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Evaluating the Accuracy of Dental Space Prediction as a Simple Visual Observation Compared to the Standard Prediction Method in Mixed Dentition Period

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ABSTRACT

Background: Investigating and analyzing the dental artery space during a mixed dentition period is very important because it is used in orthodontic treatments planning. The main purpose of this study is to compare the standard Tanaka-Johntson method and simple visual observation in the space analysis in a mixed dentition period and realizing the accuracy of the simple visual observation. **Methods Materials:** The present study follows a double blind cross-sectional study. Three patients who were in the mixed compare period were selected and six samples were collected from the upper and lower Maxilla duplicate casts. Data were analyzed using ICC and correlation and paired t-test with SPSS 22 software. **Results:** The general analysis result of the estimated sizes by specialists and residents and the obtained sizes from the Tanaka-Johntson method shows only 28% of the agreement between these two methods. The announced agreement for the sizes was 31% by residents and 22 % by specialists. According to the obtained data, the average difference between specialists and residents was at least one hundredth of a millimeter and the maximum difference was ninety-seven hundredths of a millimeter. **Conclusion:** The results of the present study show that the estimation of space difference in a simple visual observation method has not an acceptable accuracy in comparison with the Tanaka-Johntson method. In addition, the conducted estimations by residents were also slightly more accurate than that of the specialists.

INTRODUCTION

Investigating and analyzing space in a dental artery during a mixed dentition period is very important as it is used in orthodontic treatments planning. Determining the difference between the total size of the teeth and the available space in the dental arc in the mixed dentition period requires a precise prediction of the mesiodistal length of the permanent teeth that have not been raised. There are several ways to estimate the mesiodistal size of permanent teeth. Although, the estimation of mesiodistal size was raised for the first time in 1902 based on average tables (1); then, several methods were proposed for this issue by several sources. The method introduced by Tanaka-Johnston was the first standard method whose validity has been proven and it has found a great application (2-12). Tanaka-Johnston (1974) introduced a probability equation (regression) to predict the mesiodistal width of the cannabis and premolar teeth, in which the total width of the four mandibular incisors was used. Another common practice in dentistry clinics is the estimation of space difference with the direct observation of OPG radiography and gypsum cast (10). Tanaka-Johnston method is a relatively simple and non-invasive method for calculating space difference and it is precisely acceptable for both upper and lower dental arches, and for both male and female sexes. On the other hand, this method is time-consuming and requires accurate measurements of the mesiodistal length of the deciduous teeth. However, in some studies such as Zaem (3), Khanemasjedi and Basir (4), Arash and Mirkazemi (5), Hambir and Sojan (6), Jiavali et al. (7), it has been claimed that Tanaka-Johnston method is only conducted and introduced to North American patients, and racial factors can affect the information derived from the Tanaka-Johnston method and reduce its accuracy for communities with different ethnic origins. Another method that has been used in dental clinics to estimate the space difference is the direct observation of OPG radiography and gypsum casts (11). This method requires less time compared to the Tanaka-Johnson method and allows the immediate design of orthodontic treatment. The basic question about this method is whether

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the space difference estimation with the direct observation of OPG radiography and gypsum casting has the required accuracy or not?

