ORIGINAL ARTICLE

Correlation between Bolton Ratios and Different Facial Types

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ABSRACT

Aim: To correlate the Bolton ratios with vertical facial types.
Methods: This cross-sectional study was conducted at Department of Orthodontics, Faisalabad medical university and de'Montmorency College of dentistry; in which 90 lateral cephalograms and plaster casts of untreated patients were included. The patients were divided into three groups as per facial type; mesofacial, dolichofacial and brachy facial. Bolton ratios were calculated on model while SNMP, MMA, and Jaraback ratio were calculated on lateral cephalograms. The data was correlated and analyzed using SPSS version 20.0. Linear regression analysis was used to calculate Pearson's correlation coefficient for determination of correlation between the two variables. Duration of this study was January 2017 to October 2017.
Results: Statistically insignificant correlation exists between bolton ratio & facial types.
Conclusion: It was concluded that Bolton ratios and vertical facial types are not correlated.
Keywords: Bolton ratio; Vertical; Facial.

INTRODUCTION

There are six 6 keys of occlusion as proposed by Andrew's: Saggital molar relationship, correct coronal inclination and Angulation, de-rotated teeth, lack of any diastema, and flat occlusal plane[1]. Bennett and McLaughlin proposed seventh key, which was proportionate tooth mass[2].

Optimal finishing in orthodontics requires harmony in tooth mass ratios because any mismatch in Bolton ratios can results in failure to achieve Andrew's six keys of occlusion[3,4] When upper incisors were too large in relation to lower incisors, compensations included: 1) Deep bite 2) Increased over jet 3) Crowded incisors, and 4) improper posterior occlusion. On the other hand, when lower incisors were too large, compensations included: 1) Class III incisors 2) Diastema in upper arch 3) crowding in interiors and 4) lack of perfect occlusion[5].

Various authors, such as Bolton, Black, Ballard, Neff and Lundstrom, evaluated the values of tooth sizes of teeth[6-10]. Bolton analyzed 55 cases with ideal occlusion, and concluded that ratio of the sum of mesio-distal widths of the twelve lower teeth divided by the sum of the twelve upper teeth was found to be 91.3%, while for six anterior teeth this ratio was 77.2%[6]. A value greater or lesser than the norms has been associated with failure to achieve the optimal occlusion at completion of orthodontic treatment.

Rudolph *et al*[11]showed that labiopalatal incisal thickness might influence Bolton calculations. They

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proposed modified Bolton formulae by taking in to consideration the labiopalatal incisal thickness. They concluded that subject with thin labiopalatal incisal thickness (<2.75 mm) had a stronger correlation with Bolton ratio than patient with thick labiopalatal incisal thickness (>2.75 mm)[11]. Similarly, it was found that its formulae did not considered the influencing factors of incisal angulation[5] incisal inclination[6], rotations, ALD, labiopalatal incisal thickness[6,11] Overbite and overjet[6].

Following this rationale, it can be speculated that vertical facial types can also influence the Bolton ratios. The objective of present study was to investigate the relationship of Bolton ratios and facial types. Our hypothesis was that there is a correlation between Bolton ratios and inclination of upper and lower incisors.

METHODOLOGY

The cross sectional study was conducted after ethics approval at the Department of Orthodontics, Faisalabad medical university and de'Montmorency college of dentistry, in which lateral cephalograms and models of untreated subjects were included as per inclusion and exclusion criteria. Duration was January 2017 to October 2017. The sample size of 30 was calculated using Altmans normogram (Altman, 1991 p456):
P value = 0.01
Clinically relevant difference = 2.0 mm
Power = 0.8
S.D = 1

Thus total 90 subjects were required and selected, which were divided into 3 groups of 30 each, on basis of vertical facial type. Patients were

divided into 3 groups based on facial types i.e., mesofacial, dolichofacial and brachyfacial group.

