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Original

A Study of Bolton's and Pont's Analysis on Permanent Dentition of Nepalese

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Abstract: The Bolton's analysis and Pont's analysis are very useful calculations for orthodontic diagnosis. In Nepal, there is no study about Bolton's and Pont's analysis. So here we examined 100 Nepalese subjects all subjects were with molar and canine class I relationship. We have measured the model to establish a normative standard of Bolton's OR and AR for Nepalese population and to find the reliability of Pont's index for Nepalese, and to comparing them between Caucasian and Chinese. The normative value on OR of Nepalese was found to be 91.22% with a standard deviation of 1.99 and AR was 78.04% with standard deviation of 2.72. The normative standard of OR for Nepalese is similar to that obtained by Bolton for Caucasian and that of Chinese, but the normative standard of AR obtained for Nepalese is significantly different than that obtained by Bolton for Caucasian and also that of Chinese. The correlation coefficient between the measured arch width values and the corresponding calculated values according to Pont's indexes were low in all cases with r values ranging from 0.07 to 0.29. Pont's Index is not reliable for predetermination of ideal arch width values for Nepalese.

Key words: Bolton ratios, Normal occlusion, Pont index, Tooth size

Introduction

Tooth size discrepancy is a disharmony between mesiodistal tooth size of the maxillary and mandibular arch as described by Dr. Wayne Bolton in 1958. The Bolton tooth size analysis is very useful calculations for orthodontic diagnosis as it helps in predicting the final tooth positions in the arch. Correct maxillary and mandibular mesiodistal tooth size relationship is important for Ideal intercuspation between teeth of maxillary and mandibular arches and are important in the finishing stage of orthodontic treatment. For successful treatment of any malocclusion, proper diagnosis is very important. Dental casts are still considered as an essential diagnostic tool in orthodontic practice. Orthodontic treatment methods have been progressed a lot since its beginning but the diagnostic procedures have not been developed in the same way. Bolton analysis is still the widely used method for measuring tooth size discrepancies and it is always suggested before initiating orthodontic treatment on a patient. Especially in the anterior region where relative tooth sizes control the amount of overbite, overjet, crowding and spacing.

The Bolton tooth-size analysis is an intermaxillary ratio analysis designed for the purpose of localizing differences in tooth size[1]. Bolton studied on 55 white subjects with excellent occlusion (criteria for excellent occlusion was not mentioned) among them 44 subjects were orthodontically treated (non extraction cases) and 11 subjects were untreated. In his study the measurement tool was three-inch needle pointed dividers and a finely calibrated millimeter ruler to the nearest one quarter millimeter. Greatest mesiodistal diameter of all teeth were been measured. He introduced two ratios, Anterior ratio (AR) and overall ratio (OR) to determine arch discrepancy.

Anterior ratio (AR) is the percentage obtained by adding the mesiodistal width of the six mandibular anterior teeth (from right canine to left canine) divided by the mesiodistal size of the six maxillary anterior teeth (from right canine to left canine), which is 77.2 % with standard deviation of 1.65.

AR=sumof mandibular 3-3 x 100 / sum of maxillary 3-3

Overall ratio (OR) is the percentage obtained by adding the mesiodistal width of the 12 mandibular teeth (from right lower fist molar to left lower first molar) divided by the mesiodistal

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width of the 12 maxillary teeth (from upper right first molar to upper left first molar), which is with a mean of 91.3 % with standard deviation of 1.91.

OR= sum of manndibular 6-6 x 100 / sum of maxillary

When the maxillary anterior teeth are too large in relation to the mandibular anterior teeth, clinical manifestations such as increased overbite, increased overjet and crowded maxillary anterior segment. On the other hand, if the mandibular anterior teeth are too large in relation to the maxillary teeth, clinical manifestations such as, edge to edge bite, spacing in the maxillary anterior segment and mandibular crowding.