Some of the studies that have been done can be mentioned below. Hambire and Sujan (2016) conducted a study to assess the validity and usefulness of the mentioned method in Indian school children in Mumbai (6) with the idea that the Tanaka- Johnston method, created in the North American community, is racial in nature and does not necessarily fit into other ethnic groups such as Hindi. Maxillary and mandibular dental arch casts of 360 students including 147 boys and 153 girls in the age group of 12 to 15 years old were constructed with permanent teeth. Conclusion showed that there is a positive correlation between the width of mandibular incisors on one side and premolars and mandibular and maxillary canines on the other side. The other conclusion was that the Tanaka-Johnston prediction method was not sufficiently precise for the sample they were studying. Gyawali et al. (2016) conducted a study in Nepal aimed at finding a new regression equation for estimating the size of canine and premolar teeth in the Nepalese Brahmins/Chhetris population (7). One hundred Nepalese Brahmins/Chhetris, who included 50 males and 50 females, were selected from patients admitted to a clinic. The conclusion of these researchers was that the applied charts for North American children could not accurately measure Nepalese Brahmins/Chhetris samples. Ranjit O Pawar and Shweta R Bhat (2016) performed a study to determine a regression linear equation that can estimate the total mesiodistal width of mandibular and premolar permanent canines based on the total width of the permanent mandibular incisors and the first permanent molars (8). The mentioned researchers reported high correlation coefficients between the estimated and actual dimensions and concluded that the proposed method had acceptable accuracy, but should be tested for other populations. Kadu et al. (2016) estimated the canine teeth size and non-premolar teeth in a mixed population including 251 Indian patients under 21 years old using the Tanaka-Johnston method and the modified Boley gauge with Vernier caliper (13-9). The researchers concluded that the precision of the original Tanaka-Johnston method could be enhanced by a new regression equation derived from a mixed Hindi population.

The main objective of this study was to determine the prediction accuracy of dental space through simple visual observation compared to the standard prediction method in mixed dentition.

METHODS MATERIALS

The present study follows a double blind cross-sectional study. In this study, the specialized dentists and resident orthodontics of Shahed University of Tehran and Shahid Beheshti University were the research population. Among the patients admitted to the dental faculty, three patients who were in mixed dentition and who had a case with OPG and cast photographs were selected. Then, six samples were collected from the upper and lower Maxilla duplicate casts (Figure 1). Since all patients were in the mixed dentition period, calculating the mesiodistal length of canine and premolar teeth was calculated using the Tanaka-Johnston standard method. The Tanaka-Johnston equation is as follows:

The bottom half:

½ of the total maxillary bottom half + 10.5mm= Estimated width of one side canine and premolar.

The up half:

½ of the total maxillary up half + 11mm= Estimated width of one side canine and premolar.

Data were analyzed using SPSS 22 software. The statistical methods used in this study were ICC and correlation tests. These tests show the correlation between simple visual estimations and measurements performed by the standard method. Considering the studied subject, i.e. the accuracy of the size stated by the dentist, agreement indicators were required. These indicators are measured in quantitative variables based on ICC and in qualitative variables based on sensitivity and specificity indicators, and the results are expressed in the ROC chart. In the present study, a low or high estimation of the space difference is a qualitative variable, and the amount of difference, is a quantitative variable. The cut-off point in the sensitivity and specificity tables indicates the difference in dental space.

The two main hypotheses in this study were as follows:

1. There is no significant difference between the space difference estimation by the standard method and the simple visual observation method.

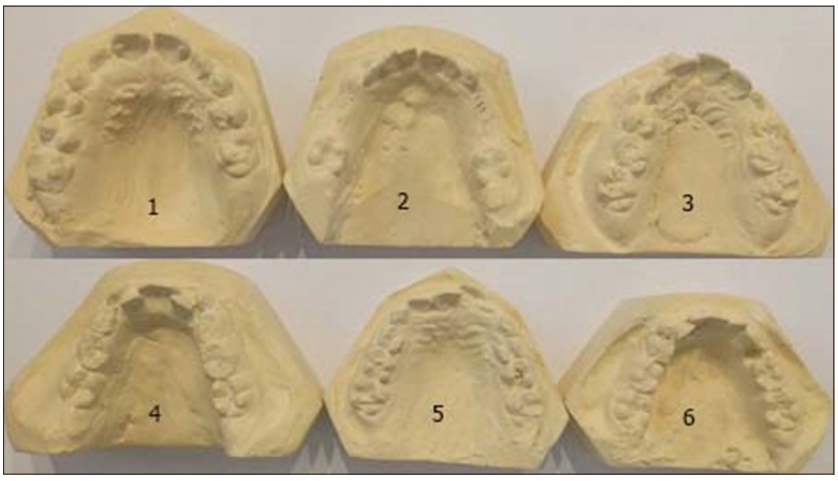

Figure 1. Cast images related to the sample patients

2. There is no significant difference between estimating the space difference by the simple visual observation method among orthodontic specialists and the orthodontic residents.

