BOLTON'S NORMS FOR HYDERABAD POPULATION

[1] Hari Prasad Rao G　　　　　[1] Professor and Head
[2] Sharmila　　　　　　　　　　[2] Post Graduate student

[1,2] Department of Orthodontics and Dentofacial orthopedics, Government Dental College, Hyderabad, Andhra Pradesh.

ABSTRACT: Success of Orthodontic treatment mainly depends on correct diagnosis. First important diagnostic aid is correct assessment of inter arch and intra arch tooth relationship. Inter arch tooth ratio analysis (Bolton's) is one which is important to build normal overjet and normal occlusion. For this analysis most of them used GV BLACK's tables for sake of mesio-distal dimensions of teeth. The present study aimed at establishing individual tooth size for Hyderabad population and reliability of Bolton's ratio to this particular population and to determine sexual dimorphism.

KEYWORDS: Bolton's, Tooth ratio, Hyderabad population, orthodontic treatment, Diagnostic aid.

INTRODUCTION

Various diagnostic aids and methods have been applied for proper diagnosis and treatment planning in Orthodontics, out of which model analysis is one of the primary or essential diagnostic aid. Study models have been used for Orthodontic records for many decades. Study models provide three-dimensional view of dento-alveolar structures and their occlusal relationship. These models allow for measurements to be made for the determination of tooth size and arch length discrepancies, as well as other measurements that have been used for research purposes. [1]

A tooth-size discrepancy conventionally has been described as a relative excess of tooth structure in one arch in relation to the other arch. It also can be defined as a disproportion among the size of individual teeth. For proper alignment and to achieve a good occlusal interdigitation of the dentition, the tooth size must be in harmony with the arch size (the sum of the width of the mandibular teeth must be smaller than the sum of the width of the maxillary teeth). If discrepancy goes undetected initially, it may be difficult to achieve an ideal occlusion at the end of the treatment. Discovering during finishing stage could lead to embarrassing delays in the completion of treatment or even worse, to a compromised result as option that may have been possible at one time are no longer viable. [2] Therefore, the ability to analyze the proportionality of the maxillary teeth to mandibular teeth is very important at the initial stage of diagnosis. Although the natural teeth match very well in most dentitions, approximately 5% of population has some degree of

discrepancy among the size of individual teeth. [3] In order for the maxillary teeth to fit well with the mandibular teeth, there must be a definite proportionality. The first investigation of mesio-distal width was studied by G.V. Black in 1902. [4] He measured a large number of human teeth and from these measurements he set up tables of mean figures which are still used as important references today. Several investigators had followed Black's investigation with modifications, and different methods have been described to evaluate inter arch tooth size relationship such as Kesling's diagnostic setup, Neff's anterior coefficient etc. [5] Even large numbers of analysis have been used but classical work done by Bolton [2] in 1958 is most acceptable and most widely used. [2] According to Bolton, a certain maxillary to mandibular tooth size relationship is important for proper occlusal inter-digitations, overjet and overbite. He established a mathematical ratio, which according to him must follow Class I occlusal pattern. He developed a method of analyzing mesio-distal tooth size ratio between maxillary and mandibular teeth by evaluation of 55 cases with excellent occlusions. The greatest mesiodistal diameter of all the teeth on each case was measured except the second and third molars. Two ratios were developed; anterior ratio (77.2 ±1.65%) which were obtained by measuring the mesiodistal width of six anterior teeth, and overall ratio (91.3 ± 1.91%) which were obtained by measuring the mesiodistal width from first molar to first molar. [6]

Fig.1: Arnmentarium used in this study

Fig.2: Trays used to take impressions

Fig.3 Impressions taken

Fig. 4 sample models--numbered

Fig. 5. Caliberated digital vernier caliperse with modified tips
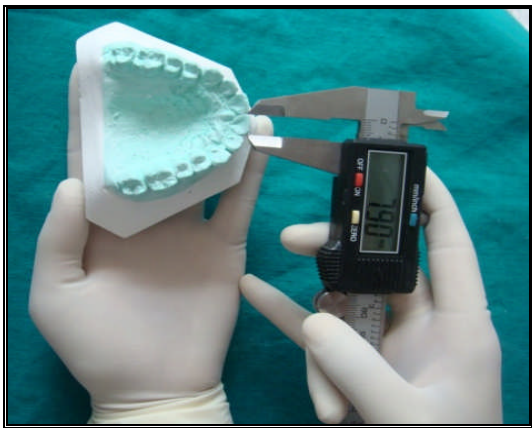