According to William R. Proffit[12] approximately 5% of the population have a significant tooth size discrepancy because of disproportionate size of the upper and lower teeth. Unless teeth are matched for the size, normal occlusion is impossible. Any anomalies in upper lateral incisors are the most common cause but variation in premolar and other teeth also present. The discrepancy of less than 1.5mm is rarely significant but larger discrepancy need orthodontic treatment but he did not specify whether this is applied to anterior tooth size ratio or overall tooth size ratio.

Bolton suggested that a ratio greater than 1 SD from his reported mean values indicates a diagnostic consideration. Other authors[1,7,8] suggested that outside 2 SD of the Bolton's mean ratio have been accepted as a clinically significant ratio for determining tooth size discrepancy. Bernabe et al[5] suggested, the 2 SD range from the Bolton standard did not predict clinically significant anterior and total tooth-width ratio discrepancies.

Few researchers found the same result as that stated by Bolton with no significant difference and few researchers found their value significantly different than that obtained by Bolton. Stifter[3] did Bolton's study in Class I dentitions and reported similar results as that of Bolton. Venessa P.[6] on Spanish population found the anterior and overall tooth size ratio was greater than that obtained by Bolton. Lew and Keng[9] studied on a group of Singaporean Chinese and reported that they had smaller maxillary central incisors still found an anterior ratio comparable with the Bolton standard. Smith et al[10] to study whether Bolton ratios were valid for different racial groups collected data systematically from pre orthodontic casts of 180 patients, including 30 men and 30 women from each of Black, Hispanic, and White groups. They concluded that Bolton ratios apply to white women only, the ratios should not be arbitrarily applied to White men, Blacks or Hispanics. Most investigators concluded that there are significant differences among ethnic and racial groups.

Pont[2] (1909) stated that the ideal arch width necessary to accommodate the dentition and relieve crowding. It can be determined by assuming a constant relationship between the sum of the mesiodistal widths of the permanent maxillary incisors (SI) and the interpremolar or intermolar arch widths. This is expressed by the following formulae,

Inter premolar arch width = sum of maxillary incisors ，˜100 /80

Inter molar arch width = sum of maxillary incisors ，˜100 /64

Pont studied on a French population, the sample size and selection criteria were not described. He proposed a method of predetermining ideal dental arch width which is now known as Pont's index. He stated that for normal dental arch there is a constant relationship exists between the sum of the mesiodistal widths of the permanent maxillary incisors (SI) and the interpremolar or intermolar arch widths. Arch width in premolar and molar area of maxillary arch were measured for Pont's analysis. Arch width in premolar area is termed as measured premolar value (MPV). MPV was measured from distal pit on occlusal surface of right upper first premolar to the distal pit of left upper first premolar. Arch width in molar area was termed as measured molar value (MMV), which was measured from mesial pit on occlusal surface of upper right first molar to mesial pit of upper left first molar. According to Pont, we can obtain the required arch width in premolar area by dividing the sum of maxillary incisor with 0.80, thus obtained premolar width is termed as calculated premolar value (CPV). In the same way molar width also can be calculated by dividing sum of maxillary incisors with 0.64, thus obtained molar arch width is termed as calculated molar value (CMV).

Pont also suggested that half of the sum of maxillary central and lateral incisor is equal to the mesio-distal width of maxillary canine in normal dental arches. All his measurement and prediction were on maxillary dental arch and did not include mandibular dental arch.

Materials and Methods

Materials

1. Alginate impression material (Zelgan, made in India, Densply India Ltd.)
2. Dental stone plaster (kalstone, made in India, Densply India Ltd.)
3. Vernier caliper (0.1mm accuracy, made in China) SPSS 11.5 statistical software package.

Methods

The sample consisted of a total of 100 Nepalese subjects, 51 male and 49 female. 600 students from nine different high schools and colleges were undergone dental examination.100 subjects were selected for the sample. The subjects in this study were of a single age group selected from randomly selected schools and colleges. The subjects were selected who met the following inclusion criteria.

1. All subjects were Nepalese citizen.
2. Class I molar and canine relationship, no crowding, no spacing and well-aligned dental arches.
3. Straight facial profile.
4. Permanent dentition from first molar to first molar, all were present, all fully erupted. Third molar may or may not present.

