Imaging Science in Dentistry 2024; 54: 336-44
https://doi.org/10.5624/isd.20240062

Positioning and preparation errors impacting dental panoramic radiographs in patients with mixed dentition

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ABSTRACT

Purpose: This study aimed to evaluate the quality of clinically indicated digital dental panoramic radiographs (DPRs) of children with mixed dentition. Despite the likely widespread use of this modality, recent research detailing errors on DPRs is scarce.

Materials and Methods: A consecutive case series was performed, including 178 DPRs from patients aged 6 to 12 years. Each DPR was reviewed for 10 distinct errors. The findings were analyzed to identify potential solutions.

Results: Nearly three-quarters of the DPRs contained multiple errors. Linear regression analysis indicated that the number of errors decreased with increasing patient age; however, this trend was not statistically significant. Notably, 3 groups of errors (2 errors each) frequently appeared together on the same DPR. When similar errors were grouped, the error incidence decreased significantly with age. Both leftward head tilting and rightward head rotation were observed, likely attributable to the design of the DPR room and the door location. The inter-rater and intra-rater reliability agreements were deemed “substantial” or “almost perfect, beyond chance” for the detection of most errors, particularly the most frequent types, which involved the “chin,” “tongue,” and “lips-open” positions.

Conclusion: As a pediatric patient ages, the number of DPR errors decreases. The results suggest several pre-exposure strategies that could reduce the error rate. These include, monitoring for a “lips-open” position as an indicator of a potential “tongue” error (occluding the palate-glossal space), and implementing dry runs. Asymmetries observed on DPR must be documented and should prompt re-examination, as they may be genuine. ***(Imaging Sci Dent 2024; 54: 336-44)***

KEY WORDS: Radiography, Panoramic; Child; Dentistry

Introduction

Although the evaluation of dental panoramic radiographs (DPRs) has been regularly reported, most studies have focused on adult patients,[1,2] including many DPRs that were ultimately considered clinically inadequate. In contrast, this study of patients with mixed dentition exclusively addresses the technical quality of DPRs deemed to be of sufficient quality for their intended clinical use. Technical perfection was defined by the absence of errors, as detailed in Table 1. DPRs are central to pediatric dentistry, accounting for 78% of all radiographs taken among children,[3] with the advantage of capturing the entire jaws in a single exposure. This modality is instrumental in assessing the growth and development of the mixed dentition[4,5] and jaws,[5] as well as for evaluating trauma, investigating suspected cysts and neoplasms, and monitoring children undergoing extensive medical treatment.[6] The patients in the present study ranged in age from 6 years old, coinciding with the eruption of the first molar, to 12 years old, when the second molar erupts.[7] Although almost every patient who attended this dental clinic was not medically compromised, it is imperative that all DPRs, regardless of their origin, are as free from technical errors as possible. This ensures that they can be thoroughly evaluated to identify any incidental findings that may influence

Received March 28, 2024; Revised June 25, 2024; Accepted June 26, 2024
Published online August 12, 2024
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the treatment plan.

Although the radiation dose from digital DPRs is considered low, the predominance of this technique in pediatric radiography necessitates careful consideration.[3] The indications must be appropriate for prescribing these radiographs, and the imaging process must be optimized to minimize retakes, which unnecessarily increase the radiation dose received by the child and the associated risk of radiation-induced damage.

To date, only 2 reports have focused on the technical quality of digital DPRs among children with mixed dentition.[7,8] Neither of these reports included an analysis suggesting strategies to avoid or minimize these errors.

