Classification and Treatment of Angle Class II Subdivision Malocclusions

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DEDICATION

to my dear husband, Ryan and mother, Dorothy

1. INTRODUCTION:

Patients with Class II subdivision malocclusions have long been a treatment challenge for clinicians[1-2]. Treating asymmetric malocclusions is inherently more difficult than treating symmetric malocclusions, as symmetry in one or both arches needs to be re-established, usually with asymmetric extractions, mechanics, or surgery. For example, Class II subdivisions that are due to maxillary dental asymmetries might be addressed with asymmetric extractions. Similarly, Class II subdivisions due to mandibular skeletal asymmetry might be ideally corrected with asymmetric mandibular advancements[3]. However, this option is often not accepted by patients, causing orthodontists to then employ other asymmetric options, such as Class II elastics, extractions, extraoral traction, orthodontic distalizers, TAD's, and fixed functional appliances[4].

At the University of Washington graduate orthodontic clinic, there are more than 20 attending faculty, trained at graduate programs from around the country. The approaches they employ to address Class II subdivisions are diverse, reflecting a variety of philosophies and temporal trends. This investigation of Class II subdivision malocclusions provided interesting insights into treatment options and outcomes. Treatment objectives included:

1. Categorize the main types of Class II subdivision malocclusions that were encountered in the University clinic from 1995 to 2011
2. Investigate the different treatment strategies employed at the University of Washington
3. Compare outcomes of differing treatment methodologies, including midline and molar correction, as well as overall occlusal outcomes
4. Evaluate final lower incisor angulation, based upon different treatment strategies

2. METHODS:

This retrospective study was approved by the Institutional Review Board at the University of Washington. The consecutively chosen sample of orthodontic records was selected from the retention files of the Orthodontic Department at the University of Washington, spanning the years 1995 to 2011. For patients from January 1995 to December 2008, it was possible to identify potential subjects by searching the retention files housed in the graduate clinic. The retention files provide a summary of each patient's diagnosis, treatment plan and final outcomes. After 2008, the retention files were not systematically collected. Therefore, initial models of all consecutively finished cases from 2008 to 2011 were evaluated to identify potential cases.

The inclusion criteria were defined as patients treated at the UW Orthodontic Graduate Clinic with a Class II subdivision malocclusion whose initial and final records included complete chart notes, intra and extra-oral photographs, study models and cephalometric radiographs. Patients with syndromes or cleft lip and palate were excluded. Categorization as a Class II subdivision required at least a half cusp difference between the right and left sides. For example, a full cusp Class II relationship on the right side and a half cusp Class II relationship on the left side would qualify.

After selecting the eligible cases, all identifiers on study casts were masked. Initial maxillary midline position was determined by evaluating patient photographs, and then this evaluation was cross-referenced with diagnostic notes in the chart. Mandibular midlines were related to the maxillary and facial midlines by assessing photographs and study casts. Again, these evaluations were cross-referenced with chart notes. A determination on mandibular skeletal asymmetry was also performed using facial photographs and chart notes. In a small number of patients, posterior-anterior cephalometric radiographs were also available. Final

midline assessments were obtained in the same fashion, although chart notes were often not available for cross-reference. Dental midlines that were within 1 mm to either side of the facial midline were considered to be symmetric with the face.

In a random and blinded fashion, two calibrated examiners independently scored all initial study casts for PAR, and, starting one week later, measured the final casts. PAR scores used in data analysis represented an average of each examiner's score. For PAR cases in which the examiners disagreed by more than 5 points, each examiner measured the casts again. If scores still differed by more than 5 points, the examiners met and a consensus score was obtained.

Periodontal probes were used to measure initial and final overjet and overbite on each set of casts using the ABO measuring standards. Digital calipers were used to measure the horizontal millimetric difference in molar relationship from Class I. The measurement was from the maxillary 1st molar mesiobuccal cusp tip to the mandibular 1st molar buccal groove. A perfect Class I molar relationship was defined as having a 0 mm discrepancy. Class II molar relationships were denoted as a positive discrepancy, and Class III molars were denoted as a negative discrepancy. In order to evaluate the success of the molar correction, a Class I or Class II target molar occlusion was established for each Class II side, based on extractions or missing teeth on the Class II side. For example, a Class II side with no missing teeth and no extractions would have a Class I relationship as the target. A Class I molar target occlusion was assigned a value of 0 mm (millimetric distance between the position of the mesiobuccal cusp tip of the maxillary 1st molar and buccal groove of the mandibular 1st molar in a Class I relationship). A Class II molar target was assigned a value of 6.5 mm, using the same measurement landmarks (This value was chosen based on the distribution of patients with a Class II target with respect to

the average distance Class II molars are typically displaced ~6.5 mm.) Molar targets were considered acceptable if they were within 1 mm of the established millimetric values (0 mm for Class I, and 6.5 mm for Class II)

Initial and final cephalometric radiographs were hand traced, and the following measurements were obtained: maxillary central incisors to NA in mm and degrees, mandibular central incisors to NB in mm and degrees, and mandibular central incisors to MP[5]. All PAR, cephalometric, and midline measurements were performed prior to the examiner's knowledge of the patient's treatment. Each chart was thoroughly examined to abstract information on the previously stated research parameters, i.e. gender, date and age at bond and debond, all treatments rendered. Details of the treatment included: extractions, headgear, fixed functional appliances, elastic use, other auxiliary appliances, and surgery recommended or completed.