Table 1: Comparison of maxillary teeth between Nepalese male and female

Teeth	*Gender*	*Mean*	*SD*	*P*
U11	M	8.78	0.55	0.122
	F	8.45	0.43	
U12	M	7.13	0.44	0.498
	F	6.94	0.41	
U13	M	8.17	0.44	0.126
	F	7.92	0.37	
U14	M	7.37	0.45	0.353
	F	7.34	0.41	
U15	M	6.84	0.53	0.352
	F	6.73	0.43	
U16	M	10.51	0.62	0.078
	F	10.34	0.38	
U21	M	8.79	0.56	0.077
	F	8.44	0.43	
U22	M	7.13	0.43	0.290
	F	6.95	0.39	
U23	M	8.17	0.44	0.04*
	F	7.93	0.34	
U24	M	7.40	0.45	0.338
	F	7.36	0.40	
U25	M	6.85	0.51	0.545
	F	6.71	0.43	
U26	M	10.50	0.56	0.163
	F	10.34	0.39	

[U1: Maxillary right teeth, U2: Maxillary left teeth , M: male, F: Female, P: Significance] [* significant P<0.05]

Table 2 : Comparison of mandibular tooth size between Nepalese male and female

Teeth	Gender	Mean (in mm)	SD	Significance
L31	M	5.42	.41	.294
	F	5.33	.35	
L32	M	6.07	.28	.931
	F	5.98	.29	
L33	M	7.26	.40	.009*
	F	6.94	.30	
L34	M	7.24	.43	.073
	F	7.13	.36	
L35	M	7.18	.40	.010*
	F	7.05	.32	
L36	M	11.34	.68	.039*
	F	11.10	.50	
L41	M	5.41	.39	.592
	F	5.33	.35	
L42	M	6.05	.31	.863
	F	5.97	.28	
L43	M	7.25	.40	.004*
	F	6.95	.30	
L44	M	7.25	.40	.079
	F	7.15	.35	
L45	M	7.18	.40	.013*
	F	7.04	.33	
L46	M	11.36	.66	.046*
	F	11.13	.49	

[L3: mandibular left teeth, L4: mandibular right teeth] [M: male, F: Female] [* significant at P<0.05]

5. No tooth agenesis or extractions.
6. No large restorations that could change the mesiodistal diameter of the tooth, no obvious inter proximal or occlusal wear of teeth.
7. No teeth with anomalous shapes.
8. Age range from 14-24 years.

   Few more criteria were added for the sample selection for Ponts research
9. No buccal or lingual tipping of the teeth.
10. No diastema.
11. No midline shift.
12. No peg lateral incisors.

The normal occlusion criteria for the sample are not considered as Angle class I normal occlusion because all of the subjects did not perfectly match to all of the criteria as described by E.H Angle for class I normal occlusion. So they have been termed as Individual Normal occlusion as described by Fu Min Kui[11], slight deviation from normal occlusion without hampering the primary function of the teeth. All samples were having Angle class I molar and canine relationship on both side with the overjet and overbite ranged from 1 to 3mm, with very few cases having 1 to 2mm crowding. No samples were with spacing.

Consent was taken from the school and the parents of the students for taking impression. Dental impression was taken with alginate impression material (Zelgan) and immediately poured with dental plaster (Kalstone) very carefully to avoid the air bubbles which can destroy the shape of the dental models. The 100 pairs of unsoaped and unwaxed dental plaster casts were given number for identification of male and female. Name, sex, date of birth and date of impression taken was recorded for each individual, number was given to all subjects and accordingly number was written in dental casts for identification.

Vernier caliper was used to measure the tooth size (greatest mesiodistal diameter). Errors in measurement was analyzed by measuring 20 pairs of dental casts (randomly selected among the 100 pairs) for the second time by the same vernier caliper, by prime investigator (both of the time) in an interval of 10 days. Paired t test was done to the first and second measurement. No significant differences found, so concluded that the measurement was reliable.

