Al-Rafidain Dental Journal

rden.mosuljournals.com

Evaluation Of Korkhaus Analysis for Maxillary Crowded Dental Arch in Mosul City.

Neam F Agha*, Lamiaa A. Hasan, Lara R. Al-Banaa

Department of Pedo. Ortho. and Prev. Dentistry, College of Dentistry, University of Mosul/ Iraq

Article information

Received: November 6, 2021
Accepted: June 12, 2022
Available online: September 30, 2023

Keywords
Korkhaus Analysis
Dental Arch
Maxillary arch

***Correspondence:**
E-mail:
neamagha@uomosul.edu.iq

Abstract

Aims A variety of the indicators have been the proposed method in-order to assist orthodontic diagnosis and treatment planning. This study aimed to appraise the applicability. the index of the Korkhaus to Iraqi persons, and to know if patients that having crowding of teeth have increase in arch length. **Material and Methods:** The sample consisted of (131) persons their age between (15-20) years, (64) boys and (67) girls, all of Iraqi origin, and live in the centre of Mosul city. **A**ll the individuals have Class I molar. relation. The sample consisted of three groups: Normal occlusion group with well aligned teeth (20) boys and (20) girls. Patients had moderate crowding, 2.5 - 4.5mm, (19) boys and (23) girls and severe crowding group, over 5mm, (23) boys and (26) girls. A linear distance was measured on a figure of the scanned study models for upper dental arches by Dimaxis program. statistical analysis with (SPSS) program at the level of $P \leq 0.05$ include: comparison between genders using in-depended t-test and, Pearson correlation coefficient among all the variables. **Results:** The results showed that the measurements (Sum of Incisors, Vertical, Measured Premolar value, measured molar value, Calculated Premolar Value, Calculated Molar Value) in normal occlusion had significantly higher mean Values in males than females. **A**lso, there is a correlation coefficient between the sum of teeth width of four anterior and the posterior arch width which is significant for normal occlusion, but there is no such relation in the most crowding sample. **Conclusions:** Korkhaus index can be used to determine arch width in Iraqi individuals with normal occlusion, patients with crowded teeth had slight proclination of incisors that is not significant other than normal occlusion**.** So Korkhaus analysis is considered to be valid for Iraqi class I normal and crowded occlusion.

الخلاصة

الأهداف: الهدف من هذه الدراسة هو تقييم قابلية تطبيق مؤشر Korkhaus على العراقيين ومعرفة اذا كان هناك زيادة في المسافة العمودية بين القواطع والاضراس لمجموعة المرضى اللذين لديهم تزاحم بالاسنان. **المواد وطرائق العمل:** تكونت العينة من (131) شخصًا تتراوح اعمارهم بين 15–20 سنة ، (64) ذكر و (67) انثى ، وجميعهم من أصل عراقي ويعيشون في وسط مدينة الموصل. جميع الأفراد لديهم اطباق من النوع الاول. ثلاث مجاميع: المجموعة الاولى لديهم أسنان جيدة المحاذاة (20) ذكر و (20) انثى. المرضى الذين لديهم ازدحام معتدل 2.5–4.5 ملم ، (19) ذكر و (23) انثى. ومجموعة الازدحام الشديد أكثر من 5 ملم (23) ذكر و (26) انثى. تم قياس المسافات الخطية على نماذج الاسنان الممسوحة ضوئيًا لقوس الفك العلوي بواسطة برنامج Dimaxis. التحليل الإحصائي باستخدام برنامج (SPSS) على مستوى $P \leq 0.05$. تشمل: المقارنة بين الجنسين باستخدام اختبار t test الزوجي ومعامل ارتباط بيرسون بين جميع المتغيرات. **النتائج:** أوضحت النتائج أن القياسات (مجموع القواطع ، القياس العمودي ، القيمة المقاسة و المحسوبة للضواحك والاضراس) للاطباق الطبيعي كان لها متوسط معنوي أعلى في الذكور عن الإناث. يوجد أيضًا معامل ارتباط بين مجموع عرض التاج الأنسي للقواطع وعرض القوس الخلفي وهو أمر مهم بالنسبة للاطباق الطبيعي ، ولكن لا توجد مثل هذه العلاقة في معظم عينات تزاحم الاسنان. **الاستنتاجات:** يمكن استخدام مؤشر Korkhaus لتحديد عرض القوس في الموصليين الذين لديهم اطباق طبيعي ، والمرضى الذين يعانون من أسنان مزدحمة لديهم ميل طفيف للقواطع مقارنة مع المرضى ذوي الاطباق الطبيعي.

