Universidad Europea

GRADUATION PROJECT

Degree in Dentistry

PROTCOLS FOR PRESCRIBING RADIOGRAPHIES IN PEDIATRIC DENTISTRY

Madrid, academic year 2024/2025

Identification number: 136

RESUMEN

Introducción: La imagen radiográfica es una herramienta clave en odontopediatría para identificar caries, alteraciones del desarrollo y traumatismos no siempre evidentes clínicamente. Debido a la mayor radiosensibilidad infantil, es fundamental aplicar protocolos que reduzcan la exposición sin comprometer la calidad diagnóstica; **Objetivos:** Evaluar y comparar las guías internacionales actuales sobre la prescripción de radiografías en pacientes pediátricos, con especial enfoque en caries y traumatismos dentales; **Materiales y Métodos:** Se realizó una revisión sistemática de la literatura en PubMed, Medline y Dentistry & Oral Science Source, incluyendo publicaciones entre 2000 y 2023. Se analizaron 27 fuentes, entre artículos científicos, libros y documentos oficiales de asociaciones como ADA, AAPD, EAPD y SEOP; **Resultados:** Las guías coinciden en la necesidad de una evaluación individualizada y en la aplicación del principio ALARA. Sin embargo, existen variaciones en la frecuencia recomendada, las técnicas utilizadas y la interpretación de las imágenes. Para caries, los intervalos varían entre 6 y 36 meses según el riesgo; en traumatismos, el IADT propone protocolos específicos según el tipo de lesión; **Discusión:** A pesar de la existencia de recomendaciones bien definidas, su aplicación clínica varía según la experiencia profesional, la formación recibida y las particularidades del paciente. La incorporación de tecnologías como la radiografía digital y el CBCT mejora el diagnóstico, pero requiere un uso prudente en niños; **Conclusión:** Es necesario estandarizar la aplicación de los protocolos, reforzar la formación profesional y promover el uso responsable de las innovaciones tecnológicas para garantizar una imagenología pediátrica segura, eficaz y adaptada a cada caso.

PALABRAS CLAVE

Odontología, Radiografías, Odontopediatría, Guías, Rayos X.

ABSTRACT

Introduction: Radiographic imaging is a key diagnostic tool in pediatric dentistry, essential for detecting caries, developmental anomalies, and traumatic injuries that are not always visible during clinical examination. Given children's increased sensibility to radiation, strict adherence to evidence-based protocols is necessary to minimize radiation exposure while maintaining diagnostic accuracy; **Objective:** This study aimed to evaluate current international guidelines for prescribing radiographs in pediatric patients with a focus on caries and trauma; **Materials & methods:** A systematic literature review was carried out using databases such as Medline, PubMed, and Dentistry & Oral Science Source, including studies and official recommendations published between 2000 and 2023. A total of 27 sources from books, articles and publications from associations such as the ADA, AAPD, EAPD, and SEOP were analyzed qualitatively; **Results:** It was shown that radiographic protocols vary by patient age, caries risk, and trauma severity. While all guidelines emphasize individualized assessment and ALARA principles, discrepancies exist in imaging frequency, technique, and interpretation. For caries detection, intervals range from 6 to 36 months depending on risk level. In trauma cases, protocols from the IADT recommend specific follow-up schedules based on injury type; **Discussion:** Despite comprehensive guidelines, variations in clinical application persist due to practitioner experience, training, and patient-specific factors. Emerging technologies like digital radiography and CBCT enhance diagnostic capabilities but require careful use in children; **Conclusion:** This study highlights the need for standardized implementation of protocols, enhanced clinician education, and responsible integration of new technologies to ensure safe and effective pediatric imaging.

KEYWORDS

Dentistry, radiographies, pediatric, guidelines, X-ray.

TABLE OF CONTENTS

1. INTRODUCTION

Pediatric dentistry plays a crucial role in the oral health of children, ensuring the normal development of their teeth and jaws. One of the essential diagnostic tools used in pediatric dentistry is radiography. X-ray imaging is very important for assessing various oral health conditions that are not always visible during clinical examination, such as cavities, developmental anomalies, periodontal diseases and traumatic injuries.

This introduction provides a comprehensive overview about general radiography in pediatric dentistry. It addresses the definition of x-rays and its basic principles, how its use has evolved in the course of time, categorizes the types of radiographic techniques relevant to pediatric dentistry, emphasizes the potential dangers of prolonged radiation exposure with a focus on the protection measures, examines different technological advances that have impacted radiography, and finally, investigates ongoing debates surrounding its use.

1.1 Definition of X-rays and basic principles

X-rays are a form of electromagnetic radiation with wavelengths ranging between 0.01 to 10 nanometers, positioning them between ultraviolet rays and gamma rays on the electromagnetic spectrum (1).

X-rays possess the unique ability to penetrate various structures depending on their density and composition. This property makes them very important in medical and dental imaging, as they can reveal the internal structures of the body, especially bones and teeth, by creating contrast in radiographic images (1).

The basic principles of X-rays involve their production and interaction with matter. X-rays are generated when high-energy electrons collide with a metal target (tungsten) inside the X-ray tube, releasing energy in the form of heat and X-ray photons. The photons leave the tube as a beam that is aimed at the receptor inside the patient's mouth by a position indicating device (PID) (1). These rays are absorbed at different rates by different tissues: denser tissues like bone take in more X-rays, therefore displaying more radiopacity on radiographs. Soft tissues on the contrary allow more rays to penetrate through them, showing radiolucency areas on the image (2). X-ray machine calibration is usually performed to make sure that the machine is operating effectively, parameters such as the kilovoltage, milliamperage, tube head stability are routinely checked by a competent technician (1).

Inside the X-ray tube we find both a cathode and an anode located within a depressurized glass shell, for the production of X-rays, a beam of electrons travel directly from the tungsten coil to reach a target point in the anode, the energy produced by the electrons upon reaching the target is partially transformed into X-rays (2).