Statistical analysis was performed with a software package (Version 11.5, SPSS). Mean, standard deviation, minimum, maximum, coefficient of correlation, coefficient of variation, independent t-test, one sample t-test were calculated.

Results

Table 3: Mean overall and anterior ratio for male, female and total

Nepalese	*Male*	*SD. M*	*Female*	*SD. F*	*Total*	*SD*
OR	91.26	1.90	91.18	2.09	91.22	1.99
AR	78.28	2.55	77.81	2.89	78.04	2.72

[SD. M: standard deviation male; SD. F: standard deviation female]

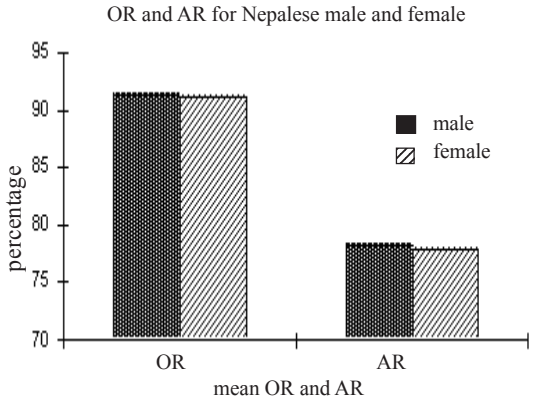

Figure 1. Mean overall and anterior ratio for male, female

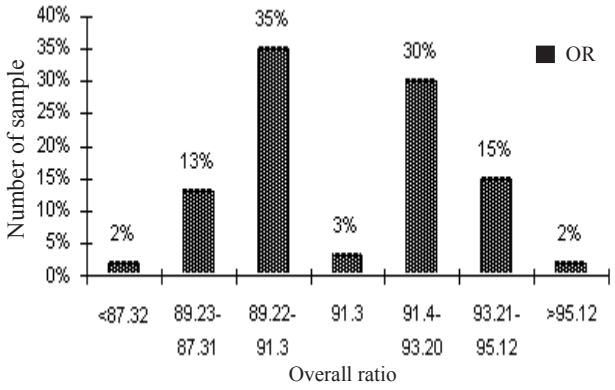

Figure 2. Percentage distribution of Nepalese in relation to OR value of Bolton

1. Tooth size

There is significant difference in mesio-distal tooth dimensions between Nepalese male and female in upper left canine, other teeth show no significant difference. Upper first molars, upper central incisors and upper second premolars show higher variability (Table 1).

Lower canines, lower second premolars and lower first molars show significant difference between Nepalese male and female. Lower first molar shows highest variability among all teeth (Table 2).

2. Overall and Anterior ratio

The mean Overall ratio (OR) for Nepalese population having class I normal occlusion is 91.22 with a standard deviation of 1.99 (male 91.26 with SD of 1.90 and female 91.18 with SD of 2.09). The mean Anterior Ratio (AR) for Nepalese is 78.04 with standard deviation of 2.72 (male 78.28 with SD of 2.55 and female 77.81 with SD of 2.89) (Table 3).

Comparing the findings of Nepalese male and female having class I normal occlusion, no significant difference was found for both OR and AR (P=0.907and P=0.57 respectively), so the combined ratio of OR and AR can be used for both male and female (Figure1).

Comparing OR and AR of Nepalese with Bolton standard shows, Nepalese subjects having OR outside 2 standard deviation of Bolton's OR were 4% (outside -2 SD were 2% and outside +2 SD were 2%) whereas subjects having AR outside 2 standard deviation of Bolton's AR were 15% (outside -2 SD were 6% and outside + 2 SD were 9%). Subjects having OR outside 1 SD Bolton standard were 32% (outside -1 SD were 15% and outside +1 SD were 17%). Subjects having AR outside 1 SD of Bolton's standard were 41%