DOI: 10.33899/rdenj.2023.132103.1146 ,

INTRODUCTION

Diagnosis in orthodontics has been defined in several ways and thus the term diagnosis has been used by different authors to refer to different things. Decision-making in orthodontics requires the establishment of a complete problem list and the creation of an adequate database[1]. Like other medical or dental specialist, the diagnosis in orthodontic treatment requires information about the patient's problems. One of the methods to obtain patient information is by analyzing the study model of patient's arch[2], the judgment comes later and the objective is to find out what is important to the patient this is the first. Second, to allow for the most effective treatment planning, it is important to take into consideration what dentofacial traits or traits are most important to the patient3.

The disproportion between tooth size and arch dimension refers to dental crowding[4]. The factors that result in crowding have not been fully detected, but the main causative factor to dental crowding has been stated as, evolutionary reduction in jaw size without an equivalent reduction in tooth dimension**Error! R eference source not found.**. An author suggested that; large tooth size is alone contributing factor in crowding[5], both large tooth dimension and small jaw size can contribute equally to dental crowding is the opinion for other[7]. less muscular stimulation due to consuming modern soft and synthetic diet is also reported as a reason for dental crowding**Error! R eference source not found.**. The fact remains that, dental crowding is the most common malocclusion form and the most important motive for people seeking for orthodontic treatment. Extraction of selected teeth, arch expansion, and inter-enamel stripping are techniques that can be commonly utilized alone or in combination to deal with the problem of crowding[8].

Many indices have been introduced to evaluate the relationship between the teeth and arch dimension and between both arches. Some researchers have captivated the predictive value of these indices and supported their use, while others test the validity of these indices in their study. Any index was designed for a particular ethnic population, so it cannot be applied to another group without studying the relevant parameters of the latter[10].

These indices have been utilized for forecast dental arch growth patterns to help in determining a treatment plan for each case. subjects with Angle's Class I crowding malocclusion may be treated satisfactorily with an extraction or non-extraction approach[11], Korkhaus et al in 1900 made use of Linder Harths equation to establish the perfect arch width in the posterior region.

The planned premolar value is determined using the equation: $\frac{SI \times 100}{85}$

The planned molar value is resolute using the equation: $\frac{SI \times 100}{64}$

Where SI = sum of the breadth of incisors. **A**n additional measurement is made from the midpoint of the junction line between the premolars to a point in between two the maxillary incisors. If there is proclination of incisors, an increase in these measurements will appear while a reduction in this measurement indicates retroclined upper incisors[12].

This study aimed to inspect and evaluate Korkhaus index of maxillary class I dental arch with normal occlusion, also for moderate and severe crowding in Mosul city population, and compare the results between two genders.

Null hypothesis

There is no difference of arch length between crowding and normal occlusion groups.

Alternate hypothesis

There is difference in arch length between crowding and normal occlusion groups.

MATERIALS AND METHODS

The approval for this work, obtained from the college of the dentistry ethics committee (Protocol ref no. 14298) on 7 March 2019.

The sample size was calculated based on single mean formula [n = (z r/D)2][13]. In which , n = the number of sample, z (constant) = 1.96 for 95% confidence, r (standard deviation) = 0.501, and D (precision) = 0.2 unit. The resulted number will be adjusted, and the final sample size at least in each group = n + (n × 0.2), yielding 9.

The sample consisted of(131) people, (64) boys and (67) girls, all of Iraqi origin, and live in the center of Mosul city. The sample consisted of three groups[12]:

1. Class I molar relation, well-aligned teeth (20) boys and (20) girls.
2. Class I molar relation with moderate crowding, 2.5 - 4.5mm crowding,(19) boys and (23) girls.
3. Class I molar relation with severe crowding group, over 5mm crowding,(23) boys and (26) girls.

