RELATIONSHIP OF MESIODISTAL TOOTH SIZE TO EXTRACTION RATE AND POST-TREATMENT CHANGES IN THE CLASS II DIVISION 1 MALOCCLUSION

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
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Mesiodistal tooth size has been implicated in untreated crowding and post-treatment alignment change. The purpose of this study was to determine if tooth size is related to malocclusion severity, extraction frequency, and post-treatment change in a group of class II division 1 subjects treated as part of a 2-phase randomized controlled clinical trial at the University of Florida. Included subjects were those who began the study and had initial Peer Assessment Rating (PAR) scores (n=257) and who completed the study and had final PAR scores (n=204). Tooth width was measured on dental casts at the completion of treatment or at the time point closest to completion of treatment, and extracted teeth were noted from the casts. It was shown that males had significantly larger teeth. Initial PAR and molar class severity did not differ by sex, but tooth size was significantly correlated in males with initial overjet (R=0.23 [upper 2-2], 0.16 [combined 2-2]) and PAR score (R=0.28 [upper 2-2], 0.18 [combined 2-2]). Tooth size had significant correlations with lower anterior alignment for females (R=0.20 [upper 2-2],

0.27 [lower 2-2], 0.23 [combined 2-2]). Tooth size was not related to initial molar class severity. More males were treated with second phase extractions with the majority of extractions done in the upper arch. Females only showed significant differences in tooth size when comparing extraction and non-extraction subjects, suggesting that females received extractions for excess tooth mass or protrusion, and males received extractions for classification purposes. There were no differences in post-treatment PAR score change between extraction and non-extraction subjects.

CHAPTER 1
INTRODUCTION

Tooth size, along with available arch length and desired ultimate tooth position, is part of the important space analysis during orthodontic diagnosis and treatment planning. Tooth size has been studied throughout the history of orthodontics to explain pre- and post-treatment crowding, differences in classification, and even for extraction guidelines.

A few studies have shown that larger teeth are associated with crowding.[1,2] However other studies found no association between tooth size and crowding[3] while others will claim that tooth size and arch dimension have equal contributions.[4] Many authors[5-10] have found males to have larger teeth than females, and ethnic tooth size differences have been shown.[9] The size of the crowns of teeth have been shown to be linked to heredity through twin studies.[11]

Skeletal and dental classification have been shown to influence tooth size and Bolton's discrepancies, class III subjects having greater differences between maxillary and mandibular tooth size than class I and class II, which did not differ.[9,12-14]

Incisor shape as defined as the ratio between mesiodistal and faciolingual dimensions[15] and contact point to cervical area mesiodistal width[16] are the major determinants in lower anterior crowding of untreated arches. However, other studies have failed to show correlation between incisor shape and crowding and have suggested that mesiodistal width alone correlates to crowding.[17,18]

Gilmore and Little[19] examined the relationship between mandibular incisor dimensions and arch alignment in 164 class I and II cases 10 years after completion of treatment. They found a weak positive correlation between incisor dimension and crowding. Glenn et al.[20] evaluated 28 nonextraction treated cases 8 years post-retention and found no association between mesiodistal or faciolingual incisor dimension and pretreatment or post-treatment incisor crowding.

Multiple scoring systems have been utilized to assign quantitative descriptors to treatment results such as Little's irregularity index[21] and the PAR index.[22] Birkeland et al.[23] found that pre-treatment PAR score was a good predictor for post-treatment PAR score and long term outcome. Pavlow[24] found that post-treatment PAR score and PAR score change is not related to Phase I treatment type in a group of class II subjects treated during a prospective clinical trial.

Given the contradiction in the literature about tooth size and crowding, we sought to examine if this relationship existed for class II subjects. In addition, we wanted to determine if sexual dimorphism in tooth size existed in our cohort. Finally, we wanted to evaluate whether tooth size related to extraction rate and PAR changes during retention.

CHAPTER 2
MATERIAL AND METHODS

Sample

This study included a sample of individuals with Class II malocclusion who participated in a prospective randomized controlled trial at the University of Florida. The design of this study was published by Keeling et al.[25] in 1998.

