

Influence of premolar extractions on tooth size discrepancy. Part Two: Analysis of Bolton values

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SUMMARY

The purpose of this study is to investigate whether the extraction of four premolars as a requirement of orthodontic therapy is a factor in the creation of tooth size discrepancies (TSD) (Bolton value (BV)), and to determine whether any tooth extraction combinations create more severe discrepancies comparing our result with the results from analogical studies.

Hypothetical tooth extractions were performed in all cases by the following combinations: all first premolars, all second premolars, upper first and lower second premolars, and upper second and lower first premolars, estimating extraction influence on TSD frequency and size.

148 pretreatment dental casts were examined. It has been determined that in normal TBI group the smallest discrepancies were created after the second (1.087 mm) and fourth types of combinations have been chosen (1.174 mm). In a low TBI group, the smallest discrepancies occur after first (1.544 mm) and third (1.568 mm) types of removal. In high TBI group the smallest discrepancies appear after type two (3.379 mm) and type four (3.586 mm) have been chosen.

Key words: Bolton index, tooth size discrepancy.

INTRODUCTION

The mesiodistal teeth widths of the maxillary and mandibular arch must be well aligned in order to obtain an excellent occlusion at the end of the orthodontic treatment. It is assumed that the process of secularization had an influence on mesiodistal teeth widths increase in modern world in the twentieth century [11,12]. Modern epidemiological research finds that 30% of the population has tooth size discrepancy (TSD) [6]. Many investigators claim that it is a serious problem which forces the orthodontists to perform thorough analysis of each patient [5,6,8,9,11,12,19], but it still remains questionable whether TSD is really causing clinical problems.

According to J.E. Freeman [6] and D.A. Crosby [5], tooth size discrepancy is clinically significant if $91.3-3.86(2S) \leq TBI \leq 91.3+3.86(2S)$. M. Heusdens [10] determines even a broader range for clinical tooth size discrepancies. She asserts that only extreme TBI discrepancies can affect the results of treatment, i.e. TSD is considered clinically significant when $91.3-5.79(3S) \leq TBI \leq 91.3+5.79(3S)$. She also points out, that premolar extractions cause in average 2 mm TSD problems, which doesn't have major influence on the post treatment results. Meanwhile P. Saatci and F. Yukay state, that at least one of four examined premolar extractions (32 out of 50 patients, who had normal TBI) cause clinical problems [18].

The purpose of this study is to evaluate what is the

distribution of changes effected by four premolar extractions in cases of normal, low and high TBI groups. Changes larger than 2 mm in BV should be considered clinically significant.

MATERIAL AND METHODS

In the Orthodontic clinic at Kaunas Medical University 148 pretreatment dental casts of patients have been selected for analysis of Bolton index and Bolton value in our study [8].

Measurements were made directly on dental casts using "Minchner design Dental Vernier" ("Dentaurum") gauge. Measurements were made in accordance with methodology described by R.C. Wheeler [23]. TBI calculated by this formula:

$$TBI = \frac{\sum_{i=31}^{36} dd_i + \sum_{i=41}^{46} dd_i}{\sum_{i=11}^{16} dd_i + \sum_{i=21}^{26} dd_i} * 100 \quad (1)$$

TBI-total Bolton index (Overall ratio);

dd_i -mesiodistal width of each tooth.

Dental arches are proportional to each other when TBI is $91.3\% \pm 1.91$, after four premolar extractions TBI is $88\% \pm 1$. These averages were marked as BI_{ideal} . When TBI quantity exceeds BI_{ideal} it means that teeth are wider in the lower jaw. If TBI quantity is less than BI_{ideal} it means that teeth are wider in the upper jaw. TBI is ideal when the number that is named as Bolton value is subtracted in the first case from the sum of lower jaw teeth width, in the second case – from the sum of upper jaw teeth width. The Bolton value is ex-

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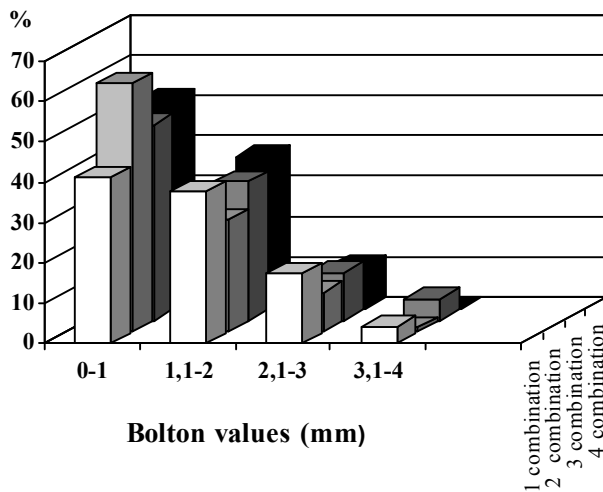