The appropriate statistical analyzes including ICC and correlation were performed to examine whether research results confirm the mentioned hypotheses or the alternative hypotheses. It is worth mentioning that, given the nature of the research data, their analysis had a particular complexity.

RESULTS

Table (1) compares the calculated space differences by the standard method on one side and the simple visual estimation method by the orthodontic specialists and residents in the six casts used on the other side. In this table, table, the mean and standard deviation of the estimated sizes can be observed by the dentists for each cast against the standard measurement of the same casts. According to this table, the difference between standard measurements by the dentists is significant, and the degree of difference is subsequently reported. The table shows that the least difference between dentists is in the case number 5 and the highest difference is in cast number 3. Figure 2 shows the actual difference of the calculated space by the standard method for each cast against the space difference proposed by the dentists. In this graph, it is also observed that the expressed sizes for the casts with the space difference of 1mm have the least dispersion and the casts with the space difference of 3mm have the most dispersion. Considering the studied subject, i.e., the accuracy of the size stated by the dentist, agreement indicators were required. These indicators are measured in quantitative variables based on ICC and in qualitative variables based on sensitivity and specificity indicators, and the results are expressed in the ROC chart. In the present study, a low or high estimation of the space difference is a qualitative variable, and the amount of difference, is a quantitative variable. The cut-off point in the sensitivity and specificity tables indicates the difference in dental space. Sensitivity indicates the degree of positive (high) dental space difference in the dentist's diagnosis, if the positivity is confirmed by the equation. Specificity represents the negativity (lower) difference in dental space and the correct diagnosis by the dentist.

Table 2 generally shows the sensitivity and specificity for the various sizes of dental space estimated by dentists. As shown in this table, the maximum sensitivity and specificity

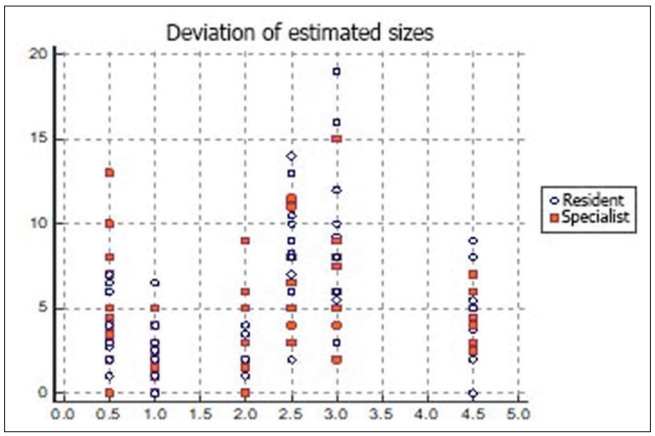

Figure 2. Graphical representation of the difference in estimated space

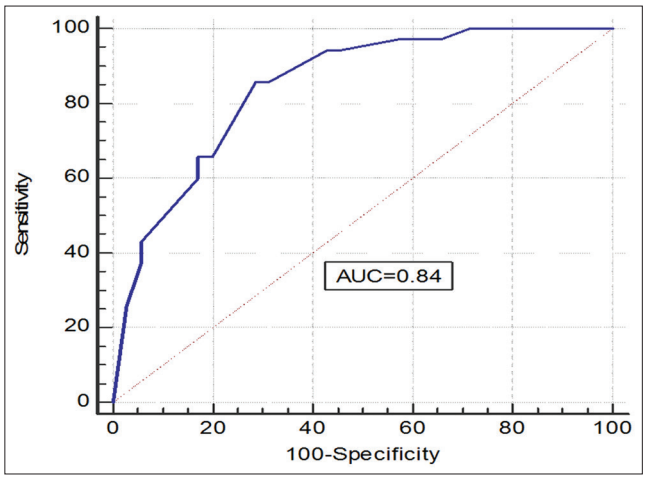

Figure 3. ROC chart for all dentists

Table 1. Mean and standard deviation of estimated sizes for each cast in millimeters divided by the studied groups