Erupted permanent teeth, no transverse or saggital skeletal issues and good quality records were included in the study. While any previous dental treatment, dental pathology and attrition, abrasion and erosions were excluded from the study.

Data Collection procedure: All lateral cephalograms were traced manually by one examiner. SN-MP, MMA and Jaraback ratios were measured to find out the vertical pattern. Plaster casts were used to evaluate the Bolton ratios using formulae[6].

Bolton Ratio (B)=

Sum of mesiodistal width of mandibular 12 teeth X100

Sum of mesiodistal width of maxillary 12 teeth = 91.3%

Anterior Bolton Ratio (B') =

Sum of mesiodistal width of mandibular 6 Anteriors X100

Sum of mesiodistal width of mandibular 6 Anteriors= 77.2%

30 casts' models were randomly taken to investigate the accuracy of a single examiner. The measurements were then repeated 14 days later and found out to be reliable.

Statistical Analysis: The data was analyzed in SPSS 21.0. The means, standard deviations, minimum and maximum values of Bolton ratios, SNMP, MMA, and Jaraback ratios were tabulated. Linear regression analysis was used to calculate Pearson's correlation coefficient for determination of correlation between the two variables i.e., Bolton ratio to vertical parameters.

RESULTS

Ninety patients were included, descriptive stats for age are shown in Table I and II. The means, standard deviations, minimum and maximum values of Bolton ratio, SNMP, MMA, and Jaraback ratios are presented in Table III. The multiple linear regression analysis showed that vertical parameters had insignificant correlation to the Bolton ratios. Overall Bolton Ratio (B) was 91. 78%±1.7, for Mesofacial 91.10%±.9, for dolichofacial 91.90%±1.8 and for brachyfacial 91.45%±1.31. Anterior Bolton Ratio (B') was 77.5%±2.09, for Mesofacial 77.23%±2.91, for dolichofacial 78.65%±2.11 and for brachyfacial 77.53%±2.04.

Table I: Descriptive stats- age in years (n=90)

N	90
Mean	19.23
SD	4.21
Minimum	13
Maximum	25

Table II: Descriptive stats for age (n=90)

Normal angle		High angle		>Low angle	
Mean	SD	Mean	SD	Mean	SD
19.12	3.45	19.54	3.90	19.19	3.98

Table III: Descriptive stats for bolton ratio and vertical parameters (n=90)

Variable	Min.	Max.	Mean	SD
Overall Bolton	87.54	96.23	91.78	1.7707
Anterior Bolton	74.67	84.09	77.05	2.097
SNMP	18.65	51.54	34.65	6.090
MMA	12.54	39.45	26.98	5.290
JARABACK	54.66	76.09	84.87	5.440

DISCUSSION

Bolton analysis was first proposed by Bolton in 1958[6] He formulated certain ratios of the dimensions of upper and lower teeth (anterior and overall) that must exist in harmony for achieving proper interdigitations of upper and lower teeth. The devised ratio for incisal segment was 77.2±0.22 and 91.3±0.26 for overall. The method to do Bolton analysis is first calculating the width of teeth from 16 to 26 and 36 to 46. Then the ratios of the sum of width of teeth from 16 to 26 and 36 to 46 are compared with Bolton's established ratios. Any deviation greater than 2 standard deviation is considered clinically significant.

There are various methods for accessing Bolton tooth size mass: Visual inspection, visual check of size of lateral incisors and 2nd bicuspids, 3D imaging, Compass and ruler and Vernier calipers with 0.1mm accuracy[12][13,14]. We utilized vernier calipers in current research which in agreement with evidence is the most accurate method[15].

Keeping in mind the fact that there is lack of sexual dimorphism regarding tooth size discrepancy in literature[16,17]. No action was made to split the subjects according to gender in current research. This is in contrast to the study in USA where Bolton ratios were found to be greater in males than females,[18] and also in a study by Bishara[19].