Methods

Tooth measurements were done on stone casts with digital calipers by one examiner [JRR]. The mesiodistal width was measured and recorded at the contact point for maxillary and mandibular incisors, canines, and premolars, bilaterally. Stone models have been validated for accurate measurement by Gilmore and Little,[19] and bilateral measurements are advocated by Ballard[26] due to his documentation of right-left tooth size discrepancies. A digital caliper was oriented parallel to the occlusal plane of the teeth and the vestibular surface of the model as per the method standardized by Moorrees and Reed.[27]

Measurements were done on final models. In the case of extraction treatment, the size of any extracted tooth was taken from models at an appropriate previous time point if available; the teeth that were extracted were noted for use in analysis. If the final models were not of good diagnostic value (fractured or distorted) measurements were done on the next available retention models. Of the 312 subjects who began the study's first phase, 257 had tooth measurements and initial PAR scores available for analysis. For subjects who may not have completed the study, models at the latest time point available were measured. Dental casts of diagnostic value were available for 204 of the 208 subjects who completed the study.

The measurements were summed for each subject as summed upper and lower 2nd premolar to 2nd premolar (5-5) and summed upper and lower lateral and central incisors (2-2) for data analysis.

Initial molar class (mild, bilateral one-half cusp; moderate, 1 side three-fourths cusp; severe, 1 side full cusp) was used to grade the severity of the class II malocclusion.[28]

Peer assessment rating (PAR) scores were used to assess post-treatment stability. The American weighted, raw unweighted, and component (upper and lower alignment, overjet, and overbite) scores were used as stability variables. To quantify post-treatment stability, the difference between PAR scores and components at DCF and DCR was calculated as ([PAR score change] = [PAR score @ DCR1,2,3…] - [PAR score @ DCF]).

Data Analysis

To determine examiner reliability, tooth width of ten randomly chosen subjects' casts was measured twice two weeks apart. For each tooth measured, the difference between the two measurement time points was averaged among the ten subjects. Mean difference ranged from 0.10mm for the lower right canine to 0.20 for upper right lateral incisor.

Chi-square test was used to compare the number of individuals with and without extractions by phase I treatment group, sex, and initial molar class severity.

Combined tooth width between male and females and between extraction and non-extraction subjects was compared with a 2 sample t-test.

Wilcoxon rank sum was used to compare combined tooth size and PAR score at DC1 by sex. It was also used to compare PAR score components and PAR score component change between extraction and non-extraction subjects.

Pearson correlation coefficients were used to examine the correlation between tooth size and DC1 PAR score and components.

ANOVA was used to determine significant differences between DC1 molar class severity groups due to tooth size.

CHAPTER 3
RESULTS

There were 257 study participants who had available tooth width data and initial PAR. There were more males (n=156) than females (n=101), but there were nearly equal numbers in each of the three phase I groups (bionator n=93; observation n=78; headgear n=86). The majority of the subjects had a high initial molar class severity (n=118), with less in the low (n=62) and mild (n=86) categories. The majority of the subjects were White (n=238), with less Black (n=4), other (n=2) and Hispanic (n=13) subjects.

Table 3-1 shows the mean tooth width for this sample. The smallest tooth was the mandibular central incisor (5.28mm) and the largest was the maxillary central incisor (8.69mm). The greatest standard deviation was noted for the maxillary left lateral incisor.

Table 3-2 depicts the mean 2-2 tooth size and DC1 PAR scores by sex. Males had significantly greater combined 2-2 tooth width for the maxillary and mandibular arches independently and together. However, there were no significant differences by sex for weighted PAR score at DC1. For females, the correlation coefficient between tooth size and DC1 PAR score and components were significant between upper 2-2 ($R=0.20$), lower 2-2 ($R=0.27$), and combined 2-2 ($R=0.23$) width for lower anterior alignment only at $p<0.05$. For males there was no significant correlation between tooth size and lower incisor alignment. However, males showed significant correlations for the following combinations: weighted PAR and upper 2-2 ($R=0.28$) and combined 2-2 ($R=0.18$); raw par and upper 2-2 ($R=0.22$); and overjet and upper 2-2 ($R=0.23$) and combined 2-2

(R=0.16), all at p<0.05. There were no other significant correlations between tooth size and PAR scores and components (data not shown).