The cathode consists of a metal filament which is the emitter of electrons in the X-ray machine. The filament is made of tungsten and contains 1% of thorium that highly increases the release of electrons, it is heated to a luminescence level by constant continuous low voltage energy and electrons are produced proportionally to the filament's temperature (2).

Inside the X-ray tube, the anode has a tungsten impact site coated by a chunk of copper metal which helps cooling the tungsten by heat dissipation, it measures approximately 0.8mm X 1.8mm greatly reducing its risk of melting. All modern X-ray machines have the same target size and of all the energy produced by the collision of electrons at the anode, only less than 1% is X-ray energy and what is left is dissipated in the form of heat (1,2).

1.2 Historical events on the use of dental X-rays

In 1895, German physicist Wilhelm Conrad Roentgen discovered X-rays while experimenting with cathode rays. He noticed that these rays could pass through various objects and create images on photographic plates, revealing the internal structures of the objects being exposed (3). Since then, dental professionals rapidly recognized the importance of radiography for visualizing internal structures of the teeth and surrounding tissues. However, in the early years, there was little to no awareness of the potential dangers of radiation, and radiographic examinations were carried out without standardized protocols.

In the mid-20th century, the emergence of radiographic safety standards marked a key point, driven by concerns about radiation exposure and its potential health effects. Organizations such as the International Commission on Radiological Protection (ICRP) and the American Dental Association (ADA) started implementing general guidelines to control the use of radiography in dental practice. In 1981 the American academy of pediatric dentistry (AAPD) published its first specific protocol for pediatric patients as the understanding of children's high sensitivity to radiation improved (4,5).

By the late 20th century, based on clinical research and technological advances in radiographic equipment, pediatric radiographic protocols had become clearer and more comprehensive. The introduction of digital radiography in the 1980s and early 1990s, enabled reductions in radiation exposure and improved image quality (3,6), leading to revisions and updates of current guidelines. Today, protocols continue to evolve, reflecting advancements in both technology and research on the risks and benefits of radiographic imaging for young patients.

1.3 Types of Radiographic Techniques in Pediatric Dentistry

In dentistry, among the most used radiographs, there are two main groups: intra-oral x-rays and extraoral x-rays.

1.3.1 Intra-oral x-rays

1.3.1.1 Bitewing x-rays

Bitewing X-rays show the crown and a portion of the roots of upper and lower teeth as well as the alveolar crest to detect interproximal cavities, monitor bone health and check previous restorations (2).

1.3.1.2 Periapical x-rays

Periapical X-rays, which captures the entire tooth to check for roots, bone issues and periapical inflammatory reactions such as abscesses at the root tip or in the surrounding bone, in pediatric cases, periapical radiographs are frequently used for specific dental issues rather than routine screening. For Periapical X-rays there are two projection techniques that can used: the long cone or paralleling technique and the short cone or bisecting technique, these techniques can be used for both digital and film-based imaging (1,2).

In the long cone technique, the sensor is put in parallel with respect to the tooth's vertical surface, while the X-ray tube is placed towards the sensor and the tooth in perpendicular way. This positioning reduces the risk of image distortion giving a representation of the tooth and its surrounding structures in their true dimensions (2). This technique is considered to be the gold standard method for its precision and reliability.

In the bisecting angle technique, the film or sensor is positioned the closest possible to the tooth's internal surface inside the mouth, the x-ray beam is then placed following an angle that bisects an imaginary line made by the sensor and the tooth's vertical surface, this technique is usually performed when it is very difficult or impossible to perform the parallel technique in cases of shallow palate, presence of torus or for patients with high gag reflexes (1,2).

1.3.1.3 Occlusal x-rays

Occlusal X-rays are an imaging technique that presents an expanded visualization of the dental arch, capturing either the palate or the floor of the mouth. This type of radiograph is particularly useful for patients who have limited mouth opening or situations where taking a periapical X-ray is not possible. they are commonly used to identify dental abnormalities, locate foreign objects, and detect supernumerary teeth (2). they can also play a role in evaluating the salivary glands, cleft palate and assessing buccal bone expansion (1).

1.3.2 Extra-oral x-ray

1.3.2.1 Panoramic x-ray

Panoramic X-ray, also called orthopantomogram (OPG) is an imaging technique that captures the mandibular and maxillary bones, showing the teeth and alveolar arches in a curved fashion and in a single view (1,2). During this x-ray procedure, the patient is standing in an upright position while the x-ray tube and the image receptor are rotating around the patient's head. OPG x-rays are mostly used to evaluate conditions involving the jaws as a whole, helpful for assessing tooth position especially third molars, traumas and fractures, teeth development in mixed dentitions, as well as bone density (2).

The advantages of panoramic x-rays include patient cooperation, simplicity and no significant increase in radiation doses in comparison to a periapical x-ray, especially in the case of a digital panoramic x-ray. However, the disadvantages are bad image quality, frequent overlapping issues especially in the premolar region (1).

1.3.2.2 Lateral skull projection

The lateral skull projection provides a general view of the skull in the sagittal plane, where both the right and left sides appear superimposed (1). Cephalometric projections, a specific type of standardized imaging, are used to obtain consistent and repeatable views of the craniofacial region (1). These radiographs are taken with a long distance (around 5 feet) between the X-ray source and the patient to reduce distortion, while the gap between the patient and the image receptor, typically 10 to 15 cm, remains constant to ensure comparability across multiple images (2). Whether captured on film or using digital technology, cephalometric images allow for the identification of key skeletal, dental, and soft tissue landmarks. These reference points are crucial for tracing anatomical lines, planes, angles, and distances, which help in analyzing craniofacial structure and diagnosing or planning treatment in orthodontics and maxillofacial surgery (1,2).

