2016

The effect of divergency on the transverse relationship

Werbitt, Jonathan Andrew

http://hdl.handle.net/2144/18307

Boston University
THE EFFECT OF DIVERGENCY ON THE TRANSVERSE RELATIONSHIP

by

JONATHAN WERBITT

D.M.D., Faculty of Dentistry, McGill University, 2013

Submitted in partial fulfillment of the requirements for the degree of

Master of Science in Dentistry
In the Department of Orthodontics

2016
APPROVED BY

First Reader: ..........................................................
Dr. Leslie A. Will, D.M.D., M.S.D.
Chair and Anthony A. Gianelly Professor
Department of Orthodontics and Dentofacial Orthopedics
Director of Graduate Orthodontics
Boston University Henry M. Goldman School of Dental Medicine

Second Reader ..........................................................
Dr. Matthew Miner, D.D.S.
Adjunct Clinical Professor,
Department of Orthodontics & Dentofacial Orthopedics,
Boston University Henry M. Goldman School of Dental Medicine

Third Reader ..........................................................
Dr. Melih Motro, D.D.S., PhD
Clinical Assistant Professor,
Department of Orthodontics & Dentofacial Orthopedics,
Boston University Henry M. Goldman School of Dental Medicine
ACKNOWLEDGEMENTS

I would like to dedicate this thesis to all the people who have helped me along the way in making this thesis possible.

I would like to thank my parents and my girlfriend who always believed in me, encouraged me, and cared for me. They had always put my needs before theirs and I cannot ever thank them enough.

I would like to thank Dr. Leslie Will for accepting me into the program, without her guidance, I would not be where I am today.

I would like to thank Dr. Paul Rigali, and Dr. John Walker for allowing me to use the data from their private orthodontic offices, and Dr. Cindy Christiansen for her statistical analysis.

I would also like to thank Dr. Matthew Miner, Dr. Melih Motro and the rest of my professors for mentoring me on this research project, for their guidance and help throughout the process was invaluable. They are truly like family to me.
THE EFFECT OF DIVERGENCY ON THE TRANSVERSE RELATIONSHIP

JONATHAN WERBITT

Boston University, Henry M. Goldman School of Dental Medicine, 2016

Major Professor: Will, Leslie A., Professor of Orthodontics and Dentofacial Orthopedics

ABSTRACT

Introduction: The aim of this study was to determine if there is a correlation between divergency, age, and the transverse width of the maxilla and mandible at the first molar level, as well as the angulation of the 1st molar teeth.

Materials and Methods: CBCT images of 94 patients between the ages of 12-62 were selected randomly and concurrently for this retrospective study. Patients were grouped into hypo-, normo- and hyperdivergent groups with Frankfort horizontal to the mandibular plane angle (FMA) <20.5, ≥22-≤28, >29.5 degrees respectively.

Results: The hypodivergent group’s maxilla was on average 1.6 mm wider than that of the hyperdivergent group (p ≤ 0.05). The inclination of the right first maxillary molar showed a R² value of 0.165 for age alone (p-value = 0.000023), while the inclination of the left first maxillary molar had a R² value of 0.136 (p-value = 0.003) for both divergency and age. The correlations between
hyperdivergent, normodivergent, and hypodivergent groups and the inclinations of the upper molars were $R^2 = 0.13, 0.19,$ and $-0.13$ respectively.

**Conclusions:** Our study agreed with the literature in that hyperdivergent patients have palatal widths that are narrower than in hypodivergent patients. We saw a positive correlation between age and molar angulations for all ages and divergences except in the left maxillary first molar of the hypodivergent patients where we saw a negative correlation.
### TABLE OF CONTENTS

ACKNOWLEDGEMENTS................................................................................................................................. iii

ABSTRACT ......................................................................................................................................................... iv

TABLE OF CONTENTS ........................................................................................................................................ vi

LIST OF TABLES................................................................................................................................................ vii

LIST OF FIGURES............................................................................................................................................. viii

REVIEW OF LITERATURE................................................................................................................................. 1

AIM AND OBJECTIVES...................................................................................................................................... 7

MATERIALS AND METHODS............................................................................................................................ 7

STATISTICAL ANALYSIS................................................................................................................................... 16