Fig.6. Mesio-distal with measurement

The formula derived by Bolton was as follows:

$$\text{Overall ratio (\%)} = \frac{\text{Sum of mesio-distal width of mandibular 12 teeth (Rt first molar to Lt first molar)}}{\text{Sum of mesiodistal width of maxillary 12 teeth (Rt first molar to Lt first molar)}} \times 100$$

$$\text{Anterior ratio (\%)} = \frac{\text{Sum of mesiodistal width of mandibular 6 teeth (Rt canine to Lt canine)}}{\text{Sum of mesiodistal width of maxillary 6 teeth (Rt canine to Lt canine)}} \times 100$$

Rt; Right **Lt:** left

The data from this sample was then used to indicate the distance from the ideal of any measured ratio and thus the size of the discrepancy. He concluded that it would be difficult for proper occlusal interdigitation or coordination of arches in the finishing stage of Orthodontic treatment without proper mesio-distal tooth size ratio between maxillary and mandibular teeth.[6] Studies on various ethnic and racial groups has been done to check the applicability of Bolton's ratio i.e. Crosby and Alexander,[7] Smith et al[8] Santoro et al,[9] Ta Ling JY, Hagg [10] etc for proper diagnosis and treatment planning.

The Bolton's analysis is considered a good indicator for evaluating the degree of inter-maxillary tooth size harmony but it would be of clinical interest to examine the ethnic variation in particular population group. Thus, the aim of our study is to determine individual tooth size and reliability of Bolton's ratio to this particular population and to determine sexual dimorphism.

Aims and Objectives

1. Determination of individual tooth size for Hyderabad population.
2. To check the reliability of Bolton's ratio in Hyderabad population.
3. To study the sexual dimorphism in individual tooth size and Bolton's ratio.
4. To compare the Hyderabad population standards with the Caucasian standards established by Bolton.

Materials and Methods

The study was conducted in the Department of Orthodontics, Government Dental College and Hospital, Hyderabad). The sample consisted of 100 male and 100 female subjects with age ranging from18 to 25 years (average age =21.5years).

Criteria for sample selection:

1. All subjects belonged to Hyderabad Population, and their parents and grandparents belonged to same population.
2. All subjects had Angle's class I molar relationship with proper intercuspation.
3. All subjects had full complement of teeth. (Permanent central incisor-first permanent molar erupted in each quadrant)
4. No retained primary tooth
5. No abnormal tooth morphology
6. There was absence of interproximal caries, restorations, or other conditions that would result in the reduction of mesiodistal tooth width.
7. All subjects had no previous history of Orthodontic treatment.
8. Good quality study casts of these subjects were fabricated and analyzed.
9. Subjects in younger age groups were chosen to minimize the changes in the mesiodistal tooth dimensions because of factors such as attrition, restoration, or caries.

Appropriate upper and lower impression trays are selected **(Fig.2)** and impressions were taken with alginate impression material**(Fig.3)**. Dental impression was taken with alginate impression material. It was immediately poured with dental stone very carefully to avoid the air bubbles which can destroy the shape of the dental models. Dental casts were allowed to dry followed by numbering for identification. Bases were then fabricated for the models. **(Fig.4)**

Cast Measuring Technique

The measurement was made directly on the casts. Teeth were measured at the largest mesiodistal dimension using a digital Vernier caliper(modified) accurate to 0.01mm (**Fig.5**) The sharp tips of the digital vernier caliper facilitated accuracy of measurement. Mesiodistal dimension of a tooth was measured from its distal contact point to its mesial contact point at its greatest interproximal distance parallel to the line of occlusion(**Fig.6**). The measurements are crosschecked to avoid technical errors.

Goose (1963)[12] suggested that the mesiodistal diameter axis should run between the contact points of the tooth crown with its neighbors, in normal occlusion. In cases of malocclusion, the positions on the crown at which the contact points would have been in normal occlusion are used. In case of a rotated tooth we have to take the mesiodistal measurement diagonally. In case of lingually inclined tooth we have to take mesiodistal measurement lingually.