Table 3-1. Mean tooth width (values in mm.)

Tooth Number	N	Mean	Std Dev	Minimum	Maximum
UR5	247	6.65	0.50	5.34	9.77
UR4	248	6.90	0.44	5.42	8.86
UR3	241	7.82	0.47	6.54	9.31
UR2	255	6.63	0.54	5.16	8.31
UR1	257	8.65	0.55	6.36	10.05
UL1	257	8.69	0.56	7.20	10.85
UL2	257	6.67	0.59	5.09	8.89
UL3	240	7.79	0.48	6.57	9.05
UL4	248	6.91	0.42	5.79	8.71
UL5	245	6.65	0.64	5.43	10.93
LL5	240	7.16	0.53	5.84	9.09
LL4	250	7.03	0.47	5.78	8.87
LL3	248	6.79	0.42	5.71	8.87
LL2	257	5.84	0.42	4.90	7.09
LL1	257	5.29	0.34	4.25	6.13
LR1	256	5.28	0.39	4.33	8.89
LR2	257	5.84	0.36	4.97	6.90
LR3	248	6.74	0.45	5.27	8.25
LR4	251	6.98	0.51	5.25	8.69
LR5	243	7.07	0.51	5.74	8.68

Tooth number is given in Palmer notation (UR, upper right; UL, upper left; LL, lower left; LR lower right)

Table 3-2. Tooth width and initial PAR by sex

	Male (n=156)		Female (n=101)		
	Mean	SE	Mean	SE	p-value
Upper 2-2, mm.	30.93	0.16	30.05	0.19	0.0004
Lower 2-2, mm.	22.47	0.10	21.86	0.13	0.0002
Combined 2-2, mm.	53.41	0.23	51.91	0.31	<0.0001
Weighted PAR	21.13	0.51	20.57	0.63	0.49

2 sample t-test used

There were no significant tooth size differences between DC1 molar class severity groups for males and females (data not shown).

Table 3-3 shows subjects treated with extractions in any arch who completed the class II study and had casts available for measurement (n=204). Note that the values for upper arch extractions represent any subjects treated with upper extractions including those who may have been treated with lower extractions (this is true for the lower extraction data as well). Although there were no significant sex differences between the number of subjects treated by nonextraction and extraction, more males were treated with extractions, and the difference was nearly significant ($p=0.053$ in both arches, $p=0.0710$ in the upper arch). There was a significantly greater number of subjects in the phase I observation group treated by extractions in any (upper or lower) arch and the upper arch alone, but not for subjects treated with lower arch extractions. A similar pattern of significance was seen when subjects were grouped by DC7 molar class severity.

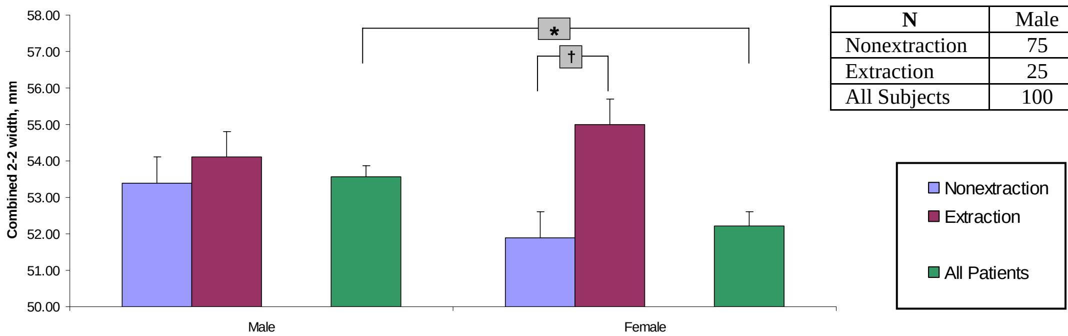
Figure 3-1 shows the combined 5-5 and 2-2 tooth width by sex and extraction for class II study participants who finished the second phase of treatment and for whom values for all 20 anterior teeth were available (n=169). Males had significantly larger teeth than females ($p < .001$). Subjects treated with extractions had more combined tooth width than those treated without extractions, though the difference is significant only for females ($p < .05$).

