Mixed Dentition Space Analysis
CBCT and some predictive methods

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Introduction

Most problems of malocclusion are the result of an imbalance between teeth size and arch size. If managed timely, they can be reduced in severity or even removed entirely[1,2]. A mixed dentition space analysis aims to predict the combined mesiodistal widths of unerupted permanent canine, first premolar and second premolar[1, 3]. There are three main approaches described:

1) Direct measurements of unerupted teeth on radiographs which is an individualized method[4]. The cone-beam computed tomography (CBCT) has many applications in orthodontic practice which justify the growing use by orthodontists[5]. The CBCT's isotropic voxel allows high accuracy in linear measurements[6-10]. Sakabe *et al.*[11] and Nguyen *et al.*[12] concluded that CBCT is a reliable and accurate method for mixed dentition space analysis. With this method, the mesiodistal width is not estimated but measured, which is a great advantage compared to the predictive methods.

2) Using prediction equations and tables based on the measurements of erupted teeth which are used to estimate size of unerupted canine and premolars. The most commonly used worldwide are Tanaka and Johnston's regression equations[13] and Moyers' Probability Tables[14].

3) Combination of both methods;

Despite the diversity of available methods, no single method has been shown to deliver high accuracy, precision and reliability, all presenting limitations.

The objectives of this study were to assess the degree of equivalence between predictions given by three models (Moyers' Predictive Tables on percentil 75 and 50 and Tanaka-Johnston's Equations) on the sum of unerupted mesiodistal teeth width of permanent canine and premolars (SUCP) and a "gold standard" given by Cone Beam Computed Tomography.

Material and Methods

The study sample comprised children (n=26) aged 8-13 years who visited the pediatric/orthodontic appointment in the Department of Dentistry, Faculty of Medicine, University of Coimbra. The inclusion criteria were that the lower permanent incisors should be present and fully erupted, with no previous orthodontic treatment, the permanent canines and premolars were not erupted and the teeth measured on dental casts had to be free of malformations, restorations, caries or fractures. All subjects had a similar ethnic background (Portuguese ancestors). The purpose of this study was explained to the parents/ guardians and the children in accordance with Helsinki Declaration. The children whose parents/guardians assented to the study were recruited, after obtaining a written consent.

DENTAL CAST MODELS

Dental impressions of the selected children were taken with irreversible hydrocolloid alginate impression material (Orthoprint, Zhermack) and immediately poured with dental stone to avoid any dimensional changes. The tooth mesiodistal width was done has described by Moorrees and Reed[15].It was used a digital caliper with a vernier scale with an accuracy of 0.01mm. The sum of the mandibular incisors was acquired and used in Moyers' tables. The predictive number was obtained from the 75 and 50 percentile. The predictive values of the SUCP were obtained using linear interpolation between the closest values. For the Tanaka-Johnston's equations we used the same value of the mandibular incisor sum in order to obtain the predictive space needed.

CONE-BEAM IMAGES

For the CBCT measurements, the images were obtained with iCAT scanner, 120 kVp, 5 mA, 8.9 seconds per revolution, 8x16cm field of view and a voxel size of 0.3 mm. The volumetric data were imported in DICOM format and analyzed with In Vivo 5 software.

FIGURE 1– Protocol for isolation of the unerupted teeth, choosing "Dental View", boosting the contrast and finaly bringing down the brightness.

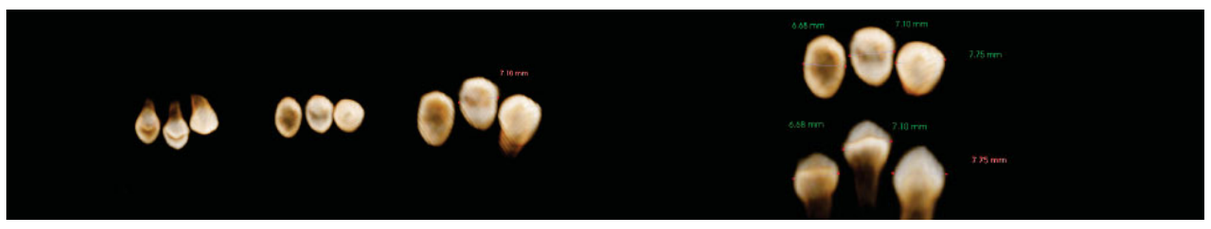


FIGURE 2– The occlusal face of each theeth was aligned with the monitor and the mesiodistal width was measured. The measurements were then confirmed from a labial/ palatal view in order to ensure the correct mesiodistal width was being measured.

FIGURE 3– Occlusal and Palatal view of the unerupted teeth with the final measurements.