Table.I. Population distribution according to sex

Sex	Number	Percentage
Male	100	50 %
Female	100	50%
Total	**200**	**100%**

Table.II. Mean, S.D. (Standard Deviation) and S.E.M. (Standard Error of Mean) of Maxillary and Mandibular Teeth Dimensions of 200 Hyderabad Subjects. (N=200)

Parameter		Mean(mm)	S.D.	S.E.M.
Maxillary teeth 654321 | 123456	Central Incisors	8.50	.61	.043
	Lateral Incisors	6.6	.51	.036
	Canines	7.6	.49	.035
	First Premolars	6.52	.42	.029
	Second Premolars	6.23	.46	.033
	First Molars	9.9	.54	.038
Mandibular teeth 654321 | 123456	Central Incisors	5.30	.37	.026
	Lateral Incisors	5.8	.33	.023
	Canines	6.6	.45	.032
	First Premolars	6.88	.42	.03
	Second Premolars	6.6	.46	.032
	First Molars	10.61	.36	.025

Table.III. Mean, S.D. (Standard Deviation) and S.E.M. (Standard Error of Mean) for Overall and Anterior Ratio of 200 Hyderabad Subjects. (N=200)

Overall Ratio (%)			Anterior Ratio (%)		
Mean	S.D.	S.E.M.	Mean	S.D.	S.E.M.
92.5	2.17	.153	77.70	3.06	.216

Table.IV.Tooth Dimensions of 100 Hyderabad Female and Male Subjects. (Male, n=100; Female, n=100

Parameter		Female Subjects			Male Subjects		
		Mean (mm)	S.D.	S.E.M.	Mean (mm)	S.D.	S.E.M.
Maxillary teeth 654321 | 123456	Central Incisors	7.94	.53	.053	8.48	.57	.057
	Lateral Incisors	6.2	.44	.044	6.56	.52	.052
	Canines	7.18	.51	.051	7.5	.4	.04
	First Premolars	6.3	.41	.041	6.64	.39	.039
	Second Premolars	6.06	.43	.043	6.3	.44	.04
	First Molars	9.68	.47	.47	10.19	.47	.047
Mandibular teeth 654321 | 123456	Central Incisors	5.03	.31	.03	5.18	.4	.04
	Lateral Incisors	5.4	.27	.02	5.6	.35	.03
	Canines	6.2	.48	.04	6.5	.36	.03
	First Premolars	6.34	.41	.04	6.6	.38	.03
	Second Premolars	6.4	.38	.03	6.9	.42	.04
	First Molars	10.49	.27	.02	10.70	.39	.03

Table. V. Mean, S.D. (Standard Deviation) and S.E.M. (Standard Error of Mean) for the Overall Ratio of Hyderabad Female and Male Subjects. (Male, n=30; Female, n=30)

Overall Ratio (%)						Anterior Ratio (%)					
FEMALE			MALE			FEMALE			MALE		
Mean	SD	SEM	Mean	SD	SEM	Mean	SD	SEM	Mean	SD	SEM
92.09	2.44	.24	92.75	1.66	.16	78.33	3.09	0.3	78.98	3.5	.35

Table .VI. Comparison of the tooth dimension of Hyderabad Population with the Caucasians Standards

Parameter	Teeth	Caucasian Mean (mm)	Hyderabad Population Mean (mm)	t-value	p-value	Sig.
Maxillary teeth 654321 | 123456	Central Incisors	8.5	8.50	.018	.98	Ns
	Lateral Incisors	6.5	6.6	2.49	.01	*
	Canines	7.5	7.6	3.32	.00	**
	First Premolars	7	6.5	-4.3	.00	**
	Second Premolars	7	6.23	-5.3	.00	**
	First Molars	10	9.9	-4.68	.00	**
Mandibular teeth 654321 | 123456	Central Incisors	5	5.5	5.66	.00	**
	Lateral Incisors	5.5	5.8	6.42	.00	**
	Canines	7	6.6	-2.59	.01	**
	First Premolars	7	6.8	-5.0	.00	**
	Second Premolars	7	6.6	-4.18	.00	**
	First Molars	11	10.61	-3.65	.00	**

p≤0.05*, p. ≤01**, NS= Not significant

Table.VII. Comparison of Overall and Anterior Ratios of Hyderabad Population and Caucasian Standards

Overall Ratio (%)				t value	p value	Sig	Anterior Ratio (%)				t value	P value	Sig.
Caucasian		Hyderabad					Caucasian		Hyderabad				
Mean	SD	Mean	SD				Mean	SD	Mean	SD			
91.3	1.9	92.5	2.17	5.3	.00	**	77.2	1.56	77.70	3.06	2.73	.00	**

p ≤ 0.05*, p ≤ 01**, NS = Not significant

Table.VIII. Comparison of Individual Tooth Dimension of Maxillary and Mandibular Teeth of Caucasian Male and Hyderabad Population Male Subjects.