Cast number	Calculated size by the equation		Number	Mean	Standard deviation
1	4.5	Resident	23	4.92	2.26
		Specialist	12	5.25	1.53
2	1.0	Resident	23	1.80	1.69
		Specialist	12	2.25	1.50
3	0.5	Resident	23	4.86	2.21
		Specialist	12	5.83	3.82
4	3.0	Resident	23	8.55	3.98
		Specialist	12	6.38	3.56
5	2.0	Resident	23	3.07	1.87
		Specialist	12	3.08	2.67
6	2.5	Resident	23	7.25	3.33
		Specialist	12	6.08	2.95

is at the cutting point of 3 mm. Figure 3 shows the ROC graph for the data in Table 2, the surface under the curve according to this graph is 0.84. Table 3 shows sensitivity and specificity for different sizes of dental space expressed by orthodontists. As shown in Table 3, the maximum sensitivity and specificity at the cut-off point is 3mm. Figure 4 is the ROC for the data in Table 3, the surface under the curve according to this graph is 0.82. Table 4 shows the sensitivity and specificity of different sizes of dental space expressed by orthodontic residents. As can be observed, the highest sensitivity and specificity is at the cutoff point of 2.75mm. Figure 5 shows the ROC chart for this data, the surface below the curve according to this graph is 0.86. Table 5 expresses the amount of agreement by dentists including residents and specialist with the size obtained by the equation. Based on the size stated in the table, only 28% of the agreement between the estimates of physicians and the measurements obtained from the standard measurement is observed. Table 6 describes the amount of agreement by dentists including residents and specialist with the size obtained from the standard measurement by the groups in question. According to the data of this table, the agreement for the announced sizes is 31% for residents and 22% for specialists. This ICC level is not significant in the expert group (p-value> 0.05). Table 7 shows the results of the measurement iteration to verify the repeatability (reliability) of the measurements. The low stan-

Table 2. Sensitivity and specificity of cut-off points are specified

Cut-off point	Sensitivity	95% CI	Specificity	95% CI
≤0	25.71	12.5-43.3	97.14	85.1-99.9
≤1.5	42.86	26.3-60.6	94.29	80.8-99.3
≤2	60	42.1-76.1	82.86	66.4-93.4
≤2.5	65.71	47.8-80.9	82.86	66.4-93.4
≤3	85.71	69.7-95.2	71.43	53.7-85.4
≤3.5	85.71	69.7-95.2	68.57	50.7-83.1
≤4	94.29	80.8-99.3	57.14	39.4-73.7
≤4.5	94.29	80.8-99.3	54.29	36.6-71.2
≤5	97.14	85.1-99.9	42.86	26.3-60.6
≤6.5	100	90.0-100.0	28.57	14.6-46.3

Table 3. Sensitivity and specificity of cut-off points for specialists

Cut-off point	Sensitivity	95% CI	Specificity	95% CI
≤0	16.67	2.1-48.4	91.67	61.5-99.8
≤1.5	33.33	9.9-65.1	91.67	61.5-99.8
≤2	50	21.1-78.9	83.33	51.6-97.9
≤2.5	58.33	27.7-84.8	83.33	51.6-97.9
≤3	83.33	51.6-97.9	75	42.8-94.5
≤3.5	83.33	51.6-97.9	66.67	34.9-90.1
≤4	91.67	61.5-99.8	58.33	27.7-84.8
≤4.5	91.67	61.5-99.8	50	21.1-78.9
≤5	100	73.5-100.0	41.67	15.2-72.3