Statistical analysis

Means and proportions were calculated for parameters of interest. Means were compared using analysis of variance and t-tests. Proportions were compared using the Chi-square test or the Fisher's exact test. Results were regarded as significant at $p < 0.05$.

The intraclass correlation coefficient (ICC) was used to determine inter-rater reliability for the PAR measurements. Based upon 20 randomly selected pairs of measurements, the ICC was 0.781 indicating acceptable inter-rater reliability. For key outcomes, 10 subjects were selected randomly for re-measurement at least one month apart. Dahlberg's formula was used to calculate intra-rater reliability for midline assessment, lower incisor to mandibular plane angulation, and molar class measurement.

$$\delta = \sqrt{\frac{\sum d^2}{2n}}$$

The intra-rater reliability for midline deviations, lower incisor to mandibular plane angulation, and molar correction were 0.19 mm, 1.23 degrees and .06 mm, respectively.

3. RESULTS:

From 1995 to 2008, 218 potential subjects were identified from the retention files (Figure 1). Another 34 potential subjects were identified from assessing models from 2008 - 2011. Sixty-two cases were excluded, as charts could not be located. Another 57 subjects were excluded due to failure to meet the subdivision inclusion criterion. Another 23 subjects were lost due to incomplete records. This left a total of 110 subjects, or 44% of those initially identified for potential inclusion.

Subjects were then placed into groups based on similarities in their midline relationships, and the etiology of their asymmetries. Specifically, Group 1 was composed of subjects whose maxillary and mandibular midlines were coincident with the facial midline. Twenty-seven subjects met this criterion (Fig 1). The etiology of the asymmetry in Group 1 was determined to be primarily dental in origin. Group 2 was composed of subjects whose maxillary midlines deviated to one side of the facial midline by more than 1 mm, but whose mandibular midlines were coincident with the facial midline. Sixteen subjects fell into this category, and their etiology was also determined to be primarily dental in origin. Finally, Group 3 was composed of subjects whose maxillary midlines were coincident with the facial midlines, but whose mandibular midlines were more than 1 mm off from the facial midline. Fifty-five subjects fell into this category, and the majority of these subjects were judged to have some degree of skeletal

mandibular asymmetry based on chin point deviation. However, 9 subjects in Group 3 were noted to have posterior cross-bites, and potential lateral shifts. To summarize, even though all subjects had Class II subdivision molar relationships, they presented with the following midline relationships:

GROUP 1 – maxillary and mandibular midlines on with facial midline

GROUP 2 – maxillary midline off from facial midline

GROUP 3 – mandibular midline off from facial midline

There were an additional 12 subjects who fell into other midline categories, such as midlines both deviated to the same or opposite sides. These subjects were excluded from further analysis due to their small numbers.

At baseline, the 3 main groups had no significant differences in gender distribution, age at banding/bonding, incisor proclination, Peer Assessment Rating (PAR) score, or overbite (Table 1). Not surprisingly, the 2 groups that were created based upon non-coincident midlines exhibited significant differences for their midline measurements (Table 1). Group 3 also had about 1 mm of additional overjet at the start of treatment.

Subjects were treated with a variety of strategies, such as extractions, headgear, elastics, fixed functionals, and surgery. The number of patients who underwent these various therapies was also recorded (Table 2). Extractions were recorded as being asymmetric or symmetric. It was interesting that the majority of subjects in all three groups were treated without extractions.

In 69 of the 98 patients, Class I molar was the goal for the Class II malocclusion. Of these 69 subjects, we found that 48 (70%) finished within 1 mm of the Class I target. One subject displayed overcorrection to super Class I relationship, and 20 subjects fell short of complete correction, finishing with end-on molars (Fig 2a). When the objective was to maintain

a Class II molar relationship, 19 of 27 subjects (70%) were within 1 mm of the 6.5 mm target. The remaining subjects completed treatment with a Class I tendency (2 subjects), or with a Super Class II relationship (6 subjects) (Fig 2b). (Please note that 2 patients who underwent surgery had a -6.5mm Class III molar relationship target)

When each group's success in reaching their molar targets was examined, it was found that Group 1 (Midlines On) reached their Class I target 78% (14/19) of the time, and reached their Class II target 75% (6/8) of the time. Group 2 (Mx Midline Off) had a 64% (7/11) success rate in reaching their Class I target, and 60% success rate in reaching their Class II target. Group 3 (Mn Midline Off), the biggest group, had 59% (23/39) reaching their Class I target, and 57% (8/14) reaching their Class II target, and 2 subjects had surgery with a Class III molar target.