1.3.2.3 Cone-beam computed tomography

CBCT (Cone Beam Computerized Tomography) is an advanced type of medical imaging, it has the ability to capture detailed three-dimensional images of the body. Unlike the classic Computerized Tomography scan, the CBCT gives a 3D general view of the teeth and jaws, has significant lower radiation doses but still higher than a traditional x-ray, has a cone-shaped x-ray beam rather than a helical one like the CT. As the CT achieves a better contrast in soft tissues, it is mainly used for full body imaging like brain, lungs or abdomen whereas the CBCT is mainly specifically reserved for dentistry and oral surgery (1). The CBCT consists of a cone that rotates around the head of the patient capturing multiple images at different angles, during the rotation, multiple images called “multiplanar” images are captured and are then are software processed to produce a very high-resolution 3D image (2).

In this section we have explained that there is a variation of radiological techniques that can be used in pediatric dentistry, each one having its characteristics, indications and limitations that have to be known and understood in order to justify their use.

Furthermore, subtle attention is required when using radiography in children, as they are more sensitive to ionizing radiation than adults (7).

This makes the establishment of precise protocols for prescribing radiographies in pediatric dentistry not only necessary but also ethically responsible.

1.4 Dangers of prolonged radiation exposure in children

Radiation exposure is particularly risky for children due to their developing bodies and longer lifespan, which can have both immediate and long-term effects (6). Because children’s cells are rapidly dividing, they are more susceptible to radiation-induced DNA damage (8). This phenomenon is much of a concern for children as they have higher proportions of bone marrow in their skulls in comparison to adults, which means that continuous and repeated exposition to x-rays can increase the risk of cancer over time (8). When X-rays or gamma rays go through the body, they have sufficient energy to ionize atoms, significantly altering very complex molecular structures. This ionization process can affect the chemical bonds in DNA, resulting in various forms of damage such as mutations.

There is also strong evidence that, apart from individual genetic susceptibility to cancer, there was a direct relationship between DNA alterations in single cells and the risk of developing cancer (2,9).

When DNA is damaged, the cell initiates a repair process to restore its original structure. However, if repair processes are incomplete or incorrect, the cell may acquire mutations. Over time, these mutations can accumulate, disrupting the normal regulatory mechanisms that control cell division and function which can cause cancer (4,9).

In radiation-induced effects there are two main categories: stochastic effects and deterministic effects. Deterministic effects are dose threshold related, which means that they only occur when the radiation dose exceeds a certain threshold whereas the stochastic effects do not have a dose threshold, they can be caused by any dose of radiation even the lowest possible (2,10).

In the stochastic effects, x-ray photons have the ability to alter the composition of complex structured molecules causing DNA mutations and even the lowest radiation dose can manifest this phenomenon, the DNA damage is directly proportional to the radiation dose, the higher the dose the more damage the DNA will suffer (10).

Stochastic effects are responsible of causing cancers, such as leukemias especially in children after long exposure of the bone marrow to radiation, thyroid cancer, salivary gland tumors (2,11).

For the deterministic effects, they only occur when radiation to tissue or organs reach a certain threshold, below this limit, the expected effects do not happen. Additionally, these effects can cause direct damages to cell such as mitotic death for example. Body organs vary in their sensitivity to ionizing radiation with ones being more radiosensitive than the others for example, lymphocytes or serous acini cells of the salivary glands are to a notable extent very radiosensitive. Even though they do not divide rapidly, when they receive high radiation doses, a programmed cascade of events that causes the quick death of cells start within hours after exposure (2,11).

1.5 Radioprotection measures.

During X-ray examinations for pediatric patients, several protective measures are essential to minimize radiation exposure. The use of a lead apron is used in standard practice, shielding most of the patient's body from scatter radiation and should be appropriately sized for children. In addition, a thyroid collar is highly recommended, as the thyroid gland is particularly sensitive to radiation, especially in young patients (2).

The radiation exposure can be significantly reduced by using digital sensors and intensifying screens reducing the exposure by up to 90% (1). Another way of minimizing radiation exposure is the use of rectangular collimation as it narrows the X-ray beam to the size of the receptor, thereby reducing exposure by up to 60% compared to traditional circular collimators (2).

Beam filtration also has been proven useful in exposure reduction, it uses aluminum filters and helps eliminate low-energy X-rays that contribute to unnecessary dose as they are not improving image quality. Finally, proper patient positioning and technique is also very important to prevent errors and retakes, which would increase cumulative radiation (1).

Pediatric protocols also insist on equipment settings to be set on lower doses, with shielding Tools like lead aprons to protect sensitive areas. Understanding these risks is essential to protecting children's health during necessary imaging procedures.

Research have shown that in CBCT radiographs, when the same dose is administered to both children and adults, the thyroid gland in children absorbs nearly four times more radiation. This increased exposure is due to differences in anatomy, making children more vulnerable to radiation effects (12).

That is why protocols for CBCT in pediatric dentistry emphasize careful case selection to make sure that the benefits of three-dimensional imaging are higher than the risks associated with increased radiation.

1.6 Advances in Radiographic Technology.

Modern innovations and technological advances have significantly influenced radiographic protocols in pediatric dentistry, leading to improvements in both safety and diagnostic capabilities. The technological shift from conventional film-based radiography to digital radiography has been particularly impactful, giving many advantages such as low-dose exposure, quicker imaging process, and improved image quality (5).

Digital sensors are more sensitive than traditional film which allows very good diagnostic imaging at reduced exposure levels by 40% to 60 % (5). Furthermore, digital images can be optimized and easily manipulated on computer software to improve diagnostic accuracy, reducing the need for retakes and additional exposure.

Artificial intelligence (AI) and machine learning are also coming out as promising tools in radiographic analysis, greatly allowing improved diagnostic accuracy and more personalized protocols. AI algorithms can assist in identifying carious lesions, predicting growth patterns and even detecting developmental anomalies, thereby efficiently helping practitioners make more informed decisions about the need for and type of imaging (13).

