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Review Article

Pediatric dental radiography: safety, techniques and diagnostic applications

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ABSTRACT

Children, with their higher cellular metabolism, longer lifespans, and smaller bodies, require specific adjustments in X-ray settings. The increased mitotic cell activity in children, coupled with their longer life expectancy, raises concerns about the potential long-term effects of radiation exposure, such as tumor development or cancer-related deaths. Therefore, radiographs should be prescribed based on individual patient needs, balancing the necessity for diagnostic clarity with the risks of radiation. Radiographs play a vital role in the diagnosis of traumatic dental injuries, as they can reveal injuries that may not be apparent through clinical examination alone. In pediatric dentistry, radiography is essential for diagnosing dental caries, monitoring growth, and identifying developmental or pathological conditions. They are invaluable in treatment planning and assessing dentofacial structures. However, the decision to use radiography should follow a comprehensive assessment, considering each child's medical, dental, as well as the clinical background, as well as environmental factors. Special techniques and considerations are necessary for infants, young children, individuals with disabilities, as well as those with gag reflexes.

Keywords: Pediatric dental radiography, Radiation exposure, Intraoral radiography, Extraoral radiography, Radiation reduction measures

INTRODUCTION

Children typically have a higher cellular metabolism and longer lifespans, but they may exhibit a reduced inclination to cooperate. When recommending X-rays for children, the settings are modified to suit their smaller bodies and less developed bone structures. It is crucial to assess the risk-versus-benefit balance, aiming to minimize radiation exposure as much as possible while adhering to personalized dose limits.[1] In children, mitotic cell activity is significantly greater than in individuals of the same size who have gone through puberty, and their longer life expectancy provides more opportunities for tumor development or the potential for cancer-related deaths caused by the exposure.[2] Considering the potentially greater impact of radiation on children, it is important to determine the necessity of radiographs based on each patient's specific needs and the calculated risks rather than adhering to a standardized protocol. Radiographs are commonly prescribed for various purposes in children, including diagnosing and planning treatment for dental diseases and developmental issues, monitoring their growth and development, and evaluating dental and alveolar trauma. In routine dental practice, radiographs are primarily used in children for diagnosing dental caries and assessing growth and maturity. Additionally, some dental abnormalities may be incidentally detected during imaging. General dental practitioners need to have sufficient knowledge of identifying common developmental and pathological conditions through radiographs to facilitate appropriate referrals and timely management of these conditions.[3]

In pediatric dentistry, the importance of radiographs as a diagnostic tool cannot be overstated, as they play a vital role in diagnosing oral conditions and monitoring the development of dentofacial structures and treatment outcomes. However, the decision to take radiographs should be based on individual patient needs, preceded by a comprehensive medical, dental, and clinical assessment, considering environmental factors affecting oral health. Special consideration must be given to specific cases, such as infants, young children, individuals with disabilities, and those prone to gag reflexes. For infants under three years of age, it is advisable to use size 0 intraoral periapical films for exposures, as they can struggle with larger films, particularly for molar projections.[4] In such cases, parental assistance may be required, with both parent and child facing the same direction and the parent stabilizing the child's head. Patients with disabilities may benefit from using intraoral films with bitewing tabs attached to a length of floss for easy retrieval. The gag reflex can be managed through distraction techniques and, if necessary, pharmacological interventions like topical anesthetics.[5] In cases involving patients with a gag reflex, handicapped children, or young children, specific modifications in the positioning of the film or film holder are recommended. One such technique is the "reverse" bitewing, where the film is positioned in the buccal vestibule, and the X-ray beam is directed through the jaws from the opposite side of the patient's head. This modification can help reduce the discomfort and gag reflex sensitivity experienced by these patients during radiographic procedures, making the process more manageable and effective for diagnosis and treatment planning.[6] In cases where patients cannot cooperate with intraoral films, extraoral radiographs like panoramic or lateral jaw projections are employed.

This review delves into the intricate world of pediatric dental radiography, exploring safety measures, techniques, and diagnostic applications, with a focus on promoting both the optimal health of young patients and the minimization of radiation exposure.

LITERATURE SEARCH

This study is based on a comprehensive literature search conducted on November 2, 2023, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed pediatric dental radiography: safety, techniques, and diagnostic applications. There were no restrictions on date, language, participant age, or type of publication.