There is already enough data available regarding correlation between Bolton ratios and saggital malocclusion. Most of the literature suggests that Bolton ratios are greatest in Class III subjects[20-21]. However a study by Sperry et al concluded that maxillary tooth ratios were in excess in Class II subjects[22]. There is also enough local data available regarding tooth size discrepancies in Pakistani population[23-26] but to our knowledge current research was first one that investigated the correlation between facial vertical types and Bolton ratios.

Result of the current study showed that Bolton Ratio was though slightly different in three facial vertical types but the difference was statistically insignificant. This is in agreement with the previously conducted local study where Asad et al[27] found no correlation between vertical patterns and Bolton ratios, as overall Bolton Ratio for Normal vertical subjects were 92.17%±2.46, for high vertical 92.34%±2.27 and for Low vertical 92.3%±2[19]. Similarly in our study overall Bolton Ratio for

Mesofacial sample was 91.10%±1.9, for dolichofacial 91.90%±1.8 and for brachyfacial 91.45%±1.31. Asad et al.[27] also found no correlation between vertical patterns and anterior Bolton ratios, as anterior Bolton Ratio for Normal vertical subjects were 77.76%±2.4, for high vertical 79.56%±2.89 and for Low vertical 78.89%±2.39. Similarly in our study overall anterior Bolton Ratio for Mesofacial sample was 91.10%±1.9, for dolichofacial 78.65%±2.11 and for brachyfacial 77.53%±2.04.

Determination of a facial type is necessary for orthodontic diagnosis and treatment planning. Facial type is dependent on many factors such as airway spaces, orofacial muscle activities, status of teeth and alveolus and malocclusion. The index used in orthodontics to define facial types is known as facial index, which is a product of facial height (Nasion to Gnathion) divided by the bizygomatic width28. We used this same index to divide our sample into 3 groups i.e., mesofacial, dolichofacial and brachyfacial. The facial type was defined as mesofacial when facial index value was 83% to 93%, brachyfacial, when facial index value was < 83% and dolichofacial when facial index value was > 93%[28].

Clinical implications of current study are that upper and lower teeth must be proportionate in dimensions in order to achieve post treatment occlusal harmony. It is however an ignored fact since variations in Bolton ratios if remain untreated could definitely lead to malocclusions. Limitations of current study are small sample size and cross sectional approach.

CONCLUSION

- Bolton ratios and vertical facial types are not correlated.
- Further large scale studies are suggested to establish strong correlation between Bolton ratios and vertical facial types.