RESULTS............................................................................................................................................................. 17

DISCUSSION...................................................................................................................................................... 21

CONCLUSIONS.................................................................................................................................................. 23

BIBLIOGRAPHY.................................................................................................................................................. 25

CURRICULUM VITAE......................................................................................................................................... 32
LIST OF TABLES

Table 1: FMA for the three types of divergencies........................................9
Table 2. Subject demographics.................................................................10
Table 3. Number of Subjects by Sex and Age..............................................10
Table 4: Definitions of cephalometric points..............................................11
Table 5. Angular measurements across the different divergency groups........19
Table 6: Description of MaxL Values from figure 5.....................................20
LIST OF FIGURES

Figure 1. Cephalometric points to construct the Frankfort to mandibular plane angle (FMA)..................................................................................................................12

Figure 2: 5mm thick cut in Dolphin...........................................................................13

Figure 3. Dental and Skeletal Landmarks and Parameters as Defined by Miner, et al 2012........................................................................................................14

Figure 4. Transverse linear and angular analysis for molar axial inclinations and maxillomandibular S' width differential (mm).....................................................15

Figure 5: Regression analysis of the right and left maxillary first molar angulations taking into account divergency.................................................................20
A crossbite is defined as an abnormal buccal, labial, or lingual relationship of a tooth or teeth in one or both jaws when the teeth are in occlusion. It may include one or more teeth, and it may be unilateral or bilateral. Several cross-sectional and longitudinal studies have reported the frequency of posterior crossbites to be between 7 to 22 per cent of the population. Some possible etiologic factors in crossbites include prolonged retention of deciduous teeth, crowding, premature loss of deciduous teeth, palatal cleft (with or without cleft of the lip), thumb-sucking, and arch deficiencies.

Betts et al. stated that posterior crossbites do not confine themselves to dental dysplasias. They are in fact more often related to an underlying skeletal problem that can result from one of the following maxillomandibular combinations:

1. Narrow maxilla and normal mandible.
2. Normal maxilla and wide mandible.
3. Narrow maxilla and wide mandible

A posterior dental crossbite commonly signifies a disturbance in the transverse arch relationship. While the etiologic implications have been
discussed in several papers, the emphasis has previously been placed on the transverse discrepancy, overlooking the vertical component.\textsuperscript{7,12-15} This may be due to the fact the etiology of vertical growth is quite complicated. Severe vertical or horizontal growth of the facial skeleton can be attributed to the failure of normal, coordinated growth of the various regions of the craniofacial complex in terms of timing, magnitude, and direction.\textsuperscript{16} A review of the literature shows no consensus on what causes a decreased or increased vertical dimension.\textsuperscript{17-28}

Hyperdivergent subjects are characterized by having a larger lower vertical face height with excessive vertical height of the maxilla as compared to hypodivergent patients.\textsuperscript{28,29} This in contrast to Hapak and Fields in 1964 who observed normal upper facial proportions,\textsuperscript{25,30} and are also in contrast to those of Atherton, Muller, Nahoum, and Siriwat and Jarabak who all reported a relative deficiency in the vertical maxillary dimension in hyperdivergent patients.\textsuperscript{26,31-34}

The literature is also quite divided when one looks at posterior facial morphology. Bjork argues that the ramal height is excessive in hyperdivergent subjects,\textsuperscript{29} while Swinehart, Sassouni, Muller, Schudy, and Nanda all found a considerable deficiency in this dimension,\textsuperscript{17,18,22,24,31,35} and Fields and associates observed no differences in the posterior facial height among the hypo and hyperdivergent patients.\textsuperscript{30}
Forster, et al. were the first to take gender into account and found that male arch widths were significantly larger than those of females ($P < 0.05$).\textsuperscript{36} For both males and females, there was a trend that as the MP/SN angle increased, arch width decreased. The study concluded that dental arch width is associated with gender and facial vertical morphology.\textsuperscript{36}

