Original Article

Displaced Premolars in Panoramic Radiography—Fact or Fallacy?

Nasila Nohadani[a]; Yango Pohl[b]; Sabine Ruf[c]

ABSTRACT

Objective: To test the null hypothesis that there is no difference between premolar position visualized on panoramic radiographs (PRs) and lateral headfilms (LHs).

Materials and Methods: The prevalence of differences in the direction of crown angulation between PR and LH was assessed. Furthermore, brass wire markers with different sagittal and transverse angulations were placed in a dry skull. With the markers in place, LHs and PRs were taken.

Results: A difference in the direction of crown angulation of unerupted second premolars between PR and LH occurred in 19.5% of patients. The reason for the angulation differences is a buccolingual orientation of the tooth, which appears as a mesiodistal angulation on the PR.

Conclusion: The null hypothesis was rejected since in one-fifth of the patients premolar projection differs between the panoramic radiograph and the lateral headfilm.

KEY WORDS: Displacement; Second premolar; Tooth angulation; Panoramic radiography; Lateral headfilm

INTRODUCTION

Lower second premolars rank third in the frequency of impacted teeth,[1] while upper second premolars are less frequently impacted.[2,3] Abnormal tooth germ positions or angulations of lower second premolar tooth germs are frequently seen on panoramic radiographs (PRs),[4] while no corresponding data exist for upper second premolars.

Wasserstein et al[4] reported that at an early developmental stage the majority of lower second premolars (56.5%) are distally inclined on the PR and move to an upright position spontaneously with progressing development. They could not find any morphological reason for this uprighting. A deviation from an upright tooth germ position might be of genetic origin because it has been shown that a distal angulation of lower second premolars is more pronounced in patients with agenesis of the corresponding antimere.[5] The spontaneous uprighting could be a result of normal changes in tooth position during eruption,[6] or it could only be simulated due to radiographic distortion following positioning errors.[7–11] The latter might be especially true because the largest amount of angular distortion has been reported to occur in the canine and premolar regions of both arches.[7,9,10]

During treatment planning of mixed dentition cases we noted a discrepancy in inclination of premolars between PRs and lateral headfilms (LHs). It was, therefore, the aim of the present study to assess the prevalence, reason, and possible clinical implications of such tooth inclination discrepancies between PRs and LHs. The null hypothesis was that there is no difference between premolar position visualized on PRs and LHs.

MATERIALS AND METHODS

E-mail Survey

An e-mail was sent to 20 orthodontic practitioners from 11 different European countries; 20 orthodontic university teachers from Austria, Germany, and Switzerland; and 20 dentists working at the dental school of the University of Berne. All were asked for cooperation in the study by examining the attached radiograph (Figure 1) and answering the e-mail stating the ''most relevant sign on the PR.'' As several clinicians

[z] Assistant Professor, Department of Orthodontics, University of Berne, Berne, Switzerland.

[b] Associate Professor, Department of Oral Surgery, University of Bonn, Bonn, Germany.

[c] Professor and Department Chair, Department of Orthodontics, University of Giessen, Germany.

Corresponding author: Dr Sabine Ruf, Department of Orthodontics, University of Giessen, Schlangenzahl 14, D-35392 Giessen, Germany
(e-mail: sabine.ruf@dentist.med.uni-giessen.de)

Accepted: May 2007. Submitted: March 2007.

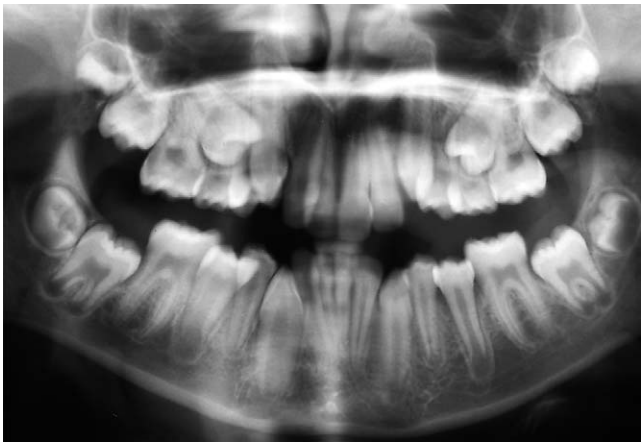

Figure 1. Panoramic radiographic section that was attached to the e-mail survey. The area of the condyles had been omitted intentionally in order to force the clinicians to concentrate their diagnosis on the dentoalveolar area.

named more than one sign, the frequency of answers per sign was evaluated. Only signs stated three or more times were included in the evaluation. The response rate was good, amounting to 75% for the orthodontic practitioners, 80% for the university teachers, and 100% for the dentists.