1.7 Controversies and Debates Surrounding Pediatric Radiographic Protocols

The balance between obtaining good diagnostic data and minimizing radiation exposure in children underline the importance of following standardized Protocols and Guidelines. Since 1981, various dental and medical organizations, such as the American dental association (ADA) and the European Academy of Pediatric Dentistry (EAPD), have introduced recommendations and protocols following the principle “As low as reasonably possible” (ALARA) for the use of radiographic imaging in pediatric patients (5,8).

These guidelines help professionals determine when radiographs are needed, the type of radiographic examination that is best suited for the case, and how often can they be repeated.

Despite the advances and clear benefits of radiographic protocols in pediatric dentistry, there remains considerable debate surrounding their application. A primary point of controversy is the appropriate frequency of radiographic exams, particularly for children at higher risk of dental caries (14). While some experts argue for regular screening to enable early diagnosis and intervention, others say that frequent exposure, even at low doses, could have cumulative effects on children’s health over time (4,6). The potential long-term consequences of repeated low-dose radiation exposure, especially in pediatric patients, are not yet fully understood, calling for a more conservative use of radiography.

Another area of debate involves the use of CBCT in pediatric patients. Although CBCT can provide very valuable diagnostic information in certain complex cases, its use in children is highly controversial due to the high radiation dose compared to conventional radiographs. According to some experts, the choice to use CBCT should carefully balance the potential benefits with the associated risks since it produces 10 to 15 the dose of a traditional radiography, and opinions vary on whether its routine inclusion in pediatric dental protocols is justified (6).

That is why protocols for CBCT in pediatric dentistry emphasize careful case selection to make sure that the benefits of three-dimensional imaging are higher than the risks associated with increased radiation.

Despite the availability of guidelines, the practical application of these protocols in clinical settings can be different, influenced by many factors such as clinician experience, patient cooperation, and the technological advancements in radiographic equipment. Additionally, advancements in digital radiography have significantly reduced radiation doses in comparison to traditional methods (6).

These technological improvements raise questions about whether current protocols are still up to date with modern practices, or if revisions are needed for better diagnostic efficacy and patient safety in a pediatric setting.

2. OBJECTIVE

This Project aims to explain what are the current protocols and guidelines for prescribing radiographies in pediatric dentistry, to understand what are the main common points and differences between them for trauma and caries diagnosis.

It will assess what are the limitations and drawbacks for the implementation of these guidelines in the current practice and the different proposed strategies to promote their application.

3. MATERIAL AND METHODS

To guide and structure this study, the following PICO question was formulated.

P: In pediatric dental patients requiring radiographic examination,
I: does adherence to specific prescribing protocols (ADA/FDA guidelines),
C: compared to non-standardized or discretionary radiographic practices,
O: reduce unnecessary radiation exposure while maintaining diagnostic efficacy

This review aimed to assess protocols for prescribing radiographs in pediatric dentistry, emphasizing radiation safety and diagnostic utility. A systematic search was conducted in PubMed, Medline, Dentistry & oral science source, as well as official articles published by different dental associations worldwide from 2000 to 2023 using keywords like 'pediatric dentistry,' 'dental radiographs,' and 'radiation safety.' Inclusion criteria encompassed guidelines and studies discussing radiographic prescriptions in children aged 0–18. Exclusion criteria were studies published before 2000 and on adult patients older than 18 years old. The research screened studies, extracted data on imaging types and protocols and compared guidelines from major dental associations. Findings were synthesized qualitatively, and the study followed PRISMA guidelines.

4. RESULTS

The search followed PRISMA guidelines using three databases like Medline, PubMed and Dentistry & oral science source, keywords such as “Protocols”, “Guidelines”, “Radiography”,” Pediatric dentistry” were used to conduct the search, roughly 400 reports were given by the databases, which 38 were selected based on their titles and abstracts. Other reports were directly extracted from organizations official websites such as American dental association (ADA), American academy of pediatric dentistry (AAPD), European academy of pediatric dentistry (EAPD), New-Zealand dental association (NZDA).

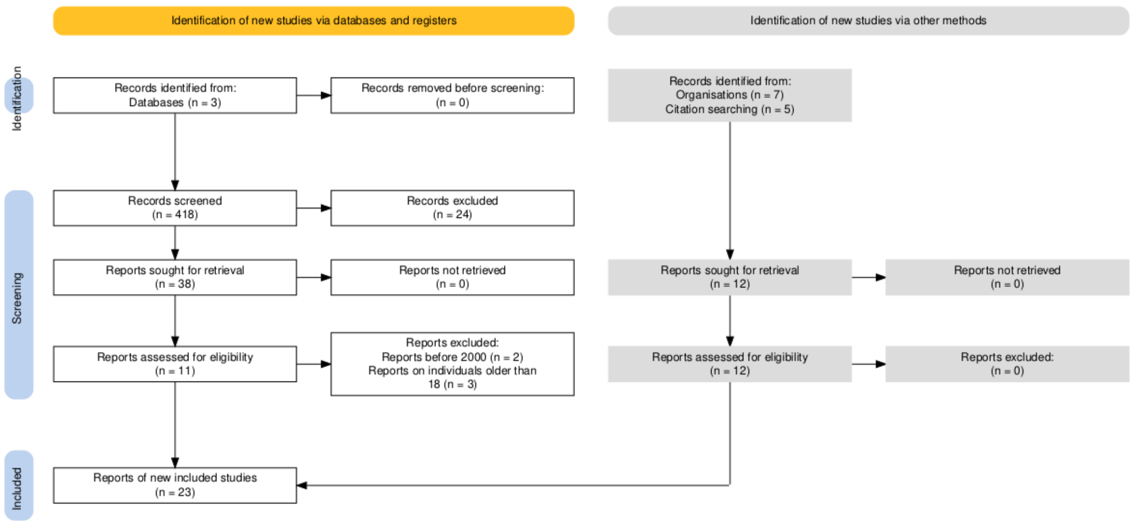

Table 1: This PRISMA flowchart illustrates the selection process of studies included in the review, detailing the identification, screening, and eligibility assessment of 418 records from databases and 12 additional sources, resulting in the selection of 23 studies (15).