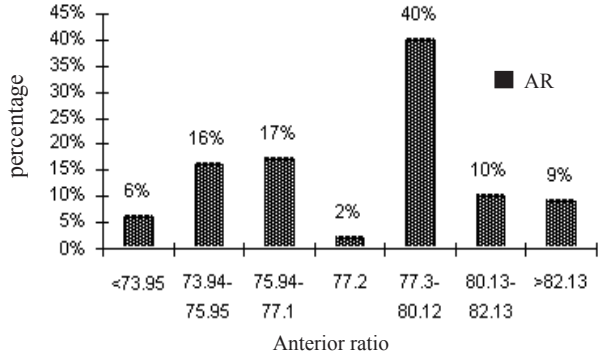

Figure 3. Percentage distribution of Nepalese in relation to OR value of Bolton

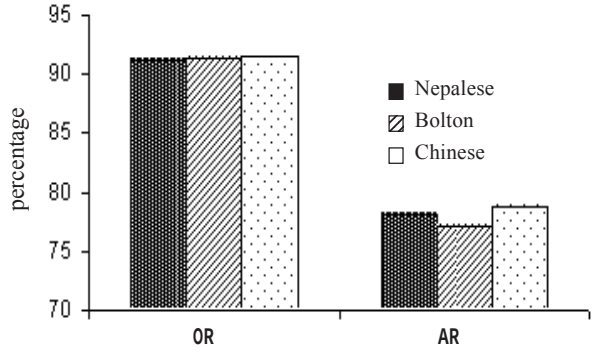

Figure 4. Comparing Nepalease mean for OR and AR with Bolton•fs standerd for caucasian and Chinese

Table 4. Comparison between Nepalese and Caucasians

Tooth	*Nepalese*	*SD (Nepalese)*	*Caucasian*	*SD (Caucasian)*	*Significance (P)*
OR	91.22	1.99	91.3	1.91	0.718
AR	78.04	2.09	77.2	1.65	0.003*

[SD: standard deviation, * significant at P<0.05]

Table 5. Comparison between Nepalese and Chinese

OR, AR	*Nepalese*	*SD (Nepalese)*	*Chinese[24]*	*SD (Chinese)*	*Significance (P)*
OR	91.22	1.99	91.5	1.51	0.175
AR	78.04	2.09	78.8	1.72	0.007*

[SD: standard deviation,*significant at P<0.05]

Table 6: Correlation coefficient (r) between measured and calculated arch width

Arch width	*Coefficient of correlation*	*Male*	*Female*
Inter premolar	r	0.242	0.233
Inter molar	r	0.074	0.29*

[*correlation coefficient significant at 0.05 level]

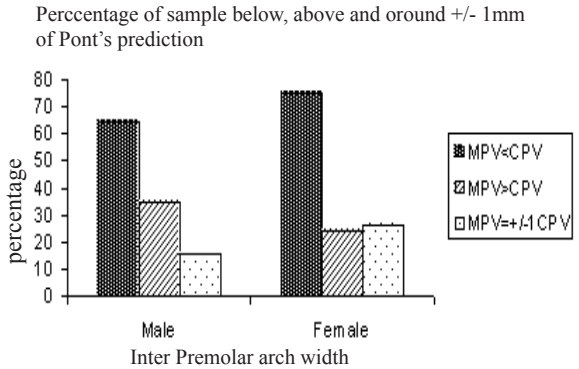

Figure 5 Difference between MPV and CPV for Nepalese male and female

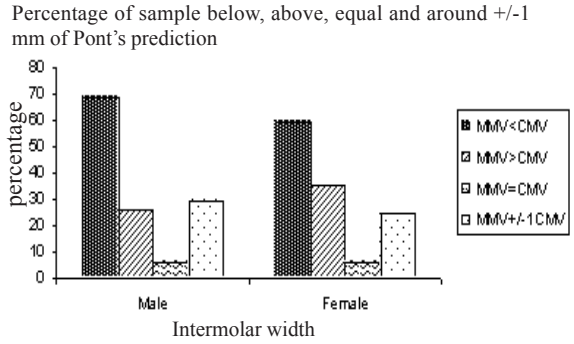

Figure 6 Difference between MMV and CMV for Nepalese male and female

(outside -1 SD were 22% and outside -1 SD were 19%). 3% of subjects were having OR similar to Bolton's OR, 35% of sample were with in -1SD of Bolton's standard, where as 30% were with in +1 SD, 13% were with in -2 SD and 15% with in +2 SD.(Figure. 2, 3)