Clinical Investigation

The radiographic material was selected from 350 patients who started treatment at the Department of Orthodontics of the University of Berne in 2003. Of the 350 patients, 144 (73 female, 71 male) patients were selected based on the presence of a mixed dentition with at least one second premolar still unerupted. Their average age was 10 years and 10 months (±13.5 months SD).

The initial PR and LH of each patient were screened for obvious discrepancies in second premolar projection between the two types of radiographs. To be included in the study at least one second premolar had to have a deviation in inclination of at least 20° mesially or distally from a perpendicular position relative to the occlusal plane (ie, a line connecting the cusp tips of the lateral teeth). The occlusal plane was defined separately on the PR and LH. All radiographic images were assessed in random order and a consensus on the presence of an inclination discrepancy had to be reached between two of the investigators (NN and SR). The root length and the vertical position of the tooth germs were used to identify the left and right teeth on the LHs. The prevalence of projective discrepancies and its direction was recorded for each un-

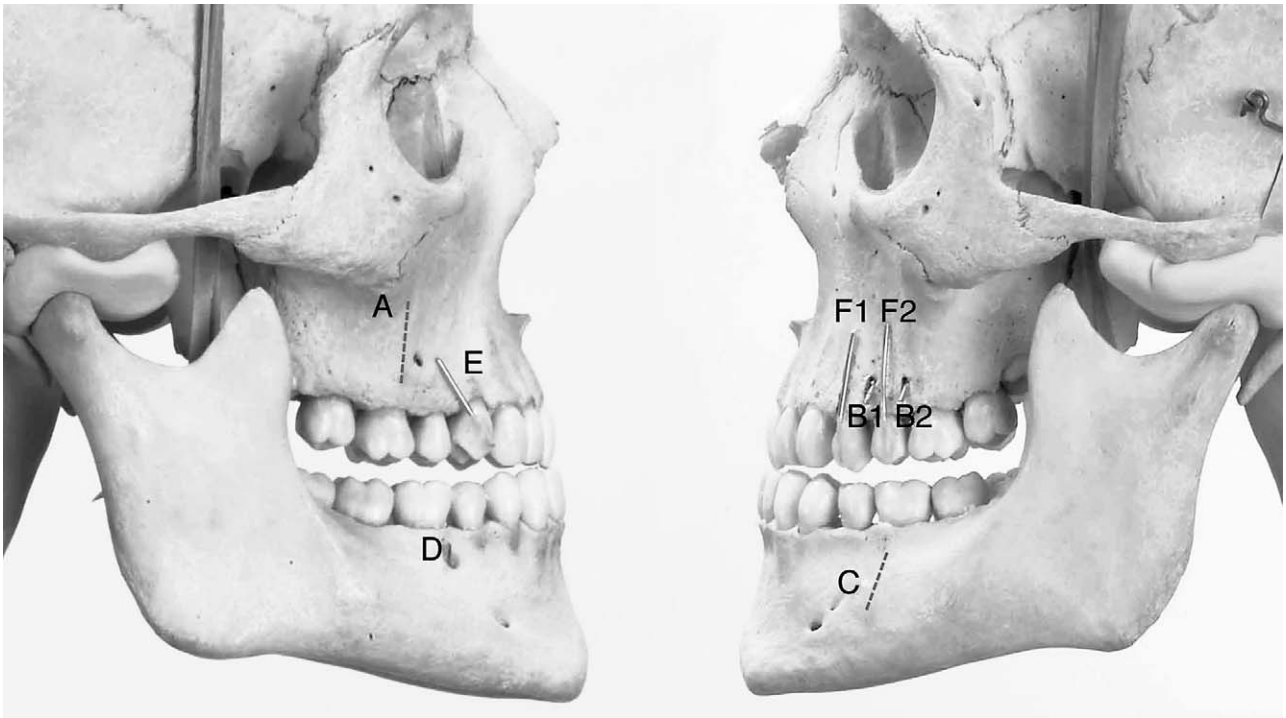

Figure 2. Location of the brass wire markers placed in the maxilla and mandible of a dry skull. (A) Buccoapical to palatocoronal direction and straight position; (B1, B2) buccocoronal to palatoapical direction with mesial inclination; (C) buccoapical to linguocoronal direction with distal inclination; (D) buccocoronal to linguoapical direction and straight position; (E) on buccal surface of tooth 14 with mesial inclination; (F1, F2) on buccal surface of the teeth 24 and 25 in a straight position. Note: The position of the pins A and C were outlined as due to their orientation; they are not visible in this view of the skull.

