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Gender Difference in the Prediction of Crown Widths of Unerupted Permanent Canines and Premolars with Crowded Teeth

Enas T Al-Jwarry
BDS, MSc (Lec.)

Dept of Pedod, Orthod, and Prev Dentistry
College of Dentistry, University of Mosul

الخلاصة

الأهداف :تهدف هذه الدراسة لمعرفة إذا كان تنبؤ مجموع أبعاد الناب والضواحك غير الظاهرة تعتمد على جنس المريض ولمعرفة إذا كان هناك اختلافات مابين الجنسين في الارتباطات مابين المتغيرات المستقلة للتنبؤ ولإنشاء معادلة التحليل للانحدار المتعدد للأسنان المزدحمة لكلا الفكين العلوي والسفلي ولكلا الجنسين .**المواد وطرائق العمل** :تتكون العينة من ٨٠ قالب للأسنان (٤٠ أنثى و٤٠ ذكر) تتراوح أعمارهم ما بين (١٤-٢٢ سنة) وجميع المرضى عندهم ازدحام في الاسنان الامامية . أيضا تم قياس طول الفك الأساسي والمسافة مابين الأسنان الطواحن لكلا الفكين ،حللت البيانات باستخدام البرنامج الإحصائي SPSS. **النتائج**: أظهرت نتائج البحث أن مجموعة الذكور أظهرت ارتباط معنوي مابين أبعاد القواطع الأول والثاني في الفك العلوي(r=0.456)، وفي الفك السفلي ما بين أبعاد القاطع الأول والثاني وطول الفك السفلي الأساسي(r=0.682). أما في مجموعة الإناث هناك ارتباط معنوي مابين القواطع الأول والثاني والطاحن الأول وطول الفك الأساسي العلوي والمسافة مابين الطواحن في الفك العلوي(r=0.742)، أما في الفك السفلي أظهرت النتائج ارتباط معنوي مابين القاطع الأول والثاني والطاحن الأول(r=724). كما أظهرت النتائج أن معاملات الارتباط (r) ومعاملات التحديد (R^2) لمجموعة الإناث اكبر بالمقارنة مع مجموعة الذكور. **الاستنتاجات**: تم إيجاد أربع معادلات تحليل الانحدار المتعدد للأسنان المزدحمة ولكلا الجنسين ووجد أن هناك اختلافات في الارتباطات المستقلة للتنبؤ مابين الجنسين.

ABSTRACT

Aims: To determine whether the accuracy of the prediction of the summed widths of unerupted permanent canines and premolars depend on the patient's gender and to examine whether there are differences between sexes in the best combination of independent variables for predicting and to developing new predicting equations for crowding patient for both jaws and both sexes. **Materials and methods:** The sample consisted of eighty dental casts (40 males and 40 females). The age ranged between (14-22) years and all patients have anterior crowding. The mesiodistal crown diameters of the central incisors, the lateral incisors, the canines, the first premolar, the second premolar, and the first molars in the maxillary and mandibular arch were measured on dental casts. Basal arch lengths and intermolar distances for the upper arch and for the lower arch were also recorded. Predicted sum widths of permanent canines and premolars in both dental arches were calculated using backward multiple regression analysis by using statistical package for social science (SPSS). **Results:** In the male subject group, there were statistically significant correlations between central incisor and lateral incisor widths in the maxilla (r=0.456) and in the mandible between lower central and lateral incisor widths and lower basal arch length (r=0.682), and in the female subject group, there were statistically significant correlations between the central incisor and the lateral incisor widths, upper first molar, upper basal arch length and upper inter molar distance (r=0.742). For the mandible, lower central and lateral incisor and lower first molar widths (r=724). Also the correlation coefficients (r) and determination coefficients (R^2) for female group are greater when compared with those for the male subject group. **Conclusions:** Four regression equations for crowding patients for both gender are establish and the best combination of independent variables for prediction was found to differ between sexes.

Key words: Unerupted canines and premolars, prediction, gender.