The change in mean PAR scores and components from final to recall time points is shown in Figure 3-2. The subjects represented are those who completed the study and who had models scored by the PAR index. The number of subjects that were recalled decreased as the interval from treatment completion increased. Also, not all subjects were recalled at every year for retention. Therefore, the number of subjects not only decreases in the later retention time points, but the subject pool is different at each retention time point. There were no significant differences between extraction and nonextraction groups at any data collection point for change in mean weighted or raw PAR, upper anterior alignment, and overjet. The nonextraction group had a significantly greater mean lower anterior alignment score change at DCR6. The nonextraction group also had a significantly greater mean overbite score change at DCR3.

Table 3-3. Percent of subjects with extractions by treatment group, sex, and DC7 molar class severity

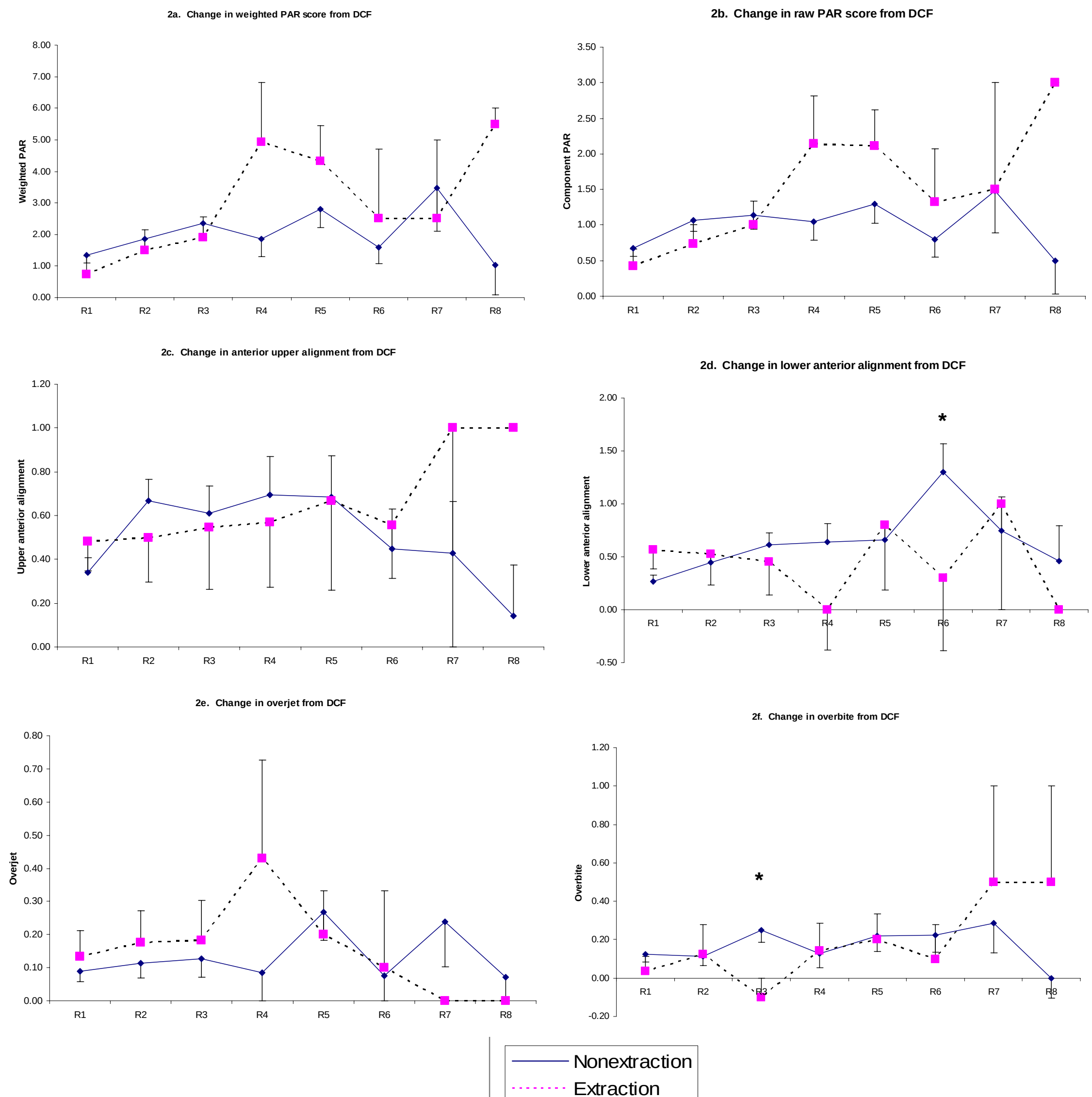
Percent (n)		Nonextraction	Extraction Upper arch	Lower arch	Both arches	p
	Total (n=204)	81% (166)	19% (38)	5%(11)	19% (38)	
Sex						
	Male	77% (94)	23% (28)	7% (8)	23% (28)	n.s.
	Female	88% (72)	12% (10)	4% (3)	12% (10)	n.s.
Phase I treatment group						
	Bionator	89% (59)	11% (7)	3% (2)	11% (7)	< 0.05
	Observation	72% (48)	28% (19)	9% (6)	28% (19)	< 0.05
	Headgear	83% (59)	17% (12)	4% (3)	17% (12)	< 0.05
Initial molar class severity						
	High	74% (73)	26% (26)	4% (4)	26% (26)	< 0.05
	Low	90% (43)	10% (5)	2% (1)	10% (5)	< 0.05
	Mild	88% (50)	12% (7)	11% (6)	12% (7)	< 0.05

