OBJECTIVE: There is little information regarding the mesiodistal angulation of permanent teeth in mixed dentition. The aim of this study was to evaluate mesiodistal root angulation of permanent incisors, canines and first molars of 100 Brazilian children, using a new horizontal reference plane based on the midpoint of the intercuspation of primary canines and permanent first molars in panoramic radiographs during the mixed-dentition phase. Material and Methods: Children were equally divided between the genders with a mean age of 8.9 years (SD=0.76), normal occlusion and no eruptive disturbances. Results: The angulation of the permanent maxillary first molars was close to the vertical, whereas the mandibular molars presented approximately 25 degrees of distal root angulation. The maxillary canines were the most distally angulated teeth, whereas the permanent mandibular canines were vertically positioned. The evaluation of the anterior maxillary area showed vertical position of permanent lateral, and central incisors with a slight distal angulation, whereas the permanent mandibular incisors tended to a mesial radicular convergence. Conclusions: The proposed reference line could be useful in mixed dentition root angulation evaluation; there was a slight asymmetry in the mesiodistal angulation among homologous teeth, and also a small variation between the male and the female groups, but no difference between 8-and 10-year-old children.

Key words: Panoramic radiography. Mixed dentition. Interceptive orthodontics. Dental occlusion.
Poor quality were repeated or discarded. The radiograph was checked and those considered of eight years old (n=14 years old). The aim was to verify any change to their age: eight (n=49), nine (n=37) and ten (n=14) years old. The analysis was done only between the youngest (eight years old) and oldest (ten years old) groups.

Data collection
The children were first chosen by visual inspection by the researcher while they were standing, looking straight at the horizon and maintaining a natural head position. The child was asked to smile and if there was no visible malocclusion, the dental occlusion was clinically examined, the cheeks being moved with a wooden spatula. The researcher evaluated the canine relationship and other deviations. All children had their panoramic radiograph taken in the same radiological clinic by Gendex Orthoralix 9200 DDE apparatus (Gendex Dental Systems, Des Plaines, IL, USA). The patients were positioned in a standard manner, with the teeth in maximum intercuspation, the occlusal plane kept horizontal and the facial midline perpendicular to it. The pictures were processed by an automatic processing machine (Xtec-Revell, São Paulo, SP, Brazil). Each radiograph was checked and those considered of poor quality were repeated or discarded.

Analysis of the Panoramic Radiograph
All panoramic radiographs were evaluated by the same examiner in a dark room, using a light box. The anatomic structures from the panoramic radiograph were drawn on 0.07-mm-thick acetate paper (29.5x15.0 cm) with a 0.05 pencil point. The drawing included the orbital lower contour, the mandible’s external profile, the contour of the permanent first molars, canines and incisors and crowns of the primary maxillary and mandibular canines. Two reference lines were drawn on both left and right sides, passing at the middle intercuspation point of the first permanent molars and the primary canines. It was decided to use a single reference line for maxillary and mandibular teeth, based on the intercuspation of the teeth (Figure 1). The mental line was discarded because in the studied sample it was noticed that the mental foramen was clearly visible in less than 20% of the children.

The long root axis was determined according to Ursi, et al. (1990). For the single-rooted teeth, the root canal image in its greatest length was selected; for the mandibular molars, the mean of the mesial and distal root canals and another point in the middle of the clinical crown was chosen, and for the maxillary molars, the palatal root image and another point in the middle of the clinical crown were used. The angles of the right and left reference lines and the long axis of the tooth were measured on each radiograph. The measured angle was external, located distally to the midline (Figure 1).

Statistical Analysis
After assessing the normality of the sample, the Student’s t-test for independent samples was selected to compare the mesiodistal root angulations between the genders, right and left lateral teeth and the extreme age ranges in the examined groups (8 and 10 years). The calculations were made with the SPSS for Windows v.12.0 software. The level of significance was 5%.

RESULTS
Method error (ME) was calculated by Dahlberg’s formula $ME = \sqrt{\frac{\sum d^2}{2n}}$ ($d =$ first and second measurements difference, $n =$ exams measured twice number) to check the intra-examiner error. One week after the first evaluation, the examiner analyzed and measured 40 radiographs again. The greatest error obtained was 1.73, which was considered small enough to be acceptable.

The mean mesiodistal root angulation for permanent molars, canines and incisors was established separately for the female and male groups (Table 1). In the maxilla, the boys had significantly greater angulations than the girls in the following permanent tooth groups: right central incisors, right and left canines. Girls’ mandibles were more angulated in the left side than in the region of the central and lateral incisors.

The data obtained in this study were analyzed as follows: the first maxillary molars, angulation
close to 90 degrees in a vertical position, whereas the mandibular molars had approximately 25 degrees of distal root angulation; the maxillary canines were the most distally angulated teeth, approximately 66 degrees. The mandibular canines were vertically positioned and the maxillary anterior area exhibited vertical lateral incisors and central incisors with a slight distal angulation. In the mandible, a root convergence to mesial was noticed, which resulted in well aligned crowns with a discrete distal angulation.

Given that the whole population has normal homogeneous characteristics, we sought to define whether homologous permanent teeth had the same angulation (Figure 2). In the maxilla, the incisors and canines were significantly more angulated on the right side. In the mandible, the first molars were significantly more angulated on the left side, and the right lateral incisors were more angulated than the left lateral incisors.