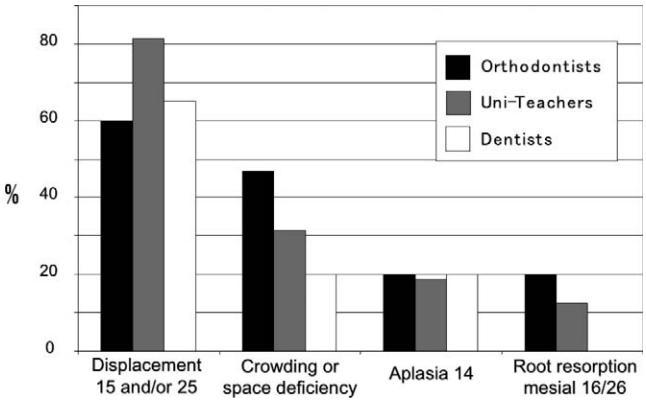

Figure 3. Results of the questionnaire survey performed among 20 orthodontists (black), 20 university teachers (grey), and 20 dentists (white). The frequency of all relevant signs (indicated ≥3 times) is given. Compare with Figure 1.

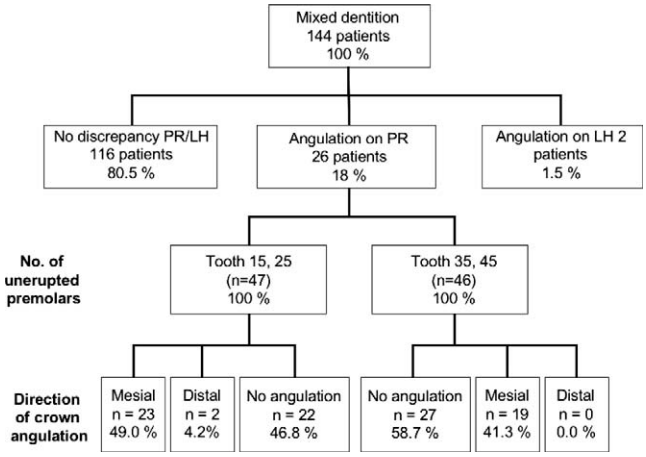

Figure 4. Distribution and angulation of unerupted second premolars as seen on panoramic radiographs and lateral headfilms of 144 mixed dentition patients.

erupted second premolar. All PRs and LHs had been taken the same day for each patient and were part of the routine diagnostic procedures for treatment planning.

The PRs of the patients were taken with an analog Cranex Tome (Soredex) using Kodak T-Mat-G RA films. The LHs were taken with a cephalostat which consisted of three different parts: the rack (Philips, Holland), the generator (Varian HS, Canada), and the emitter (Comet, Switzerland). AGFA Curix HAT 1000L Plus films were used.

Experimental Investigation

A dry skull with complete maxillary and mandibular dentition was selected. In order to simulate the effect of different tooth positions on the radiographic image, pieces of brass wire (0.9 mm diameter, 10–22 mm length) were placed in varying positions and directions in the premolar area of the maxilla and mandible (Figure 2). The different wire lengths allowed the accurate identification of the left and right markers in the LHs.

With the brass wire markers in place, PRs and LHs were taken with the skull in ideal position according to the manufacturer's operating instructions. A supporting device with a 3-D-Fluid head, which allowed for free rotation of the skull around the horizontal, sagittal, and transverse axes, enabled the exact positioning of the skull in the panoramic unit and the cephalostat. The incisal edge-to-edge position required for the PRs was assured with a silicone record between the condyles and the glenoid fossa. The mandible was secured to the skull with elastics.

The PRs were taken with three different units: Gendex Orth Oralix FD 5 Ceph (analog, Philips, Holland), Cranex Tome (analog), and Cranex Excel D (digital, Soredex). Identical exposure data were used (63 kV,