Parameter	Teeth	Caucasian Male Mean (mm)	Hyderabad Male Mean (mm)	t-value	p-value	Sig.
Maxillary teeth 654321 | 123456	Central Incisors	8.79	8.48	-5.3	.00	**
	Lateral Incisors	6.23	6.56	6.4	.00	**
	Canines	7.53	7.53	3.2	.94	NS
	First Premolars	6.6	6.86	-3.3	.001	**
	Second Premolars	6.54	6.3	-3.2	.002	**
	First Molars	10.69	10.19	-10.32	.00	**
Mandibular teeth 654321 | 123456	Central Incisors	5.58	5.18	-9.8	.00	**
	Lateral Incisors	6.2	5.6	-14.12	.00	**
	Canines	6.5	6.94	-12.43	.00	**
	First Premolars	6.79	6.83	-4.04	.0	**
	Second Premolars	6.81	6.9	2.38	.019	*
	First Molars	11.36	10.70	-5.0	.00	**

p≤0.05*, p. ≤01**, NS= Not significant

Table.IX. Comparison of Overall and Anterior Ratio of Male Subjects of Caucasian and Hyderabad Population

Overall Ratio (%)				t value	p value	Sig	Anterior Ratio (%)				t value	P value	Sig.
Caucasian		Hyderabad					Caucasian		Hyderabad				
Mean	SD	Mean	SD				Mean	SD	Mean	SD			
91.7	2.04	92.75	1.6	-4.3	.00	**	76.8	1.49	78.9	2.89	3.34	.00	**

Table .X. Comparison of Individual Tooth Dimension of Maxillary and Mandibular Teeth of Caucasian Female and Hyderabad Population

Parameter	Teeth	Caucasian Female Mean (mm)	Hyderabad Female Mean (mm)	t-value	p-value	Sig.
Maxillary teeth 654321 | 123456	Central Incisors	8.54	.41	7.94	.53	-11
	Lateral Incisors	6.21	.18	6.23	.44	.52
	Canines	7.35	.59	7.38	.39	-3.2
	First Premolars	6.59	.47	6.69	.41	-4
	Second Premolars	6.41	.49	6.06	.43	-7.8
	First Molars	10.64	.52	9.68	.47	-9.8
Mandibular teeth 654321 | 123456	Central Incisors	5.56	.48	5.03	.31	-16
	Lateral Incisors	6.17	.31	5.4	.27	-5.3
	Canines	6.91	.37	6.2	.48	-14
	First Premolars	6.77	.42	6.8	.41	-10
	Second Premolars	6.78	.46	6.48	.38	-7.3
	First Molars	11.21	.39	10.49	.27	-5.4

p≤0.05*, p ≤01**, NS= Not significant

Table.IX. Comparison of Overall and Anterior Ratio of Female Subjects of Caucasian and Hyderabad Population

Overall Ratio (%)				t value	p value	Sig	Anterior Ratio (%)				t value	P value	Sig.
Caucasian		Hyderabad					Caucasian		Hyderabad				
Mean	SD	Mean	SD				Mean	SD	Mean	SD			
90.8	1.85	92.09	2.44	3.8	.00	**	77.5	1.62	78.3	3.09	3.2	.002	*

p≤0.05*, p. ≤01**, NS= Not significant

The sum of mesiodistal width of twelve maxillary teeth i.e., from the right first permanent molar to the left first permanent molar, were measured and compared with the sum of mesiodistal width of the mandibular twelve teeth, i.e., from the right first permanent molar to the left first permanent molar. The ratio between the two was the percentage relationship of mesiodistal tooth dimension of mandibular arch to mesiodistal tooth dimension of maxillary arch which was called the "overall ratio", with a mean of 91.3%. If the overall ratio exceeded 91.3%, it indicates mandibular tooth material excess. If ratio was, less than 91.3% it indicates maxillary tooth material excess.