To determine measurement reliability, a intraexaminer and intereaminer calibration was performed by measuring 5 casts and 5 cone-beam images randomly selected. It was applied a concordance correlation coefficient (CCC) between each model's predictions (Moyers 75, Moyers 50 and Tanaka-Johnston) and SUCP measurements using CBCT.

Results

For the systematic error, there were no significant differences on any tooth between the first and second evaluation (intraexaminer) and between operators (p> 0.05). The random error estimates are clinically tolerable because Dahlberg vary between 0 and 0,51 mm.

TABLE 1 – Maxilla and mandible descriptive statistics on SUCP values (mm) given by the Cone Beam Computed Tomography (CBCT), Moyers' tables on percentiles 75 and 50, and Tanaka-Johnston's models (n = 26 in all cases).

	Mean *(Maxilla/Mandible)*	**Std - Deviation** *(Maxilla/Mandible)*	**Minimum** *(Maxilla/Mandible)*	**Maximum** *(Maxilla/Mandible)*
CBCT	21.82 / 21.75	1.29 / 1.32	19.81 / 19.5	25.06 / 25.84
Moyers 75	23.02 / 22.68	0.67 / 0.73	21.93 / 21.49	24.16 / 23.95
Moyers 50	22.38 / 21.98	0.66 / 0.73	21.29 / 20.79	23.55 / 23.25
Tanaka-Johnston	22.90 / 22.40	0.61 / 0.61	21.91 / 21.41	23.96 / 23.46

TABLE 2 – Maxilla and mandible concordance correlation coefficient with the CBCT and paired t-tests for each pair Model-CBCT (n = 26). Table 2 shows that all models have a very poor agreement with the CBCT as the highest CCC value is very far from 1.

			Paired t-test
	CCC *(Maxilla/Mandible)*	**P –value** *(Maxilla/Mandible)*	**Mean difference (mm)** *(Maxilla/Mandible)*
Moyers 75	0.18 / 0.24	0.000 / 0.000	1.20 / 0.93
Moyers 50	0.26 / 0.33	0.031 / 0.358	0.56 / 0.23
Tanaka-Johnston	0.18 / 0.25	0.000 / 0.013	1.08 / 0.65

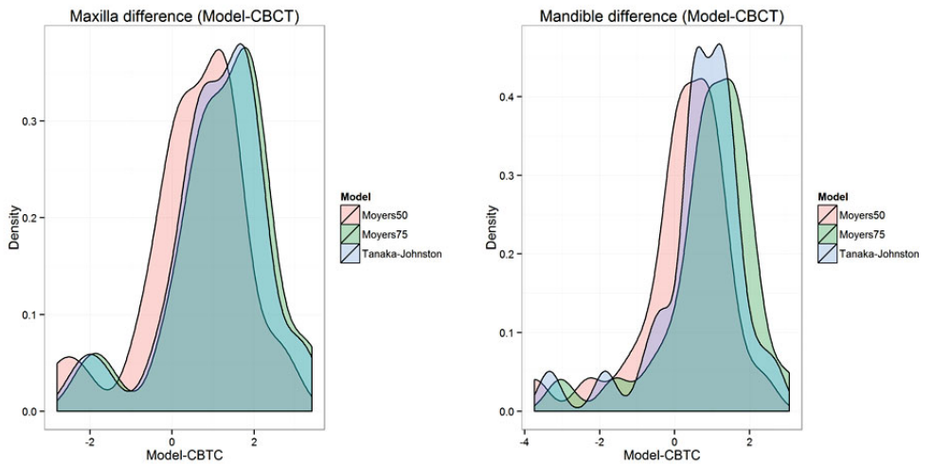


FIGURE 4 – Maxilla and mandible density functions approximations for the difference (Model-CBCT) for each model (Moyers' tables on percentiles 75 and 50, and Tanaka-Johnston's models, n = 26 in all cases). All 3 models tend to overestimate the CBCT.

Difference *(Model-CBCT)*	***Moyers p75*** *n (%)*	***Moyers p50*** *n (%)*	***Tanaka e Johnston*** *n (%)*
< - 1.5 mm	2 (7.7%)	2 (7.7%)	2 (7.7%)
-1.5 to 0 mm	2 (7.7%)	4 (15.4%)	2 (7.7%)
0 to 1 mm	7 (26.9%)	9 (34.6%)	8 (30.8%)
1 to 1.5 mm	3 (11.5%)	7 (26.9%)	3 (11.5%)
> 1.5 mm	12 (46.2%)	4 (15.4%)	11 (42.3%)
Total	26 (100%)	26 (100%)	26 (100%)

TABLE 3– Maxilla differences (mm) between each model's SUCP predictions and SUCP measurements using CBCT (n = 26).