2% of sample were with AR similar to Bolton's AR, 17% were with in -1 SD of Bolton's standard, where as 40% with in +1, 16% were with in -2 SD and 10% with in +2 SD, 6% outside -2 SD and 9% outside +2 SD (Figure 3).

Comparison of OR and AR between Nepalese and Bolton's normal standard for caucasians and Chinese[11] (Figure 4). No significant difference in OR between Nepalese, Caucasians (table 2) and Chinese (table 3) but there is significant difference in AR between Nepalese and Bolton standard and also Nepalese and Chinese AR mean.

Correlation coefficients determined between the measured arch width values (MMV,MPV) and the corresponding calculated values according to Pont's index (CMV,CPV) were low in all cases for males and females, with r values ranging from 0.07 to 0.29 (Table 6).

The differences between measured and calculated arch width values were calculated and found out the percentage sample having the measured arch width below or above or similar or around ±1mm of the calculated arch width value according to Pont's formula separately for male and female (Table 7).

The differences between the actual and predicted arch width values for each subject were large, for the intermolar width, ranged from "10.13 to +8.69 mm and for interpremolar width, ranged from "3.50 to + 7.38 mm. This shows the wide range of possible error if the index were to be applied clinically. Moreover, these differences show that Pont's index tends to overestimate the arch width required to relieve crowding (Figure 5, 6).

Percentage of sample having measured premolar value for male below Pont's prediction 64.7%, above 35.3% and around ±1mm was 15.6%. For female below Pont's prediction 75.5%, above

Table 7: Percentage of samples having measured arch width values below,above, and ±1 mm around Pont's prediction

Arch width	*Gender*	*Less than Pont's prediction*	*Similar to Pont's prediction*	*Above Pont's prediction*	*Value within ± 1 of Pont's prediction*
Inter premolar	Male	64.7%	0%	35.3%	15.6%
	Female	75.5%	0%	24.5%	26.5%
Inter molar	Male	68.5%	6%	25.5%	29.5%
	female	59.2%	6.1%	34.7%	24.5%

Table 8. Mean value S.I, MPV, MMV for Nepalese maleand female

	Male	*Female*	*Significance*
S.I	31.87 mm	30.88 mm	0.23
MPV mean	38.33 mm	37.13 mm	0.61
MMV mean	48.53 mm	47.42 mm	0.17

[S.I: Sum of Incisor, MPV : Measured Premolar Value, MMV : Measured Molar Value]

24.5% and around ±1mm was 26.5%.

Percentage of sample having measured molar value for male below Pont's prediction 68.5%, above 25.5%, similar 6% and around ±1mm was 29.5%. For female below Pont's prediction 59.2%, above 34.7%, similar 6.1% and around ±1mm was 24.5%.

No significant difference was found between Nepalese male and female in sum of maxillary incisors, premolar arch width and molar arch width (Table 8).

Discussion

Samples of this study and that of Bolton's study were different. In Bolton's study there were 55 models with excellent occlusion, among them 44 were orthodontically treated (non extraction cases), 11 were untreated. This study consists of 100 samples (51 male, 49 female), none of them were orthodontically treated and were having individual normal occlusion with class I molar and canine relationship. No crowding, no spacing. Age of the subjects in this study ranged from 14-24 years of age. Study was done on younger group to minimize the alteration of the mesio-distal tooth dimensions because probability of attrition, restoration, or carries will be less in younger age.