Practitioners generally believe that DPR acquisition is less intimidating for a child than other dental procedures. Nevertheless, the motion of the X-ray source and the receptor around the patient's head may still influence the child's behavior. As children mature, they develop the ability to adjust to various environments.[9] Typically, 4- to 7-year-olds employ behavioral coping mechanisms, 8- to 10-year-olds increasingly utilize cognitive strategies, and 11- to 18-year-olds rely even more on cognitive strategies while demonstrating improved self-control.[9]

Most dentistry worldwide is conducted in dental offices, with radiography performed by either a dentist or a trained and registered clinical assistant. In North America, while the assistant may capture the images, the dentist is ultimately responsible for their prescription, quality assurance, and interpretation, as well as the mentoring of clinical staff. These responsibilities are outlined in dental school accreditation documents,[10] which not only govern dental student training but also influence professional standards. A key factor in selecting a particular DPR unit is its capacity to offer focal trough dimensions and exposure conditions that

Table 1. The 10 error types on dental panoramic radiographs

Error type (term)		Impact of the error on image
Anteroposterior relative to focal trough	Anterior to focal trough	Anterior teeth narrower and shorter; more spine superimposition over the ramus and condyles; premolars overlap; orbits sit closer together.
	Posterior to focal trough	Anterior teeth are wider and blurred; condyles are farther apart laterally; orbits are farther apart. Entire image appears larger; condyles are found at the edge of the image.
Frankfort horizontal plane (termed "chin" in text and figures)	Chin upwards	Reverse smile. Occlusal plane is flat or inverted; the real, double, and ghost images of the hard palate form a radiopaque line superimposed on the roots of maxillary teeth; condyles may be positioned outside the image edge; orbits appear wider and larger; maxillary incisors may appear blurred.
	Chin downwards	Exaggerated smile; blurred mandibular incisor apices; orbits closer together; hyoid may appear elongated or overlap the mandible.
Patient is shifted from midline ('shift')		Structures ipsilateral to the side toward which the patient is shifted appear narrower mesiodistally; contralateral structures appear wider.
Rotation/patient turns the head ('rotate')		The teeth and ramus ipsilateral to the side toward which the patient is turned appear wider; contralateral structures appear narrower due to unequal horizontal magnification.
Midline of head tilted away from vertical plane ('tilt')		The condyle ipsilateral to the tilting appears lower and smaller; the chin on the contralateral side appears higher and larger; teeth may overlap; potential blurring.
Tongue NOT against hard palate ('tongue')		A radiolucent band representing the palatoglossal airspace may overlay the maxilla, frequently observed in the apices of maxillary teeth.
Lips open		Dark airspace in the shape and location of the lips can obscure the crowns of upper and lower anterior teeth.
Incorrect neck extension, often when patient adopts a slumped posture ('neck')		Ghost image of the cervical spine appears in the middle of the image, making the anterior region of the image difficult to visualize; washed-out appearance.
Patient movement during the exposure		Interrupted continuity of the mandibular border; portions appear blurry.
Metal artifact (inadequate preparation)		Bright opacity of the object and ghost image on the opposite side and in a superior position.

accommodate the anticipated range of patient ages.[11] The unit in this study featured a single focal trough size and exposure conditions that were optimal for patients with mixed dentition, who were generally of similar jaw size and shape.

The objectives of this study were to determine the types and frequencies of technical errors on DPRs of patients with mixed dentition and to ascertain whether patient age influences the incidence of these errors.

Materials and Methods

Ethical approval was obtained for this research (H19-01925), and a signed consent form was collected from each child's parent or guardian. The records and DPRs of 178 consecutive patients aged 6 to 12 years, who first attended the clinic between January 1, 2015, and June 30, 2019, were reviewed. The study sample was constrained by timing, as the review period coincided with the active phase of a competency-based training program involving the same trainers. Furthermore, the onset of the coronavirus disease 2019 (COVID-19) pandemic shortly after this period precluded the possibility of increasing the sample size due to the global disruption of the dental profession. Each DPR was prescribed following a full clinical examination and produced using a single digital DPR machine (ProMax; Planmeca, Helsinki, Finland). The same focal trough size was used for all pediatric study participants. Notably, the exposure time was 14 seconds, which is shorter than the average of 18 seconds for larger focal troughs, thus minimizing both the radiation dose and the exposure time. Each DPR was taken by a student operator who had already established a rapport with the child. This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[12]