Difference *(Model-CBCT)*	***Moyers p75*** *n (%)*	***Moyers p50*** *n (%)*	***Tanaka e Johnston*** *n (%)*
< - 1.5 mm	2 (7.7%)	2 (7.7%)	2 (7.7%)
-1.5 to 0 mm	2 (7.7%)	5 (19.2%)	3 (11.5%)
0 to 1 mm	9 (34.6%)	12 (46.2%)	9 (34.6%)
1 to 1.5 mm	3 (11.5%)	5 (19.2%)	7 (26.9%)
> 1.5 mm	10 (38.5%)	2 (7.7%)	5 (19.2%)
Total	26 (100%)	26 (100%)	26 (100%)

TABLE 4 – Mandible differences (mm) between each model's SUCP predictions and SUCP measurements using CBCT (n = 26).

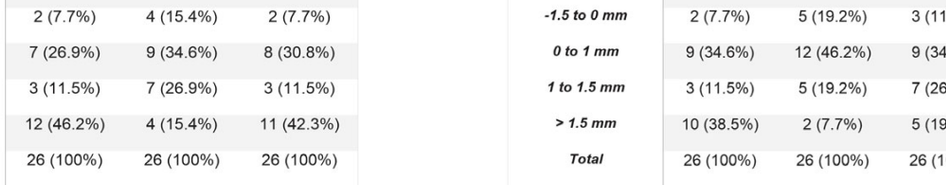
Discussion

Neither overestimation nor underestimation of the teeth widths is acceptable, as they can lead to erroneous treatment planning. However, it is important to correlate predictive values with their clinical significance. Lee-Chan et al[16] suggested that differences between actual and predicted measurements lower than 1.0 mm are clinically acceptable.

The results of this study show a greater standard-deviation for CBCT than the other 3 predictive models. This can be perceived as a limitation of the predictive models in their ability to represent interindividual variations. The statistics suggest that the model behind Moyers' tables on percentiles 50 seems like the one with the best performance with the closest values to the CBCT.

When we take into consideration the CCC, all the models have a very poor agreement with the CBCT, as the highest CCC value is very far from 1. Moyers 50 shows the highest CCC values (0.26 mm maxilla, 0.33 mm mandible). The mean difference is statistically significantly different than zero for all models but mandible's Moyers 50. Although, as stated before, and according to Flores-Mir et al[17] and Lee-Chan et al[16] these values must be interpreted with caution and according to their clinical significance. Moyers' 50 Maxilla mean difference is statistically significantly different than zero but it is inferior to 1.0 mm, which makes it clinical acceptable. Also, Moyers' 50 shows most percentage of case between 0 and 1.0 mm, with a slightly bigger tendency to overestimation for the maxilla, explaining the lower CCC value. However, Tanaka-Johnston and Moyers' 75 show more cases of over-estimation. Moreover the overestimation, represents a bigger problem when deciding what will be the treatment plan. The results of this study are in accordance with previous studies published for the Portuguese population[18].

The isotropic voxel of CBCT (equal in the 3 dimensions) allows an image reconstruction without magnification.12 The image resolution is affected by voxel size. The smaller the size, the better the resolution but it is inversely correlate to the radiation dose[19, 20]. Mosfeghi et al[9] compared measurements obtained with 0.15 mm voxel and 0.3 mm voxel concluding that there is no statistically difference between the two sizes. There is also the possibility of error, with the value error ranging from 0 to the voxel size per measurement. In this study, the sum of the measurement of the C, P1 and P2 could lead to a maximum underestimation of 0.9 mm. As this value is always under 1.0 mm, this underestimation is statistically not significant[6, 9]. Based in this conclusion, the voxel size used in this study was 0.3 mm, in order to decrease the radiation dose. This value should be taken into account, although it is not statistically or clinically significantly.



The individual variation is an important factor to take into account when planning an orthodontic treatment. With the CBCT the orthodontist can detect any abnormal shaped tooth, macro or microdontia which would pass undetected with the predictive methods. In this study, there was a case of macrodontia, a second mandibular premolar with more than 11.0 mm. This explains the severe underestimation of almost 4.0 mm.

Conclusion

In this study, after analyzing the data it can be seen that this sample suggests that Moyer's percentile 50 is the predictive model with the lowest percentage of absolute deviations from the cone-beam computed tomography, when compared to Moyers' 75 and Tanaka-Johnston equation. Also Moyers' 50 percentile is more balanced between over and underestimation unlike Moyers' 75 and Tanaka-Johnston equation.

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