Fig.1. Frequency and magnitude of Bolton values created by removal of different combinations of premolars in normal TBI group

1 combination – all first premolar extractions, 2 combination – all second premolar extractions, 3 combination – upper first, smaller second premolar extractions, 4 combination – upper second, smaller first premolar extractions.

pressed in millimeters. We can write this from formula (1):

$$BV = \begin{cases} (\sum_{i=31}^{36} dd_i + \sum_{i=41}^{46} dd_i) - const * (\sum_{i=11}^{16} dd_i + \sum_{i=21}^{26} dd_i), & \text{when } TBI > TBI_{ideal} \\ (\sum_{i=11}^{16} dd_i + \sum_{i=21}^{26} dd_i) - \frac{1}{const} * (\sum_{i=31}^{36} dd_i + \sum_{i=41}^{46} dd_i), & \text{when } TBI < TBI_{ideal} \\ 0, & \text{when } -TBI = TBI_{ideal} \end{cases} \quad (2)$$

dd_i - mesiodistal width of each tooth, $i=11-16, 21-26, 31-36, 41-46$,

$$const = \begin{cases} 0.913 - BV \text{ before extraction,} \\ 0.88 - BV \text{ after extraction} \end{cases}$$

148 analyzed cases according to TBI were divided in three groups:

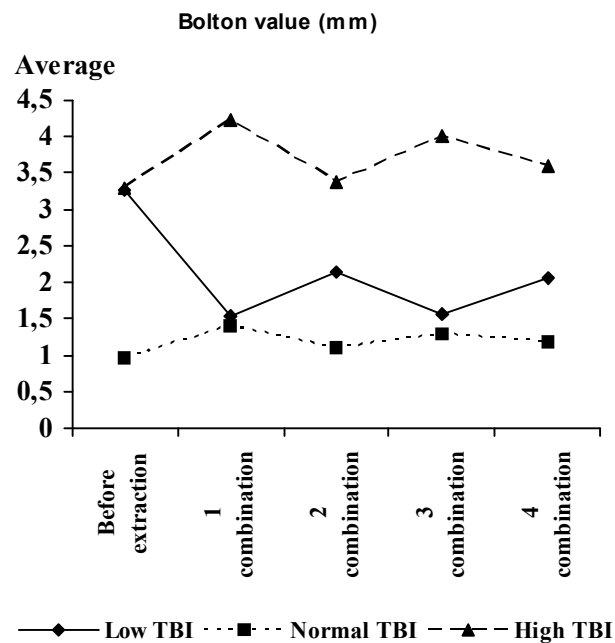


Fig. 2. Changes of BV (mm) averages after hypothetical teeth extraction combinations in normal, low and high TBI groups

1. Normal TBI (91.3% 1.91) – 93 patients
2. Low TBI (<89.39%) – 27 patients
3. High TBI (>93.21%) – 28 patients

In these groups we assessed the influence of hypothetical first and second premolar extraction variations on TSD frequency effecting changes in appearance and size. These combinations are:

- 1) all first premolars,
- 2) all second premolars,
- 3) upper first and lower second premolars,
- 4) upper second and lower first premolars

In hypothetical cases according to formulas (1, 2) when calculating TBI and BV, extracted teeth widths are equated to zero.

Statistical analysis was performed using SPSS 12.0. The mean (\bar{x}) standard deviations (s) were used as descriptive values. In comparing multiple measurement averages one

Table 1. Mean Bolton values before and after hypothetical tooth extractions in normal TBI group

	Before extractions	After first premolars	After second premolars	After upper first. smaller second premolars	After upper second. smaller first premolars
Min	0.009	0.004	0.012	0.004	0.012
Max	2.281	3.360	2.916	3.588	2.928
Mean	0.957	1.387	1.087	1.292	1.174
Standard deviation	0.602	0.871	0.753	0.956	0.748
Standard error	0.062	0.090	0.078	0.099	0.078

n=93

Table 2. Mean Bolton values before and after hypothetical tooth extractions in low TBI group

	Before extractions	After first premolars	After second premolars	After upper first. smaller second premolars	After upper second. smaller first premolars
Min	1.963	0.005	0.736	0.044	0.168
Max	6.482	5.241	5.873	4.673	6.441
Mean	3.261	1.544	2.138	1.568	2.067
Standard deviation	1.218	1.377	1.246	1.385	1.505
Standard error	0.234	0.265	0.240	0.267	0.290

n=27

Table 3. Mean Bolton values before and after hypothetical tooth extractions in high TBI group