The medical history in each patient's electronic health record (Romexis; Planmeca) was examined for any conditions that could lead to craniofacial malformation or asymmetry. Since none of the 178 patients exhibited such characteristics, all were included in the study. Each DPR was evaluated against the information in Table 1, which lists 10 errors as identified by other authoritative sources.[7,13-16] Only 1 patient underwent repeat DPR, and this individual was excluded from the study. A single exposure setting for the DPR unit (60 kV, 4 mA, and 14 s) was utilized; thus, only positional errors were considered.

The exposure of the DPR unit was managed from an adjacent room (Fig. 1). The operator maintained direct visual supervision of both the patient and the unit through the lead-glass window during the entire exposure, enabling termination of the process if patient movement was detected.

Fig. 1. Photograph of the dental panoramic radiographic unit facing the adjacent room through the lead-glass window, from which the exposure is acquired. The photograph was taken from the doorway, which features a sliding door that is fully closed during the exposure. The patient is instructed to focus on the red cross immediately adjacent to the window for the duration of the procedure.

The 2 expert trainers, who were clinical faculty members, included a registered dental hygienist and a certified dental assistant. By the beginning of 2015, both had gained experience through the standardized competency-based training program. The primary reviewer was a registered dentist. Initially, a pilot study involving 30 DPRs was conducted to discuss and establish error criteria and to calibrate the primary reviewer with the 2 expert trainers.

All DPRs were reviewed on a light-emitting diode backlit display monitor equipped with in-plane switching technology, which allows for ultra-wide viewing angles, under reduced ambient lighting.[17]

To assess inter-rater reliability, 30 DPRs were evaluated by the primary reviewer and the 2 other expert reviewers using the Fleiss kappa value.[18] The Cohen kappa[19-22] was employed to quantify the intra-rater reliability, specifically the level of agreement for the primary reviewer between 2 time points: when the entire sample was reviewed and during the review of a second set of 20 DPRs. A random number generator (available at https://rdrr.io/snippets/) was utilized for the reliability analyses.

Confidence intervals and *P*-values were calculated under the null hypothesis that the kappa value would not exceed zero.[21] The *P*-values of the kappa tests provided information on the presence or absence of statistical significance, applying a threshold of 0.05. The magnitude of the kappa estimates, along with their confidence intervals, reflects the practical significance and aids in interpreting the level of agreement, with categories of "almost perfect, beyond chance," "substantial," "moderate," "fair," and "poor." A confidence interval that did not include zero suggested statistical significance for the kappa estimate.

The effect of age on the number of errors was estimated using simple linear regression,[20] with the number of errors as the response variable and age as the explanatory variable. Although the response variable—number of errors—was discrete and could be modeled using count data models such as negative binomial or quasi-Poisson, visual inspection suggested that the data were normally distributed and could be reasonably approximated by a continuous variable. Furthermore, treating the variable as continuous rather than as a count variable facilitated clearer interpretation of the results. Thus, the slope of the age variable represents the change in the mean number of errors for each additional year of patient age.

Additional exploratory analysis was performed to evaluate the impact of age on the number of errors, with similar errors grouped together. This categorization emerged as a clear pattern during the examination of the DPRs. Subsequently, the influence of age on the number of these errors after grouping was estimated using a standard linear regression model.

Results

The most common age range of the 178 consecutive patients with mixed dentition, at the time the DPRs were taken, was 8 to 10 years. Only 4 (2.2%) of the DPRs were completely free of errors. Of the 10 error types listed in Table 1, only 9 were found in Figure 2A, as no metal artifacts were detected. The most common types of errors were "chin" (66.8%) and "tongue" (60.7%). The other error types occurred as follows, in descending order: "tilt" (48.3%), "lips open" (46.6%), "rotate" (31.5%), "shift" (26.4%), "neck" (21.3%), "movement" (9.0%), and "anteroposterior" (1.8%).