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INTRODUCTION

Successful orthodontic treatment is based on comprehensive diagnosis and treatment planning. A few of the fundamental factors in the diagnosis are spacing condition, tooth size, arch form and its dimensions, as well as the tooth arch discrepancies.[1,2] For the patient with mixed dentition accurate prediction of the sum of mesiodistal diameters of clinical crowns of unerupted permanent canines and premolar is indispensable especially in choos-

ing appropriate methods for space control including space regaining and serial extraction.[3]

There are several basic methods of predicting mesiodistal diameters of the unerupted canines and premolar, application of middle values,[4] probability tables or regression equations,[5] correlation-statistic methods[6] and combination of x-ray and correlation-statistic methods.[7]

The widely used Tanaka and Johnstan space analysis is a simple method to predict the size of unerupted canine and premolars in mixed dentition with an acceptable accuracy for both jaws and both genders.[8] To improved the accuracy of prediction other variables such as the mesiodistal crown width of maxillary incisors and /or of both maxillary and mandibular molars have also been used as predictors.[9-11] Ibrahim *et al.,* found the combination of the sums of lower permanent first molars and upper permanent central incisors was the best predictor for the mesiodistal width of both maxillary and mandibular permanent canines and premolars and the newly proposed prediction equation may be considered clinically useful for mixed dentition.[12] Legovic *et al.,* developed multiple linear regression equations used the buccolingual tooth widths as independent variables in their regression equations.[13] Several simple linear regression equations have been proposed for populations of different ethnic origins.[14-18]

Also, other methods used regression equations and devoted a separated equation to each jaw and sex.[19-20] The aims of this study were to determine whether the accuracy of the prediction of the summed widths of unerupted permanent canines and premolars depends on the patient 's gender and to examine whether there are differences between sexes in the best combination of independent variables for predicting and to development a new predicting equations for crowding patient for both jaws and both sexes.

MATERIALS AND METHODS

The samples selected in the Department of Orthodontic, Collage of Dentistry, University of Mosul and consisted of eighty dental casts (40 males and 40 females), the age ranged from (14-22) years and all patients have anterior crowding and all casts met the following criteria: full permanent dentitions except for third molar teeth and had no congenitally missing teeth and no abnormally sized or shaped teeth and no proximal caries or filling.

Measurements were made using a digital caliper (Dental Vernier, Dentaurum), the mesiodistal crown diameters of the central incisors (U1 and L1), the lateral incisors (U2, L2), the canines (U3, L3), the first premolars (U4, L4), the second premolar (U5, L5), and the first molars (U6, L6) in the maxillary and mandibular dentitions were measured on dental casts obtained from the subjects and the measurement done according to the method described by Moorrees *et al*.,[21]

Molar basal arch lengths (UBAL for the upper dentition and LBAL for the lower dentition) and intermolar distances (UIMD for the upper dentition, LIMD for the lower dentition) were also recorded Figure (1). Also we used the mean of the right and left mesiodistal crown diameters for each tooth.

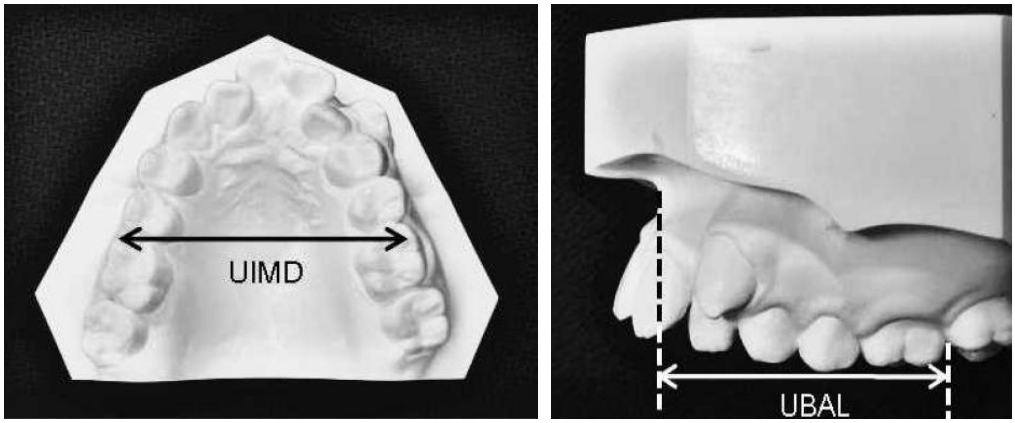

Figure (1): UIMD: Upper intermolar distances, UBAL: upper basal arch length.

