ORIGINAL CONTRIBUTION

Relationship of bolton's ratios and tooth-size discrepancy

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Abstract. The aim of this study was to determine whether there are differences in the influence of tooth size discrepancies among malocclusion groups in the general population; to know if there are any effects of tooth size discrepancies from region to another, and to study Bolton's ratio of tooth size discrepancy in relation to malocclusion treatments. A quantitative study was carried out using many studies published in the English language from various population groups from different countries. Well defined guidelines for conducting analyses of observational studies were followed by electronic database (Entre Pub Med, www.ncbi.nim.nih.gov). Additionally, a search in the Science Direct database (www.sciencedirect.com) will be performed, and data will be collected on the following items for the retrieved studies: year of publication, study design, materials (study sample, control sample,) methods of measurement, authors' conclusions, and reference lists of relevant articles would be screened.

INTRODUCTION

The main purpose in comprehensive orthodontic treatment is to achieve optimal final occlusion, over jet and overbite. Tooth sizes and arches discrepancies of maxillary and mandibular are important factors for reaching this goal. The sizes of the maxillary and mandibular teeth are defined as mesio distal widths. [1] The relationships between the maxillary and mandibular teeth must be in specific dimensions, to ensure secure inter-cuspation, overbite and over jet. Orthodontists have different opinions about focusing on the significance of tooth size discrepancy and the necessity to measure it clinically [2] even though, in most individuals the natural teeth are fit together in proper way. However, about 5% of population has tooth size discrepancies which may cause Malocclusion3.

A number of studies have shown that the prevalence of significant of tooth size discrepancy is rather high. Some researchers have established a relationship between tooth size discrepancy and malocclusion, such as [13], [16], [17] and [18]. They found that Class III subjects had greater mandibular tooth size excess than the Class II and I. Others showed class II malocclusions had greater maxillary tooth size excess than other Classes [13]. However, other studies reported no significant differences [14] and [17].

On the other hand, many causes may influence the size and shape of dental arches, for instance bone growth, genetics, tooth eruption and inclination, ethnic history, and function [20] and [21] Many studies have been conducted concerning the evolution of arch width

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and transverse craniofacial, to calculate changes due to treatment, setbacks and growth. [22] and [23] several researchers studied the transverse morphology and development of Class I compared with Class II division 1 and class II division. [24] and 25 while very few studies were included, four types of anteroposterior occlusion were compared.

Objectives

Tooth size discrepancy: Bolton's analysis:

Bolton [1] conducted the best known study of tooth size discrepancy in relation to malocclusion treatments [2]. He used his method in cases to analyze mesio-distal tooth size ratios between maxillary and mandibular teeth with standard occlusion. He measured the greatest mesio-distal width of all the teeth, excepting the second and third molars on each case. Bolton collected forty-four dental casts from patients who were orthodontically treated (non-extraction) with excellent occlusion, and eleven untreated subjects. As samples, he selected "big group of excellent occlusion casts with extreme care" from ten private practices in Washington and Oregon, and from the University of Washington, Department of Orthodontics. Bolton used a three-inch needle point divider and a finely calibrated millimeter ruler to measure the greatest mesio-distal diameter from first molar to first molar for each dental cast. This data was used by Bolton to establish the means and statistical measures of dispersion for two ratios that he published for use in assessment of the interarch relationship, to aid in orthodontic diagnosis and treatment planning. Bolton recorded and measured the sum of the mesio-distal tooth sizes of the mandibular arch (from first molar to first molar), and divided this sum by the mesio-distal tooth sizes of the maxillary arch (from first molar to first molar). Then he multiplied this value by 100 to gain the percentage of mandibular and maxillary tooth discrepancy. He named this value the "over-all ratio". He used the same method to calculate a percentage relationship between anterior teeth (from canine to canine), and termed "anterior ratio" Bolton expressed his ratios as follows:

Formulas used to determine the ratio of the anterior teeth, canine to canine (3-3), and the ratio of both posterior and anterior teeth, first molar to first molar.