The same method was used in setting up a ratio between the maxillary and mandibular anterior teeth. Mesiodistal crown dimensions of maxillary and mandibular anterior's i,e. from Rt canine to Lt canine were measured. The ratio between the two was the percentage relationship of mandibular anterior mesiodistal tooth dimension to maxillary anterior mesiodistal tooth dimension which was called the "anterior ratio", with a mean value of 77.2 %. If the anterior ratio exceeded 77.2%, it indicates mandibular tooth material excess. If ratio was, less than 77.2% , it indicates maxillary tooth material excess.

Results:

Present study was conducted on 200 subjects and results were tabulated, (**Table.I-XI**. Values thus obtained were subjected to statistical analysis. No significant difference was found between the mesiodistal crown dimensions of right and left side, so their values were combined and their mean value were obtained which was used for further calculation and there is difference between male and female teeth dimensions i.e male teeth dimensions are somewhat larger than female teeth dimensions.

Statistical Analysis

Standard descriptive statistics (mean, standard deviation and standard error of mean) were calculated for the each sample. Comparison was made between the male and female subjects, and also between the present established OVERALL RATIO and ANTERIOR RATIO. Unpaired t test was used to compare Shimla hill population's measurements with Bolton's norms and to

determine sexual dimorphism. $p \leq 0.05$ was represented by the single star(*) and was considered as significant. $p \leq 01$ was represented by the double star(**) and was considered as highly significant and NS represent the non significant variables.

Discussion

Table.I represents the sample size with sex distribution. The study group was consisted of 200 subjects out of which 100 were males (50%) and 100 were females (50%).

Table II represents the Mean, Standard deviation and Standard error of Mean of maxillary and mandibular teeth dimensions of 200 Hyderabad population subjects. **(Graph -I)**. Tooth dimension for maxillary central incisor, lateral incisor, canine, first premolar, second premolar, first molar had a mean value and standard deviation of 8.50±0.61, 6.6±0.51, 7.6±0.49, 6.52±0.42, 6.23±0.46, 9.9±0.54 in mm respectively. Tooth dimension for mandibular central incisor, lateral incisor, canine, first premolar, second premolar, first molar had a mean value and standard deviation of 5.30±0.37, 5.8±0.33, 6.6±0.45, 6.88±0.42, 6.6±0.46, 10.61±0.36 in mm respectively.

Table III represents the overall ratio and anterior ratio for 200 subjects of Hyderabad population, which had a mean value of 92.5% and 77.7% respectively. **(Graph -II)**
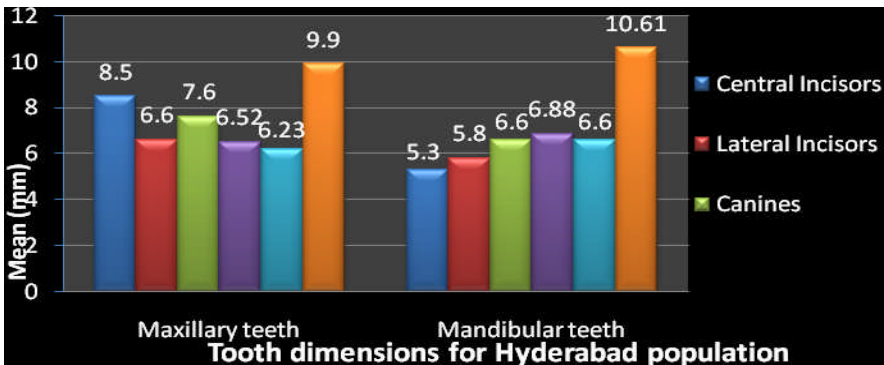
Table IV represents the tooth dimension for 100 Hyderabad population female subjects for maxillary central incisor, lateral incisor, canine, first premolar, second premolar, first molar were 7.94±0.53, 6.2± 0.44, 7.18±0.51, 6.3±0.41, 6.06±0.43, 9.68±0.47 in mm respectively. Tooth dimension for 100 Hyderabad

population female subjects for mandibular central incisor, lateral incisor, canine, first premolar, second premolar, first molar were 5.03±0.31, 5.4±0.27, 6.2±0.48, 6.34±0.41, 6.4±0.38, 10.49±0.27 in mm respectively.