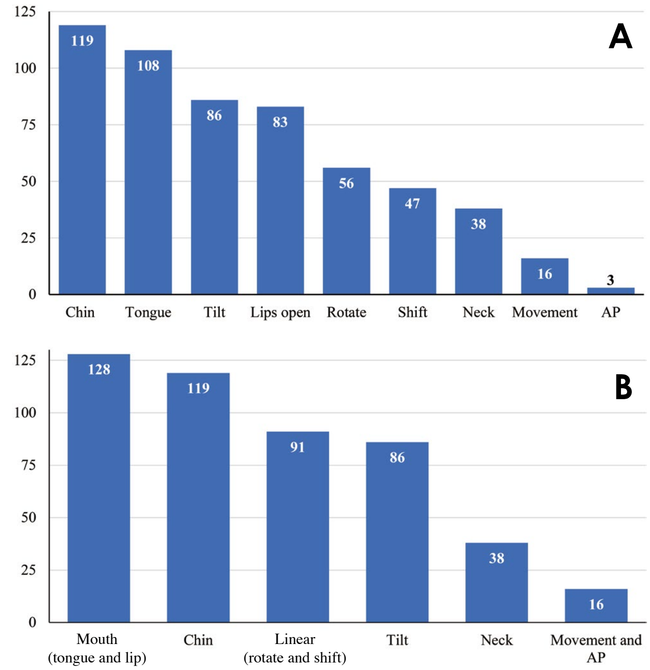

Fig. 2. A. The number of errors of each type. No errors were categorized as "metal." B. The number of errors, as displayed as (A), after regrouping the types into 6 categories. AP: anteroposterior.

Approximately 85% of "rotate" errors occurred rightward, while nearly 80% of "tilt" errors were observed toward the left, and 80% of "chin" errors were in the upward direction. More than 1 error was found in 73% of the DPRs. Among DPRs with multiple errors, the most common number of errors was 3, occurring in 56 DPRs (31.5%). The maximum number of errors found on any DPR was 6, affecting 3 DPRs (1.7%), as shown in Figure 3. All 178 DPRs addressed the clinical indications for their prescription.

Figure 2B illustrates the impact of grouping the error types. As with the original analysis (Fig. 2A), the error count was normally distributed, and the count variable was approximated by a normally distributed continuous variable. In nearly every instance where a "movement" error was identified, an "anteroposterior" error was also present. Combining "anteroposterior" and "movement" errors had minimal impact on the dataset. In contrast, it was observed that of the 128 DPRs (72%) with either a "tongue" or "lips-open" error, 64 exhibited both error types. This suggests that certain errors were mutually inclusive and likely stemmed from similar operator mistakes, thereby justifying their combined categorization under "mouth." Moreover, the relationships between errors led to the classification of "rotate" and "shift" as "linear.'