These articles underline the relevance of using evidence-based guidelines in dental radiography. They highlight how systematic reviews and expert opinion help reduce errors in clinical practice Organizations such as the American Academy of Pediatric Dentistry (AAPD), the American Dental Association (ADA), The faculty of General Dental Practice (FGDP), New Zealand dental association (NZDA), the European association of pediatric dentistry (EAPD) and the Spanish association of pediatric dentistry (SEOP) recommend radiographic assessment basic on individual factors such as caries risk, clinical examination findings and developmental stage (5), (8), (14), (16), (17).

According to these organizations the prescription of bitewing radiographs should follow individual patient risk levels, with high-risk patients requiring more frequent assessments than those at low risk (14), (17).

4.1 Protocols to perform radiographs

In pediatric dentistry we can find protocols for caries and trauma which will be explained separately in this section.

4.1.1 For caries in children

- **According to Caries Risk (AAPD 2023)**

Table 2: recommended radiographic examination intervals for children and adolescents, organized by dentition stage (primary, mixed, and permanent) and caries risk classification (low, moderate, high) (18).

Classification	**Children with Primary Dentition (until eruption of first permanent molar)**	**Children with Mixed Dentition (after eruption of first permanent molar)**	**Adolescents with Permanent Dentition (until eruption of third molar)**
Low Risk	Radiographs every 12–24 months	Radiographs every 12–24 months	Radiographs every 18–36 months
Moderate Risk	Radiographs every 6–12 months	Radiographs every 6–12 months	Radiographs every 12–24 months
High Risk	Radiographs every 6 months	Radiographs every 6 months	Radiographs every 6–12 months

- **According to Visit and Caries Risk (ADA 2012)**

Table 3: Radiographic guidelines for children and adolescents based on dentition stage and clinical context, indicating appropriate imaging types and frequencies for new patients, those at increased caries risk, and those at low risk (5).

Classification	**Children with Primary Dentition (until eruption of first permanent molar)**	**Children with Mixed Dentition (after eruption of first permanent molar)**	**Adolescents with Permanent Dentition (until eruption of third molar)**
New Patient	Individual radiographic exam, selecting periapical/occlusal and/or bitewings if posterior surfaces are not visible or cannot be probed. Patients without disease signs and with open interproximal contacts may not require radiographs.	Radiographic exam using posterior bitewings and optionally panoramic or periapical images.	Individual exam using posterior bitewings plus panoramic or bitewing with selected periapical areas.

Recall with Clinical Caries or Increased Risk	Bitewing radiographs every 6–12 months if interproximal surfaces are not visible.	Bitewing radiographs every 6–12 months if interproximal surfaces are not visible.	Bitewing radiographs every 6–12 months if interproximal surfaces are not visible.
Recall with No Caries and No Increased Risk	Bitewing radiographs every 12–24 months if interproximal surfaces are not visible.	Bitewing radiographs every 12–24 months if interproximal surfaces are not visible.	Bitewing radiographs every 18–36 months.

- **According to Lesion Severity (EAPD 2020)**

Table 4: Recommended radiographic intervals based on caries severity and dentition stage, indicating when imaging is appropriate for patients ranging from primary to permanent dentition (8).

Classification	Children with Primary Dentition (until eruption of first permanent molar)	Children with Mixed Dentition (after eruption of first permanent molar)	Children/Adolescents with Permanent Dentition (until eruption of third molar)
No caries	Not indicated.	Not indicated.	Every 3–5 years.
Caries limited to enamel	Every 2–3 years.	Not indicated.	Every 2 years.
Caries reaching the amelodentinal junction	Every 12 months.	Every 12 or 24 months.	Every 12–24 months.
Caries in the outer third of dentin	Every 12 months.	Every 12 months.	Every 12 months.

The ADA 2012 radiographic recommendations are based on patient type and caries risk. For new patients, the type of radiograph varies by age and dentition: young children may need periapical/occlusal or bitewing images if posterior surfaces are not visible, while older children, adolescents, and adults typically require bitewings and panoramic or selected periapical radiographs.

For patients with clinical caries or increased risk, bitewing radiographs are advised every 6–12 months in children, adolescents, depending on the ability to visually or tactilely assess interproximal surfaces.

For low-risk patients without caries, the recommended intervals are longer: 12–24 months for young children, 18–36 months for adolescents (5,14).

The AAPD 2023 guidelines for radiographic frequency in pediatric patients are based on their caries risk level. For children with temporary or mixed dentition, radiographs are recommended every 12–24 months, if the caries risk is low, every 6–12 months if the risk is moderate, and every 6 months if the risk is high. The same intervals apply to adolescents with permanent dentition, ensuring early detection and management of carious lesions tailored to the patient's individual risk profile (14,18).

The EAPD 2020 recommends intervals for taking radiographic dental images based on both the severity of carious lesions and the patient's age and dental development stage. For children with temporary dentition, no radiographs are indicated if no caries are present, while images are recommended every 12 months if lesions reach the enamel-dentin junctions or the outer third of the dentin.

In mixed dentition, radiographs are not indicated when lesions are absent or when they only reach the enamel. However, radiographs should be prescribed every 12 to 24 months when caries reaches the enamel-dentin junction and every 12 months when caries reach the external third of the dentin.

For children or adolescents with permanent dentition, intervals vary from 12 months to 3–5 years depending on caries presence and depth. In the absence of caries, radiographs should be prescribed every 3 to 5 years, when caries reach the enamel, a radiograph should be taken every 2 years, for lesions reaching the enamel-dentin junction a radiograph should be prescribed every 12-24 months and for deep caries reaching the external third of the dentin, a radiograph should be prescribed every 12 months (8,14).