Extraction Upper Arch = any subject with extractions in upper arch.
Extraction Lower Arch = any subject with extractions in the lower arch.
Extraction Both Arches = any subject with extractions in either arch.
Chi-square test used.



N	Male	Female
Nonextraction	75	62
Extraction	25	7
All Subjects	100	69

Figure 3-1. Mean combined 2-2 tooth width by sex for extraction and nonextraction subjects (with standard error).
2 sample t-test used. *Significant difference male v. female $p < .001$. †Significant difference (extraction v. nonextraction) $p < .05$.



	R1	R2	R3	R4	R5	R6	R7	R8
N (Nonext)	121	96	63	46	41	40	21	14
N (Ext)	29	16	11	7	9	10	2	2

Figure 3-2. Change from DCF in mean PAR score and components for extraction and nonextraction groups (with standard error). **2a**, weighted PAR; **2b**, raw PAR; **2c**, upper anterior alignment; **2d**, lower anterior alignment; **2e**, overjet; **2f**, overbite. Wilcoxon rank sum test used. *Significant (extraction v. nonextraction) at $p < .05$.

CHAPTER 4
DISCUSSION

Previous retrospective studies examined tooth size differences by comparing crowded and non-crowded dentitions.[1,2] This study, while retrospective, utilizes a subject pool treated as part of a prospective randomized controlled clinical trial.[25] Phase I treatment was determined by randomization, while phase II treatment plan was determined by using a collaborative treatment plan by sending phase II records to multiple practitioners across the country.[29] It should be noted that the extraction frequency represented here is a result of model analysis and represents actual treatment rather than the collaborative treatment plan.

Our investigation of tooth size in Class II subjects had a similar outcome as previously reported studies[5-10] with respect to sex differences. Our findings showed that males had approximately 3.4 mm greater tooth mass for the 20 anterior teeth and 1.3 to 1.5mm greater tooth mass for the 8 anterior teeth. Molar class severity and DC1 PAR score did not differ by sex, suggesting that tooth size may not influence these measures. We were not able to confirm the findings of Lavelle[9] in regards to ethnic differences in tooth size due to the predominately white sample in this study.