Inter-rater reliability, estimated using the Fleiss kappa,

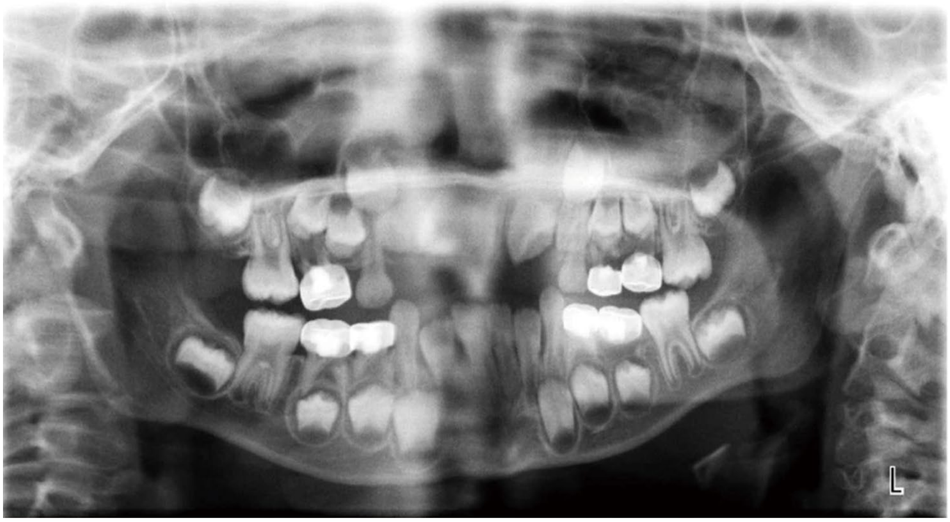

Fig. 3. Dental panoramic radiograph displaying 6 errors. Specifically, the patient is positioned too far posterior to the focal trough, resulting in blurry and widened anterior teeth. The chin is tilted upward, generating a reverse smile effect and increased intercondylar and orbital widths. The patient's head is rotated to the right, making the right side appear wider, and the head is tilted toward the right, shifting the image lower with the right condyle displaced rightward. Additionally, the patient moved late in the exposure, causing blurring over the cervical vertebrae on the right. The lips are open, as indicated by a circular radiolucency around the bite stick.

Table 2. Inter-rater reliability: Fleiss kappa estimates

Error	Kappa	95% CI	*P*-value	Level of agreement
Chin up	0.79	0.54-1.05	<0.05	Substantial
Chin down	0.81	0.56-1.07	<0.05	Almost perfect
Shift to right	1.00	0.75-1.25	<0.05	Almost perfect
Shift to left	0.92	0.67-1.18	<0.05	Almost perfect
Tilt to right	0.78	0.53-1.03	<0.05	Substantial
Tilt to left	0.78	0.53-1.03	<0.05	Substantial
Rotate to right	0.73	0.48-0.99	<0.05	Substantial
Rotate to left	1.00	0.75-1.25	<0.05	Almost perfect
Tongue	0.73	0.48-0.98	<0.05	Substantial
Lips open	0.80	0.55-1.05	<0.05	Substantial
Movement	0.28	0.03-0.53	<0.05	Moderate
Neck	0.56	0.30-0.81	<0.05	Fair

CI: confidence interval

and intra-rater reliability, assessed with the Cohen kappa, are presented in Table 2 and Table 3, respectively.

The linear regression analysis of the 9 ungrouped errors (Fig. 4A) exhibited an insignificant decrease in the mean number of errors with a 1-year increase in child age, displaying an estimated increment of −0.091 (95% CI: −0.200, 0.018) and a *P*-value of 0.102. The R^2 value of 0.00953 indicates that only a very small proportion of the variance in errors can be explained by age.

The exploratory analysis, in which errors that manifested similarly were grouped (Fig. 4B), revealed that the mean number of errors decreased significantly with each 1-year increase in patient age, with an estimated increment of −0.122 (95% CI: −0.216, −0.028) and a *P*-value of 0.0115 (R^2=0.036).

Discussion

In the previous experience of the study institution, the quality of DPRs varied considerably—even when performed with the same DPR unit—among edentulous patients,[23] a heterogeneous group for whom a standardized technical DPR approach was not feasible. Accordingly, the present study of a mixed-dentition population was performed in a highly standardized manner. The number of consecutive patients with mixed dentition included in the research was limited to those DPRs made during the competency-based course as well as by the onset of the COVID-19 pandemic a few months after the study began. Nonetheless, the sample size of 178 consecutive DPRs in the current report is comparable to the 146 in a study by Peretz et al.[7] and the 241 in