$$\frac{\text{Sum 3-3 (mandibular)}}{\text{Sum 3-3 (maxillary)}} \times 100 = \text{Anterior Ratio}$$

$$\frac{\text{Sum 6-6 (mandibular)}}{\text{Sum 6-6 (maxillary)}} \times 100 = \text{Total Ratio (Over-all ratio)}$$

Methods of Measuring Mesio-Distal Tooth Dimension

It is essential to have a quick and easy method of measurement if it is to be employed widely. In the same way, no method of measurement is strong without clear and thorough documentation of reproducibility. Traditionally, the methods of measuring a tooth's mesio-distal size on dental models can be defined as manual methods, and use either a Boley gauge (Vernier calipers) or needle-pointed dividers [26].

Other previous studies Othman *et al.* [2] Proffit [27] and Tomassetti *et al.* [8] have found the advantages of using the digital method for measuring Bolton's tooth width analysis. The anterior and posterior ratios can be quickly calculated by using a digital caliper linked to computer. In this finding, a digital caliper was used to calculate only the mesio-distal tooth size of the samples.

Currently, there is a new method using an A RMI 550, a three dimensional measuring device (SAM Präzisionstechnick GmbH, München, Germany), which was used to evaluate the models to the nearest 0.01 mm (Figure 1). Measurements were taken of the mesio-distal tooth widths of all teeth, according to the method described by Moorrees *et al.* [29].

MATERIALS AND METHOD

The main goal of the study were to conclude whether there is a difference in tooth size discrepancies among difference malocclusion groups in population and between genders, to know if there are any influence of tooth size discrepancies from country to another, and to know the relationship between the tooth size discrepancy and malocclusion.

Collecting results from previous studies was our first task, followed by storing them in order to build database. The search of literature is not complete in the strict sense, and it cannot be covered the whole world, but our hope is to include all the most important previous studies, in addition to making smaller study. Next, we explored the databases through several methods and steps.

Observational studies, such as cross-sectional surveys, cohorts and case-control studies were included. The studies of population were based on non-patients studies, which included both adults and adolescents. Also, we have included studies that covered only adolescents.

TABLE 1 . Descriptive comparison of anterior ratio and overall ratio for malocclusion groups

Author (s)	Country	Gender	Year Published	Number of Cases	Anterior Ratio	Overall Ratio
Singla Anil, Mahajan Monika	Himachali	Males	2010	50	77.89	92.42
		Females		50	77.45	91.62
Banu SAGLAM AYDINATAY	Turkey	Males	2010	86	78.28	91.255
		Females		110	78.27	91.435
Husamettin Oktay and Esengiil Ulukaya	Erzurum,	Males	2009	216	78.892	92.434
	Turkey	Females		284	78.896	92.118
Mihovil Strujit et al;	Croatia	Males	2009	127	78.39	91.71
		Females		174	77.81	91.60

TABLE 2 . Descriptive comparison of anterior ratio and overall ratio for gender

Author (s)	Country	Occasion Type	Year Published	Number of Cases	Anterior Ratio	Total Ratio
Kristin Lopatiene,	Lithuania	I	2009	71	78,075	92,937
Aiste Dumbravaite		II		91	77,703	92,506
		III		19	78,084	93,083
Iffat Batool, Assad Abbas,	Pakistan	I	2008	37	77,67	91,64
S. Ausaf Ali Rizvi,		II		68	80,14	90,79
Irum Abbas		III		30	79,58	91,13
Tancan Uysal,; Zafer Sari,	Turkey	I	2005	156	78,56	91,90
Faruk Ayhan Basciftci;		II-1		157	78,50	91,12
Badel Memili,		II-2		34	79,00	91,94
		III		113	78,83	91,69
Hamid Reza Fattahi,	Iran	I	2006	50	79,44	91,85
HamidReza Pakshir and		II-1		50	77,73	90,65
Zohreh Hedayati		II-2		50	78,72	91,09
		III		50	80,16	93,14

The terminology used in review papers on TSD was utilized to identify MeSH and free text terms. A comprehensive search was performed by combining the terms "tooth size discrepancy", "Bolton Ratio", "malocclusion groups", "relationship between Bolton ratio and malocclusion", "TSD",", "cause of malocclusion", and "tooth size". The references of all relevant studies and existing reviews were screened for additional relevant publications.