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REFERENCES

1. Andrews LF. The six keys to normal occlusion. American journal of orthodontics. 1972 Sep 1;62(3):296-309.
2. McLaughlin RP, Bennett JC. Finishing with the preadjusted orthodontic appliance. InSeminars in orthodontics 2003 Sep 30 (Vol. 9, No. 3, pp. 165-183). WB Saunders.
3. Hajar A. Tooth Size Discrepancy Importance as a Diagnostic Tool for Orthodontic Treatment Planning: A Review. International Arab Journal of Dentistry. 2015 Aug;6(2):87-92.
4. Sarver DM. orthodontics & esthetic dentistry: mission possible! A Broader Approach to Interdisciplinary Esthetic Treatment. Journal of Cosmetic Dentistry. 2016 Jan 1;31(4).
5. Bolton WA. The clinical application of a tooth-size analysis. American Journal of Orthodontics. 1962 Jul 1;48(7):504-29.
6. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. The Angle Orthodontist. 1958 Jul;28(3):113-30.
7. Black GV. Descriptive anatomy of the human teeth. SS White manufacturing Company; 1902.
8. Ballard ML. Asymmetry in tooth size: a factor in the etiology, diagnosis and treatment of malocclusion. The Angle Orthodontist. 1944 Jul;14(3):67-70.
9. Neff CW. Tailored occlusion with the anterior coefficient. American journal of orthodontics. 1949 Apr 1;35(4):309-13.
10. Lundström A. Intermaxillary tooth width ratio and tooth alignment and occlusion. Acta Odontologica Scandinavica. 1955 Jan 1;12(3-4):265-92.
11. Rudolph DJ, Dominguez PD, Ahn K, Thinh T. The use of tooth thickness in predicting intermaxillary tooth-size discrepancies. The Angle Orthodontist. 1998 Apr;68(2):133.
12. Proffit WR, Fields HW, Sarver DM. Contemporary Orthodontics-E-Book. Elsevier Health Sciences; 2014 Mar 12.
13. Naidu D, Freer TJ. Validity, reliability, and reproducibility of the iOC intraoral scanner: a comparison of tooth widths and Bolton ratios. American Journal of Orthodontics and Dentofacial Orthopedics. 2013 Aug 31;144(2):304-10.
14. Celikoglu M, Nur M, Kilkis D, Sezgin OS, Bayram M. Mesiodistal tooth dimensions and anterior and overall Bolton ratios evaluated by cone beam computed tomography. Australian orthodontic journal. 2013 Nov;29(2):153.
15. Shellhart WC, Lange DW, Kluemper GT. Reliability of the Bolton tooth-size analysis when applied to crowded dentitions. The Angle Orthodontist. 1995 Oct;65(5):327-34.
16. Doodamani GM, Khala AS, Mala Manohar U. Assessment of crown angulations, crown inclinations, and tooth size discrepancies in a South Indian population. Contemporary clinical dentistry. 2011 Jul;2(3):176.
17. Hashim HA, Najah AS, Hashim AH. Bolton tooth size ratio among qatari population sample: An odontometric study. Journal of orthodontic science. 2017 Jan;6(1):22.
18. Richardson ER, Malhotra SK. Mesiodistal crown dimension of the permanent dentition of American Negroes. American journal of orthodontics. 1975 Aug 1;68(2):157-64.
19. Bishara SE, Jakobsen JR, Abdallah EM. Comparisons of mesiodistal and bnccolingnal crown dimensions of the permanent teeth in three populations from Egypt, Mexico, and the United States. American Journal of Orthodontics and Dentofacial Orthopedics. 1989 Nov 1;96(5):416-22.
20. Araujo E, Souki M. Bolton anterior tooth size discrepancies among different malocclusion groups. The Angle orthodontist. 2003 Jun;73(3):307-13.
21. Nie Q, Lin J. Comparison of intermaxillary tooth size discrepancies among different malocclusion groups. American Journal of Orthodontics and Dentofacial Orthopedics. 1999 Nov 30;116(5):539-44.
22. Sperry TP, Worms FW, Isaacson RJ, Speidel TM. Tooth-size discrepancy in mandibular prognathism. American journal of orthodontics. 1977 Aug 1;72(2):183-90.
23. Mushtaq N, Tajik I. Mesiodistal crown dimensions and Bolton ratio in the Khan research Laboratories employees and their families. Pakistan Oral & Dental Journal. 2012 Jun 1;32(1).
24. Shahid F, Alam MK, Khamis MF. Maxillary and mandibular anterior crown width/height ratio and its relation to various arch perimeters, arch length, and arch width groups. European journal of dentistry. 2015 Oct;9(4):490.
25. KUNDI IU, Bashir U, ZAHID S, Shaheed S. Bolton tooth size analysis of Pakistanis of 13 to 20 years in Islamabad city. Pakistan Oral & Dental Journal. 2012 Dec;32(3).
26. Batool I, Abbas A, Rizvi SA, Abbas I. Evaluation of tooth size discrepancy in different malocclusion groups. J Ayub Med Coll Abbottabad. 2008;20(4):51-4.
27. Asad S, Naeem S, Ul-Hamid W. Bolton Analysis For Different Sagital Problems & Its Coreltion With Dental Parameters. Pakistan Oral & Dental Journal. 2008 Jun;28(1):91-8.
28. Rakosi T, Jonas I, Graber T. Orthodontic diagnosis (Color Atlas of Dental Medicine). 1st ed. Thieme; 1993.