Table 4. Sensitivity and specificity of cut-off points for orthodontic residents

Cut-off point	Sensitivity	95% CI	Specificity	95% CI
<0	0	0.0-14.8	100	85.2-100.0
≤0	30.43	13.2-52.9	100	85.2-100.0
≤1	43.48	23.2-65.5	95.65	78.1-99.9
≤1.5	47.83	26.8-69.4	95.65	78.1-99.9
≤2	65.22	42.7-83.6	82.61	61.2-95.0
≤2.5	69.57	47.1-86.8	82.61	61.2-95.0
≤2.75	69.57	47.1-86.8	78.26	56.3-92.5
≤3	86.96	66.4-97.2	69.57	47.1-86.8
≤4	95.65	78.1-99.9	56.52	34.5-76.8
≤6	95.65	78.1-99.9	30.43	13.2-52.9

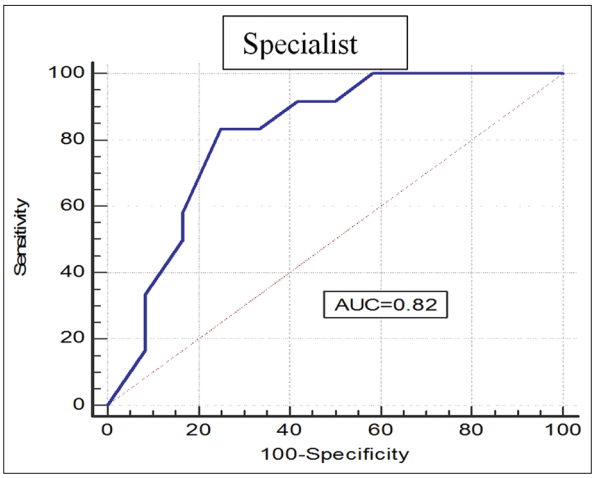

Figure 4. ROC chart for specialists

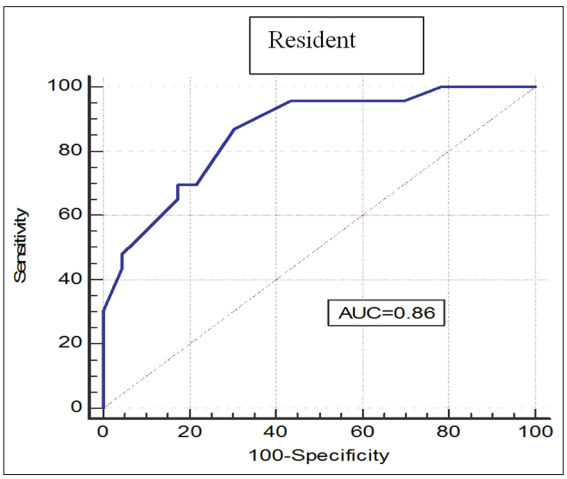

Figure 5. ROC Chart for Residences

dard deviation and p-values higher than 0.05 indicate that there is no significant difference between the two stages of measurement, which means the repeatability and reliability of the data by the examiner.

DISCUSSION

The Main Question

The basic question in this study was whether the space difference estimation with the direct observation of OPG radiography and gypsum casting has the required accuracy or not? According to Table 5, only 28% of the agreement is observed between the estimations of physicians and the measurements obtained from the standard measurement. This amount of agreement between the simple visual observation method and the standard method is insufficient and a fundamental revision of the ophthalmic observation technique, including the training of testers, is necessary to increase the amount of agreement. On the other hand, the low level of agreement between the two methods could be due to technical deficiencies in the provision of casts. Therefore, the improvement of custody techniques could increase the amount of agreement. There are occasionally unavoidable conditions in the provision of casts that cause deficiencies. In addition,

Table 5. ICC in all studied subjects

		95% CI		p-value
ICC	0.288	0.065	0.457	0.007

Table 6. ICC according to the studied groups

	ICC	95% CI		p-value
Residents	0.315	0.041	0.510	0.014
Specialist	0.223	–0.242	0.514	0.145