Table 3. Intra-rater reliability: Cohen kappa estimates

Error	Kappa	95% CI	*P*-value	Level of agreement
Chin up	1.00	1.00-1.00	<0.05	Almost perfect
Chin down	0.74	0.40-1.07	<0.05	Substantial
Shift to left	0.56	0.18-1.94	<0.05	Moderate
Tilt to left	0.34	−0.01-1.03	0.06	Fair
Rotate to right	0.57	0.14-1.00	<0.05	Moderate
Tongue	0.67	0.34-1.00	<0.05	Substantial
Lips open	0.70	0.39-1.00	<0.05	Substantial
Movement	0.69	0.28-1.09	<0.05	Substantial
Neck	0.12	−0.33-0.58	0.6	Poor

CI: confidence interval

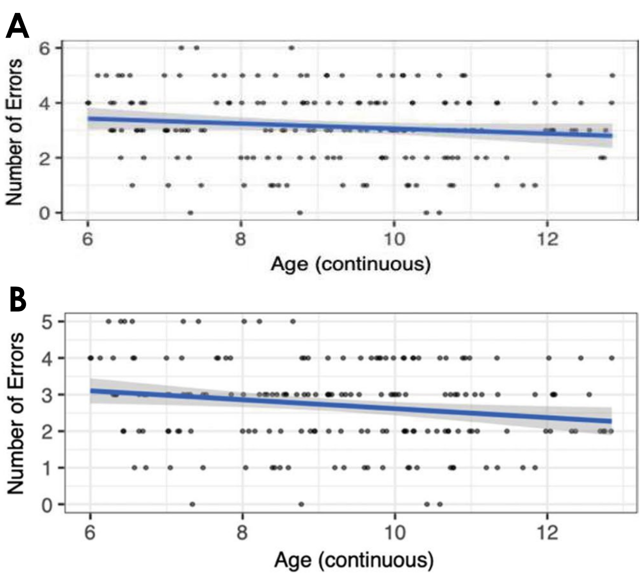

Fig. 4. A. Jitter plot displaying the number of errors for each dental panoramic radiograph plotted against age. B. Jitter plot showing the number of errors after grouping for each dental panoramic radiograph, also plotted against age. The number of errors declined as age increased.

an investigation by Bakbaznesjad-Emaeili et al.[8] While the types of errors in the current report also resembled those found by Peretz et al.,[7] the present study used throughout the same focal trough and same exposure settings that were entirely appropriate for these mixed-dentition patients. In contrast, Peretz et al. used the same trough size for patients with mixed and permanent dentition, resulting in the heads of the mixed-dentition group being positioned too far forward.[7] Consequently, 45% of the DPRs of patients with mixed dentition in the Peretz et al. study were deemed non-diagnostic,[7] whereas only 1 DPR was excluded for this reason in the present study. Furthermore, 42% of the DPRs in the Peretz et al. study required increases in brightness and/or contrast for proper display,[7] whereas all DPRs in this report were adequately exposed using exposure values appropriate for children 12 years old or younger. However, the percentage of cases without any positioning errors—thus technically perfect—was similarly low in both studies: 2.8% (4 DPRs) in the current report and 1.4% (2 DPRs) in Peretz et al.[7]

Reliability analysis was conducted to evaluate the degree of subjectivity in the primary outcome, which was the number of errors. This analysis revealed high levels of agreement among the reviewers (inter-rater reliability) and consistency within the assessments of the primary reviewer (intra-rater reliability). Specifically, the inter-rater reliability, as measured by Fleiss kappa estimates, showed "almost perfect, beyond chance" to "substantial" agreement for nearly all error types. The exceptions were "movement" and "neck" errors, which exhibited "moderate" and "fair" agreement, respectively. Similarly, the intra-rater reliability, assessed using the Cohen kappa, displayed "almost perfect, beyond chance" to "substantial" agreement for most error types. As exceptions, "rotate to right" and "shift to left" were rated as moderate, "tilt to right" as fair, and "neck" as poor.