The mesiodistal angulation values were also compared between the youngest (eight years old) and oldest (ten years old) groups and no statistically significant differences were found.

### Table 1- Mesiodistal angulation of different teeth in children [mean age 8.9 years ± standard deviation (SD=0.76)] with mixed dentition, according to gender

| Teeth                      | Teeth angulations (degrees), (mean±SD) | P-value |
|----------------------------|----------------------------------------|---------|
|                            | Male (n=50)                            | Female (n=50) |   |
| Maxillary arch, right side |                                        |          |   |
| First molar                | 91.16±4.71                            | 89.84±3.95 | 0.132 |
| Canine                     | 69.66±5.95                            | 65.94±6.93 | 0.005 |
| Lateral Incisor            | 89.82±7.04                            | 86.98±7.36 | 0.052 |
| Central Incisor            | 81.32±6.53                            | 77.74±5.79 | 0.005 |
| Maxillary arch, left side  |                                        |          |   |
| First molar                | 90.82±4.18                            | 90.16±3.97 | 0.420 |
| Canine                     | 67.10±5.57                            | 63.74±7.06 | 0.010 |
| Lateral Incisor            | 87.02±7.06                            | 85.16±7.04 | 0.190 |
| Central Incisor            | 78.12±5.81                            | 76.86±8.21 | 0.378 |
| Mandibular arch, right side|                                        |          |   |
| First molar                | 75.98±5.23                            | 75.06±5.80 | 0.406 |
| Canine                     | 86.16±7.45                            | 83.42±8.47 | 0.089 |
| Lateral Incisor            | 108.74±6.60                           | 110.08±11.14 | 0.502 |
| Central Incisor            | 104.70±7.68                           | 106.70±8.96 | 0.233 |
| Mandibular arch, left side |                                        |          |   |
| First molar                | 78.64±4.88                            | 79.16±5.45 | 0.616 |
| Canine                     | 85.38±7.38                            | 86.70±8.82 | 0.419 |
| Lateral Incisor            | 102.42±6.61                           | 105.74±9.43 | 0.044 |
| Central Incisor            | 98.44±5.95                            | 102.50±8.02 | 0.005 |

**Figure 1**- Panoramic radiograph showing the anatomic structures, the dental long axes and the angles measured relative to the reference line measured on the external side.
DISCUSSION

This study measured the mesiodistal root angulations of permanent incisors, canines and first molars among Brazilian children with normal occlusion in mixed dentition. A new horizontal reference line was used for measuring the tooth angulation.

The study of Ursi, et al. 17 (1990) suggested using superior and inferior reference lines for the evaluation of the mesiodistal axial inclination in the panoramic radiographs of adults with permanent dentition, with the superior line passing through the lowest points of the right and left orbits and the inferior line through the centre of the right and the left mental foramina. Our study suggests using a reference line passing through the intercuspation mid-point of the permanent first molars and primary canines, to the right and the left sides, respectively. The choice was justified mainly by the difficulty of locating the mental foramen in the mixed dentition, which is small and superimposed by the tooth germs. Also, the permanent first molars and the primary canines are visible and easily identified structures, reducing the reference line errors.

The males showed angulations of 5 to 6 degrees greater than those of the females. Other studies report that differences of up to five degrees between the genders are clinically acceptable11,17. The alterations in the anterior mandibular area could be attributed to the panoramic radiograph distortions mentioned in the literature5,8.

The comparison of mesiodistal root angulations between the homologous permanent teeth showed statistically significant differences for the maxillary incisors and canine groups. Our results support the idea that asymmetrical eruption may be present in normal mixed dentition. Some studies5,14-16 report that there is no alignment pattern for the maxillary incisors, which may be protruded and present diastemas, which decreases the aesthetics, despite being a normal occlusion requiring no treatment.

Evaluation of the youngest (eight years old) and the oldest (ten years old) groups in the same mixed dentition revealed no differences. This could justify the absence of alterations in the mesiodistal angulation between these two groups, suggesting that no influence was established by canine eruption until that time.

Despite some inherent degree of distortion8, the panoramic radiograph is the most practical examination for evaluating tooth angulations. In the maxilla, however, the panoramic radiograph may lead to an overestimation of canine angulation4. The comparison of panoramic radiography with cone beam computed tomography revealed the anterior maxillary roots’ over-inclination in a mesial direction and the posterior roots’ over-inclination in a distal direction10. The greatest alteration occurred between the maxillary canines and the first premolars10. With regard to the anterior mandibular angulations, the authors10 reported that they were not bilaterally symmetric and the posterior roots tended to be mesially inclined. The results of our study also failed to show bilateral symmetry for the majority of the evaluated teeth.

The proposed reference line could be useful in mixed dentition root angulation evaluation. The normal values established for the root angulation of permanent teeth in the middle mixed dentition in Brazilian children may offer parameters for the early diagnosis of deviations, as well as signs of normal asymmetric pattern of eruption. This study determined the acceptable mean values in a homogeneous group, but longitudinal studies are welcome to confirm this normal behavior.

CONCLUSIONS

The following conclusions can be drawn: the proposed reference line could be useful in mixed dentition root angulation evaluation; there was a slight asymmetry in the mesiodistal angulation among homologous teeth, and also a small variation between the male and the female groups, but no difference between 8-and 10-year-old children.

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