DISCUSSION

Intraoral radiography in pediatric dental practice

Intraoral radiography refers to a dental imaging technique where the image detector is positioned inside the patient's mouth while the X-ray machine is placed outside the mouth, directing X-rays towards the image detector. This setup allows for close proximity to the teeth, resulting in high-detail images with minimal distortion. Three main techniques are employed for intraoral radiographs: the parallel technique, the bisecting angle technique, and the occlusal technique. The parallel technique is preferred, when possible, as it ensures geometrically accurate images and is aided by image detector holders. The parallel technique is also used for bitewing radiographs (Figure 1).[7] The bisecting angle technique, while more challenging, can be an alternative when patients cannot tolerate parallel alignment, though it is less frequently used due to potential discomfort caused by image detector holders (Figure 2).[7] The occlusal technique, using photostimulable phosphor storage plates, is employed when neither of the previous methods is feasible and offers sufficient diagnostic quality. Different orientations, such as maxillary and mandibular occlusal views at various angles, can be utilized for specific diagnostic purposes. To protect the phosphor storage plates from damage, a simple technique involving wooden tongue depressors is recommended. These techniques ensure that pediatric patients receive the necessary radiographic evaluations with minimal discomfort and maximum diagnostic yield in dental practice (Figure 3).[7]

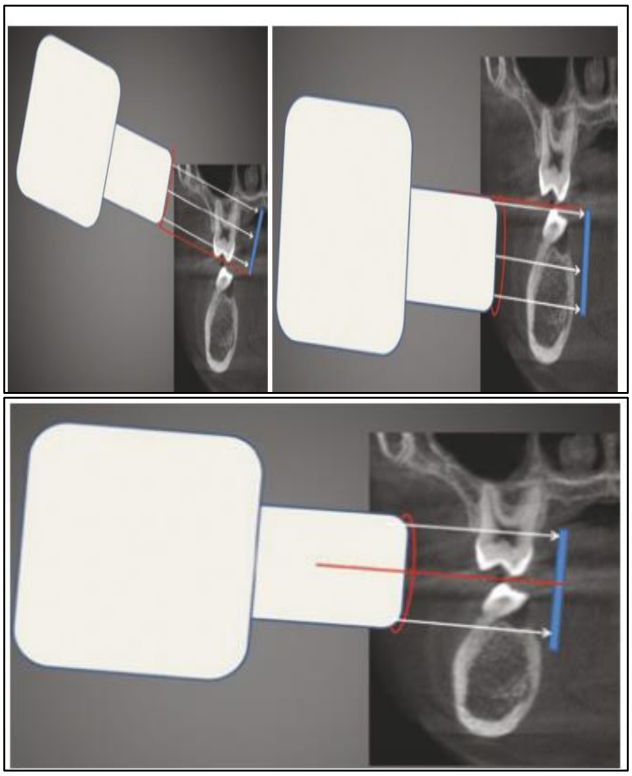

Figure 1: The parallel technique illustrated schematically for a maxillary (left) and mandibular (right) right molar and for a bitewing radiograph (bottom image).[7]

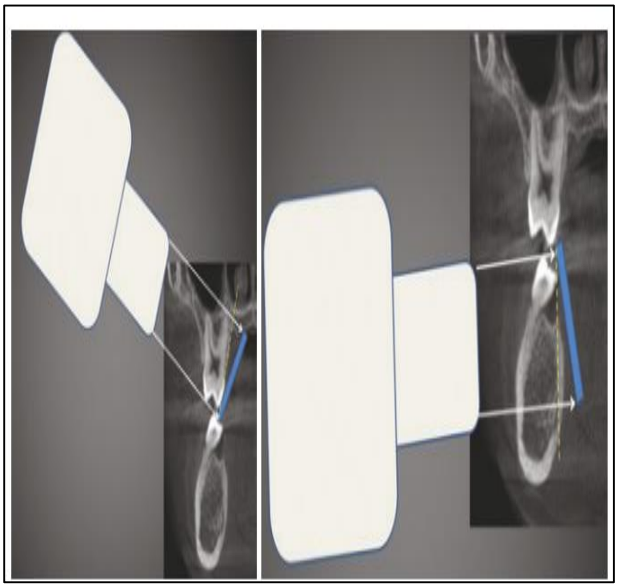

Figure 2: Schematic illustration of the bisecting angle principle in the maxilla (right) and mandible (left). The yellow dotted line represents the imaginary bisecting angle between the tooth and image detector.[7]