While behavior improves with age among patients with mixed dentition,[9] this study was the first to investigate whether the types and frequencies of DPR errors also changed as patients aged. Notably, young children exhibiting particularly poor behavior were referred to a pediatric dental specialty clinic. Consequently, the behavior of the patients in this study may be better than that typically seen in a general community clinic, given that approximately 9% of children exhibit dental anxiety.[24] Nevertheless, prior research has demonstrated that the anticipated improvement in behavior with age does not translate to improved intraoral radiographic quality.[25] The longer exposure time required for DPR compared to intraoral imaging might be expected to further increase the number of movement-related errors. This hypothesis was supported by the longer exposure time of 14 seconds in the present study. Movement errors in this study accounted for 9%, significantly higher than the 2.5% reported by Peretz et al.,[7] who used a shorter exposure time of 13 seconds (Fisher exact test; $P=0.015$). Another factor contributing to patient movement was the re-emergence of the X-ray tube from behind the patient, appearing on the patient's left side at the end of the exposure. The sudden presence of this object may have startled participants, prompting head movement (Fig. 3). To mitigate any fearfulness among pediatric patients, a "dry run" (mechanical operation of the unit without radiation exposure) can be performed before the actual exposure. This allows the operator to reassure patients that the rotating DPR is harmless and convey that they should remain perfectly still during the procedure. The value of dry runs has been recently validated in medical radiology.[26]

While Table 1 detailed the criteria for each error, the evaluation process was acknowledged to be subjective. "Rotation" and "shift" errors were often identified by an increased dimension on one side and a decreased dimension on the contralateral side. To mitigate this subjectivity, multiple landmarks, such as ramus width, tooth width, and tooth overlap, were utilized to gauge patient positioning. Asymmetry or atypical width of the ramus, overlap of adjacent teeth, or a wide appearance of other anatomical structures could have resulted from either or both errors. Consequently, "shift" and "rotation" were collectively categorized as "linear.'

It was initially assumed that each patient exhibited perfect symmetry, and thus, that any deviation observed on the DPR was attributable to at least 1 error. However, asymmetry is common among growing patients, with more than half of these individuals exhibiting moderate (symmetry deviation of 3-5 mm) or severe (deviation exceeding 5 mm) asymmetry in the width and height of the mandibular ramus.[27] Consequently, a DPR displaying asymmetry could have accurately depicted the anatomy of a properly positioned patient. Retrospective reports, including both this and prior analyses, on growing patients may erroneously suggest that a perceived anomaly results from an incorrect DPR technique. In the future, all errors identified on DPRs should be carefully evaluated, and the patient should be concurrently re-examined for asymmetry.

Nearly every DPR in the current study contained at least 1 error (97.8%), a figure comparable to the 98.6% reported by Peretz et al.[7] However, 74% of DPRs in the present study had multiple errors, a rate significantly higher than that of 62% found by Peretz et al. ($\chi^2=26.84$; $P<0.0001$).[7] One might expect that a higher number of errors would correspond to an increased rejection rate for DPRs. However, the rejection rate observed in this study was almost negligible at 0.6%, markedly lower than the global mean of 4.1% (range: 2.9-11.6%).[28]