The SEOP guidelines for caries are based on the protocols and guidelines elaborated by the American academy of pediatric dentistry AAPD, the American dental association ADA and the European association of pediatric dentistry EAPD (14).

4.1.2 For trauma in children

The International Association of Dental Traumatology (IADT) has developed detailed guidelines to support clinicians in the immediate and urgent care of traumatic dental injuries (TDIs). These recommendations are based on scientific evidence obtained by systemic reviews and expert consensus, ensuring a reliable and up-to-date guideline for practice (19).

A key aspect of the guidelines is the emphasis on accurate diagnosis, treatment planning, and consistent follow-up to obtain the best possible outcomes for patients. Each injury, whether it’s a luxation in a primary tooth or a crown fracture in a permanent one, requires a careful approach. Clinicians are encouraged to evaluate each case holistically, taking into account not only the clinical presentation but also factors like the patient's age, level of cooperation, financial situation, and ability to comply with treatment (19).

Radiographic assessment plays a key role in early management as the international association of dental traumatology (IADT) strongly recommends immediate imaging after trauma (19).
The choice of radiographs such as periapical or panoramic x-rays depends on the type of injury and greatly helps in visualizing the full extent of the damage. Early and appropriate imaging technique is essential for the diagnosis of injuries that are not always visible during clinical exams, ensuring quick and effective treatment (19).
On the tables below, it is shown the recommendations to perform x-rays after different types of trauma injuries for both primary and permanent dentitions.

TABLE 5: Primary dentition follow-up protocol according to the international association of dental traumatology (IADT) (19).

R = radiograph advised even if no clinical signs or symptoms.

Injury Type	1W	4W	8W	3M	6M	1Y	At 6Y old
Enamel fracture	No follow up						
Enamel/dentin fracture							
Crown fracture						R (only if endodontic treatment carried out)	
Crown/root fracture						R (only if endodontic treatment carried out)	
Root fracture							
Alveolar fracture		R		R			
Concussion							
Subluxation							
Extrusion							
Lateral luxation							
Intrusion							
Avulsion							

TABLE 6: Permanent dentition follow-up protocol of the international association of dental traumatology (IADT) (19).

R = radiograph advised even if no clinical signs or symptoms.

Infraction	2W	4W	6-8W	3M	4M	6M	1Y	Yearly up to at least 5Y
Enamel fracture	No Follow up		R			R		R
Enamel/dentin fracture			R			R		R
Crown fracture			R		R	R		R
Crown/root fracture			R		R	R		R
Root fracture (apical third, mid-third)	R		R		R	R		R
Root fracture (cervical third)	R		R		R	R		R
Alveolar fracture	R		R		R	R		R
Concussion		R				R		R
Subluxation						R		R
Extrusion	R		R		R	R		R
Lateral luxation		R				R		R
Intrusion	R		R		R			R
Avulsion (mature tooth)	R		R		R	R		R
Avulsion (immature tooth)	R		R		R	R		R

The “SOCIEDAD ESPANOLA DE ODONTOPEDIATRIA” and the international association of dental traumatology have published guidelines and recommendations on the management of dental injuries with their respective radiological protocol.

The Sociedad Española de Odontopediatría (SEOP) provides radiographic recommendations for dental injuries, categorizing them into two main groups: traumatisms and luxations.

In cases of traumatisms, no radiographic examination is required when the enamel is unfractured, or in the event of simple enamel or enamel-dentin fractures. However, when the trauma involves a complicated crown fracture affecting enamel, dentin, and pulp or a crown-root fracture, whether or not the pulp is involved, an occlusal X-ray is recommended. More

severe injuries, such as radicular fractures, necessitate both occlusal and periapical radiographs, while alveolar fractures also require an occlusal view.
For luxation injuries, the SEOP advises obtaining an occlusal X-ray in cases of subluxation and extrusive luxation, primarily to rule out radicular fractures. In instances of lateral luxation, an occlusal radiograph is useful to evaluate the displaced tooth's alignment with adjacent teeth. Intrusive luxation should be assessed with either an occlusal or periapical X-ray to determine the tooth's position relative to the underlying permanent tooth. Finally, in cases of avulsion, an occlusal radiograph is necessary to verify that no fragments of the tooth remain inside the socket (14).

4.2 Protocols, similarities and differences
The European Academy of Pediatric Dentistry (EAPD) has issued a table within its guidelines outlining the eligibility criteria for radiographic examinations. Among these criteria we can find objective clinical indicators such as the presence of deep periodontal pockets or visible carious lesions as well as data obtained from medical history, including a family history of dental anomalies or prior episodes of dental pain. In the absence of such clinical signs or pertinent medical information, the EAPD states that radiographic imaging is not justified and therefore should not be performed. Additionally, the EAPD insists that all radiographic decisions should be made on an individual basis, adapted to each patient’s specific condition (8).
Moreover, the EAPD encourages the use of high-sensitivity image receptors and rectangular collimation in intraoral radiography as these measures significantly reduce radiation exposure in pediatric patients.
Since 1981, the American Academy of Pediatric Dentistry (AAPD) has consistently supported the instructions of the American Dental Association (ADA), as outlined annually in its official publication. The ADA’s latest update to these guidelines was released in 2012.
The ADA has stated that instead of conducting radiographic imaging routinely, x-ray imaging can only take place after completing a full clinical evaluation and reviewing the patient’s dental and medical history. The decision regarding the type, quantity, and timing of radiographs must be personalized depending on each patient’s specific needs. Radiographs are considered appropriate only when they are expected to provide diagnostic information that will directly impact the patient's treatment and when the patient is physically capable of undergoing the procedure (5,18).
Recommendations for ALARA are also made In the AAPD guidelines on prescribing dental radiographs for infants, children, adolescents, and persons with special healthcare needs. The

AAPD insists on radiographic beam collimation, lead aprons shielding as well as the use of the highly sensitive image detectors.