In 2005, Wagner and Chung came to an interesting conclusion that helps to distinguish why some skeletal cross bites are not manifested as dental crossbites.\textsuperscript{37} While the growth of the maxilla plateaus at about 14 years of age, the skeletal width of the mandible continues to grow, at least in the low- and average-angle groups. Thus it is possible that as the mandible continues to increase in width, the mandibular molars compensate by inclining lingually and thereby maintaining the intermolar width. In fact, a number of authors\textsuperscript{28,38–40} have suggested that individuals with increased vertical dimensions have maxillary posterior teeth that tend to be more buccally inclined, whereas those with decreased vertical dimensions have maxillary posterior teeth that tend toward a more lingual inclination.\textsuperscript{28,36,38,39,41}

Musculature has always been considered to have a role in this close relationship between the transverse dimension and vertical facial morphology. In fact, a number of studies have illustrated the influence of masticatory muscles on craniofacial growth.\textsuperscript{42–49} The general consensus is that individuals with strong
masticatory musculature are often associated with a brachyfacial pattern.\textsuperscript{36} The muscular hyperfunction causes an increased mechanical loading of the jaws. This, in turn, may cause an induction of sutural growth and bone apposition, which then results in increased transverse growth of the jaws and bony bases.\textsuperscript{42–49} Thus it makes sense that the association between masseter muscle thickness and craniofacial width is reported to be positive.\textsuperscript{47,50} This is in agreement with the studies by Kiliaridis and Katsaros,\textsuperscript{51} who stated that the functional capacity of the masticatory muscles may be considered as one of the factors influencing the width of the maxillary dental arch.\textsuperscript{51} Thus hyperdivergent patients would be expected to have a maxillary arch that is more constricted. A narrower maxilla would lead to a tendency of lingual crossbite in high MP-SN angle cases. Isaacson et al. reported this in 1971. They concluded that the width of the palate through the molar area is increased as the MP/SN angle decreased.\textsuperscript{38}

Several studies investigating masseter thickness have also illustrated an effect on the inclination of posterior teeth such that subjects with short faces generally exhibit increased masseter muscle mass, which may result in posterior teeth that are more lingually inclined.\textsuperscript{42,43,45,47,52}

Increased muscle activity also has a role in cortical thickness. It was found that interradicular cortical bone 5 mm below the alveolar ridge is, at most sites,
thicker in hypodivergent than in hyperdivergent subjects.\textsuperscript{53} Patients with the hyperdivergent facial type tend to have less dense buccal cortical bone in the maxillary and mandibular alveolar processes than those patients with other facial types.\textsuperscript{54}

The inclination of the mandibular plane is a major determinant of the vertical dimension of a face (long, average, or short). A person with a steeper mandibular plane (larger MP-SN angle) often has a long anterior facial height, a smaller ratio of posterior to anterior facial height, and a short mandibular ramus height. Conversely, a person with a flat mandibular plane (smaller MP-SN angle) has a short anterior facial height, a larger ratio of posterior to anterior facial height, and a long mandibular ramus height.\textsuperscript{37} Wagner and Chung found that at age 6, children with high MPA angles had narrower maxillary and mandibular widths than their low angle peers. This trend continued until age 18. From ages 6 to 14, maxillary width showed a steady and similar rate of increase for all 3 groups (0.90-0.95 mm per year), yet a plateau was reached at age 14 for all groups. Mandibular width increased at a steady rate (about 1.6 mm/year) for all 3 groups until age 14, and a plateau was reached for the high-angle group. For the low- and average-angle groups, mandibular growth continued from ages 14 to 18 but at a slower rate (0.85 mm and 0.39 mm per year, respectively). Thus it was easy to suggest that vertical facial patterns (with low or high mandibular plane
angles) might play a strong role in the transverse growth of the maxilla and the mandible possibly resulting in a crossbite.\textsuperscript{37}

In 1982 Ricketts published \textit{Orthodontic Diagnosis and Planning} using the Rocky mountain data systems archive.\textsuperscript{55} He showed steady growth from ages 9 to 16. This data did not separate the males from the females. For the mandible, he found steady growth from ages 6 to 14 for all facial types. For the high-angle (MP/SN) group, there was no longer an increase in Ag-Ag. However, the average-angle and low-angle groups continued to increase in width until age 18. Snodell et al showed that girls’ mandibular growth measured from 6-6 and 7-7 continued until age 18.\textsuperscript{56} In contrast, Krogman, suggested that growth in the width of both jaws tends to be completed before the adolescent growth spurt and is affected minimally by adolescent growth changes.\textsuperscript{57} Growth in the width of the jaws is reported to finish the earliest, followed by sagittal growth and finally vertical development. An exception is in the posterior areas where the jaws grow wider as they grow in length in the posterior direction.\textsuperscript{58} In the maxilla this width primarily affects the second molar region and potentially third molars, if they erupt. For the mandible both the molar and bicuspid region widths show small increases in width up until the end of growth.\textsuperscript{59,60} Enlow stated that the postnatal growth of the human maxilla parallels that of the mandible, and that it is
suggested that the various remodeling movements of the growing maxilla contribute to the functional basis of drifting teeth.\textsuperscript{61}