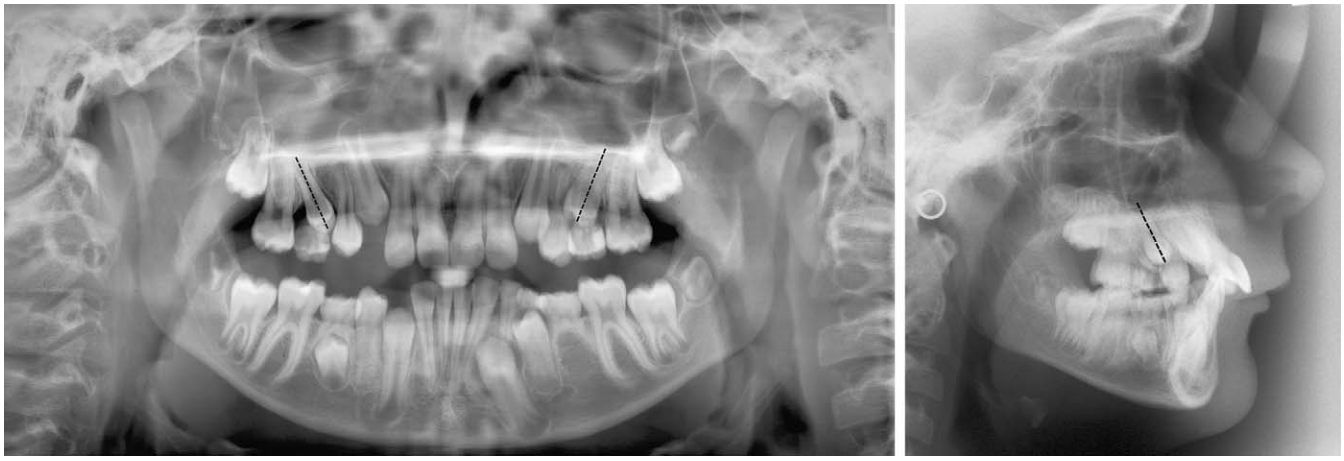

Figure 5. An 11-year 9-month old boy exhibiting mesially inclined second premolars on both the panoramic radiograph and the lateral headfilm.

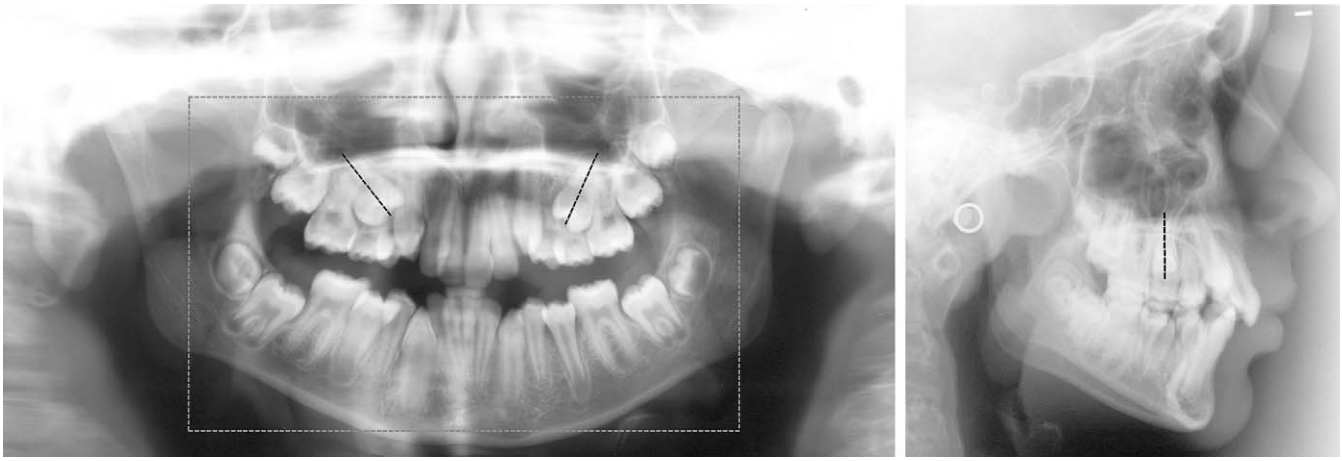

Figure 6. An 11-year 3-month old girl exhibiting mesially inclined upper second premolars on the panoramic radiograph, but orthograde premolars on the lateral headfilm. The section marked on the panoramic radiograph was used in the e-mail survey.

Figure 7. A 13-year 5-month old boy exhibiting orthograde lower second premolars on the panoramic radiograph but distally angulated lower second premolars on lateral headfilm.

6 mA and 15–23 seconds) for all units. Kodak T-Mat-G RA films were selected for the analog radiographs and Fuji Dry Imaging Film blue base DI-AT for the digital radiographs. The LHs were taken with the same unit as in the clinical part of the study (see above).

To compensate for the missing soft tissue x-ray absorption of the skull, a 1-mm copper plate was placed in front of the x-ray aperture during all radiographs.

RESULTS

Questionnaire Survey

The results of the questionnaire survey are given in Figure 3. A total of four different signs were indicated three or more times by the 60 clinicians (compare with Figure 1). The most frequent sign (60.0%–81.3%) was a displacement or mesial angulation of the teeth 15 or 25; followed by crowding or space deficiency for the incisors or premolars (20.0%–46.7%); aplasia of tooth 14 (18.8%–20.0%), and root resorption at the mesial root of the tooth 16 or 26 (0%–20.0%).

Clinical Investigation

The majority (80.5%) of the 144 mixed dentition patients with unerupted second premolars exhibited no discrepancy in premolar projection between the PRs and LHs. In 28 patients (19.5%) discrepancies in premolar angulation between the PRs and LHs (Figure 4) were seen. Two types of discrepancies were noted. In 26 patients (18%) at least one second premolar was imaged in a mesially or distally angulated position on the PR, while on the LH the corresponding tooth appeared straight. In the two remaining patients (1.5%),