The data was collected from patients attending POP department in the college of dentistry, Mosul university, and from a private clinic. Some criteria were considered in selecting the sample including:

1. Subjects in the age group between 15-20 years with a full complement of teeth except for 3rd molar.
2. No apparent facial abnormality, no extraction, or congenitally missing teeth. In addition, all teeth were without any fracture or badly carious lesions.

After taking impressions for the upper dental arch with alginate, the prepared plaster models were trimmed.

Computer Analysis of the Study Models

The models were placed directly on the glass window of the computer scanner(brother DCP-T300) with a metal ruler. The obtained figures was saved at (PC) laptop (Dell) for measuring the dimensions needed by using the software

Dimaxis program (version3.2.1.), figure (1). Distortion that occurred by the scanning procedure was corrected by the ruler and then corrected automatically by the Dimaxis program.

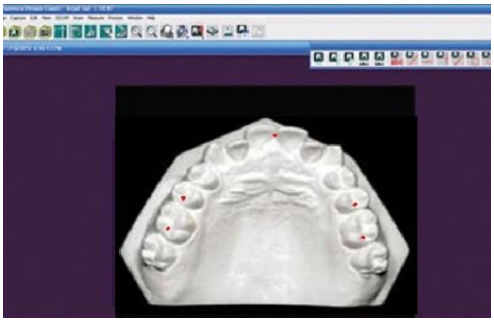

Figure (1): Dimaxis program

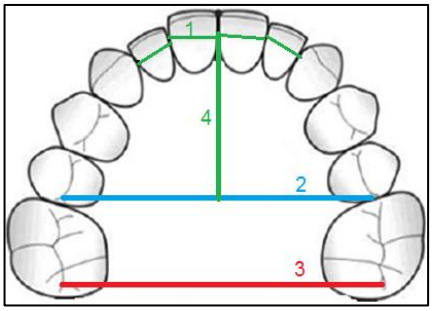

Figure (2): arch dimensions

Dental Arch Dimensions

Linear distances (Fig.2) were calculated on the copy of the study models for upper dental arches by Dimaxis program to establish arch dimensions [13].

1. Sum of Incisors (SI): the largest width of the incisors was measured and recorded in millimeters.
2. Measured Premolar Value (MPV): the distance between the distal end of the occlusal groove of the upper right and left 2nd premolar in mm.
3. Measured Molar Value (MMV): the distance between the distal pits on the occlusal surface of the upper right and left 1st molar in mm.
4. The Vertical distance from the midpoint of the inter-premolar line to a point in between two the maxillary incisors is measured in mm.

The measurements of each study cast were recorded directly in the data sheets and then transferred into the excel program to calculate the following equations:

Calculated Premolar Value (CPV): is measured using the equation: $\frac{SI \times 100}{85}$

Calculated Molar Value(CMV): is measured using the equation: $\frac{SI \times 100}{64}$

Method error

To assess intra examiner reliability, method error was estimated by choosing twenty pairs of dental casts, randomly selected from the study sample measurements were recorded twice, by the same operator after two weeks intervals results were compared and the t-value of the correlated sample were determined to indicate the difference between the means of computed measurements, no significant difference was found between the two readings ($p < 0.05$).

Statistical analysis

Statistical analysis was done with (SPSS) program to analyze the data at the level of

significance at P≤0.05. The statistical analysis used include comparison between genders using in-depended t-test and, Pearson correlation coefficient among all the variables.

RESULTS

Comparison between males and females for Korkhaus index values in normal occlusion is shown in the table (1), it shows significant differences between the two genders for all the variables, that males have a higher value than females

Comparison of the Korkhaus index between males and females for moderate and severe crowding in table (2) the two malocclusions shows non-significant differences between the two genders for all the variables.

Table (3) reveals Pearson correlations of normal occlusion, which demonstrated a correlation with significant differences between SI with each of MPV, & MMV. And the correlation of MPV with MMV, CPV, and CMV. Also MMV with, CPV and CMV for both genders.

Table (4) for Pearson correlations of moderate crowding, there is a high correlation with significant differences between MPV with each MMV, CPV, and CMV. No correlation was found between SI with MPV and MMV for both genders.