Final midlines were then evaluated (Table 3). In Group 1 (Midlines On), the midlines remained coincident at the end of treatment. In Group 2 (Mx Midline Off), the maxillary midline finished on average 0.6 mm away from the ideal midline position. When Group 3 was evaluated, (Mn Midline Off), difficulty was noted in achieving the correction, averaging a 1.0 mm deviation from the ideal midline position at the end of treatment. This mandibular midline difference was significantly different than the other 2 groups at the end of treatment. To summarize, midline correction, especially in the mandibular arch, was often not always achieved.

In each of the 3 groups, initial PAR scores were higher in subjects who were treated with extractions than those who were treated without extractions, primarily due to the influence of crowding on selection of a treatment plan (Table 4). Although not statistically significant for all groups, extraction treatment also seemed to be associated with slightly longer treatment times (Table 4). The cases treated surgically tended to have unusually long treatment times due to

extenuating circumstances. In the end, regardless of extraction status, final PAR scores were similar, indicating both extraction and non-extraction cases reached a similar finish (Table 4).

When a Class I molar was the target for the Class II side, lower incisor proclination was significantly greater (103.5 degrees), compared to Class II molars that were targeted to remain with a Class II relationship (99.7 degrees). Additionally, lower incisors proclined significantly more when fixed functional appliances were used (105.9 degrees), compared to elastics only (101.8 degrees).

Treatment trends at UW were evaluated in 5-year increments from 1995-2011. The extraction rate decreased from over 50% to around 30% over the period of the study (Fig 3). Headgear also decreased from about 35% to 18%. Elastic use as the only auxiliary appliance to address the Class II relationship almost doubled, from 20% to 38%. Surprisingly, surgery decreased (from 10% to 0%), and fixed functional appliances increased from 0% to about 15%.

4. DISCUSSION:

Of the Class II subdivision subjects we studied, half of the asymmetries were due to mandibular dental midline displacement. Many of these subjects were judged to have a skeletal etiology, as their chins were deviated towards the Class II side. Additionally, mandibular surgery was listed as an option for the majority of these patients. This finding is consistent with Sanders et al.[6], who stated that the primary contributing factor responsible for a Class II subdivision malocclusion is a deficient mandible, due to either reduced ramus height or mandibular length, on the Class II side. However, other studies have reported that the main factor contributing to the asymmetric anteroposterior relationships in Class II subdivision malocclusions is the dentoalveolar component[2,7,8]. Janson et al.[9] reported that in approximately

61% of Class II subdivision malocclusions, the mandibular midline was the midline noncoincident with the face. This finding is similar to our 50% value for asymmetry due to mandibular midline deviation.

A Class I molar relationship was the treatment goal in the majority of the subjects in this study, regardless of the subdivision etiology. Interestingly, even when multiple treatment strategies are employed in an attempt to achieve Class I molars bilaterally, we are only able to reach this goal 64% of the time (vs. 63% for Cl II target success). Group 1 (Midlines On) and Group 2 (Mx Midline Off) showed a greater ability to reach their molar targets than Group 3 (Mn Midline Off), who reached their targets only about half of the time. This may be due to the tendency for Group 3 asymmetries to be skeletal in origin, which would be more difficult to correct than those due to a dental etiology. Also, our success in achieving Class I molar relationship can be highly dependent on the patient's level of compliance[10-12]. If maintaining a Class II relationship is a viable option, perhaps it should be considered more often. Janson et al[10] reported in one of his studies that treatment plans that maintained the anteroposterior relationship of the posterior segments resulted in better correction of the malocclusion. Maintaining the current molar relationship usually required less patient compliance with extraoral appliances or intermaxillary elastics. It also appeared to result in reduced lower incisor proclination, as well as less Class II mechanics.

Of the 98 subjects, mandibular asymmetric advancement surgery was recommended as a treatment option for 30 of these patients. Twenty-nine of these were in Group 3 (Mn Midline Off). Only 4 of those 30 patients chose to correct their asymmetry with orthognathic surgery. (The 2 patients undergoing surgery in Group 2 both had maxillary LeFort procedures.) Even if surgery is an appropriate treatment solution to correct the skeletal asymmetry[3], it seems patients

often do not view their malocclusions or facial asymmetries severe enough to undergo the associated risks and expense. In fact, it appears that the rate of orthognathic surgery in the UW graduate clinic has decreased over the past 15 years for these patients.

When planning treatment, it is often assumed that dental midlines can be predictably aligned with facial midline. As a result of this study, the investigators discovered that midline correction was challenging, and often incomplete. Should more asymmetric extraction plans be employed for our patients? Janson and colleagues[10] reported a greater improvement of the initial interdental midline deviation and a tendency for a better treatment outcome when Class II subdivision patients are treated with asymmetric extraction of 3 premolars, compared with extraction of 4 premolars. Interestingly, in Group 2, which represented subjects with maxillary midline deviation and a maxillary dental asymmetry, less than half of the subjects were treated with extractions at all (Table. 2). When considering Janson's claim and the logistics of aligning a deviated maxillary midline, it seems that extraction treatment plans could aid in better midline correction. However, in the absence of crowding, 3 or 4 premolar extraction plans might not be desirable options due to facial profile considerations.