There were differences between males and females in regards to the pattern of correlation between initial PAR components and tooth size. Anterior tooth size in males significantly correlated with overjet and weighted PAR. The significant correlation in females was with lower anterior alignment. The suggestion is that larger teeth in class II children is manifested differently for boys than girls, such that boys show their arch length discrepancy with overjet, and girls with lower crowding. The correlation between lower incisor size and lower anterior alignment (R=0.27, females) is similar to the correlation between incisor size and Little's irregularity index reported for treated and untreated cases by Smith et al.[18] and to that reported by Gilmore and Little[19] for post-retention cases. However, correlations in the range or R=0.30 are of questionable clinical value.

While there were no significant differences in the number of males and females requiring second phase extractions, the trend was that more males (28) than females (10) had extractions, suggesting that the greater tooth mass may be related to more males being treated with extractions.

Comparing nonextraction and extraction subjects showed that subjects treated with extractions had significantly greater mean tooth mass for the 5-5 and 2-2 measurements. This comparison alone would suggest that subjects with larger teeth had more crowding and that our findings agree with those of Doris et al.[1] and Norderval et al.[2] However, only 11 of the 38 extraction subjects had extractions in both arches. With the majority of extractions being done in the upper arch, the suggestion is that the majority of extractions were done for classification and maxillary anterior retraction rather than for crowding.

Furthermore, extraction frequency also showed significant differences with respect to DC7 molar class severity, with 26.3% of severe class II subjects having extractions and 11.4% of low and mild class IIs having extractions. This is also suggestive that phase II extraction decision is heavily influenced by the overall requirement for attaining a desirable finishing classification.

The influence of phase I treatment on the frequency of extractions was significant. Those with bionator or headgear phase I treatment had significantly fewer extractions (13.9%) than the phase I observation group (28.4%). The suggestion is that phase I treatment cuts the likelihood of having extractions during phase II treatment in half. A similar study done at the University of North Carolina[30] found an extraction rate of approximately 17% in the observation group, 15% in the headgear group, and 38% in the bionator group. They noted that the difference in extraction rate approached but was not statistically significant.

The extraction rates for this study do not reflect the previously reported consensus treatment plans[29] as our extraction frequency was determined by looking at post-treatment casts rather than the treatment plan. Therefore, these rates, while showing interesting trends, should be interpreted with caution as they represent the treatment preferences of a few practitioners.

There was a significantly greater difference in tooth size between extraction groups for females, but not for males. With more males overall requiring extractions, less difference in tooth size between extraction and nonextraction subjects is due to a majority of subjects having extractions for classification purposes rather than for crowding.

Post DCF PAR score and component change did not show any trends in statistical significance when comparing extraction and nonextraction groups. A possible explanation for this is that there is no difference in relapse between extraction and nonextraction subjects. However, different methods of retention were used for these subjects, including removable Hawleys and fixed retention. One might feel that fixed retention would prevent alignment changes. Efforts are being made to group these subjects by retention type to analyze relapse. However, this could be difficult due to the comparison of PAR values of subjects with fixed retention to those with Hawley retainers due to the variable compliance with Hawley retainers. Additionally, the impact of third molar status has not been examined.

CHAPTER 5
CONCLUSIONS

In summary, males had significantly larger teeth than females. Initial PAR score and molar classification did not differ between males and females. For males, initial weighted PAR score and overjet correlated with upper and combined upper and lower anterior tooth size, while in females showed correlation between lower anterior alignment and all measures of anterior tooth size. Tooth size was not related to initial molar class severity.

During the second phase of treatment, there was a trend for more male subjects being treated with extractions during the second phase of treatment. The majority of extractions were done in the upper arch, with very few subjects having extractions in the lower arch. The difference in tooth width for females treated with extractions compared to females treated without extractions was much greater than the same difference for males. There were significant differences in the number of subjects receiving extractions when grouped by phase I treatment group and by DC7 molar class severity, with the observation group and the severe class IIs having more extractions. There were few significant differences between extraction groups with respect to PAR and component scores at the end of treatment and throughout the retention period

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BIOGRAPHICAL SKETCH

Juddson Reed received his BA in chemistry from Wake Forest University in 1999. He received a DMD in 2003 and a Certificate in Orthodontics and Master of Science in dental sciences in 2006 from the University of Florida College of Dentistry.