Table (5) for Pearson correlations of severe crowding, shows a high correlation with significant differences between MPV with each MMV, CPV, and CMV.

Comparison of Vertical Variable between groups shown in table (6), there is a larger mean value for crowding groups (moderate & severe) than the normal one, although it is not significant in both groups.

Table (1): Comparison of the Korkhaus index values between males and females in normal occlusion

Variables	sex	Mean	Std. Deviation	t- value	Sig. at P≤0.05	
SI	M F	28.80 28.07	1.33 1.25	3.582	.012	S
Vert	M F	21.16 19.91	0.86 0.99	4.118	.006	S
MPV	M F	42.14 40.44	2.50 2.38	5.769	.001	S
MMV	M F	47.66 46.27	2.91 2.65	5.613	.000	S
CPV	M F	33.88 33.02	1.57 1.47	3.582	.012	S
CMV	M F	45.00 43.86	2.08 1.96	3.582	.012	S

SI: Sum of Incisors, Vert: Vertical MPV: Measured Premolar Value, MMV: Measured Molar Value, CPV: Calculated Premolar Value, C MV: Calculated Molar Value, M-males, F- females.

Table (2): Comparison of the Korkhaus index values between males and females in moderate & severe crowding

Variables		Sex	Mean	SD.	t- value	Sig. at $P \leq 0.05$	
SI	Moderate	M	28.63	1.73	1.29	.225	NS
		F	28.57	2.35			
	severe	M	30.51	2.59	.478	.638	
		F	30.17	2.17			
Vert	Moderate	M	22.61	2.00	1.07	.306	NS
		F	22.31	2.41			
	severe	M	21.87	2.50	.335	.741	
		F	21.57	2.64			
MPV	Moderate	M	49.18	3.06	1.35	.205	NS
		F	47.86	3.05			
	severe	M	39.87	2.90	.665	.514	
		F	39.30	2.39			
MMV	Moderate	M	42.43	3.15	0.44	.664	NS
		F	41.89	3.57			
	severe	M	46.93	3.36	1.08	.290	
		F	45.82	2.72			
CPV	Moderate	M	33.68	3.01	1.29	.225	NS
		F	32.48	2.77			
	severe	M	35.89	3.04	.478	.638	
		F	35.50	2.55			
CMV	Moderate	M	44.73	2.71	1.29	.225	NS
		F	43.07	3.68			
	Severe	M	47.67	4.04	.478	.638	
		F	47.15	3.39			

SI: Sum of Incisors, Vert: Vertical MPV: Measured Premolar Value, MMV: Measured Molar Value, CPV: Calculated Premolar Value, C MV: Calculated Molar Value, M-males, F- female

Table (3): Pearson Correlations of normal occlusion

			SI	**Vert**	**MPV**	**MMV**	**CPV**	**CMV**
SI	Per	M	1	.055	.832*	.757*	1	1
		F	1	.051	.833*	.785	1	1
	Sig	M		.906	.020	.049	.000	.000
		F		.890	.011	.043	.000	.000
Vert	Per	M	.055	1	-.340	-.245	.055	.055
		F	.045	1	-.283	-.310	.060	.053
	Sig	M	.966		.456	.597	.906	.906
		F	.943		.51	.69	.912	.890
MPV	Per	M	.832*	-.340	1	.953**	.832*	.832*
		F	.893*	-.331	1	.976**	.817*	.810
	Sig	M	.020	.456		.001	.020	.020
		F	.027	.445		.001	.o23	.021
MMV	Per	M	.757*	-.245	.953**	1	.757*	.757*
		F	.742*	-.260	.896**	1	.698*	.763*
	Sig	M	.049	.597	.001		.049	.049
		F	.041	.598	.001		.052	.046
CPV	Per	M	1	.055	.832*	.757*	1	1
		F	1	.054	.825*	.756*	1	1
	Sig	M	.000	.906	.020	.049		.000
		F	.000	.892	.031	.047		.000
CMV	Per	M	1	.055	.832*	.757*	1	1
		F	1	.057	.785*	.753	1	1
	Sig	M	.000	.906	.020	.049	.000	
		F	.000	.902	.031	.045	.000	