The data were analyzed using statistical package for social science (SPSS), statistical descriptive; means, minimum, maximum and standard deviation were calculated.

Pearson's correlation coefficients (r) between each independent variable and dependent variable were calculated. Backward multiple regression analysis was performed, with U1, U2, U6, L1, L2, L6, UBAL, LBAL, UIMD, and LIMD as the independent variables and the sum of the mesiodistal crown diameters of the permanent canines and premolars in the same dental arch as dependent variables. For each dental arch, the best combination of independent variables with the greatest R^2 values was determined. Finally, new equations were developed for both gender and for each dental arch.

The accuracy of our prediction equations tested by using a 24 control samples (12 males and 12 females), the conditions of these subjects were the same as those described above then the mesiodistal crown diameter, intermolar distance and basal arch length of upper and lower arches measured and the sum of mesiodistal crown diameter of canine and premolars estimated and this give the actual values.

While the measured values of the sum of mesiodistal crown diameter of canine and premolars obtained from our prediction equation mention later.

The data were analyzed using statistical package for social science (SPSS), the significant differences between the actual values and measured values were tested using the independent samples *t*- test.

RESULTS

The descriptive statistics (mean, minimum value, maximum value and standard deviations) for mesiodistal crown diameter of maxillary and mandibular arches for both genders are shown in Table (1).

The Pearson's correlation coefficients between each independent variable and dependent variable are shown in Tables (2) and (3).

In the male subject group, there were statistically significant correlations between central incisor and lateral incisor widths in the maxilla (r=0.456) and in the mandible between lower central and lateral incisor widths and lower basal arch length (r=0.682), and in the female subject group, there were statistically significant correlations between the central incisor and the lateral incisor widths, upper first molar, upper basal arch length and upper inter molar distance (r=0.742). For the mandible lower central and lateral incisor and lower first molar widths (r =724).

Table (1): Descriptive statistics (mean, minimum value, maximum value and standard deviations) for mesiodistal crown diameter of maxillary and mandibular arches for both genders.

Variables		N	Minimum	Maximum	Mean	±SD
Male	U1	40	7.09	10.06	8.8464	.56333
	U2	40	6.02	8.15	6.9981	.51965
	U3	40	6.91	9.00	8.0754	.42591
	U4	40	6.05	8.24	7.0998	.51580
	U5	40	5.55	8.64	6.7862	.46656
	U345	40	19.22	23.51	21.9614	.98053
	U6	40	8.81	12.02	10.4014	.57874
	UB	40	39.00	48.00	43.6155	2.39402
	UI	40	42.25	53.58	48.6102	2.73917
	L1	40	4.64	6.12	5.4485	.29324
	L2	40	4.53	6.89	6.0134	.42419
	L3	40	5.60	7.87	7.0665	.53798
	L4	40	6.24	7.81	7.1210	.36622
	L5	40	6.00	8.18	7.3199	.48807
	L345	40	18.93	23.47	21.5074	1.09962
	L6	40	10.28	12.78	11.3578	.62020
	LB	40	36.90	45.24	40.6470	1.99309
	LI	40	39.19	51.43	44.4330	3.06716
Female	U1	40	7.59	10.10	8.6661	.57360
	U2	40	4.80	7.82	6.7555	.59223
	U3	40	6.40	8.91	7.7580	.49977
	U4	40	6.15	8.26	7.0384	.47191
	U5	40	5.79	8.33	6.6950	.53708
	U345	40	19.23	24.63	21.4914	1.21661
	U6	40	8.90	11.73	10.2303	.64651
	UB	40	37.95	49.40	42.8697	2.61949
	UI	40	38.05	52.66	47.8410	3.19215
	L1	40	4.75	6.11	5.3578	.32913
	L2	40	5.21	7.10	6.0060	.40292
	L3	40	6.05	7.60	6.8181	.36412
	L4	40	6.37	8.82	7.1740	.48914
	L5	40	6.50	8.91	7.1818	.45595
	L345	40	19.29	25.14	21.1739	1.07766
	L6	40	10.05	12.99	11.1106	.65628
	LB	40	37.00	44.74	39.9020	1.69459
	LI	40	38.41	52.00	43.4625	2.92124