Both the AAPD and EAPD agree on the fact that radiographic decisions should based on individual clinical assessment. However, their guidelines regarding bitewing intervals for caries detection are to a small extent different: in terms of frequency, the AAPD is more permissive than the EAPD regarding radiographic usage (20).

4.3 Protocols for the use of Cone Beam Computed Tomography

Cone Beam Computed Tomography (CBCT) is a valuable imaging tool in pediatric dentistry, but its use must be justified on a case-by-case basis, ensuring that the benefits outweigh the potential risks associated with radiation exposure, especially in children who are more susceptible to its effects (21).

Existing guidelines for CBCT use in pediatric dentistry are often inadequate, lacking robust evidence and proper methodology, which highlights the need for more comprehensive and specific guidelines tailored to the pediatric population (21).

The review of literature found limited evidence specific to pediatric patients regarding the diagnostic efficacy of CBCT, necessitating a wider examination of studies that include adult data to inform pediatric applications (21).

However, CBCT may be indicated in exceptional cases, such as acute infections which the source cannot be assessed using traditional radiography, or for assessing root fractures when conventional imaging does not provide sufficient information (21).

The protocols emphasize the importance of patient cooperation during CBCT imaging, particularly in pediatric cases where movement can affect the quality of the images obtained (12). Overall, the application of CBCT in pediatric dentistry should adhere to core foundations of radiation safety: justification, optimization, and limitation of exposure, ensuring that the radiation dose is kept as low as reasonably achievable.

5. DISCUSION

5.1 ALARA Principle

The ALARA principle, which stands for "As Low as Reasonably Achievable," is emphasized as a fundamental guideline in radiography, particularly in pediatric dentistry, to minimize radiation exposure while ensuring diagnostic efficacy (17).

It is highlighted in the articles that radiographs should only be taken when the benefits outweigh the risks associated with radiation exposure, reinforcing the need for careful consideration before imaging (17). Recommendations for dose reduction techniques are provided, including the use of rectangular collimation, variation in tube voltage, and the selection of digital radiography, which can significantly lower radiation doses while maintaining image quality (17).

The principle has evolved over time, with discussions emerging about the shift from ALARA to ALADA (As Low as Diagnostically Achievable), emphasizing a balance between image quality and radiation dose (22).

The importance of adhering to local, state, and federal regulations regarding radiation safety is emphasized in the articles, ensuring that best practices are followed by practitioners in accordance with the ALARA principle (18).

Continuous education and updates on radiation safety practices are encouraged to keep pace with advancements in technology and research, ensuring that the ALARA principle remains relevant and effectively implemented (14,18,22).

5.2 Parental perspective of dental radiographs

Perspective of dental X-ray can vary depending on the level of education of parents as well as their past experiences with radiographs, parents with higher levels of education and frequency of dental visits were associated with better knowledge and positive attitudes (23,24).

Current literature suggests that parents generally had a positive attitude towards dental radiography, but the lack of knowledge about protective gear indicates a gap in understanding safety protocols (24). Educated parents may exhibit a more informed and cautious attitude, recognizing the importance of safety measures.

5.3 Variations in Practitioner Adherence

Professionals may interpret and apply guidelines inconsistently, leading to variations in patient care. This inconsistency can be due to different levels of familiarity with the guidelines or personal biases, which can affect the nature and quality of treatments provided the patients (16).

A study in the United States comparing the prescription patterns of panoramic radiographs between general practitioners and Pediatric dentists found discrepancies, particularly around the typical age of eruption of the permanent first molar. Pediatric dentists were more likely to prescribe radiographs in alignment with guidelines, indicating that specialized training in pediatric dentistry may enhance adherence to recommended protocols.

This study also shows a discrepancy between general practitioners and pediatric dentists and when compared to the guidelines. These findings indicate a need for more thorough and better articulated education in pediatric oral radiology for clinicians. The frequent presence of individualized radiographs or using clinical judgement in the guidelines suggests that clinician-based factors affect prescription of strictly necessary oral radiography (25).

5.4 Education and Training Gaps

Dentists should implement radiation and protection protocols in their practices therefore, ongoing education and training are essential for practitioners to stay updated on guidelines. However, when opportunities for professional development are limited, outdated practices may persist, and adherence to updated recommendations can be compromised (16).

To cope with the challenges presented by the pediatric population, dental professionals can rely on continuous training and professional development in order to optimize radiographic protocols, this can be implemented through education courses, interactive workshops and seminars to improve their clinical expertise as well as their confidence when it comes to treating patients with complex medical backgrounds. By insisting on specialized knowledge and practical skills, these programs help ensure that dental professionals are well prepared to treat patients safely and effectively (26).

Ongoing programs may tackle a variety of topics such as behavior management techniques, adaptive use of equipment and cultural sensitivity. Case-base learning, sharing clinical experiences and collaboration between dental professionals can significantly help develop competence and self-esteem in delivering qualitative treatments. Additionally, a philosophy of extended learning and quality improvement can be implemented through support, tutoring and peer collaboration within the dental community (26).

6. CONCLUSIONS

This project set out to explore and clarify the current protocols and guidelines for prescribing radiographs in pediatric dentistry, with a particular focus on their application in the diagnosis of caries and traumatic dental injuries. Through this research, it became clear that while international guidelines generally share common principles such as the emphasis on individualized assessment, radiation safety, and diagnostic necessity there are also notable differences in the recommended intervals, imaging techniques, and criteria for specific clinical scenarios. In cases of trauma, radiographic protocols tend to be more structured and injury-specific, requiring careful follow-up to monitor healing and detect complications. For caries detection, radiographs are primarily prescribed based on caries risk assessment, emphasizing preventive care and minimizing unnecessary exposure. However, despite the existence of these well-documented guidelines, their consistent application in clinical practice remains limited. Factors such as clinician awareness, patient cooperation, resource availability, and varying interpretations of guidelines all contribute to this gap between recommendation and reality.

