other oral ulcerative lesions, such as aphthous ulcers. However, hand, foot, and mouth disease usually features similar cutaneous lesions on the hands and feet, although the lesions may be limited to cutaneous or oral manifestations in some cases. Afflicted patients are most contagious during the initial week of their infection. Coxsackievirus A16 remains for weeks after symptoms have dissipated, and the patient remains infectious to others during this time [40].

Treatment for hand, foot, and mouth disease is supportive and palliative. Painful oral lesions can complicate a patient's ability to masticate food and to swallow, so softer, blander foods and liquid nutritional supplements may be required. Analgesics compatible with the patient's medical history may be used to decrease oral discomfort. Patients with hand, foot, and mouth disease should be instructed not to scratch or manipulate fluid-filled vesicles in any manner as the contents are infectious and can inoculate other areas.

There is no current vaccine available to prevent hand, foot, and mouth disease. Recovery from the disease only confers immunity against the viral strain that caused the infection, not against other coxsackievirus genotypes. It is a self-limiting disease, but complications, such as viral meningitis or encephalitis, can occur.

RECURRENT APHTHOUS STOMATITIS

Recurrent aphthous stomatitis features painful ulcerative lesions (also known as recurrent aphthous ulcers or more commonly as canker sores) that generally heal without scarring in immunocompetent patients but can recur at any time. The size is a demarcation for the categorization of these lesions. Minor aphthae are less than 1 cm at the greatest diameter; major aphthae exceed this dimension. Each type of lesion only involves nonkeratinized tissues, such as the buccal and labial mucosa, the soft palate, and the surface layer of the floor of the mouth. Movement of the mucosa affected by lesions of either size is painful and can interfere with speaking, eating, and swallowing. Major aphthae tend to have irregular shapes and borders and more depth. The numbers of both can vary, although solitary lesions are uncommon. Lesions of aphthous stomatitis feature a shallow yellow base and an intense erythematous halo peripherally.

The incidence of these lesions varies from 20% to 60% and can reflect the actual population studied. Many patients develop the condition during the first two decades of life [55]. There has yet to be a bacterial, viral, or fungal etiology that can be attributed to the origin of these lesions, but a genetic predisposition to the occurrence is possible. When both parents have a history of these lesions, there is a 90% chance that their children will be similarly affected [56]. Common predisposing factors include physical and emotional stress and sensitivity to ingredients in toothpaste and/or mouthwash, such as sodium lauryl sulfate and alcohol [57; 58]. Tissue manipulation during dental or medical procedures, during which the oral tissues are stretched or manipulated by instruments, is a source of local trauma that can cause the development of these ulcers. Nutritional

deficiencies in vitamin C, folic acid, iron, and vitamin B12 are other potential etiologies [58]. Systemic chemotherapy and radiotherapy targeting malignant lesions of the oropharynx can cause the development of overlapping aphthous ulcers of considerable size that can serve as areas of systemic access of pathogenic organisms. Occasionally, these ulcers occur as part of a disease such as Behçet syndrome. In patients with Behçet syndrome, major aphthae are more frequent than minor aphthae and occur simultaneously on the nonkeratinized oral mucosa, uvula, and genitals [58]. Sensitivity to certain medications, including NSAIDs, angiotensin-converting enzyme inhibitors, and bisphosphonates, may produce an aphthous-like tissue reaction. Given the multitude of medications available and potential untoward effects that can occur in the patients who take them, this could be a potential issue for numerous medications.

Treatment and Prognosis

The lesions of recurrent aphthous stomatitis usually revolve spontaneously. Minor aphthae resolve within 7 to 14 days from onset with no residual scarring. Major aphthae can take three weeks or longer to heal and usually do so with scar formation. Antibiotics are only needed if the involved areas become secondarily infected. Treatment is usually designed to avoid contact with these lesions, as a traumatic incident will exacerbate the pain and prolong healing. Palliation of the symptoms associated with these lesions consists of topical anesthetic preparations and systemic analgesics, as needed. A diet that minimizes both acidity and extreme temperatures and avoids foods with sharp edges will facilitate proper nutritional support and minimize physical trauma to the affected areas [58]. Patients with removable orthodontic retainers may refrain from using them if an aphthous ulcer is adjacent to their extensions.

As the name would suggest, these lesions have periodic recurrences. Because more serious lesions such as squamous cell carcinoma can appear in a multitude of different forms, patients should be advised that lesions that do not heal should be re-evaluated for a biopsy.

ORAL AND MAXILLOFACIAL TRAUMA FROM CHILD ABUSE AND NEGLECT

Traumatic injuries to the teeth and the structures of the oral and maxillofacial complex may be the result of falls, sports injuries, car accidents, or violence. Usually, the maxillary anterior teeth take the brunt of the trauma, as they are the first teeth to encounter traumatic forces. The extent of coronal/radicular (root) fracture, the age of the patient, the degree of root development and apical closure of permanent teeth, the medical history, and access to dental care can all influence the ability to restore traumatized teeth. Of the most concern are oral injuries, cutaneous and intra-oral mucosal bruising, and other injuries to the head and neck that occur due to child abuse and neglect.