It was not surprising to find that treatment time tended to increase with extractions. This study agrees with Fink and Smith[13], who also found the number of extracted premolars has a direct relationship to treatment time, with treatment time increasing by 0.9 months for each extracted premolar. These results are also similar to those of Alger[14], who found extraction cases to average 4.6 months longer than non-extraction cases.

In this study of varying groups and treatment strategies, it was found that the final PAR scores were comparable. This would indicate that orthodontists are relatively successful in

correcting all types of Class II subdivisions. It would be interesting to know if similar results would be seen if ABO measurement standards were used.

The resulting effect that treatment strategies had on lower incisor angulation were not surprising, with Class I targets and fixed functionals leading to more proclination[15]. Although there was no adjustment for extractions, interproximal reduction, or elastic use, the groups that were compared did have similar initial mandibular incisor proclination, averaging about 96 degrees.

It would be interesting to investigate the long-term stability of these Class II subdivision treatment modalities in the future. For example, are asymmetries corrected with extractions more stable than those corrected with elastics or functional appliances?

There were limitations in this study. Because it was retrospective, we depended on the accuracy and availability of the orthodontic records. Assessment of the etiology of the asymmetry was based on photographs, chart notes, casts, and only in some instances, were P-A cephs available. More subjects in Groups 1 and 2 would have provided increased power to evaluate various outcomes. Many patients received a combination of treatment approaches and therefore, it is difficult to draw strong conclusions about any one particular component of treatment. Also, practitioners recommended treatments that they felt were most appropriate for their patients, and the patients had some role in the acceptance of the final treatment plan. Strengths of the study include the consecutive sampling, the inclusion of many practitioners, and the blinded assessment of the outcomes.

5. CONCLUSIONS:

Based upon the results of this study, we conclude the following:

1. Half of the Class II subdivision cases treated at the University of Washington from 1995-2011 presented with mandibular asymmetry. About 25% presented with maxillary and mandibular midlines coincident with the face, and were due to a maxillary dental asymmetry. Another 15% presented with maxillary midlines deviated from facial, and were also due to a maxillary dental asymmetry.
2. The treatment strategies employed at the University of Washington show trends toward less surgery, extractions, and headgear, and trends toward more fixed functional use.
3. Complete correction of midlines is not always achieved, especially in the case of mandibular skeletal asymmetry.
4. Final PAR scores were comparable, regardless of the origin of the asymmetry or extractions status.
5. Lower incisor proclination was increased when fixed functional appliances were used, as well as when a Class I molar relationship was the target for the Class II side.

6. REFERNCES:

1. Turpin DL. Correcting the Class II subdivision malocclusion. *Am J Orthod Dentofacial Orthop.* 2005 Nov;128(5):555-6.

2. Alavi D.G., E.A. BeGole and B.J. Schneider, Facial and dental arch asymmetries in Class II subdivision malocclusion, *Am J Orthod Dentofacial Orthop* **93** (1988), pp. 38–46.

3. Janson M, Janson G, Sant'Ana E., Simao TM, and M.R. de Freitas. An orthodontic-surgical approach to Class II subdivision malocclusion treatment. J Appl Oral Sci. 2009;17(3):266-73.

4. Smith SS, Alexander RG. Orthodontic correction of a Class II Division 1 subdivision right open bite malocclusion in an adolescent patient with a cervical pull face-bow headgear. *Am J Orthod Dentofacial Orthop.* 1999 Jul;116(1):60-5.

5. Little R.M. *Roentgenographic Cephalometry an Individualized Learning Program University*

of Washington Analysis; 1977; 1-101

6. Sanders DA, Rigali PH, Neace WP, Uribe F, Nanda R. Skeletal and dental asymmetries in Class II subdivision malocclusions using cone-beam computed tomography. *Am J Orthod Dentofacial Orthop.* 2010 Nov;138(5):542.e1-20

7. Rose JM, Sadowsky C, Begole EA, Moles R. Mandibular skeletal and dental asymmetry in Class II subdivision malocclusions. *Am J Orthod Dentofacial Orthop* 1994;105:489-95.

8. Janson G.R., A. Metaxas, D.G. Woodside, M.R. de Freitas and A. Pinzan, Three-dimensional evaluation of skeletal and dental asymmetries in Class II subdivision malocclusions, *Am J Orthod Dentofacial Orthop* 2001, pp. 406–418.

9. Janson G, de Lima KJ, Woodside DG, Metaxas A, de Freitas MR, Henriques JF. Class II subdivision malocclusion types and evaluation of their asymmetries. *Am J Orthod Dentofacial Orthop.* 2007 Jan;131(1):57-66.