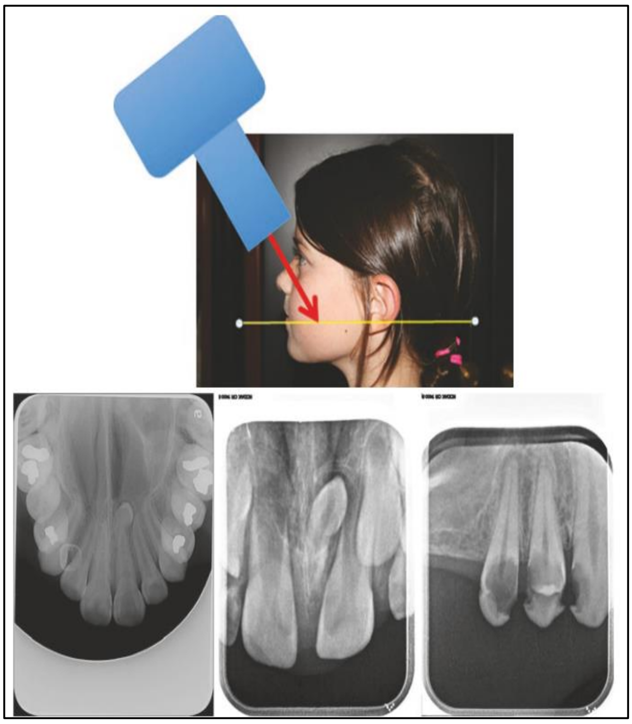

Figure 3: The standard occlusal technique illustrated (yellow line represents the occlusal plane, the red arrow the X-ray beam aimed through the bridge of the nose at a 65° angle with the occlusal plane). At the bottom three examples of occlusal radiographic images of the maxilla are shown: left-hand-side image is a size 4 plate, middle and right-hand-side image is a size 2 plate.[7]

Extraoral radiography in pediatric dental practice

Extraoral radiography plays a significant role in diagnostic imaging. This technique involves placing both the X-ray machine and the image detector outside the patient's mouth. Extraoral radiography should be used carefully, taking into account the specific diagnostic needs of each case while minimizing radiation exposure to young patients. Proper patient positioning, equipment calibration, and adherence to radiation safety principles are essential to obtaining high-quality images with the lowest possible dose. There are several methods for extraoral radiography, including panoramic imaging, cephalometric imaging, oblique lateral radiographs, and cone-beam computed tomography (CBCT).[7]

Panoramic imaging techniques**,** such as Panorex, orthopantomogram, and dental panoramic tomography, involve a synchronized movement of the X-ray source and image detector, both rotating in opposite directions around the patient's head. This dynamic process generates a focal trough, a distinctive three-dimensional horseshoe-shaped slice, encompassing the patient's jaws in sharp focus. To cater to different patient sizes, a vertical, narrow-slit X-ray beam can be adjusted accordingly for adult or pediatric settings. Precise patient positioning is paramount to achieving optimal imaging results, with consideration for the Frankfort horizontal plane alignment. Patients are typically instructed to bite in an end-to-end position and maintain closed lips with the tongue against the hard palate during exposure to reduce motion artifacts. Additionally, removing metallic objects and removable dental appliances is crucial to prevent interference or artifacts in the final image.[7]

Cephalometric imaging plays a vital role in orthodontic and orthognathic surgery planning. These radiographs are typically utilized for assessing facial and dental structures. To ensure precise imaging, a cephalostat is employed to correctly position the patient's head, and it is essential that the teeth are in occlusion during exposure to capture accurate anatomical relationships. There are different approaches to obtaining cephalometric images; some machines employ a one-shot technique, while others perform a scan of the entire skull. Regardless of the method used, accurate patient positioning is crucial for obtaining reproducible and clinically valuable results, aiding orthodontists and oral surgeons in treatment planning and evaluation.[7]

An oblique lateral radiograph is a specialized radiographic technique that utilizes a stiff cassette equipped with a phosphor storage plate in conjunction with an intraoral X-ray machine. During this procedure, the patient's positioning is essential; they are required to turn their head towards the side where the cassette is positioned, creating a keyhole effect for imaging. This technique serves as a valuable alternative when patients have difficulty tolerating other radiographic procedures, offering a less intrusive way to capture diagnostic images while ensuring patient comfort and cooperation.[7]