U1:upper central incisor; U2: upper lateral incisor; U3: upper canine; U4: upper first premolar; U5: upper second premolar; U345: sums of mesiodistal width of upper canine and premolars; U6:upper first molar; UB:upper basal arch length; UI:upper intermolar distance; L1:lower central incisor; L2: lower lateral incisor; L3: lower canine; L4: lower first premolar; L5: lower second premolar; L345: sums of mesiodistal width of lower canine and premolars; L6: lower first molar; LB: lower basal arch length; LI: lower intermolar distance. SD= standard deviation.

Table (2): Pearson's correlation coefficients (r) between independent variables and dependent variable for maxillary teeth.

Gender		U1	U2	U345	U6	UB	UI
Male	U1	1	.600(**)	.445(**)	.084	.370(*)	.239
	U2	.600(**)	1	.346(*)	-.048	.443(**)	.162
	U345	.445(**)	.346(*)	1	.054	.142	.196
	U6	.084	-.048	.054	1	.064	-.066
	UB	.370(*)	.443(**)	.142	.064	1	.344(*)
	UI	.239	.162	.196	-.066	.344(*)	1
Female	U1	1	.533(**)	.360(*)	.270	.587(**)	.332(*)
	U2	.533(**)	1	.429(**)	.142	.241	.005
	U345	.360(*)	.429(**)	1	.546(**)	.487(**)	.489(**)
	U6	.270	.142	.546(**)	1	.316(*)	.462(**)
	UB	.587(**)	.241	.487(**)	.316(*)	1	.506(**)
	UI	.332(*)	.005	.489(**)	.462(**)	.506(**)	1

**Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

Table (3): Pearson's correlation coefficients (r) between independent variables and dependent variable for mandibular teeth.

Gender		L1	L2	L345	L6	LB	LI
Male	L1	1	.576(**)	.627(**)	.278	.234	.228
	L2	.576(**)	1	.522(**)	.245	.361(*)	.236
	L345	.627(**)	.522(**)	1	.358(*)	.373(*)	.208
	L6	.278	.245	.358(*)	1	.540(**)	.278
	LB	.234	.361(*)	.373(*)	.540(**)	1	.567(**)
	LI	.228	.236	.208	.278	.567(**)	1
Female	L1	1	.747(**)	.599(**)	.247	.330(*)	.064
	L2	.747(**)	1	.595(**)	.182	.294	.139
	L345	.599(**)	.595(**)	1	.478(**)	.221	.076
	L6	.247	.182	.478(**)	1	.252	.235
	LB	.330(*)	.294	.221	.252	1	.453(**)
	LI	.064	.139	.076	.235	.453(**)	1

**Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed).

The regression equations for estimating the sum of the mesiodistal crown widths of the unerupted canines and premolars, and their corresponding adjusted R^2 values, as determined by backward multiple regression analysis, were calculated. The regression equations derived in this study for predicting the mesiodistal crown widths of unerupted permanent canines and premolars were as follows:

For the male patients,

Upper: $Y = U1\times0.647+U2\times0.232+14.617$.

Lower:

$Y=L1\times1.804+L2\times0.450+LB\times0.109+4.545$.

For the female patients,

Upper: $Y=U1\times-0.418+U2\times0.869+U6\times0.629+UB\times0.121+UI\times0.101+2.775$

Lower:

$Y=L1\times0.853+L2\times0.900+L6\times0.579+4.770$.