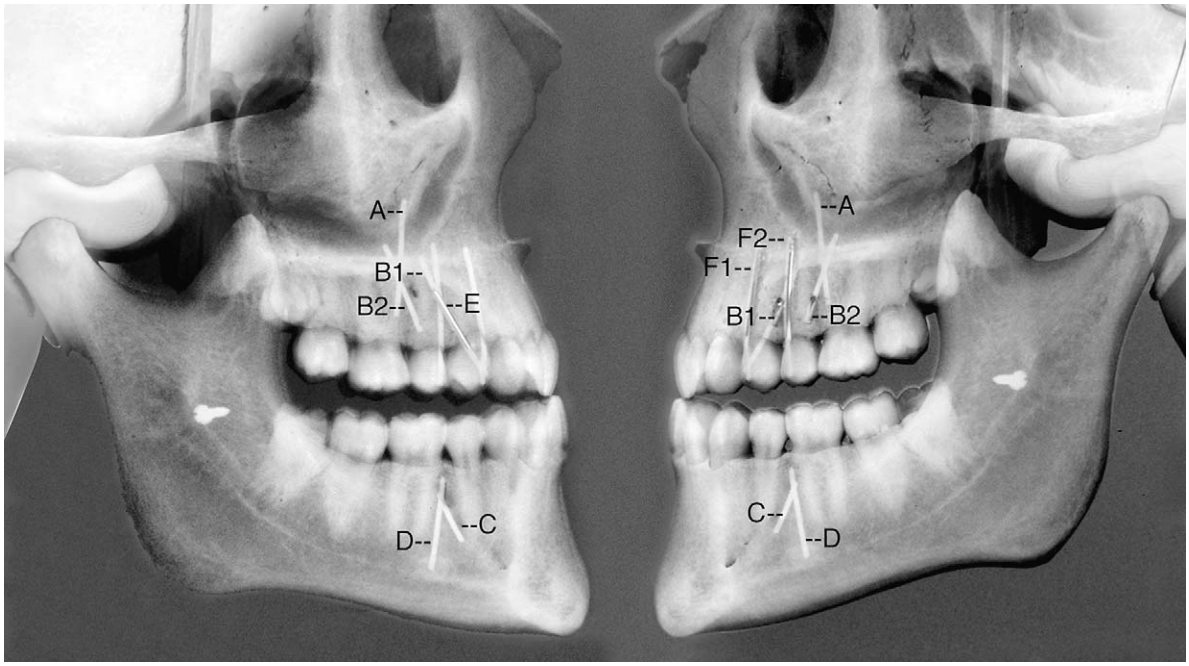

Figure 8. Superimposition of the left and right side of the dry skull with the brass wire markers in place with the corresponding lateral headfilm.