CBCT is a powerful imaging technique used in various medical and dental applications. It operates by emitting a conical X-ray beam and performing a single rotation around the patient's head, which results in the creation of a detailed three-dimensional image of the target area. One of the advantages of CBCT is its flexibility, as the field of view and resolution can be adjusted to match specific diagnostic requirements. To ensure the quality of the images, it is crucial to minimize patient motion during exposure to prevent artifacts that could affect the interpretation. CBCT offers precise measurements and allows for viewing in multiple planes, making it an invaluable tool in various medical and dental fields for accurate diagnosis and treatment planning.[7]

Additional imaging techniques in pediatric dental practice

Multislice computed tomography (MSCT) employs a slender X-ray beam in a fan-shaped configuration along with detectors to produce intricate cross-sectional body images. MSCT is ideal for both hard and soft tissue imaging, offering high-resolution images. However, it comes with a higher radiation dose compared to other imaging methods like panoramic radiography and CBCT. It is typically used in cases of severe trauma or systemic diseases affecting both hard and soft tissues.[7]

Hybrid imaging systems combine MSCT with other imaging modalities like positron-emission tomography (PET-CT) and single-photon emission computed tomography (SPECT-CT) to diagnose and monitor cancer. These systems involve the injection of radiopharmaceuticals, which emit radiation for scanning. The resulting images are merged with MSCT images to assess organ function and pathology.[7]

Magnetic resonance imaging (MRI) utilizes powerful magnetic fields and radio waves to generate precise images of the body's soft tissues. Unlike CT, MRI does not use ionizing radiation, making it safer for imaging soft tissue. It is commonly used in cases where soft tissue pathology or temporomandibular joint (TMJ) disorders affecting muscles and condylar discs are suspected. However, MRI can be noisy and restricted, requiring sedation for some pediatric patients.[7]

Ultrasonography, or echography, is an imaging modality that uses ultrasonic waves to visualize the body's internal structures. It does not involve ionizing radiation and is less expensive than an MRI or CT. Ultrasonography is useful for imaging salivary gland problems, muscular issues, and lymph node hypertrophy in pediatric dental cases. It requires a coupling agent such as gel for good contact and can vary in frequency to control penetration depth and resolution. Color Doppler can be used to visualize vascularization.[7]

These additional techniques are particularly useful in cases involving soft tissue pathology, trauma, or systemic diseases. However, their use should be judicious due to considerations of radiation exposure for MSCT and patient comfort for MRI.

Guidelines for radiographic exposures in children

As presented by the European academy for pediatric dentistry (EAPD) and the American academy for pediatric dentistry (AAPD), emphasize the importance of justifying the need for dental radiographs based on clinical findings and patient history. These guidelines stress the individualized approach to radiographic decisions, with a focus on high-caries-risk patients receiving bitewings every 12 months and low-caries-risk patients waiting up to 24-36 months.[7] Both organizations advocate for radiation reduction measures, such as the use of sensitive image detectors and rectangular collimation, to minimize radiation exposure to children. Additionally, initiatives like "The image gently alliance" have further contributed to raising awareness about reducing radiation dose in pediatric imaging without compromising image quality, underscoring the commitment to the safety and well-being of young patients in radiographic examinations.

Diagnostic applications

Diagnosis of dental caries and periodontal conditions

Bitewing radiographs play a crucial role in identifying proximal carious lesions, particularly in posterior teeth, where visual or tactile examination alone may miss a substantial portion of caries.[8,9] The American Academy of Pediatric dentistry recommends their use, especially when visual inspection is inadequate. These radiographs facilitate classification based on the extent and location of caries. Anterior occlusal radiographs are valuable for assessing caries in maxillary anterior teeth and selected primary molars, providing insights into the depth of caries involvement. Periapical radiographs are essential for evaluating root canal patency, furcation involvement, and pulp-treated primary molars. They are also indispensable in monitoring root resorption and assessing the development of permanent teeth. In permanent dentition, periapical radiographs aid in the diagnosis of conditions like granulomas and cysts, which can arise from long-standing pulpal infections. Additionally, extraoral radiographs, such as panoramic radiographs or computed tomography scans, become necessary when dental caries progresses to cause space infections, allowing for a comprehensive assessment of infection spread and enabling immediate and aggressive intervention. Overall, a combination of intraoral and extraoral radiographic techniques is instrumental in diagnosing and managing dental caries and associated conditions effectively.[3]