Table (4): Pearson Correlations of moderate crowding

			SI	Vert	MPV	MMV	CPV	CMV
SI	Per	M	1	-.011	.402	.228	1	1
		F	1	.102	.560	.435	1	1
	sig	M		.973	.221	.500	.000	.000
		F		.669	.073	.181	.000	.000
Vert	Per	M	-.011	1	.170	.387	-.011	-.011
		F	.102	1	-.097	.091	-.102	-.102
	sig	M	.973		.616	.232	.973	.973
		F	.669		.777	.789	.669	.669
MPV	Per	M	.402	-.170	1	.881**	.602	.602
		F	-.560	-.097	1	.847**	.660	.660
	sig	M	.221	.616		.000	.021	.021
		F	.073	.777		.001	.043	.043
MMV	Per	M	-.228	-.387	.881**	1	.628	.628
		F	-.435	.097	.847**	1	.635	.635
	sig	M	.500	.239	.000		.050	.050
		F	.181	.789	.001		.041	.041
CPV	Per	M	1	.011	.602	.628	1	1
		F	1	.102	.660	.635	1	1
	sig	M	.000	.973	.021	.050		.000
		F	.000	.669	.043	.041		.000
CMV	Per	M	1	-.011	.602	.628	1	1
		F	1	-.102	.660	.635	1	1
	sig	M	.000	.973	.021	.050	.000	
		F	.000	.669	.043	.041	.000	

* Correlation is significant at the 0.01 level (2-tailed).Per- Pearson correlation, M-males, F-females.

Table (5): Pearson Correlations of severe crowding.

			SI	Vert	MPV	MMV	CPV	CMV
SI	Per	M	1	.407	.265	.237	1	1
		F	1	.216	.233	.245	1	1
	sig.	M		.075	.273	.242	.000	.000
		F		.280	.243	.219	.000	.000
Vert	Per	M	.407	1	.393	.337	.407	.407
		F	.216	1	.285	-.051-	.216	.216
	sig.	M	.075		.127	.146	.075	.075
		F	.280		.150	.799	.280	.280
MPV	Per	M	.265	.493	1	.805*	.721*	.721*
		F	.233	.485	1	.742*	.733*	.733*
	sig.	M	.273	.027		.000	.000	.000
		F	.243	.030		.000	.000	.000
MMV	Per	M	.237	.337	.805*	1	.737*	.737*
		F	.245	-.051	.742*	1	.745*	.745*
	sig.	M	.242	.146	.000		.000	.000
		F	.219	.799	.000		.000	.000
CPV	Per	M	1	.407	.721*	.737*	1	1
		F	1	.216	.733*	.745*	1	1
	sig.	M	.000	.075	.000	.000		.000
				.280	.000	.000		.000
CMV	Per	M	1	.407	.721*	.737*	1	1
		F	1	.216	.733*	.745*	1	1
	sig	M	.000	.075	.000	.000	.000	
		F	.000	.280	.000	.000	.000	

* Correlation is significant at the 0.01 level (2-tailed).Per- Pearson correlation, M-males, F-females.

Table (6): Comparison of vertical variable between groups

	sex	mean	SD	t- test	sig
Normal moderat Crowd	M	21.16 22.61	0.86 2.00	.552	.012 NS
Normal moderat Crowd	F	19.91 22.31	0.99 2.41	.986	.024 NS
Normal Sever Crowd	M	21.16 21.87	0.86 2.50	.983	.363 NS
Normal Sever crowd	F	19.91 21.57	0.99 2.64	.150	.886 NS

M-males, F- females.

DISCUSSION

The present study was done to assess the validity of Korkhaus analysis in crowded arches, the validity was estimated first on normal occlusion, then the analysis was applied for crowded teeth. Crowding usually result from a difference between tooth size and dental arch size, which may be coincident with narrow arch or variability in the length of the dental arc, Korkhaus index have frequently been

The results of the present study showed that all the measurements in normal occlusion had a significantly higher mean value in males than in females, this comes in coordination with previous studies carried out by [14 - 17]. These results support the view that males had larger measurements of all body dimensions including skull, basal bone, and teeth in addition to a longer growth period than females. Females as well had smaller bony ridge and alveolar processes, weaker facial muscles than in males[18].