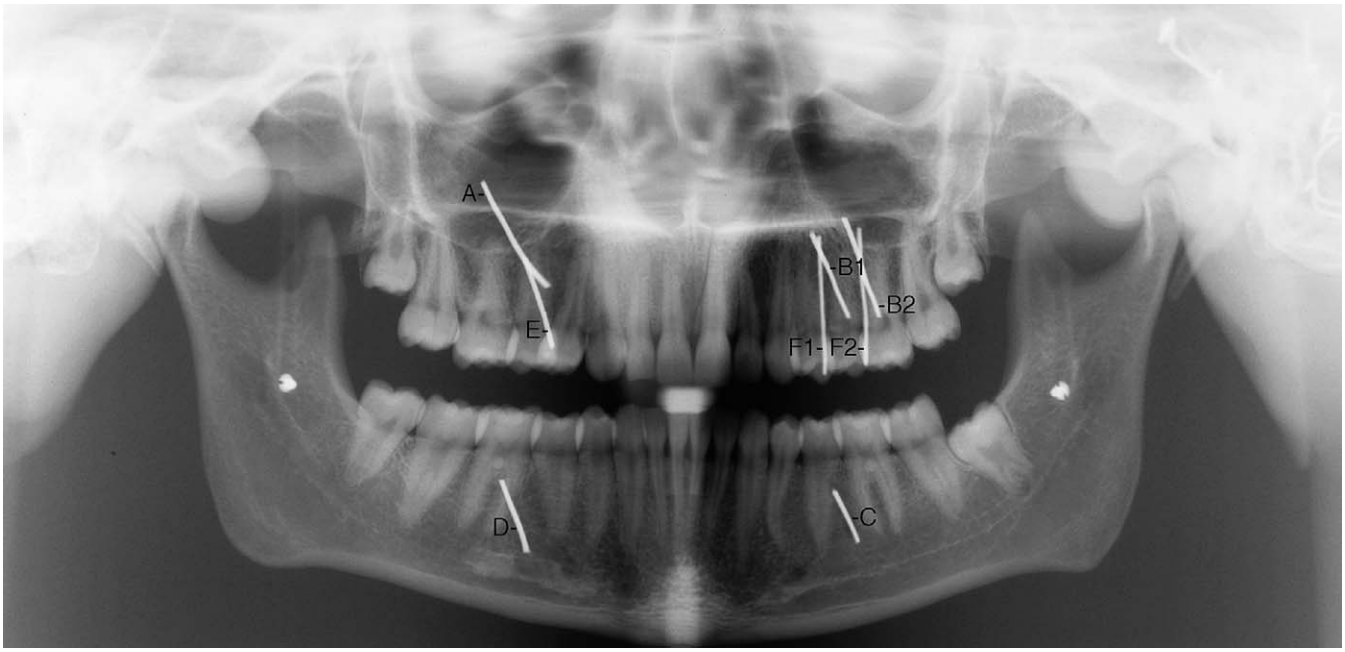

Figure 9. The panoramic radiograph of the dry skull with brass wire markers in place. It was taken with the Gendex Orth Oralix FD 5 Ceph unit.

the opposite was the case (angulation on LH, but straight position on PR).

The total number of unerupted second premolars in the 26 patients with angulated premolar projections on the PR amounted to 93. They were quite equally distributed among the four quadrants and the two jaws. The majority of the teeth were projected with the crown mesially inclined both in the upper (49%) and lower (41.3%) jaw (Figure 4) on the PR as compared to LH. Unerupted second premolars projected in a distally angulated position were seldom found (4.2%) and were only observed in the upper jaw.

Figures 5, 6, and 7 show three case reports demonstrating the different possible premolar projections.

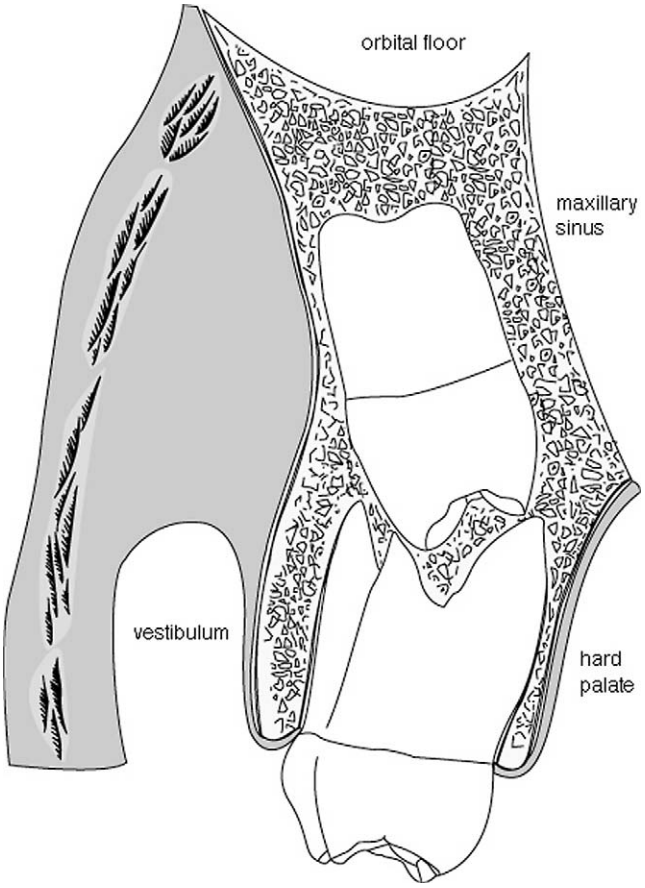

Figure 10. Schematic illustration showing a common inclination of an unerupted upper second premolar. Note the buccopalatal inclination in relation to the deciduous molar. (Modified according to Van der Linden and Duterloo.[6])

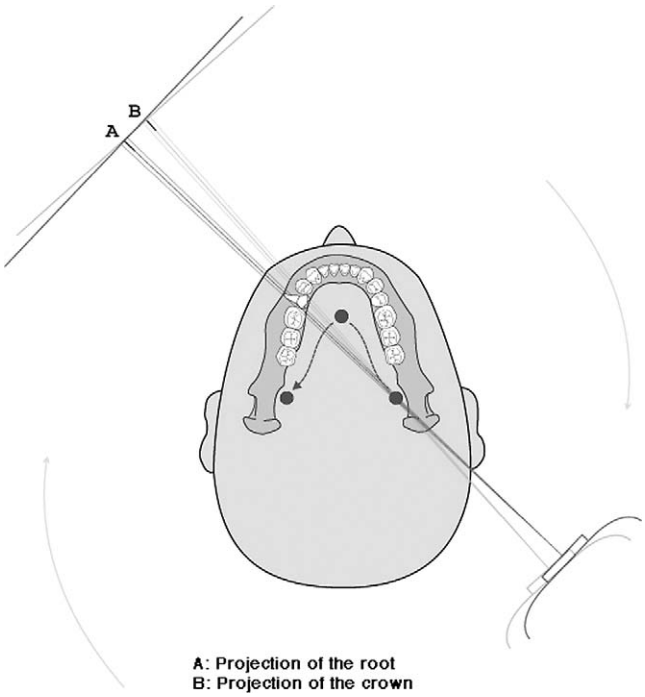

Figure 11. Schematic illustration demonstrating the effect of a buccolingual inclination of a second premolar on its projection in the panoramic radiograph. Note that the beam hits the buccal part of the tooth (in this case the root) first, thus projecting it more posteriorly on the film compared to the lingual part of the tooth (in this case the crown).