Tooth dimension for 100 Hyderabad population male subjects for maxillary central incisor, lateral incisor, canine, first premolar, second premolar, first molar were 8.48±0.57, 6.56±0.52, 7.5±0.4, 6.64±0.39, 6.3± 0.44, 10.19±0.47 in mm respectively. Tooth dimension for 100 Hyderabad population male subjects for mandibular central incisor, lateral incisor, canine, first premolar, second premolar, first were 5.18±0.4, 5.60±0.35, 6.5±0.36,6.6±0.38,6.90±0.42,10.70±0.39 in mm .

Table-V represents the Mean, Standard Deviation and Standard Error of Mean for the overall ratio of 100 Hyderabad female and male subjects**.** Overall ratio and anterior ratio for 100 female subjects of Hyderabad population was 92.09% and 78.33% respectively. Overall ratio and anterior ratio for 100 male subjects of Hyderabad population was of 92.75% and 78.98% respectively. **(Graph -III)**
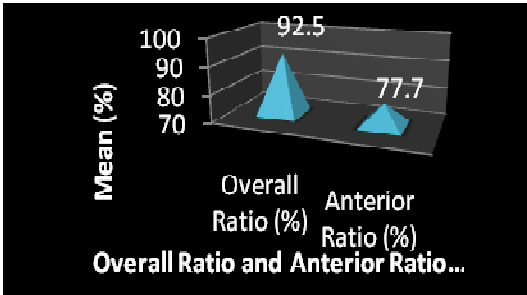
Table VI represents the comparison of the tooth dimension of Hyderabad population with the Caucasians norms. Tooth dimension for maxillary central incisor was equal in both Caucasian and Hyderabad population.[13-23.] Tooth dimension for maxillary lateral incisor, canine, mandibular central incisor and lateral incisor were larger than the Caucasian norms with statistically significant differences $(P \leq 0.01)$.Tooth dimension for maxillary first premolar, second premolar, first molar, mandibular canine, first premolar, second premolar and first molar were smaller than the Caucasian norms with statistically significant $(P \leq 0.01)$. For maxillary central incisor value obtained was statistically non significant. **(Graph -IV)**

Table VII represents the comparison of overall and anterior ratios of Hyderabad population and Caucasian**.** Overall ratio for 200 subjects of Hyderabad population was 92.5%, which was more than the Caucasian norms with statistically significant difference $(P \leq 0.01)$. Anterior Ratio of 200 Hyderabad population was 77.7%, which was more than the Caucasian norms with statistically significant difference[13,14,15] $(P \leq 0.01)$. **(Graph -V)**

Table VIII represents the comparison of individual tooth dimension of maxillary and mandibular teeth of Caucasian male and Hyderabad population subjects. Tooth dimension for maxillary lateral incisor, first premolar, mandibular canine and first and second premolar were larger than the Caucasian norms with statistically significant differences $(P \leq 0.01)$.
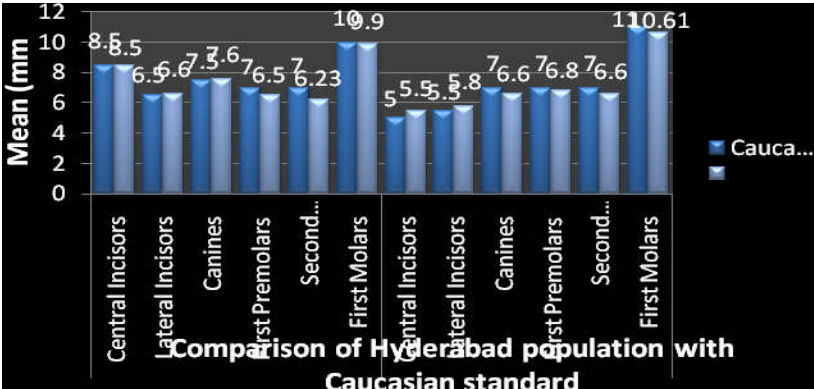
Graph. 1 Represents the Tooth dimensions for Hyderabad population.
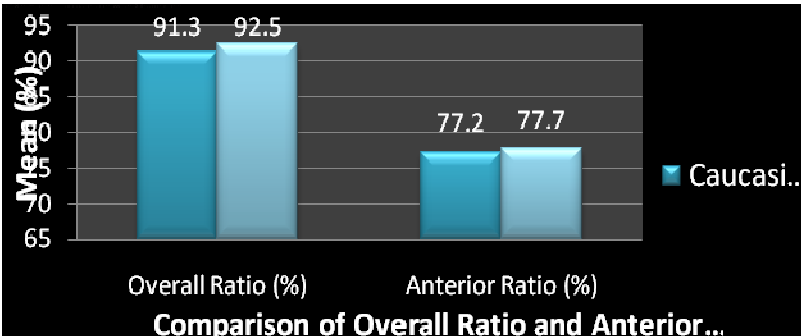