In moderate and severe crowding samples males had larger mean values for all the variables than females although no-significant difference was noticed, this is linked to either one or both of these variables. Dissimilar jaw sizes will require a different amount of expansion (i.e unilateral, bilateral, or three-dimensional expansion), so Korkhaus method could be valid for different people and different ethnic groups. In addition, genetic variation, food habit among different population groups affects jaw growth. This study is the first to assess Korkhaus index on Mosul inhabitants

because, tooth size arch form discrepancies are a common occurrence, which may prevent attainment of normal occlusion. These discrepancy may be the cause of the deviation from normal occlusion, these results agree with a study carried out by Ul-Hamid[19] and Doris et al[20].

A high correlation coefficient of normal occlusion between sum of incisors SI with the arch width in premolar MPV and molar region MMV which are significant, this result indicates that this index is useful to determine good arch width with incisors dimension in our populations. As the subjects of normal occlusion were carefully selected according to the criteria of arch form, and

alignment. So Korkhaus index is considered to be valid for our people, these findings agree with many studies carried out on both Ponts and Korkhaus indexes like Hong et al[21], Joondeph et al[22] , Gupta et al[23] and Ordoubazary et al[18], they found a significant relation present between incisor dimensions with inter-premolar and inter-molar widths.

No such relation could be found in both moderate and severe crowding samples, so that expansion may be needed in some cases of this malocclusion as stated by Korkhaus index.

A high correlation coefficient was found between MPV and MMV for the three sample groups because the two variables were located at the posterior region of the dental arch. Also, a high correlation coefficient was found between MPV and MMV with each CPV and CMV for the three groups, as the sample selection depends on molar class I occlusion. These results disagree with Rathi and Fida[24] study, they found low correlations between experiential and Pont's predict arch widths. These differences are due to the different indices (because of the limited data about Korkhaus analysis) and racial variability. Low correlation between Vert and SI also for the three sample groups.

The mean value of the vertical variable is larger in moderate and severe crowding cases than in normal, it indicates an increase of dental arch length, it means slight proclination of anterior teeth to accommodate the crowded teeth, this result comes in coordination with Korkhaus saying," an increase in this measurement is seen in proclined anteriors while a decrease in this value denotes retroclined upper anteriors".

Also agrees with a study carried out by Pawar and Jayade[10], suggesting the absence of anterior teeth proclination of normal case samples. No limitation for this work had been found.

Declaration of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript

CONCLUSION

After examining diagnostic dental casts taken of untreated subjects, the following conclusion were reached. Korkhaus index is reliable for predetermination of ideal arch dimensions for Iraqi with normal occlusion in Mosul city. Patients with crowding had slight proclination of anterior teeth. Males have a significant higher incisor width, premolar and molar width than female only in normal occlusion with no significant difference in moderate and sever crowding.