For each paper the following information was extracted:

Title, author, year of publication, aim of the study, number of cases, participation rate population, numbers of male and female subjects, sample information about the population, country of study, criteria and definition of TSD, type of sampling, overall and anterior ratio (in percentage), malocclusion groups and references.

Our last step was to be more precise and to specify in the research. We selected around 50 articles published in English that fit to our criteria. We divided our study into three schedules: the first compared the results in different populations; the second discussed differences in dental classes; and the last was concerned with comparisons between genders.

RESULTS

A breakdown of the search results by databases can be seen in Table 1. After checking for duplicates and excluding studies that did not fulfill the selection criteria, the 1989 was earliest year of publication, and the latest 2011. (94%) of the studies were published during the last ten years.

The aim of our study was to determine the correlations between tooth size discrepancies among malocclusion classes in many population samples, which included the gender and comparing the results of all researches which we selected. Mentioned worth, that the importance of tooth size discrepancies in orthodontic diagnosis has widely mentioned in the literature and accepted by the orthodontic community because the relationship between the upper and lower anterior and posterior dentition is related to the orthodontic finishing excellence [2-14-15].
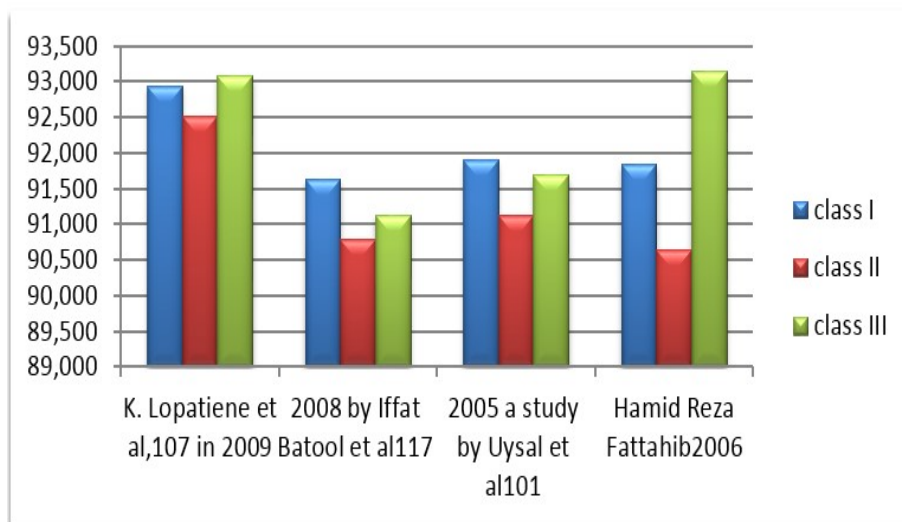

FIGURE 1 *.* Descriptive comparison of anterior ratio and overall ratio for malocclusion groups
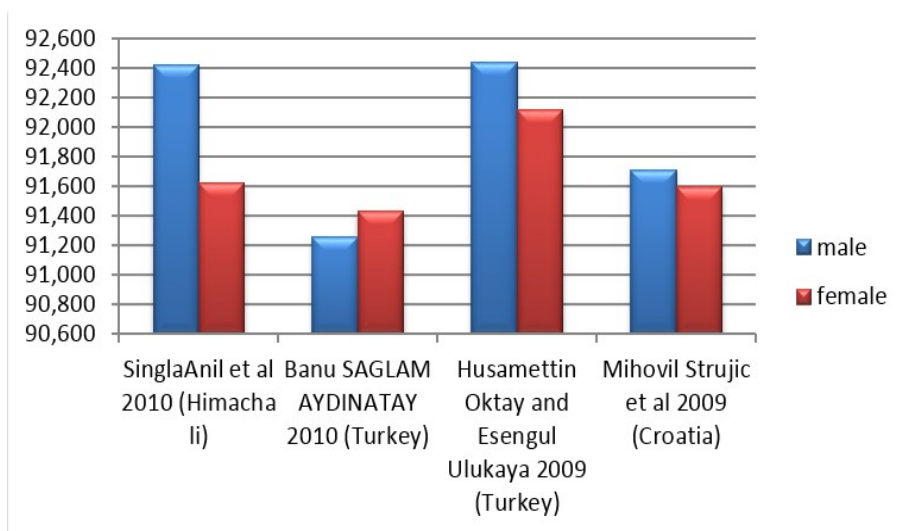
FIGURE 2 *.* Descriptive comparison of anterior ratio and overall ratio for gender