Graph.2 Represents the Overall Ratio and Anterior Ratio for Hyderabad population
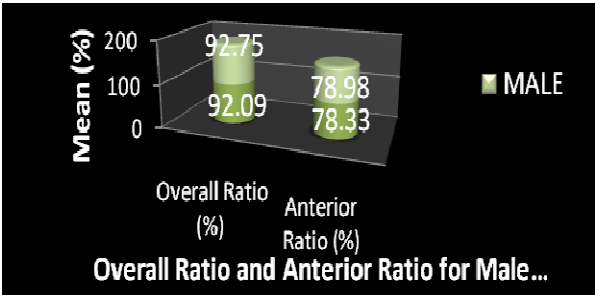
Graph. 3:Represents the Overall Ratio and Anterior Ratio for Male and Female Hyderabad population.

Graph.4. Represents the Comparison of Tooth Dimensions of Hyderabad population with Caucasian standard.

Graph. 5. Represents the Comparison of overall and Anterior tooth ratios of Hyderabad population with Caucasian standard.

Tooth dimension for maxillary central incisor, maxillary second premolar, maxillary first molar, mandibular central incisor, lateral incisor, and first molar were smaller than the Caucasian norms with statistically significant difference (P≤0.01) .Tooth dimension for maxillary canine was equal in both Caucasian and Hyderabad population and was statistically not significant.

Table IX represents the comparison of overall and anterior ratio of male subjects of Caucasian with Hyderabad population. Overall ratio for 100 male subjects of Hyderabad population was 92.75% which was more than the Caucasian norms with statistically significant difference (P≤0.01). Anterior Ratio of 100 male subjects of Hyderabad population was 78.98% which was more than the Caucasian norms[16] with statistically significant difference (P≤0.01).

Table X represents the comparison of individual tooth dimension of maxillary and mandibular teeth of Caucasian and Hyderabad population female subjects. Tooth dimension for maxillary lateral incisor, maxillary canine, maxillary first premolar and mandibular first premolar were larger than the Caucasian norms with statistically significant difference (P≤0.01) [16,17]

Tooth dimension for maxillary central incisor, second premolar, first molar, mandibular central incisor, lateral incisor, canine, second premolar and first molar were smaller than the Caucasian norms with statistically significant difference (P≤0.01).The value obtained for maxillary lateral incisor was not statistically significant.

Table XI represents the comparison of overall and anterior ratio of female subjects of Caucasian and Hyderabad population. Overall ratio for 100 female subjects of Hyderabad population was 92.09% which was more than the Caucasian norms with statistically significant difference (P≤0.01). Anterior Ratio of 100 female subjects of Hyderabad population was 78.3% which was more than the Caucasian norms [21, 22 23] with statistically significant difference(P≤0.05).

CONCLUSION

From the above study the following conclusions were drawn:
1. Tooth dimensions for Hyderabad population were larger than the observed mean values for Caucasians.
2. The values obtained for overall as well as anterior ratio were larger for Hyderabad population, not in accordance with the standards set by Bolton .
3. Statistically significant difference was observed between the findings of male and female subjects of Hyderabad population and Caucasians, but this difference was non-significant when comparison was done between male and female subjects of Hyderabad population .

From this study it can be concluded that ,for evaluation of Hyderabad population for Orthodontic treatment, instead of Caucasian standards Hyderabad population standards can be used as a yardstick.