10. Janson G, Dainesi EA, Henriques JF, de Freitas MR, de Lima KJ. Class II subdivision treatment success rate with symmetric and asymmetric extraction protocols. *Am J Orthod Dentofacial Orthop.* 2003 Sep;124(3):257-64;

11. Burstone CJ. Diagnosis and treatment planning of patients with asymmetries. *Semin Orthod.* 1998 Sep;4(3):153-64.

12. Lewis D. The deviated midlines. *Am J Orthod* 1976;70:601-16.

13. Fink DF, Smith RJ. The duration of orthodontic treatment. *Am J Orthod Dentofacial Orthop* 1992;102:45-51.

14. Alger DW. Appointment frequency versus treatment time. AM J Orthod Dentofacial Orthop 1998;94:436-9

15. Reddy P, Kharbanda OP, Duggal R, Parkash H. Skeletal and dental changes with nonextraction Begg mechanotherapy in patients with Class II Division 1 malocclusion. *Am J Orthod Dentofacial Orthop* 2000;118:641-48.

Figure 1: Case Selection

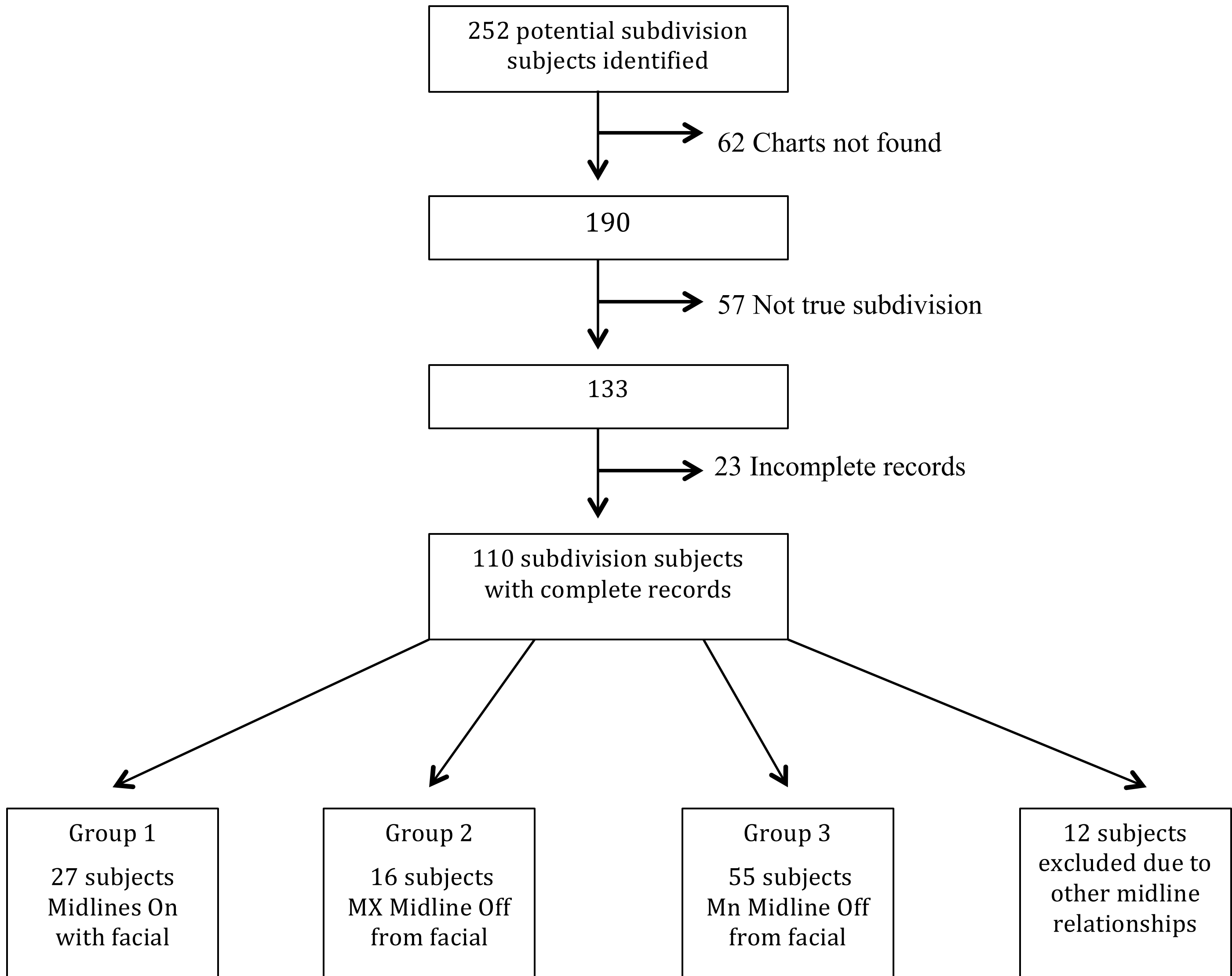
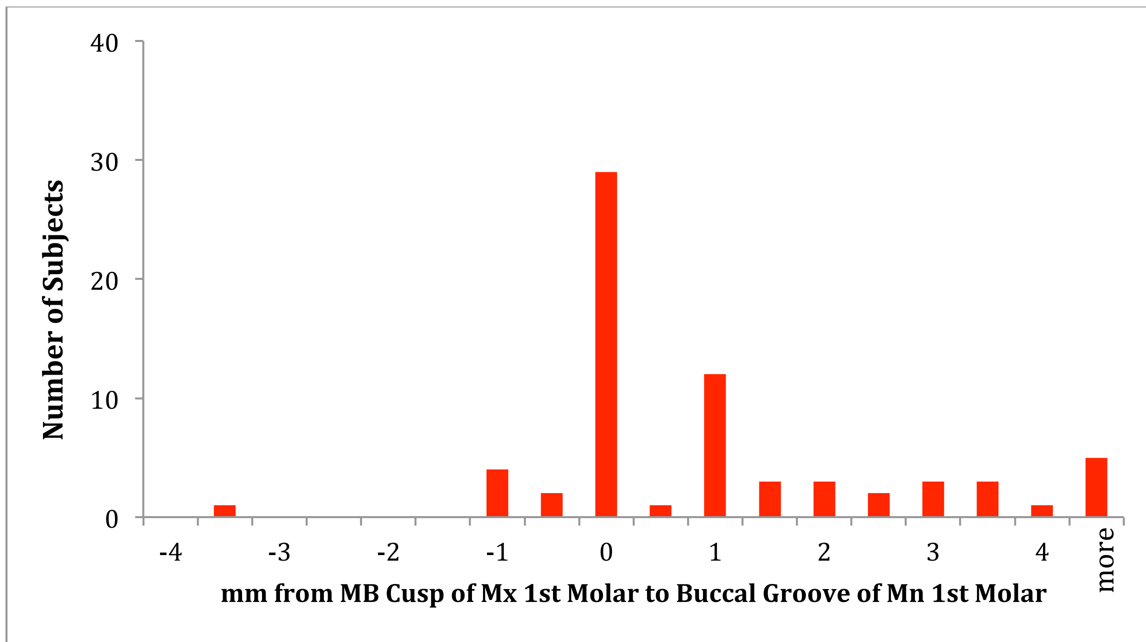
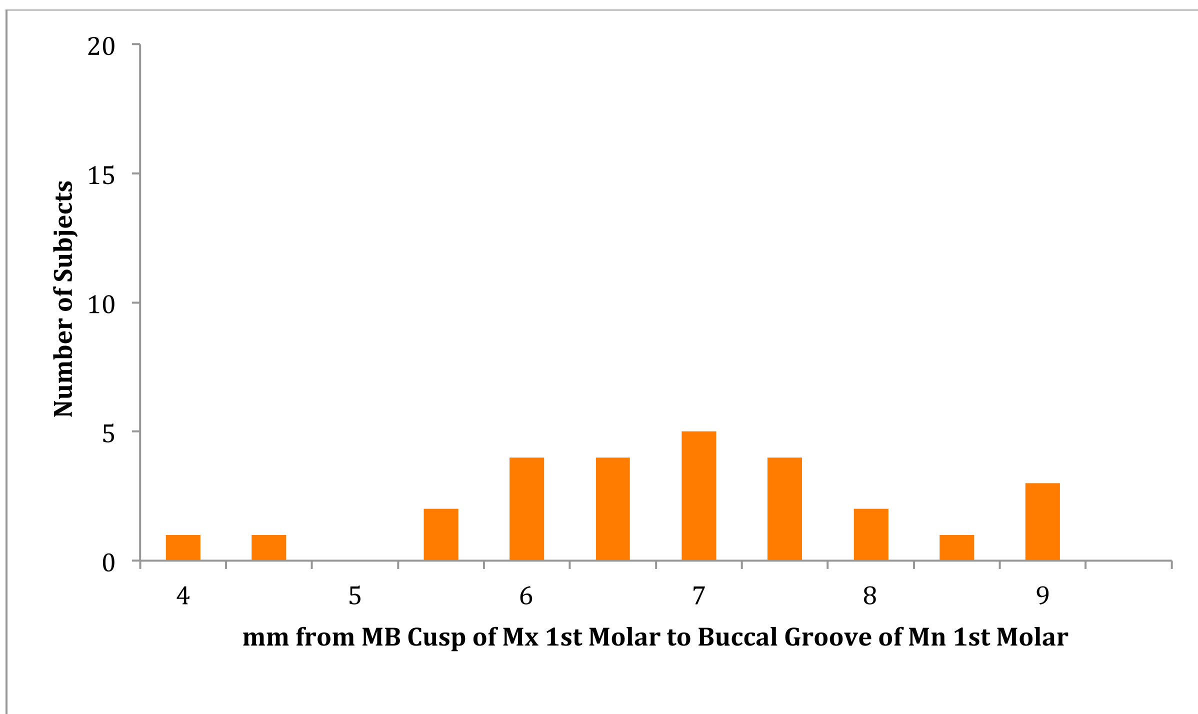