Where Y equals the estimated sums of mesiodistal crown widths of the unerupted permanent canines and premolars in millimeters.

The best combinations of independent variables for predicting the sum of the unerupted permanent canines and premolars were obtained by U1, U2 for the maxilla and by L1, L2, and LB for the mandible in the male subject group and by U1, U2, U6,UB and UI for the maxilla and by L1, L2and L6 for the mandible in the female subject group. The adjusted R^2 values were 0.165 for the maxilla and 0.421 for the mandible in the male subject group,

and R^2 values were 0.484 for the maxilla and 0.485 for the mandible in the female subject group.

The independent samples *t*-test between measured vales and actual values determined for the sum of the mesiodistal crown diameters of the canine and premolar and show there is no significant differences between the actual values and measured values at 0.05 level as in the Table(4).

Table (4): The independent samples *t*- test between measured vales and actual values determined for the sum of the mesiodistal crown diameters of the canine and premolar for both arches and both genders.

Gender		values	N	Mean	SD	SE	Sig.	*t*-value
Male	upper	actual	12	21.9180	.75445	.21779	.967	.042
		measured	12	21.9060	.64729	.18686		
	lower	actual	12	21.4629	.83012	.23963	.810	-.244
		measured	12	21.5506	.92899	.26818		
female	upper	actual	12	21.0596	.81961	.23660	.692	-.401
		measured	12	21.1968	.85699	.24739		
	lower	actual	12	20.7450	1.15933	.33467	.652	.457
		measured	12	20.5359	1.08062	.31195		

DISCUSSION

It is important to predict mesiodistal crown diameter of the permanent canines and premolars in the mixed dentition, which helps to determine malocclusion and its further development.[22] Because prediction models are generally applied to patients in the mixed dentition stage to estimate whether sufficient space can be attained in the permanent dentition for spontaneous tooth alignment, in our judgment, evaluating those subjects with obvious tooth crowding, rather than those subjects with normal occlusion, would be more useful for developing prediction models that can be generally applied to patients in the mixed dentition stage.[3] Previous reports [23,24] have documented that the mesiodistal diameters of clinical tooth crowns in subjects with crowding are greater than those of subjects who exhibit normal occlusion. Accordingly, we selected subjects that were diagnosed as exhibiting crowding of teeth with a severity greater than 3 mm in terms of the irregularity index.[25]

Also, it was found that mesiodistal crown diameters had significantly statistical difference in gender. Hence, the mesiodistal crown diameters were assessed and investigated separately for the male and the female.[22] The difference between male and female tooth widths is been shown in several studies.[26-28]

According to Staley *et al.*,[29] the prediction of the width of the crowns of the teeth is more reliable on the left than on the right side of the jaw and this disagreement with Awni[30], Legovic *et al.*,[13] and Jarjees[31] who found there is no significant difference in the mesiodistal crown diameter of the teeth between right and left sides of the jaws for both male and female, so in our study the mean of right and left side is taken for both gender.

The result of the present study showed statistically significant correlations for maxillary arch between U1and U2 for male, while for female, there is a statistically significant correlations between U, U, U, UB and UI.

In the mandibular arch, a statistically significant correlations between L1, L2 and LB , while for female , there is a statistically significant correlations between L1,L2and L6. The inclusion of some skeletal jaw base size in our models was found to have improved predication efficiency, especially for the female subject group so we found the greater determination coeffi-

cients in female subjects when we added the skeletal jaw base size (UIM and UB) as independent variable to the regression equations.

Also, the correlation coefficients (r) and determination coefficients (R^2) for female group were greater when compared with those for the male subject group. This result agrees with results of Alther *et al*.,[32] and disagreement with result reported by Frankel and Benz [33], Yuen *et al*.,[34], Melgaco *et al*.,[35] and Tome *et al*.,[3] and this result is due to sexual dimorphism in predicting tooth size may be explained by Alvesalo[36] who reported that the Y chromosome affects both dentin and enamel growth and affect tooth crown size ,while the X chromosome affects only enamel growth .Also Buwembo *et al*.,[37] found a sex difference in the correlation values which may be attributed to the size of the canine and premolars in the maxillary and mandibular arches. Also for the control group, a high accuracy in prediction was found in the sum of mesiodistal crown diameter of canines and premolars when used our prediction equations.