Even a DPR that is not technically "perfect" due to positioning errors is unlikely to be so diagnostically useless that it must be retaken.[29] This is particularly true with pediatric patients, given the well-known increased risk of radiation-induced damage.[30] Imperfections in the anterior sextant are especially common, as it is recognized that even DPRs of optimal quality can exhibit artifacts due to the superimposition of the spine, which limits the value of DPRs for evaluating pathology in the anterior sextants of the mandible and maxilla.[17] However, the posterior sextants of the mandible (both body and ramus) and maxilla are typically well displayed. This is particularly true of the maxilla when the patient is instructed to keep the tongue in contact with the palate during exposure, thereby occluding the palatoglossal space. Unfortunately, an associated error occurred in nearly two-thirds of DPRs in the present report, as well as in the mixed-dentition population reported by Peretz et al.[7] and in almost three-quarters of the juvenile orthodontic patients described by Granlund et al.,[13] indicating widespread prevalence. This is likely due to operator-patient communication issues. However, effective communication is a 2-way process with several essential components, including facial expression, and the body language of the operator must remain consistent for the intended message to be understood.[5] Communication is a central part of the radiological procedure and influences children's experiences in a medical setting,[31] yet the literature on this topic in dentistry is almost non-existent, with the exception of a report by Cordesmeyer et al.[32] Although the Image Gently in Dentistry campaign directs proper radiological procedures according to a 6-step plan, it does not address operator-child patient communication, except to suggest using the term "X-ray" rather than "radiograph," as the former is more commonly used in dentist-patient communications.[30] Nevertheless, medical radiology already employs certain tactics to prepare, educate, or familiarize children with radiological procedures.[33] One of these is the "mock scan," the magnetic resonance equivalent of the "dry run" used in radiotherapy,[26] but more appropriate in dentistry.

Cordesmeyer et al.[32] demonstrated that the palatoglossal space can be eliminated with the use of a special appliance; however, this technique was applied only to juvenile and adult patients. While the closing of the lips and their movement can be observed, it is challenging to verify full compliance, specifically regarding whether the patient has brought the tongue into contact with the palate to close the palatoglossal space—an issue also observed in adults.[7] The detection of a "lips-open" error is a reliable indicator of a potential concurrent "tongue" error, as evidenced by their co-occurrence in exactly half of the cases with either of these errors. Consequently, the observation of "lips-open" errors before exposure should prompt re-instruction of the patient to keep the tip of the tongue on the back of the front teeth. Although this guidance is not documented in the literature, it has been shown to be effective in orthodontic practice. Accordingly, "lips-open" and "tongue" errors were collectively categorized as "mouth" errors, since both typically result from patients not following instructions or the instructions not being communicated clearly.

"Anteroposterior" errors were grouped with "movement" issues, as motion represents the most likely cause of both. Ultimately, the 9 errors in Figure 2A were reclassified into 6 groups (Fig. 2B).

An unexpected finding was that rotation occurred to the right in 85% of cases, while tilt occurred to the left in 89%. The layout of the room in which DPRs were acquired featured a door to the patient's left and a window directly in front of the patient, where the operator stands during exposure. Patients likely tilted their heads to the left to watch the operator leave the DPR room (and close the sliding door behind them), then rotated their heads to the right to see the operator upon their reappearance at the window. In this fashion, despite correct initial positioning, the patient moved prior to exposure. Following the study, a red cross was placed adjacent to the window (Fig. 1) in the patient's view. Patients were instructed to focus on this marker throughout the procedure. Although this intervention has yet to be evaluated, since it was applied as a direct consequence of the findings after study completion, it was immediately implementable since it causes no harm.

While this report concurs with the statement that it is challenging to take panoramic radiographs without positioning errors,[29] the findings indicated a decrease in the number of DPR errors as pediatric patients age. This decrease may stem in part from improved communication between the operator and the older patient with mixed dentition. Moreover, a review of the results and subsequent reflection indicated a potential solution that was implemented immediately.

In conclusion, although almost all DPRs were technically adequate for their clinical purposes, they were not without flaws. The most common errors were "chin" and "tongue." Additionally, most radiographs exhibited more than 1 error. Certain errors, such as the "tongue" and "lips open" types, frequently occurred in conjunction as do certain other errors. As asymmetry is commonly reported in patients with mixed dentition, it is important clinically to evaluate observed asymmetry on DPRs, as it may represent a real condition rather than a technical error. Notably, the number of errors per DPR decreased as the age of the child increased.

Conflicts of Interest: None

Acknowledgments

We are very grateful to the late Professor David Kennedy and to former colleagues, Jodi Ekk and Dr. Erika Ridgway for their contributions to this study.

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