Table 7. Repeatability of the data by the examiner

	Mean	Standard deviation	Median	p-value
atm1.1	22.44	1.02	21.98	0.753
atm1.2	22.44	1.05	21.98	
atm2.1	14.36	3.00	14.18	1.000
atm2.2	14.37	3.06	14.25	
atm3.1	13.80	3.18	12.52	0.500
atm3.2	13.85	3.10	12.62	
atm4.1	20.97	2.37	21.76	0.917
atm4.2	21.04	2.56	21.76	
atm5.1	6.33	0.08	6.32	0.026
atm5.2	6.43	0.03	6.45	
atm6.1	5.60	0.28	5.56	0.916
atm6.2	5.63	0.40	5.45	
atm7.1	5.32	0.14	5.26	0.459
atm7.2	5.33	0.14	5.27	
atm8.1	6.31	0.05	6.34	0.157
atm8.2	6.34	0.09	6.34	

only the mesiodistal length of the teeth is considered in the Tanaka-Johnston method and the accuracy of the teeth rotation, corroding, stenosis curves, etc. is ignored. While in the visual technique, dentists consider all the variables during evaluation of gypsum casts and space estimations. This can be a reason for a poor agreement between the two methods.

Table 7 shows the results of measurement iteration to verify the repeatability (reliability) of the measurements. The low standard deviation and p-values higher than 0.05 indicate that there is no significant difference between the two stages of measurement, which means the repeatability and reliability of the data by the examiner.

Sub Questions

First question: Do the accuracy of orthodontic specialists and orthodontic residents' estimations depend on their experience? In other words, does the accuracy of the estimation increase by increasing the professional experience? Table 6 shows the degree of agreement between the estimated sizes by simple visual observation and the standard method for both groups of orthodontic specialists and orthodontic residents. As can be observed this agreement is slightly higher for the

resident group about 32%, while this value for the specialists is 22%. In other words, the accuracy of the estimation by specialists is less than the residents, and the relationship between the experience and the accuracy of the estimation is inverse, which is somewhat contrary to expectation. The most reasonable justification would be less willingness of specialists to cooperate and spend time, which may be due to a lot of work. On the other hand, residents are being trained. They consider time consuming for estimation as a part of their learning in any case and they have the time to read more and even repeat the estimations easily. Another justification can be the role of visual acuity in better and more accurate estimation.

Second question: If the accuracy of the direct visual observation method was less than the Tanaka-Jahnston method, whether the potential defect is negligible? The research results indicate a very low (average 28%) agreement between the estimations by direct observation and standard estimation. This poor agreement indicates that the simple visual method is not negligible with the present condition of the defect and if it is based on the advantages of this method, then a working method should be developed to reduce this deficiency to an acceptable level.

Third question: Is the Tanaka-Johnson method known as a standard for estimating the difference in dental arch space in a mixed dentition period, are they free from racially-ethnical concealment in Iranian cases and is it useful? The design of the present research has not been a direct answer to this question. For this question to be answered without a doubt, the research report of the researchers who investigated this issue was examined. In all of these papers, it was concluded that the Tanaka-Johnston method was not sufficiently precise in the studied races (3), (4), (5), (6), (7).

CONCLUSION

It can be concluded from the research the direct visual observation with conventional methods does not have sufficient accuracy to estimate the difference in dental space. In addition, the simple visual defect is not negligible with current conditions, and thus it cannot be a good alternative to the standard method. In addition, the accuracy of estimations by orthodontic residents is somewhat better than the corresponding specialists. Finally, it is recommended to use both methods of direct measurement of can be used simultaneously and modified Tanaka-Johnston equations for Iranian ethnicity considering the influence of the standard Tanaka-Johnston method on racial factors, and also the inadequacy of the simple ocular method with direct observation of radiography of OPG and gypsum casts.

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