Diagnosis of trauma to primary and young permanent teeth

Diagnosing trauma to primary and young permanent teeth is crucial for providing appropriate treatment and ensuring optimal outcomes. Radiographs play a vital role in the diagnosis of traumatic dental injuries, as they can reveal injuries that may not be apparent through clinical examination alone.[10] For primary dentition, different types of injuries, such as intrusion, lateral luxation, fractures, and avulsion, may require specific radiographic assessments. In permanent dentition, various conventional and two-dimensional radiographic images and angles are recommended to assess injuries, including enamel and dentine fractures, pulp exposure, crown-root fractures, root fractures, alveolar fractures, and more.[11] CBCT can also be valuable in certain cases to visualize the direction of fractures in relation to marginal bone and assess crown and root ratios. Reimplantation following avulsion is critical consideration, and radiographs are essential for evaluating the socket's patency and the tooth's position before and after reimplantation. Delayed reimplantation can lead to ankylosis and infra-occlusion, emphasizing the need for regular clinical and radiographic follow-ups to monitor progress and determine appropriate treatments.[12] Extra and intraoral radiographic imaging techniques are recommended based on patient's age, dental development stage, and nature of trauma, with parallel images and positioning devices for consistent measurements and accurate assessments. Cases involving midfacial fractures, panoramic radiographs/ alternative projections may be necessary, while periapical/occlusal radiographs with different angulations are recommended for detecting root/alveolar bone fractures.[3]

Diagnosis of common oral pathologies in children

Odontogenic cysts, such as radicular cysts, dentigerous cysts, buccal bifurcation cysts, and odontogenic keratocysts, often manifest radiographically as well-defined, unilocular radiolucencies with specific characteristics, including location and size.[13] Radicular cysts, commonly found in nonvital permanent teeth, exhibit features consistent with adult cases. Dentigerous cysts, which usually relate to permanent dentition, are identified based on the distance between the tooth crown and cortex. Buccal bifurcation cysts, affecting young children, present as well-defined radiolucent areas around the roots of affected teeth, often leading to delayed eruption and swelling. Odontogenic keratocysts, typically seen in young adults, appear as unilocular radiolucencies with scalloped borders around tooth roots.[14]

Nonodontogenic cysts, like the nasopalatine canal cyst, are characterized by well-defined radiolucencies in the anterior maxilla, impacting the central incisor roots occasionally.[15] Benign tumors, including odontomas, odontogenic myxomas, and benign cementoblastomas, exhibit distinct radiographic features, such as radiopacity or radiolucency, and may involve adjacent structures.[3] Hemangiomas and ameloblastomas, although less common, have unique radiological presentations. The radiographic image of hemangioma may show different patterns, appearing either as a single or multi-chambered structure with varying levels of translucency. The border of the lesion can range from being unclear, resembling a malignant tumor, to clearly defined. Within the tumor, there may be linear bony structures arranged in a manner reminiscent of spokes radiating from the center to the edge. This condition can lead to tooth resorption as well as the enlargement or premature eruption of developing teeth. When lesion affects the inferior alveolar canal, it causes an enlargement of the canal.[16] Ameloblastomas are predominantly found in posterior regions of the maxilla and mandible, with a higher prevalence in the mandible, accounting for over 80% of cases. While they are commonly observed in adults, they can also affect teenagers and young adults. These tumors exhibit slow growth and local invasiveness.[17] Radiographically, they often appear as multilocular radiolucencies, although unilocular lesions are more commonly seen in children, often coinciding with unicystic ameloblastoma. It is worth noting that radiographic findings may not always align with specific histologic type of ameloblastoma.