The head, neck, and arms of pediatric patients should be assessed for signs of bruising or injuries without plausible explanation. All members of the dental profession should be cognizant of their responsibility as advocates for children and adolescents who are victims of physical and emotional abuse. This is a moral and ethical obligation, as all states require dentists to report suspected cases of child abuse to the appropriate social service or law enforcement agencies.

Many cases of child abuse go unreported, so it is difficult to determine the exact number of children affected by physical, emotional, and psychologic abuse. According to the U.S. Department of Health and Human Services, the rate of child abuse and neglect was 8.4 per 1,000 children in 2020 [29]. Neglect represented the most frequent type of abuse, occurring in 76.1% of victims; physical abuse occurred in 16.5% of victims. Dental professionals are often the practitioners who have the most frequent interactions with children and therefore must be attentive to any signs of physical abuse, as abusive injuries to children often involve the face, jaw, mouth, teeth, and tongue [13]. Studies indicate that approximately 65% of abused children have visible injuries to the head, face, neck, and intraoral

regions [49]. Child abuse should be considered as a potential source for injuries that are inconsistent with an explanation as to their origin, when several injuries in various stages of healing are present, when children or adolescents appear reluctant or fearful to discuss their injuries, and if parents or guardians appear evasive or defensive when they are questioned about the origin of the child's injuries.

While there is no single injury to the head, neck, oral, or perioral region that is absolutely indicative of child abuse, some injuries and patterns should be viewed with more suspicion than others. Injuries or bruises in the shape of a distinguishable object, such as a belt buckle, strap, rope, electrical cord, clothes iron, or hand, are cause for concern [49]. The cheeks and lips are the most common site of intentionally inflicted injuries in the oral and perioral region, with injuries to the oral mucosa, teeth, gingival tissues, and tongue following behind [49; 50]. Beyond the oral and perioral region, the neck should be included as a part of the comprehensive examination of the child. Bilateral bruise marks or rope burns on the neck may be the result of an attempt to strangle the child; bilateral bruising on a child's arms may be indicative of shaking injury. Bruising and lacerations of the ears and the adjacent skin may be related to abuse; bilateral lesions and traumatic injuries to the ears are rarely accidental in nature. However, this may not be easily visible if hair extends over the ears. Hematomas within the oral cavity and in the perioral area can develop if a child is struck by a hand or a blunt object. Fractures or loss of multiple permanent or deciduous teeth may be the result of being slapped, punched, or struck.

Child sexual abuse may also have oral and perioral manifestations. Venereal warts (*Condyloma acuminatum*) are suspicious for sexual abuse when they occur in a child's oral cavity [49]. These warts appear as cauliflower-like lesions on the lips, palate, and tongue. Forced oral-genital contact can also produce bruising and petechiae (i.e., small foci of hemorrhagic areas caused by trauma to and the rupture of small blood vessels); this most frequently occurs in the area of the soft palate [49].

REPORTING

In many states, dental professionals are legally required or mandated to report any suspected cases of child abuse, maltreatment, and/or neglect that they encounter in their professional roles. However, studies have shown that many professionals who are mandated to report child abuse and neglect are concerned and/or anxious about reporting. Identified barriers to reporting include [51; 52; 53]:

- Professionals may not feel skilled in their knowledge base about child abuse and neglect. In addition, they lack the confidence to identify sexual and emotional abuse.
- Professionals may be frustrated with how little they can do about poverty, unemployment, drug use, and the intergenerational nature of abuse.
- Although professionals understand their legal obligation, they may still feel that they are violating patient confidentiality.
- Many professionals are skeptical about the effectiveness of reporting child abuse cases given the bureaucracy of Child Protective Services (CPS) and the large caseloads.
- Practitioners may be concerned that they do not have adequate or sufficient evidence of child abuse.
- Practitioners may have a belief that government entities do not have the right to get involved in matters within the family arena.
- There may be some confusion and emotional distress in the reporting process.

The failure to identify and report child abuse may result in continued abuse of the child and potentially severe consequences. Improved and ongoing education about child abuse and maltreatment has been shown to improve identification and reporting rates among dental professionals. The education should include [54]:

- Management and outcomes
- The role of the CPS investigator

- The role of the physician/other reporting professional
- The benefits of CPS involvement
- The benefits of mandated education on identification/reporting
- The benefits of professional debriefing for the reporter
- The benefits of collaboration (e.g., with local emergency departments, pediatric specialists)

Other suggestions for improving reporting include [54]:

- Improving the relationship between CPS and dental providers
- Allowing certain registered professionals with demonstrated expertise in identifying/treating child abuse "flexible reporting options" (e.g., deferring reporting when no immediate threat exists or making the report confidentially and deferring an investigation until deemed necessary)
- Improving interaction with the legal system

EATING DISORDERS AND DENTAL HEALTH

Few behavioral or psychologic problems have as direct an adverse effect upon the teeth and the oral mucosa as anorexia nervosa and bulimia nervosa. There are classic oral manifestations of these eating disorders that members of the dental staff may discover during the course of routine dental treatment.