1. Tooth size

In this study lower left first molar showed the highest variability among all other teeth, the SD is 0.68 for male 0.50 for female. Upper second premolar, Upper first molar and Upper central incisors also show higher variability. For upper right second premolar the SD is 0.53for male0.43 for female, upper left second premolar the SD is0.51 for male 0.43for female, upper right first molar the SD is 0.62 for male 0.38 for female, upper left first molar the SD is 0.56 for male 0.39 for female, upper right central incisors the SD is 0.55 for male 0.43 for female, upper left first incisors the SD is 0.56 for male 0.43 for female (Table 1, 2). Lower left canine shows statistically significant difference between male and female, the mean is for male 7.26,for female is 6.94 (Table 2). Result of this study matches with the finding of Shrestha R.[13] on his study on permanent dentition of Nepalese, he also found the tooth size of upper and lower molars and maxillary incisors with higher variability. Santoro et al[14] imply high variability for the maxillary first molar dimensions and maxillary central and lateral incisor also presented high variability. This suggests that these teeth could be responsible for incongruity in the anterior ratio and should be examined clinically at the beginning of treatment to detect any major size and shape variations. These differences could be attributed to differences in measurement techniques. Tancan Uysal[15] the mesiodistal dimensions of the maxillary teeth showed greater variability than the mandibular teeth, with the first molar dimensions having the greatest variability. The size of the maxillary lateral incisor also was highly variable. Hayder Abdullah[16] in population of Riyadh studied the variability of tooth width by means of coefficient of variation, upper right first molar showed the least variability, whereas the lower right second premolar showed the highest variability. The upper right first premolar showed the least variability, whereas the upper left lateral incisor showed the highest variability. In the malocclusion group the mesiodistal tooth width of the upper and lower central incisors, lower left lateral incisor, and lower first molars were significantly higher than in the normal occlusion group.

2. Bolton's Analysis

In this study, OR for Nepalese obtained is 91.26 for male with SD of 1.90 and 91.18 for female with SD of 2.09, AR Male 78.28 with SD of 2.55 and for female 77.81 with SD of 2.89. OR and AR for male and female shows no significant difference. There is no significant difference between Nepalese male and female in OR and AR (Table 3, Figure1). For Caucasian the OR is 91.3 with SD of 1.91, which is similar to Nepalese .AR is 77.2 with SD of 1.65, which is smaller than Nepalese (Table4). For Chinese the OR is 91.5 with SD of1.51, which is similar to Nepalese .AR is 78.8 with SD of 1.72, which is bigger than Nepalese (Table5).

Bolton[1] suggested that a tooth size ratio greater than 1 SD from his reported mean values indicated a need for diagnostic consideration. More recently, tooth-width ratio outside 2 SD of Bolton's mean tooth width ratio are defined as clinically significant[7,8].

With the result of this study on Nepalese suggest that the value outside Bolton 2 SD that is OR value beyond (87.32 to 95.12) and AR value beyond (73.95 to 82.13) could be considered as clinically significant and need diagnostic consideration.

3. Pont's analysis

Pont's research was done exclusively on French race. For Pont, his standard is 80 for ideal inter premolar arch width, 64 for ideal inter molar arch width. Studies were applied to populations of different ethnic origins to determine whether the Pont's index could be applied to different populations by different authors.

In this study no statistically significant difference found in maxillary incisors between Nepalese males and females (Table 8).

In this study correlation was found between MMV and CMV and between MPV and CPV with r value ranging from 0.07 to 0.29, which suggest the correlation between measured arch width in premolar and molar area and its corresponding calculated arch

width according to Pont's index is very low (Table 6). Most of the Nepalese measured arch width values smaller than Pont's prediction. Which means Pont's Index tends to overestimate the arch width required to relieve crowding (Table 7, Figure 5, 6).

Conclusions

The result obtained from this study lead to following conclusions,

1. The normative standard of OR for Nepalese is similar to that obtained by Bolton for Caucasian and that of Chinese, but the normative standard of AR obtained for Nepalese is significantly different than that obtained by Bolton for Caucasian and also that of Chinese.

2. There is no significant difference between Nepalese male and female in OR and AR.

3. Pont's index is not reliable for predetermination of ideal arch width values for Nepalese male and female.

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