Malignant tumors encompass two distinct conditions

Ewing sarcoma, a relatively uncommon tumor, typically arises in long bones but can manifest in the jaw during a person's second decade of life, with tendency for posterior mandibular region. Radiographically, it appears as poorly defined, radiolucent lesion lacking clear boundaries. Bone destruction occurs irregularly, and periosteal reactions can manifest as onion peel appearance, sunburst/spiculae patterns/triangular lifting of the periosteum. Radiological assessments also reveal displacement/damage to unerupted tooth follicles, irregular tooth eruptions, loss of lamina dura, root resorption, tooth eruption anomalies, widened canals, and more.[18]

Acute lymphocytic leukemia presents with distinct panoramic radiograph changes in 63% of affected children, encompassing cancellous bone loss, trabeculation and lamina dura reduction, thickened periodontal spaces, crypts of developing teeth thinning, tooth displacement, mental foramen enlargement, periosteal new bone formation, and the disappearance of the mandibular canal's radiopaque border. Most commonly, these alterations affect the molar and premolar regions of the maxilla and mandible, with these radiographic changes attributed to both the disease's activity and the impacts of anticancer chemotherapy.[19]

Bone disorders like simple bone cysts, fibrous dysplasia, and cemento-ossifying fibromas are typically identified based on their radiographic appearance, including the presence of radiolucencies, ill-defined borders, and their impact on tooth displacement. Paranasal sinus abnormalities are often assessed in growing children, with normal development considered until puberty. Understanding normal sinus development is essential for distinguishing pathologic conditions.[3]

Evaluation of the TMJ and related abnormalities requires various imaging techniques, including MRI, CT/CBCT, plain radiographs, and ultrasound scans. These imaging modalities help in assessing both osseous and soft tissue changes in the TMJ region. Accurate diagnosis is particularly crucial in cases of juvenile idiopathic arthritis, where subclinical inflammation can be identified early to prevent TMJ destruction.[20]

Salivary gland-related abnormalities may also affect pediatric patients, necessitating imaging techniques like Doppler sonography, CT, and MRI for diagnosis. A thorough understanding of normal salivary gland development, anatomy, and imaging appearance at different ages is vital for distinguishing normal variants from pathologic conditions.[21]

Diagnosis of common developmental anomalies in children

These anomalies can broadly be categorized into anomalies in number, anomalies in size and shape, and anomalies in eruption patterns.

Anomalies in number encompass conditions like hyperdontia, hypodontia, oligodontia, and anodontia, which involve variations in the number of teeth. Hyperdontia, characterized by supernumerary teeth, can lead to complications such as delayed eruption or impaction of permanent teeth, dentigerous cyst formation, or root resorption. Radiographic assessment, preferably using CBCT, aids in accurate localization and planning for surgical extraction. Conditions like cleidocranial dysplasia, Crouzon syndrome, and Gardner syndrome may present with hyperdontia as one of their oral characteristics. Hypodontia, oligodontia, and anodontia, on the other hand, refer to the absence of teeth to varying degrees. These conditions may be associated with genetic mutations and are often diagnosed through clinical examination and radiographic evaluation, with treatment planning tailored to the specific patient's age and the number and location of missing teeth.[3]

Anomalies in size and shape include conditions like dens invaginatus and dens evaginatus. Dens invaginatus, characterized by an in folding of enamel and dentin during tooth development, can affect teeth such as the maxillary lateral incisor and central incisors. Radiographic examination, including periapical radiographs, helps diagnose these lesions, with CBCT providing a more detailed assessment.[22] Dens evaginatus, a tubercular structure extending from the tooth's surface, is commonly found on the mandibular second premolar and other posterior teeth. Radiographic imaging aids in early diagnosis and treatment planning.

Fusion and gemination are conditions that can affect tooth morphology. Fusion results from the partial union of two different dental germs, while gemination is the incomplete division of a single dental germ. Radiographically, these conditions can have distinct features that impact treatment decisions.

Anomalies in eruption patterns can lead to malocclusion and tooth loss. Ectopic eruption, often seen in first permanent molars, can be identified through radiographic examination and may require intervention based on the degree and severity of resorption. Impacted maxillary canines, present in a small percentage of the population, may be diagnosed when there is a missing or peg lateral or palpation of the canine's bulge is not possible. Radiographic assessment, including panoramic or periapical images, aids in the diagnosis of these anomalies, with treatment recommendations depending on the patient's age and specific radiographic findings.

CONCLUSION

In pediatric dentistry, the importance of radiographic examination alongside clinical assessment cannot be overstated. Commonly prescribed for diagnosing dental caries and evaluating growth and development, dental practitioners must exercise caution regarding radiation exposure. Adhering to established guidelines based on age and dental development stages is vital. Dental anomalies are often incidentally discovered through systematic radiographic evaluation. For traumatic dental injuries and complex cases like cysts and tumors, timely referral to specialists is essential for proper management.

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