The exact etiology of eating disorders is unknown, but a combination of genetic, hormonal, social, cultural, and attitudinal factors are believed to be involved. Images in mass media that promote a thin body as a vehicle to success and happiness have been implicated in altering a person's perception of his or her appearance [59].

ANOREXIA NERVOSA

Patients with anorexia nervosa have an extreme obsession with their body weight and the restriction of food intake. Women comprise 90% to 95% of anorexia cases, and it is estimated that 1% of all women between 12 and 25 years of age have anorexia, with the onset usually occurring during the adolescent years [60]. Anorexic patients often view themselves as overweight even though most are 15% or more below ideal weight.

Patients with anorexia go to extreme measures to lose weight and prevent weight gain. The most common mechanism is restricting or halting eating. Other patients may exercise excessively. Some patients with anorexia will use laxatives, enemas, or self-induced vomiting as a supplemental means to control their weight. These behaviors can lead to severe acute and chronic medical problems. Patients may appear emaciated but refuse to acknowledge the serious nature of the problem and do not consider the potential medical consequences of the disease.

Women who are anorexic often have irregular menstrual cycles. The skin can become dry and thin and at greater risk for traumatic injury. The restriction of caloric intake can stunt the physical and mental development of children and adolescents, and cognitive damage is possible in all patients. Problems with the cardiovascular system, including hypotension, bradycardia, and cardiac arrhythmias, are very common. Self-induced vomiting and use of laxatives can cause a severe disturbance in the body's mineral and electrolyte balance, and a drastic reduction of the minerals potassium, sodium, and calcium can interfere with the conduction of nerve impulses and the contraction of smooth, skeletal, and cardiac muscle. Failure of multiple organs and systems can lead to death. If part of the disease process, repeated episodes of self-induced vomiting can cause ulceration of the esophageal lining, with the subsequent development of esophageal varicosities and bleeding. Oral effects are generally limited to those caused by extreme starvation and malnutrition.

BULIMIA NERVOSA

Patients with bulimia nervosa tend to lack the emaciated appearance of patients with anorexia nervosa; their body weight and appearance often appears normal. Bulimia features recurrent binge eating, in which a large quantity of food is consumed in a short time, followed by purging (e.g., self-induced vomiting, use of diuretics, laxatives, or enemas) to compensate for the excessive overeating. During binging episodes, the bulimic patient experiences a loss of control over the quantity and variety of food consumed [62]. The practice of binge eating and purging must continue at least twice a week for three months for a diagnosis of bulimia nervosa to be made [61].

The teeth and the oral mucosa of bulimic patients can undergo damage as the recurrent regurgitation of highly acidic gastric contents can induce pathologic change in both. In addition, the mucosa of the soft palate and the anterior pharyngeal area can be traumatized when fingers or objects are inserted to induce vomiting. Healing of these areas may be prolonged by the physical and chemical assault associated with this repetitious behavior. Ulcerated areas of the oral mucosa may lead to local or regional oral infections. The virulence of infections can be exacerbated when the altered nutritional status of these patients compromises their immune response.

Enamel is the hardest substance in the human body, but the repeated exposure to the hydrochloric acid in regurgitated gastric contents over an extended period of time can lead to a unique pattern of enamel erosion called perimylolysis. Perimylolysis features the loss of enamel on the lingual, occlusal, and incisal surfaces of the teeth. As opposed to attrition, which is the loss of enamel from repetitive tooth-to-tooth contact or abrasion via an external source (e.g., excessive or overly forceful tooth brushing), the gradual dissolution of the enamel matrix in patients with bulimia leaves a glossy, smooth surface, most commonly on the lingual surfaces of the maxillary anterior teeth [63]. Any lost enamel cannot be regenerated. The underlying matrix of dentin is then exposed; it will wear faster than enamel and is more prone to caries. While enamel is devoid of any neural element, dentin contains dentinal tubules whose odontoblastic processes can perceive thermal stimuli as a source of pain. This can cause patients to neglect oral hygiene and increase the risk of caries and periodontal disease. The irreversible loss of enamel will also cause a change in the occlusion, decreasing the vertical dimension of occlusion. The loss of tooth structure requires that more complicated and expensive restorative options, such as crowns, be utilized. The loss of enamel support around composite or amalgam restorations can lead to their weakening and ultimate loss. The amount of time necessary for the enamel to be eroded in such fashion can range from six months to two years [64].

CONCLUSION

Dental treatment of the pediatric patient can be a rewarding experience. Dental schools vary in the amount of pedodontic clinical training undergraduate students receive, and each clinician's expertise and comfort level with pediatric patients will vary, especially the treatment of those who are very young or those with complex dental problems. Professional ethics require the clinician to assess if he or she has the clinical and interpersonal skills required for these patients. Referral to a pedodontist or a general practitioner with excellent skills in the treatment of pediatric and adolescent patients should be considered if it is in the best interest of the patient. Each child and adolescent is unique in their personality, medical history, and psychologic needs and well-being. Recognizing and respecting these qualities is the foundation upon which a relationship of mutual trust and respect is built.

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