	Before extractions	After first premolars	After second premolars	After upper first. smaller second premolars	After upper second. smaller first premolars
Min	1.965	2.544	1.052	1.580	1.620
Max	10.565	11.056	8.964	9.756	10.264
Mean	3.297	4.218	3.379	4.011	3.586
Standard deviation	1.757	1.722	1.524	1.691	1.660
Standard error	0.332	0.325	0.288	0.320	0.314

n=28

Table 4. Comparison of the paired BV means before and after hypothetical four premolar extractions in normal TBI group

Combinations of teeth extraction	BV differences before and after extractions	Standard deviation	p	95% difference of CI averages	
				The smallest value	The largest value
1	-0.430	0.105	0.000	-0.639	-0.222
2	-0.130	0.083	0.120	-0.295	0.035
3	-0.335	0.111	0.003	-0.555	-0.115
4	-0.217	0.080	0.008	-0.376	-0.058

way analysis of variance was employed. Student's t-tests were used to compare the results and variation coefficient. McNemar's test was used to compare the equality of proportions in two dependent samples. Level of significance was chosen 0.05. Three independent investigators performed all measurements on dental casts. No statistically significant intra-individual ($p < 0.01$) and inter-individual ($p < 0.05$) differences of the measurements were found.

RESULTS AND DISCUSSION

Bolton values before and after the hypothetical premolar extractions in four combinations were calculated in order to assess the incidence of changes and to evaluate their clinical importance. When TSD is bigger than 2 mm that is considered clinically significant.

In the normal TBI group in 85% of the cases BV after hypothetical extractions changed 0-2 mm in any chosen combination, in 15% of cases BV changed 3-4 mm or more (Fig. 1).

BV minimal and maximal values, means, standard deviations and errors were calculated in all the four extraction combinations in three observed groups and were compared

with primary TSD distribution, with the objective of evaluating the frequency of changes, which occur after four premolars had been extracted.

It has been found that in the normal TBI group the smallest discrepancies were created after the second ($\bar{x} = 1.087$ mm) and fourth combinations of extractions ($\bar{x} = 1.174$ mm) - i.e. extracting four second premolars and/or two upper second and two lower first premolars, and the largest after first ($\bar{x} = 1.387$ mm) or third ($\bar{x} = 1.292$ mm) combinations of extractions has been used (Table 1).

In a low TBI group the smallest discrepancies occur after first ($\bar{x} = 1.544$ mm) and third ($\bar{x} = 1.568$ mm) types of removal - i.e. extracting four first premolars and/or two upper first and two lower second premolars, and the largest TSD occur after second ($\bar{x} = 2.138$ mm) or fourth ($\bar{x} = 2.067$ mm) types of removal (Table 2).

In high TBI group the smallest discrepancies appear after second combination ($\bar{x} = 3.379$ mm) and fourth combination ($\bar{x} = 3.586$ mm) are chosen, while the largest were found after first combination ($\bar{x} = 4.218$ mm) and third combination ($\bar{x} = 4.011$ mm) (Table 3).

Blocked data variance dispersal analysis was performed

Table 5. Comparison of the paired BV means before and after hypothetical four premolar extractions when TBI group is low

Combinations of teeth extraction	BV differences before and after extractions	Standard deviation	p	95% difference of CI averages	
				The smallest value	The largest value
1	1.72	0.104	0.000	1.50	1.93
2	1.12	0.108	0.000	0.90	1.34
3	1.69	0.156	0.000	1.37	2.01
4	1.19	0.146	0.000	0.89	1.49

Table 6. Comparison of the paired BV means before and after hypothetical four premolar extractions when TBI group is high

Combinations of teeth extraction	BV differences before and after extractions	Standard deviation	p	95% difference of CI averages	
				The smallest value	The largest value
1	-0.921	0.075	0.000	-1.076	-0.767
2	-0.082	0.112	0.467	-0.312	0.147
3	-0.714	0.139	0.000	-0.998	-0.430
4	-0.290	0.103	0.009	-0.501	-0.079

Table 7. The comparative analysis of data from KMU Orthodontic clinic's and P. Saatci, F. Yukay studies

	Kaunas Medical University study	P. Saatci, F. Yukay study
N	93	50
Min	0.009	0.040
Max	2.281	2.010
Mean	0.957	0.885
Standard deviation	0.602	0.595
Standard error	0.062	0.084

to compare BV averages. The data block was made of primary BV and BV after four hypothetical teeth removal. In all the cases zero hypothesis about BV equality of averages was rejected ($p < 0.01$). Post hoc Bonferroni criterion was used to determine which BV averages statistically differ significantly from primary BV averages. In Tables 4-6, the comparisons of double average in each of groups are given.