Experimental Investigation

Figure 8 shows a superimposition of the dry skull with the brass-wire markers in place and its corresponding LH. An exact superimposition of all brass wire markers and their radiographic image was possible, thus indicating the projective reliability of the LH for mesiodistal tooth angulations. In other words, straight markers were projected in a straight position and angulated markers in an angulated position irrespective of their buccolingual inclination.

In Figure 9 the PR of the dry skull with brass wire markers is shown. When comparing the projection of the different brass wire pins (A–F2) between the PR and the LH, it can be seen that all pins with a buccolingual difference between the position of the apical and coronal part of the pin (pins A, B1, B2, C, and D) differed in their mesiodistal projection between the two types of radiographs. All pins without a buccolingual inclination (pins E, F1, and F2), exhibited the same mesiodistal angulation on the PR and the LH.

In case of a buccolingual orientation of the pin, its buccal part was projected distally, and the lingual part was projected mesially on the PR. The buccolingual orientation had a greater impact on the mesiodistal projection on the PR than the actual mesiodistal angulation. This was most obvious in the pins B1 and B2 which were inserted in the buccocoronal to palatoapical direction and at the same time inclined mesially (Figures 2 and 8). On the PR (Figure 9), however, they appeared distally inclined. There were no basic differences in the projection of the teeth and the angulation of the pins between any of the three panoramic units.

DISCUSSION

In addition to the reported data several x- and y-coordinates of the teeth were measured and analyzed statistically in an attempt to identify a metrical interrelation. However, no such interrelation was found. This appears logical because the experimental part of the study revealed that the reason for the false-positive inclination of second premolars on the PR was a buccolingual inclination of the tooth germ and thus, a difference in the z-axis.

The reason for the false-positive projection in panoramic radiography is due to the principles of the radiographic technique itself. The canine and premolar regions of both arches are most susceptible to angular distortion because of the orientation of the beam in

Figure 12. Intraoral occlusal photographs of the girl exhibiting mesially inclined upper second premolars on the panoramic radiograph, but orthograde premolars on the lateral headfilm (see Figure 6). The comparison of the photos taken at 11 years 3 months and 12 years 0 months shows a normal eruption of the upper second premolars within the dental arch. No interceptive extraction of the deciduous predecessors was performed.

relation to the dental arch.[7,9,10] In case of a buccolingual inclination of a tooth (Figure 10), the angulated orientation of the beam will result in a smaller, blurred and distal projection of the buccal part of the tooth, while the lingual or palatal part will be projected widened, blurred, and mesially.

In the present study the buccolingual inclination of the pins had a greater impact on the mesiodistal inclination in the PR than the actual mesiodistal inclination of the pin. This was true for all three panoramic units tested (Gendex Orth Oralix FD 5 Ceph, Cranex Tome, and Cranex Excel D). The finding is in concordance with the results of Lucchesi et al,[12] while Tronje et al[8] maintained that a buccolingual inclination of an object only influences the mesiodistal projection slightly.

The fact that the LH image is not affected by buccolingual tooth inclinations is due to the more perpendicular orientation of the beam relative to the dental arches. Other studies on the discrepancy in tooth angulation between PR and LH have been conducted by Gavel and Dermaut.[13] They concluded that positional changes of maxillary canines on LHs approximate the real position, whereas the information obtained from PRs are not always easy to understand and must be interpreted with caution. Also Lucchesi et al[12] came to the conclusion that plane-film techniques are more accurate for assessing mesiodistal root angulation than panoramic radiography. And, Peck et al[14] stated that panoramic images do not accurately show the mesiodistal root angulations of patients, and therefore recommended the use of cone beam CT. However, the latter is not yet readily available to all orthodontists.

Although the fact that panoramic radiography does have an inherent error of creating distortion as the 3-D bone structure is reduced to a 2-D image is well known, there are still many misinterpretations of tooth angulations. Correspondingly, the questionnaire revealed that the majority (60.0%–81.3%) of the clinicians indicated the mesial inclination or displacement of the premolars to be the most relevant sign on the PR. In reality, however, the panoramic radiograph section sent to the 60 clinicians displayed a false-positive mesial crown angulation of both upper premolars. This demonstrated that the interpretation of tooth germ positions using the PR exclusively has high clinical impact and might lead to possibly unnecessary therapeutic decisions such as extractions of deciduous molars or surgical exposure of crowns.