7. SUSTAINABILITY

Ensuring the sustainable application of radiographic protocols in pediatric dentistry requires a balanced approach that prioritizes both diagnostic efficacy and long-term patient safety. A fundamental priority is to limit ionizing radiation exposure in children, who are particularly vulnerable to its cumulative effects. By adhering to international principles such as justification, optimization, and dose limitation, dental professionals can minimize unnecessary exposure and contribute to more sustainable healthcare practices.

Sustainability in this context also involves the integration of evidence-based guidelines into routine clinical practice. This can be achieved through continued professional education, institutional policy support, and the adoption of decision-making tools that facilitate guideline-compliant imaging. Encouraging dental practitioners to regularly update their knowledge and adapt to evolving best practices promotes not only better clinical effectiveness but also improved environmental responsibility, by reducing the frequency of redundant or radiographic procedures of low diagnostic value.

8. REFERENCES

1. Stabulas-Savage JJ. Frommer's Radiology for the Dental Professional. 10th ed. St. Louis, MO: Elsevier; 2019.

2. White SC, Pharoah MJ. Oral Radiology: Principles and Interpretation. 6th ed. St. Louis, MO: Mosby/Elsevier; 2009.

3. Ige TA, Hasford F, Tabakov S, et al. medical physics development in Africa – status, education, challenges, future. Med Phys Int J. 2020;3(Special Issue):303–317.

4. ICRP. Recommendations of the ICRP. ICRP Publication 26. Ann ICRP. 1977;1(3).

5. American Dental Association, U.S. Department of Health and Human Services. Dental Radiographic Examinations: Recommendations. 2012.

6. Benavides E, Krecioch JR, Connolly RT, et al. Optimizing radiation safety in dentistry. J Am Dent Assoc. 2024;155(4):280–293.e4.

7. Looe HK, Pfaffenberger A, Chofor N, et al. Radiation exposure to children in intraoral dental radiology. Radiat Prot Dosimetry. 2006;121(4):461–465.

8. Espelid I, Mejàre I, Weerheijm K. EAPD guidelines for use of radiographs in children. Eur J Paediatr Dent. 2003; 1:40–48.

9. ICRP. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann ICRP. 2007;37(2–4).

10. Schüler IM, Hennig C-L, Buschek R, et al. Radiation exposure and frequency of dental, bitewing, and occlusal radiographs in children and adolescents. J Pers Med. 2023;13(4):692. doi:10.3390/jpm13040692

11. Bushong SC. Radiologic Science for Technologists: Physics, Biology, and Protection. 10th ed. St. Louis, MO: Elsevier; 2013.

12. Aps JKM. Cone beam computed tomography in paediatric dentistry: overview of recent literature. Eur Arch Paediatr Dent. 2013;14(3):131–140.

13. Miloğlu Ö, Güller MT, Tosun ZT. The use of artificial intelligence in dentistry practices. Eurasian J Med. 2022;54(Suppl 1): S34–S42. doi:10.5152/eurasianjmed.2022.22301

14. Consejo General de Dentistas de España. Compilación del uso de la radiología en odontología por las sociedades científicas. 2024. ISBN: 978-84-128595-3-9.

15. Haddaway NR, Page MJ, Pritchard CC, McGuinness LA. PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. *Campbell Syst Rev*. 2022;18: e1230. https://doi.org/10.1002/cl2.1230

16. Horner K. Radiographic selection criteria: new guidelines, old challenges. Br Dent J. 2013;214(4):201–203. doi: 10.1038/sj.bdj.2013.158

17. Fogarty WP, Drummond BK, Brosnan MG. The use of radiography in the diagnosis of oral conditions in children and adolescents. N Z Dent J. 2015;111(4):144–150.

18. American Academy of Pediatric Dentistry. Prescribing dental radiographs for infants, children, adolescents, and individuals with special health care needs. In: The Reference Manual of Pediatric Dentistry. Chicago, IL: American Academy of Pediatric Dentistry; 2024. p. 313–317.

19. Levin L, Day PF, Hicks L, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: general introduction. Dent Traumatol. 2020;36(4):309–313. doi:10.1111/edt.12574

20. Sandeepa NC, Aswin N, Johnson J, Ashok M, Niranjana P. Imaging in pediatric dental practice. Int J Clin Pediatr Dent. 2023;16(1):1–8.

21. Bukhari M, Raza A, Nazir R, Arif A, Maqsood A. Diagnostic efficacy of cone beam computed tomography in paediatric dentistry: a systematic review. Pak Oral Dent J. 2023;43(2):91–96.

22. Kühnisch J, Anttonen V, Duggal MS, et al. Best clinical practice guidance for prescribing dental radiographs in children and adolescents: an EAPD policy document. Eur Arch Paediatr Dent. 2020;21(4):375–386. doi:10.1007/s40368-019-00493-x

23. Birant S, Ilisulu SC, Özcan H. Parents’ perspective towards dental radiography for children. J Dent Sci. 2023; 18:1778–1785. doi: 10.1016/j.jds.2023.05.015

24. Sreenivasan SK, Lolayekar N, Sheth P, Rao D. Knowledge, attitude, and practices of parents toward pediatric dental radiography. J Health Allied Sci NU. 2021; 12:448–453.

25. Yepes JF, Powers E, Downey T, Eckert GJ, Tang Q, Vinson L, Maupomé G. Prescription of panoramic radiographs in children: a health services assessment of current guidelines. Pediatr Dent. 2017;39(4):217–224.

26. Adeghe EP, Okolo CA, Ojeyinka OT. Optimizing dental screening protocols for children with special healthcare needs: enhancing access and prevention. Int J Front Sci Technol Res. 2024;6(1):54–61. doi:10.53294/ijfstr.2024.6.1.0029