With the many controversies related to the prevalence of tooth size discrepancy among malocclusion groups, it is not surprising that the estimation of this prevalence has varied considerably. Concern has been expressed regarding the lack of generally accepted standards for definitions, methods of investigation, and presentation of results. These factors probably explain more of the variations than do any real differences between samples.

This study was used to evaluate the results of about 50 studies regarding the prevalence of TSD among malocclusion groups, and tried to explain the associated factors. Any investigators have used ±2 SD, equivalent to about 3mm or more, for corroborating a clinically significant discrepancy. This number is corrected by removal of the tooth structure and/or prosthetic alteration.

For our research, we selected several studies which compared TSDs among malocclusion classes (Tables 1, 2). However, these studies have different data generally. These studies have selected randomly from several ethnic groups (Saudi Arabian, Chinese, Nepalese, Lithuanian, Turkish, Brazilian, Iranian, Japanese, Irish, Jordanian, Pakistani, British, American (white and black), Iraqi, Croatian, Thai, Malaysian, Indian, Belgian, Peruvian and Spanish).

Several authors found that there were no significant differences between malocclusion groups for instance. However, other authors found significant differences between malocclusion groups. Most studies found no differences in the mean Bolton ratio between the sexes, and in those studies which found a difference, it was small. The differences in the results between this study and other investigations might be attributed to differences in sample size, methods of analysis, and the large standard deviations found in this study.

CONCLUSION
1. The comparison between different malocclusion groups:
A. The overall and anterior Bolton ratio comparison showed no statistically significant difference between Angle Class I, II, and III in about 45% of studies.
B. The results of this study indicate that the prevalence of Tooth Size Discrepancy among malocclusion groups is about 55% of studies in different population.

C. The results revealed that 70% of studies which had TSD among malocclusion groups that Class III malocclusion had a significantly greater prevalence of tooth size discrepancies than those with Class I and Class II malocclusions.

2. The population comparisons:

A. The anterior Bolton ratio comparison in different populations revealed that 74% (4668 cases) of studies didn't show any significantly differences, whereas 26% (1230 cases) of study revealed significantly differences (See in Table 3).

B. The overall Bolton ratio comparison in different populations showed that 97% (5738

TABLE 3 *.* Distribution of anterior ratios using bolton's published mean of 77.2 ± 1.65%

	Number of Studies	%
77.2±1.65	25	74%
> 1.65	9	26%

cases) of studies had no significantly differences; whereas only 3% (160 cases) of studies showed significantly differences (see in Table 4).

TABLE 4 *.* Distribution of posterior ratios using Bolton's published mean of 91.3 ± 1.91%.

	Number of Studies	%
91.3± 1.91	33	97%
>1.91	1	3%

3. Gender comparisons:

Around 40% of gender studies revealed significant differences between (males and females studies) comparing with Bolton ratio of tooth size discrepancy, and whereas approximately 60% of studies showed that no statistically significant differences in the prevalence of TSD with regard to gender. Final conclusion showed that the estimation of this prevalence has varied considerably because of many controversies related to the prevalence of tooth size discrepancy among malocclusion groups.

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