Figure 2: Molar targets and final molar occlusion (96* Subjects)
*2 subjects omitted with Class III final molar target



2a. Class II Side with Class I Target



2b. Class II Side with Class II Target

Figure 3. Trends in treatment over time

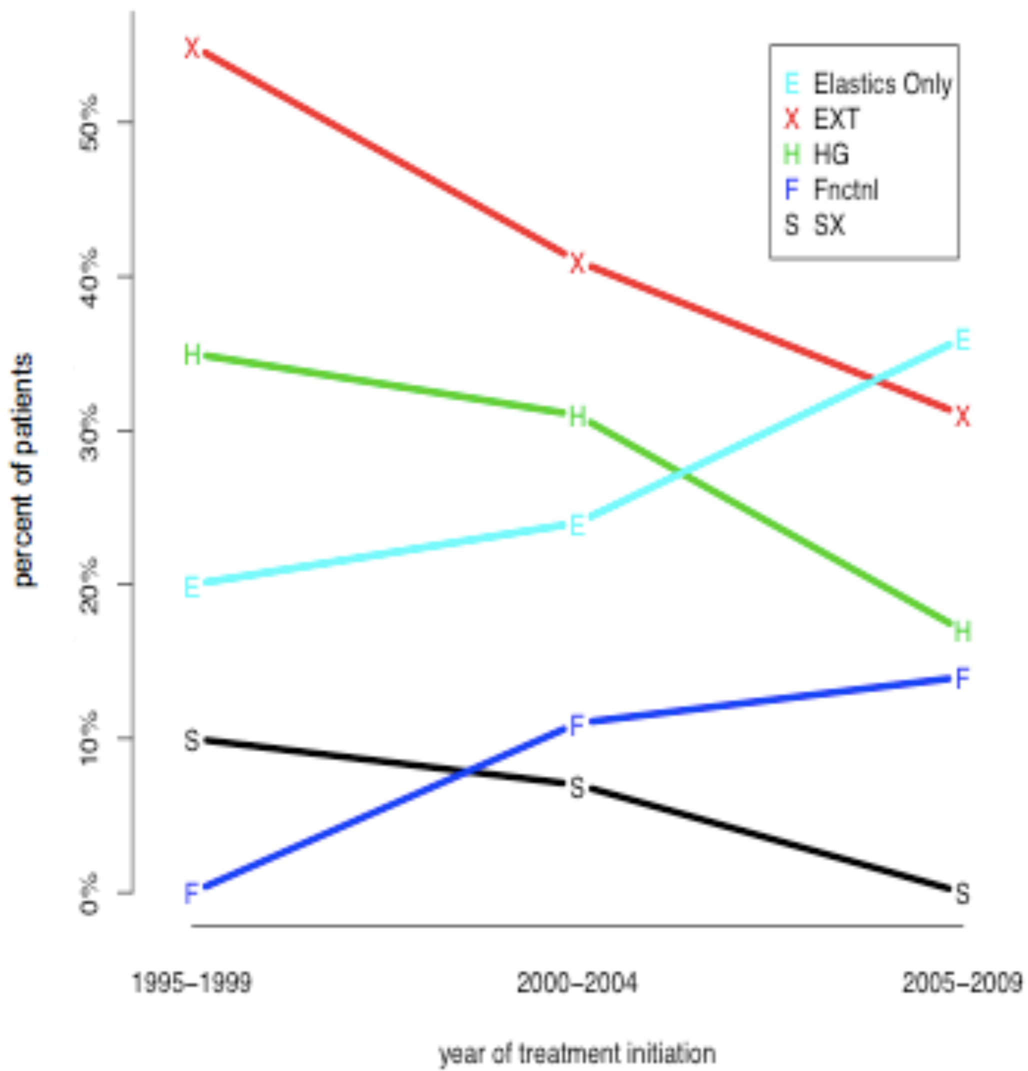


Table I: Initial Characteristics

Variables	Total Sample (n=98)		Group 1 *(n=27)*		*Group 2 (n=16)*		Group 3 *(n=55)*		
Female Gender, n (%)	53 (54)		16 (59)		10 (63)		28 (51)		0.70
Initial age (y-m) median (mean)	13-2 (18-9)		13-9 (17-3)		15-3 (20-8)		14-11 (19-7)		0.57
	mean	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*p-value*
Maxilla to Mx incisors									
Mx1.NA (degrees)	20.6	8.1	18.8	7.9	21.2	7.9	21.3	8.7	0.39
Mx1-NA (mm)	5.3	2.6	5.7	2.8	4.3	2.3	5.3	2.5	0.069
Mandible to Mn Incisors									
Mn1.NB (degrees)	25.9	7.6	26.6	5.2	28.4	7.7	24.8	8.8	0.27
Mn1.NB (mm)	6.0	2.8	5.8	2.4	7.0	2.7	5.8	2.9	0.38
Mn1.MP (degrees)	96.2	8.0	95.9	6.1	98.1	8.1	95.9	8.7	0.75
Mx midline deviation (from facial midline)	0.6	0.9	0.2	1.0	2.3	1.0	0.3	1.0	<0.001
Mn midline deviation (from facial midline)	1.4	1.1	0.6	1.1	0.4	1.1	2.3	1.1	<0.001
Class II side (mm from Class I)*	3.6	1.3	3.4	1.3	3.7	1.2	3.6	1.3	0.76
Class I side (mm from Class I)*	0.2	0.9	0.2	1.1	0.1	0.5	0.0	0.9	0.67
Initial overjet	5.2	2.2	4.3	2.1	4.8	2.3	5.7	2.2	0.016
Initial overbite	4.6	1.9	4.4	2.2	3.9	2.2	4.9	1.7	0.10
Initial PAR score	28.1	10.4	25.2	10.0	28.7	10.0	29.3	9.0	0.26
Extraction Rate %	41%		48%		38%		35%		0.74

Group 1 = Midlines On
Group 2 = Maxillary Midline Off
Group 3= Mandibular Midline Off
*These values indicate the position of the mesiobuccal cusp of the maxillary 1st molar relative to the buccal groove of the mandibular 1st molar

Table II: Treatments* by Group

	Group 1 (n=27)			Group 2 (n=16)			Group 3 (n=55)		
	NE (n=14)	Ext (n=13)		NE (n=10)	Ext (n=6)		NE (n=35)	Ext (n=20)	
		Asym (5)	Sym (8)		Asym (4)	Sym (2)		Asym (16)	Sym (4)
Elastics	10	4	5	10	4	2	27	15	4