CONCLUSION

The present study found a higher accuracy in predicting the sum of mesiodistal tooth crown widths of unerupted permanent canines and premolars in the female subject group than in the male subject group. The best combination of independent variables for prediction was found to differ between sexes not only in the dental tooth size factors, but also in the skeletal jaw-base size factors. Also, new regression equations for crowding patient for both jaws and both sexes were established.

REFERENCES

1. Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics. 4th ed .St.Louis, Mosby. 2007; p; 169.
2. Zilberman O, Huggare V, Parikakis A. Evaluation of the validity of tooth size and arch width measurements using conventional and three dimensional virtual orthodontic models. *Angle Orthod*.2002; 73(3):301-306.
3. Tome W, Ohyama Y, Yagi M, Takada K. Demonstration of a sex difference in the predictability of widths of unerupted permanent canines and premolars in a Japanese population. *Angle Orthod*. 2011; 81(6):938–944.
4. Pancherz H, Schaffer C. Individual based prediction of size of the supporting zones in the permanent dentition. A comparison of the Moyers method with a unitary prediction value. *J Orofac Orthop*.1999; 60: 227-235.
5. Chandna A, Gupta A, Pradhan K, Gupta R. Prediction of the Size of Unerupted Canines and Premolars in A North Indian Population - An In Vitro Study. *JIDA*. 2011; 5(3): 329-333.
6. Legovic M, Hautz Z. Spacing of permanent incisors and it is influence on the available space for mandibular canines and premolars. *Acta stomatol croat*.1989; 23(4): 291-302.
7. Salman K, Jarjees H. Prediction of mesiodistal crown diameter of the unerupted lower premolars. *Al-Rafidine dent J*. 2004; 4(1): 73-78.
8. Tanaka MM, Johnston LE. The prediction of the size of unerupted canine and premolars in a contemporary orthodontic population. *J Am Dent Assoc*. 1974; 88(4): 798–801.
9. Melgac¸o CA, Arau´ jo MST, Ruellas AC. Mandibular permanent first molar and incisor width as predictor of mandibular canine and premolar width. *Am J Orthod Dentofacial Orthop*. 2007; 132: 340–345.
10. Nourallah WA, Gesch D, Khordaji MN, Splieth C. New regression equations for predicting the size of unerupted canines and premolars in a contemporary population. *Angle Orthod*. 2002; 72(3):216–221.
11. Mittar M, Dua VS, Wilson S. Reliability of permanent mandibular first molars and incisors widths as predictor for the width of permanent mandibular and maxillary canines and premolars. *Contemp Clin Dent*. 2012 Apr; 3(Suppl 1):S8-S12.
12. Ibrahim IA, Elkateb MA, Wahba NA, El Harouny NM. A digital method to predict the mesiodistal widths of canines and premolars in an Egyptian sample. *J Clin Pediatr Dent.* 2011; 35(4): 421-7.
13. Legovic´ M, Novosel A, Legovic´ A. Regression equations for determining mesiodistal crown diameters of canines and premolars. *Angle Orthod*. 2003; 73(3): 314–318.