The clinical part of the investigation revealed that second premolar angulation discrepancies in terms of a false-positive mesiodistal inclination of the premolars on the PR in comparison to the LHs occurred in almost every fifth patient (18.0%), while a false-negative mesiodistal inclination was seen in only 1.5% of the patients. The fact that the majority of the premolars in both jaws were inclined mesially on the PR is in contrast with the findings of Wasserstein et al,[4] who reported a prevalence of 56.5% distally and 25% mesially inclined unerupted lower premolars on PRs.[4] The lower overall prevalence of inclined premolars in the present study is most likely due to the fact that only teeth with discrepancies in angulation between PR and LH were evaluated and not the absolute amount of teeth with angular deviation.

But why is such a high percentage of premolars in both jaws buccolingually inclined? For the upper second premolar, such a buccolingual inclination during the eruption path (Figure 11) seems to be within normal variation.[6] For the lower second premolar, no corresponding data could be found.

In case of a displacement of a premolar an interceptive extraction of the corresponding deciduous molar is thought to facilitate the normal eruption.[15,16] However, 91.5% of the lower premolars become upright during development,[4] and an early loss of the corre-

sponding deciduous molar does not influence the inclination of the premolar significantly.[17] Furthermore, the present results demonstrated that in 18% of the children with unerupted second premolars the displacement seen on PRs is a false-positive finding. Therefore, we need further information to decide more precisely when patient interceptive extractions are beneficial to patients because many patients might not require any interceptive treatments at all (Figure 12).

CONCLUSION

- The null hypothesis was rejected since in one-fifth of the patients the premolar projection differs between the panoramic radiograph and the lateral headfilm.

REFERENCES

1. Alling CC, 3rd Catone GA. Management of impacted teeth. *J Oral Maxillofac Surg.* 1993;51:3–6.
2. Andreasen JO. The impacted premolar. In: Andreasen JO, Petersen JK, Laskin DS, eds. *Textbook and Color Atlas of Tooth Impactions. Diagnosis, Treatment and Prevention.* Copenhagen: Munksgaard; 1997:177–195.
3. Oikarinen VJ, Julku M. Impacted premolars. An analysis of 10.000 orthopantomograms. *Proc Finn Dent Soc.* 1974;70: 95–98.
4. Wasserstein A, Brezniak N, Shalish M, Heller M, Rakocz M. Angular changes and their rates in concurrence to developmental stages of the mandibular second premolar. *Angle Orthod.* 2004;74:332–336.
5. Shalish M, Peck S, Wasserstein A, Peck L. Malposition of unerupted mandibular second premolar associated with agenesis of its antimere. *Am J Orthod Dentofacial Orthop.* 2002;121:53–56.
6. Van der Linden FPGM, Duterloo HS. *Development of the Human Dentition: An Atlas.* Hagerstown: Harper & Row; 1976:204–205.
7. Philippe RG, Hurst RV. The cant of the occlusal plane and distortion in the panoramic radiograph. *Angle Orthod.* 1978; 75:317–332.
8. Tronje G, Welander U, McDavid WD, Morris CR. Image distortion in rotational panoramic radiography. III. Inclined objects. *Acta Radiol Diagn (Stockh).* 1981;22:585–592.
9. Samawi SS, Burke PH. Angular distortion in the orthopantomogram. *Br J Orthod.* 1984;11:100–107.
10. McKee IW, Glover KE, Williamson PC, Lam EW, Heo G, Major PW. The effect of vertical and horizontal head positioning in panoramic radiography on mesiodistal tooth angulations. *Angle Orthod.* 2001;71:442–451.
11. Stramotas S, Geenty JP, Petocz P, Darendeliler MA. Accuracy of linear and angular measurements on panoramic radiographs taken at various positions in vitro. *Eur J Orthod.* 2002;24:43–52.
12. Lucchesi MV, Wood RE, Nortje CJ. Suitability of the panoramic radiograph for assessment of mesiodistal angulation of teeth in the buccal segments of the mandible. *Am J Orthod Dentofacial Orthop.* 1988;94:303–310.
13. Gavel V, Dermaut L. The effect of changes in tooth position of unerupted canines on cephalograms. *Eur J Orthod.* 2003; 24:49–56.
14. Peck JL, Sameshima GT, Miller A, Worth P, Hatcher DC. Mesiodistal root angulation using panoramic and cone beam CT. *Angle Orthod.* 2007;77:206–213.
15. Burch J, Ngan P, Hackman A. Diagnosis and treatment planning for unerupted premolars. *Pediatr Dent.* 1994;16: 89–95.
16. Collett AR. Conservative management of lower second premolar impaction. *Aust Dent J.* 2000;45:279–281.
17. Wasserstein A, Shalish M. Adequacy of mandibular premolar position despite early loss of deciduous molar. *ASDC J Dent Child.* 2002;69:254–258, 233–234.