References

1. Hunter WS, Priest WR. Errors and discrepancies in measurement of tooth size. J Dent Res 1960; 39: 405-514.
http://dx.doi.org/10.1177/00220345600390022301
2. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. Angle Orthod 1958; 28:113-130.
3. Yang CJ, Chu FT, Qian YF. Bolton tooth size discrepancy among different skeletal malocclusion groups. Pubmed Publication 2009;18(3) 251-254.
4. Black GV. Descriptive Anatomy of Human Teeth, 5th edition, Philadelphia: S.S. White, 1902.
5. Neff CW. Tailored occlusion with the anterior coefficient. Am J Orthod 1949; 35: 309-314.
http://dx.doi.org/10.1016/0002-9416(49)90045-7
6. Bolton WA. The clinical application of a tooth size analysis. Am J Orthod. 1962;529.
7. Crosby DR, Alexander. The occurrence of tooth size discrepancies among different malocclusion groups. Am J Orthod DentofacialOrthop 1989; 95: 457-461.
http://dx.doi.org/10.1016/0889-5406(89)90408-3
8. Smith SS, Buschang PH, Watanabe E. Interarch tooth size relationships of 3 populations: ''does Bolton's analysis apply?'' Am J Orthod Dentofacial Orthop. 2000; 117:169–174 http://dx.doi.org/10.1016/S0889-5406(00)70228-9
9. Santoro M, Ayoub ME, Pardi VA et al. Mesiodistal crown dimensions, and tooth size discrepancy of the permanent dentition of Dominican Americans. Angle Orthod 2000; 70: 303-307
10. Ta TA, Ling JY, Hagg U. Tooth-size discrepancies among different occlusion groups of southern Chinese children. Am J Orthod Dentofacial Orthop. 2001; 120:556–558.
http://dx.doi.org/10.1067/mod.2001.118998
11. Ballard ML. Asymmetry in tooth sizes a factor in the etiology, diagnosis, and treatment of malocclusion. Angle Orthod 1944; 14: 67-71.
12. Sherwood R. Steadman. Predetermining the overjet and overbite. Angle Orthod 1949;19:101-105.
13. Moorrees CFA, Thomsen SO, Jensen E. Mesiodistal crown diameters of the deciduous and permanent teeth in individuals. J Dent Res 1957; 36: 39-47.
http://dx.doi.org/10.1177/00220345570360011501
14. Stifter A study of Pont's, Howes', Rees', Neff's and Bolton's analyses on Class I adult dentitions. Angle Orthod 1958; 28: 215-225.
15. Gran SM, Lewis AB The sex differences in intraindividual tooth size communalities. J Dent Res 1965;44:476-479.
http://dx.doi.org/10.1177/00220345650440030601

16. Lavelle CL. Maxillary and mandibular tooth size in different racial groups and in different occlusal categories. Am J Orthod. 1972;61:29–37. http://dx.doi.org/10.1016/0002-9416(72)90173-X

17. Arya BS, Savara BS, Thomas D. Relation of sex and occlusion to mesiodistal tooth size. Am J Orthod. 1974; 66:479-486. http://dx.doi.org/10.1016/0002-9416(74)90109-2

18. Richardson ER, Malhotra SK. Mesiodistal crown dimension of the permanent dentition of American Negroes. Am J Orthod. 1975; 68:157–164. http://dx.doi.org/10.1016/0002-9416(75)90204-3

19. Bishara SE.et.al. Mesiodistal crown dimensions in Mexico and the United States. Angle Orthod October 1986.

20. Bishara SE, Jakobsen JR, Abdallah EM, Fernandez Garcia A. Comparisons of mesiodistal and buccolingual crown dimensions of the permanent teeth in three populations from Egypt, Mexico and the United States. Am J Orthod Dentofacial Orthop. 1989; 96:416–422. http://dx.doi.org/10.1016/0889-5406(89)90326-0

21. Merz ML, Isaacson RJ, Germane N, Rubenstein LK. Tooth diameters and arch perimeters in a black and a white population. Am J Orthod Dentofacial Orthop.1991;100:53–58. http://dx.doi.org/10.1016/0889-5406(91)70049-3

22. Shellhart WC, Lange DW, Kluemper GT, Hicks EP, Kaplan AL. Reliability of the Bolton tooth size analysis when applied to crowded dentitions. Angle Orthod 1995; 65:327–34.

23. Freeman JE, Maskeroni AJ, Lorton L Frequency of Bolton tooth size discrepancies among orthodontic

Corresponding Author

Dr.**G. Hari Prasad Rao** M.D.S.
Professor and Head
Department of Orthodontics
Government Dental College Hyderabad
3-5-803/1, Opp. Bharateeya Vidya
Bhavan, Sher Gate, King Koti,
Hyderabad 500029
Phone No:9246154346
Email: harigutti@yahoo.com