14. Al-Khadra BH. Prediction of the size of unerupted canines and premolars in contemporary Arab population. *Am J Orthod Dentofacial Orthop*. 1993; 104(4):369–372.
15. Jaroontham J, Godfrey K. Mixed dentition space analysis in a Thai population. *Eur J Orthod* 2000; 22(2) : 127-34.
16. Diagne F, Diop-Ba K, Ngom PI, Mbow K. Mixed dentition analysis in a Senegalese population: Elaboration of prediction tables. *Am J Orthod Dentofacial Orthop*. 2003; 124(2): 178-83.
17. Marchchioni VM, Silva MC, Araujo TM, Reis SR. Evaluation of the effectiveness of the tanaka –Johnston method for predication of the mesio-distal diameter of unerupted canines and premolars. *Pesqui Odontol Bras*.2001; 15:35-40.
18. Barun Dasgupta and Shabnam Zahir. Comparison of two non-radiographic techniques of mixed dentition space analysis and evaluation of their reliability for Bengali population. *Contemp Clin Dent.* 2012; 3(Suppl 2): S146–S150.
19. Flores-Mir C, Bernabe E, Camus C, Carhuayo MA, Major PW. Predication the mesio-distal canine and premolar tooth width in a sample of Peruvian adolescents. *Orthod Craniofac Res*. 2003; 6:173-176.
20. Jaju k, Gulve N, Chitko S. A new equation for predicting the width of unerupted permanent canines and premolars for cosmopolitan Indian population. *J Indian Orthod So*.2010; 44(2):83-88.
21. Moorrees CF, Reed RB. Correlation among crown diameter of human teeth. *Arch Oral Bio*.1964; 9:685-697.
22. Peng H, Wang X, Chen K. The predication equation of the permanent canine and premolar crown. *Hua Xi Kou Qiang Yi Xue Za Zhi*. 2000; 18(1):55-7.
23. Puri N, Pradhan KL, Chandna A, Sehgal V, Gupta R. Biometric study of tooth size in normal, crowded, and spaced permanent dentitions. *Am J Orthod Dentofacial Orthop*. 2007; 132: 279.e7–279.e14.
24. Agenter MK, Harris EF, Blair RN. Influence of tooth crown size on malocclusion. *Am J Orthod Dentofacial Orthop*. 2009; 136: 795–804.
25. Little RM. The irregularity index: a quantitative score of mandibular anterior alignment. *Am J Orthod*. 1975; 68: 554–563.
26. Jaju K, Gulve N, Chitko S. A new equation for predicting the width of unerupted permanent canines and premolars for cosmopolitan Indian population. *JIOS*. 2010; 44(2):82-88.
27. Mahmoud B, Hamed I, Taib H. Accuracy of Four Tooth Size PredictionMethods on Malay Population. *ISRN Dent*. 2012; 2012(523703):1-4.(www.ivsl.org)
28. Ahluwalia P, Jodhka S, Thomas A. Prediction of Mesio-distal width of Canines and premolars in a sample of north Indian population. *IJDA*.2011; 3(3):568-571.
29. Staley RN, Shelly TH, Martin JF. Prediction of lower canine and premolar widths in the mixed dentition. *Am J Orthod*. 1979; 76:300–309.
30. Awni KM. Comparison between Tanaka /Johnston and Boston University prediction approach in a group of Iraqi pupils. *Al-rafidain Dental J*.2005; 5(2):154-160.
31. Jarjees HT. Estimation of the crown widths of unerupted canine and premolars by using vistibulo-oral crown dimensions of permanent teeth. *Al-Rafidain Dent J*.2012;12(2):350-355.
32. Altherr ER, Koroluk LD, Phillips C. Influence of sex and ethnic tooth-size differences on mixed-dentition space analysis. *Am J Orthod Dentofacial Orthop*. 2007; 132:332–339.
33. Fra¨ nkel HH, Benz EM. Mixed dentition analysis for black Americans. *Pediatr Dent*. 1986; 8:226–230.
34. Yuen KK, Tang EL, Lai L. Mixed dentition analysis for Hong Kong Chinese. *Angle Orthod.* 1998; 68:21–27.
35. Melgac¸o CA, Arau´ jo MST, Ruellas AC. Mandibular permanent first molar and incisor width as predictor of mandibular canine and premolar width. *Am J Orthod Dentofacial Orthop.* 2007; 132:340–345.
36. Alvesalo L. Sex chromosomes and human growth. A dental approach. *Hum Genetics*. 1997; 101:1–5.
37. Buwembo W, Kutesa A, Muwazi L, Rwenyonyi C. Prediction of width of unerupted incisors, canines and premolars in a Ugandan population: A cross sectional study.*BMC Oral Health*. 2012; 12(23):1-6.