Declaration of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

REFERENCES

1. Birni D, and Harradine N. Excellence in Orthodontics. In diagnosis and treatment planning, 23rded, 2012, [E-book] http://www.excellence in orthodontics.com.
2. Kurniawan I, Soemantri ESS, and Evangelina IA. Dental arch symmetry analysis in orthodontic treatment. *Padjadjaran Journal of Dentistry*. 2008;20(2):89-94.
3. Graber L, Vanarsdall R, and Vig K. Orthodontics: Current Principles And Techniques. In special consideration in diagnosis and treatment planning, 5thed., Mosby of Elsevier Inc. 2011.
4. Hwang HS, Relationship of dental crowding to tooth size and arch width. *Kor J Ortho*. 2004;34(6): 488-96.
5. Phulari BS Orthodontics Principles and Practice. In chapter 8, 1st ed, Jaypee Brothers Medical Publishers, 2011.
6. Bughagis I, Elorfi S. An odontometric study of tooth size in normal, crowded and spaced dentitions. *J Orthod Sci*. 2013, 2:3. doi: 10.4103/2278-0203.119681. http://www.jorthodsci.org
7. Kaundal JR. Evaluation of crowding in relation to tooth size, arch size and arch form in North-East Indian population. *J Pharm Biomed Sci*. 2013; 31(31): 1199-1204.
8. Proffit WR, Fields HW, Larson BE, Sarver, DM Contemporary Orthodontics. In the Etiology of Orthodontic Problems, 6th ed. Elsevier, Inc., 2019.
9. Hussain SS, Ashraf B, and Khan KQ. Relationship of dental crowding to tooth size and arch dimensions in class I normal and class I malocclusion sample. *Pakistan Oral & Dental Journal*. 2014;34(4):660-664.
10. Pawar RL, and Jayade VP. Reliability of Various study model indices in an adult population of north Karnataka. *J Indian Orthod.Soc*. 2013, 47:4. doi: 10.5005/jp-journals-10021-1203. https://journals.sagepub.com
11. Dhakal J, Shrestha RM, Pyakurel U. Assessment of Validity of Pont's Index and Establishment of Regression Equation to Predict Arch Width in Nepalese Sample. *Orthodontic Journal of Nepal*, 2014; 4(1): 11-16
12. Singh G, textbook of orthodontic. *In* Diagnosis, 2nded., Jaypee Brothers Medical Publishers LTD, India, 2007.pp. 85-86.
13. Rachna M & Anuj SP. A Comparative Evaluation of Impact Strength, Compressive Strength, Tensile Strength, Hardness and Dimensional accuracy of Autopolymerized, Postpolymerized Microwave Exposed Autopolymerized and Heat-Cured Denture Base Resins-An in Vitro Study. *Saudi J. Oral. Dent. Res*., 2018; 3(5): 164-170.
14. Haralabakis NB, Sifakakis L, Papagrigorakis M, and Papadakis G. The correlation of sexual dimorphism in tooth size and arch form. *World J Orthod*. 2006; 7(3):254-262.
15. Al–Sarraf H, Abdul–Mawjood AA, Al–Sayagh N Re–assessment of Pont's index

in Class I normal occlusion. *Al–Rafidain Dent J*. 2006; 6(1): 1-5.

16. Al-E'nizy JA, and Agha N. Association between upper dental arch dimensions and facial type in adult with class I normal occlusion. *International Journal of Enhanced Research in Science, Technology & Engineering*,2015;4(9): 188-205.
17. Islam R, Alam MK, Shahid F, Khamis MF. Global Dental Arch Dimension Norms and Sexual Disparities: An over View. *Bangladesh Journal of Medical Science*. 2019;18(1):30-35.
18. Ordoubazary M, Zafarmand A, Madani A, Ordoubazary A. Comparison of Pont's and Korkhaus indices at different populations. *Hellenic Orthodontic J*. 2007;10:67-74.
19. Ul-Hamid MW and Rahbar MI. Dental crowding and its relationship to tooth size and arch dimensions. *Pakistan Oral & Dent J*. 2005; 25(1):47-52.
20. Doris JM, Bemard BW, and Kuftinec MM. A biometric study of tooth size and dental crowding. *Am J Orthod*. 1981; doi: 10.1016/0002-9416(81)90080-4. https://pubmed.ncbi.nlm.nih.gov/6938140/
21. Hong Q, Tan J, Koirala R, Lina Y, Shimizu T, Nakano K, et al A Study of Bolton's and Pont's Analysis on Permanent Dentition of Nepalese. *Journal of Hard Tissue Biology*. 2008;17(2):55-62.
22. Joondeph DR, Riedel RA, and Moore AW. Pont's Index: A clinical evaluation. *Angle Orthod*. 1970; doi: 10.1043/0003-3219(1970)040.0112:PIACE.2.0.CO. https:// pubmed.ncbi.nlm.nih.gov/
23. Gupta DS, Sharma VP, and Aggarwal SP . Pont's Index As Applied on Indians. *Angle Orthod*. 1979; doi:10.1043/0003-3219. http://meridian.allenpress.com.
24. Rathi MK, Fida M. Applicability of Pont's index in orthodontics. *J Coll Physicians Surg Pak*. 2014; doi: 04.2014/JCPSP.256260. https://www.ncbi.nlm. nih.gov/pubmed /24709239.