In normal TBI group (Table 4) after extracting four second premolars (2 combination), BV averages statistically didn't change ($p = 0.12$), it can be stated that extracting four second premolars TSD changes are smallest. Other combinations of teeth removal cause statistically more significant ($p < 0.01$) bigger changes. The largest TSD changes appear after extracting first premolars - approximately of 0.43 mm.

As it is shown in Table 5 in low TBI group after teeth removal, in all cases, BV average statistically significantly decreases ($p = 0.000$). The biggest average reduction in sizes (1.72 mm and 1.69 mm) is obtained after extracting four first premolars (1 combination) and/or two upper first and two lower second premolars (3 combination) also the lowest number of TSD cases is gained.

It is showed in Table 6, that in high TBI group BV average statistically didn't change significantly after extracting four second premolars ($p = 0.47$) (2 combination). In other cases of extraction BV averages are bigger than original ones ($p < 0.01$).

Graphical BV average (in mm) changes in hypothetical extraction cases in normal, low and high TBI groups are showed in Fig. 2. The biggest changes arise in low and high TBI groups. In normal TBI group the biggest average changes (0.5 mm) (1 combination) aren't clinically significant. In low TBI group the situation is getting better when TSD decrease by 2 mm, after first and third combination of removal. In high TBI group the clinical situation isn't really getting worse, because of 0.2 mm changes after second and fourth combinations of extraction, but after first or third combinations TSD increase 0.8mm and can cause serious problems.

While examining BV changes in upper and lower jaws it has been found, that in high TBI group teeth in lower jaw remain too wide despite of chosen hypothetical extraction combination. Analogically, in low TBI group upper jaw teeth remain too wide (except 1 and 2 combinations). There is no data if anyone has done any research in examining TSD changes in high and low TBI groups after premolar extractions were performed, therefore the obtained data (while

Table 8. The comparative analysis of Bolton values before and after hypothetical teeth extractions from KMU Orthodontic clinic's and P. Saatci, F. Yukay studies

A, all first premolars					
After extractions	Min	Max	X	SD	P
KMU	0.004	3.360	1.387	0.871	0.39
P.Saatci, F.Yukay	0.010	3.720	1.252	0.916	
B, all second premolars					
After extractions	Min	Max	X	SD	P
KMU	0.012	2.916	1.087	0.753	0.07
P.Saatci, F.Yukay	0.040	2.580	0.840	0.769	
C, Upper first, lower second premolars					
After extractions	Min	Max	X	SD	P
KMU	0.004	3.588	1.292	0.956	0.88
P.Saatci, F.Yukay	0.110	3.800	1.175	0.924	
D, Upper second, lower first premolars					
After extractions	Min	Max	X	SD	P
KMU	0.012	2.928	1.174	0.748	0.19
P.Saatci, F.Yukay	0.070	2.990	1.004	0.715	

TBI is normal) has been compared with analogical research, performed by P. Saatci, F. Yukay [18] (Table 7 and 8).

The respondents from both chosen groups had normal TBI – 91.3% 1.91. The results of the studies show, that statistically significant changes occur when first four premolars, two upper first and two lower second premolars, and two upper second and two lower first premolars are extracted. KMU and P. Saatci, F. Yukay averages in all of the cases don't differ from each other ($p > 0.05$). The only tendency of difference can be found in case B ($p < 0.1$) (Table 8).

Comparative analysis allows us to claim, that extraction of second premolars made statistically less significant changes, but extraction of first premolars highly influences TSD. Avoiding more noticeable TSD, W.A. Bolton [4], S.S. Smith [20], P. Saatci, F. Yukay [18] suggested (while TBI is normal) extracting not the first lower jaw premolars, but second premolars, which have high variability of sizes. Our research confirmed this opinion.

CONCLUSIONS

The obtained data allows us to state that when:

1. TBI is normal, smallest TSD changes appear after extracting four second premolars. Regardless of the chosen way of teeth removal BV changes from 0-2 mm in approximately 85% of all the cases, while 15% of all the cases change by 3-4 mm.

2. TBI is low, the smallest TSD changes appear after extracting first four premolars and/or two first upper and two second lower premolars. After extracting four first premolars or two first upper and two second lower premolars clinical TSD problems disappear when TBI decreases approximately in 1.7 mm.

3. TBI is high; the smallest of TSD is after extracting second four premolars. After extracting four first premolars or two first upper and two second lower premolars in high TBI group, TSD increase (approximately 0.8 mm) and cause serious clinical problems.

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