Headgear	4	0	2	3	1	2	7	3	1
Fixed Functional	2	0	1	2	0	0	5	0	1
Surgery	0	0	0	1	1	0	2	2	0

*Patient could be treated with more than one technique

Table III Final Characteristics

	Total Sample (n=98)		*Group* 1 *(n=27)*		Group 2 *(n=16)*		Group 3 *(n=55)*		
Variables	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*P*
Treatment time (months)	29.7	13.3	27.8	11.2	35.5	16.7	29.0	13.1	0.17
Maxilla to Mx incisors									
Mx1.NA (degrees)	24.2	7.0	23.2	5.1	26.5	6.7	24.1	7.8	0.34
Mx1-NA (mm)	5.3	2.2	5.1	1.8	5.8	1.7	5.2	2.6	0.60
Mandible to Mn Incisors									
Mn1.NB (degrees)	31.9	5.6	32.9	5.9	31.5	5.6	31.6	5.6	0.58
Mn1.NB (mm)	7.1	2.3	7.3	2.3	7.7	2.1	6.9	2.4	0.44
Mn1.MP (degrees)	102.3	7.4	102.7	7.8	100.4	6.0	102.6	7.6	0.55
Mx midline deviation									
from facial midline	0.2	0.6	0.2	0.5	0.6	0.7	0.2	0.5	0.07
Mn midline deviation									
from facial midline	0.7	0.9	0.3	0.6	0.2	0.4	1.0	1.0	0.0001
Final overjet	3.1	1.1	2.9	0.8	3.2	0.6	3.1	1.3	0.48
Final overbite	2.5	0.9	2.4	0.6	2.5	0.8	2.5	1.1	0.84
Final PAR score	6.9	5.5	6.4	5.4	6.0	5.3	7.4	5.7	0.61

Group 1 = Both Midlines On
Group 2 = Maxillary Midline Off
Group 3= Mandibular Midline Off

Table IV: Initial and Final PAR and Treatment Times

	GROUP 1 (n=27)					GROUP 2 (n=16)						GROUP 3 (n=55)						
	Ext *(13)*		*Non-Ext (14)*			Ext *(5)*		*Non-Ext (9)*		Surgery *(2)*		Ext *(18)*		*Non-Ext (33)*		Surgery *(4)*		
Variables	*mean*	*SD*	*mean*	*SD*	***P***	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*	***P***
Tx time (months)	31.3	12.5	25.3	10.0	*0.18*	32.0	8.5	29.3	12.1	68.8	9.1	32.0	9.6	25.0	9.0	50.4	29.1	*0.008* *
Initial PAR score	29.4	11.2	21.3	7.7	*0.026* *	32.6	10.6	27.4	9.8	16.3	12.4	32.5	9.9	26.6	8.6	39.0	13.5	*0.008**
Final PAR score	6.7	3.9	6.1	6.3	*0.74*	5.0	6.3	6.8	6.5	7.2	6.0	7.1	3.9	7.7	6.5	5.1	3.4	*0.48*

Group 1 = Both Midlines On
Group 2 = Maxillary Midline Off
Group 3= Mandibular Midline Off
* Significant difference between extraction vs.. non-extraction