The purpose of this study is to evaluate if there is a difference between mandibular and maxillary intermolar width and first molar angulation to the occlusal plane and their relationship to the patient’s divergency and age.

**AIM**

The aim of this study is to explore the relationship between vertical divergency and the dental and/or skeletal transverse relationships that may be present.

**OBJECTIVES**

The objective of this study is to determine if a correlation exists between the FMA angle, alveolar width and molar angulations using cone beam CT imaging.

**MATERIAL AND METHODS**

The cone beam CT scans of 1276 patients taken in centric relation at the time of initial orthodontic records at two private orthodontic offices were reviewed retrospectively. CBCT images of 94 patients between the ages of 12-62 were selected randomly and concurrently from Boston University’s repository.
The institutional review board of Boston University reviewed and approved the consent forms, study protocols, and affiliation agreements with the practices before data collection. Each patient had a 20-second CBCT scan performed on an i-CAT scanner (17cm (h) x 23cm (d)) (i-CAT Classic Imaging Sciences International, Hatfield, Pa) with a voxel size of 0.4 mm.

**Exclusion and Inclusion Criteria:**

Inclusion criteria were: (1) Having a full permanent dentition with the exception of third molars, (2) being between the ages of 12 to 62 years old, (3) having no significant medical problems, (4) having no previous orthodontic treatment, (5) Angle Cl I molar, defined as the maxillary mesiobuccal cusp being within 1.5mm of the mandibular buccal groove.

Patients with dentoalveolar clefts, patients with decayed or crowned teeth, and patients with craniofacial abnormalities were excluded.

**Patient Demographics:**

Using a desired statistical power level of 0.8 and a probability level of 0.05, the power analysis revealed that a minimum of 31 subjects per group were needed for a two-tailed hypothesis. We identified 94 patients by consecutively
selecting patients that fit our exclusion and inclusion criteria from a previously randomly assorted database. The final sample consisted of 31 study subjects with FMA <20.5, our hypodivergent group; 32 study subjects with FMA ≥22-≤28, our normodivergent group; and 31 study subjects with FMA >29.5, our hyperdivergent group. A 1.5 degree boundary area was set since there is variation in the literature on the SD surrounding the FMA mean of 25\textsuperscript{62,63}. Some sources say the SD is +/- 3 while others say it is +/- 4.5\textsuperscript{62,63}. Since there is a disagreement we made the SD +/- 3 and then eliminated any patients that lay within 1.5 degrees of the borders to minimize the possibility of a patient being misassigned due to measurement error. The mean FMAs for the hypodivergent, normodivergent, and hyperdivergent groups were distinctly separate at 16.08, 24.51 and 31.47 degrees, respectively. (See table 1) The subjects’ demographics can be seen in tables 2, and 3.

Table 1: FMA for the three types of divergencies

<table>
<thead>
<tr>
<th>Average</th>
<th>Hypodivergent</th>
<th>Normodivergent</th>
<th>Hyperdivergent</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMA</td>
<td>16.08 +/- 3.47</td>
<td>24.51 +/- 1.67</td>
<td>31.47 +/- 2.04</td>
</tr>
</tbody>
</table>
Table 2. Subject demographics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hypodivergent</th>
<th>Normodivergent</th>
<th>Hyperdivergent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>19F:12M</td>
<td>21F:11M</td>
<td>26F:5M</td>
</tr>
<tr>
<td>Mean Age (Yrs)</td>
<td>35.19 +/- 12.7</td>
<td>33.56 +/- 14.78</td>
<td>36.64 +/- 16.17</td>
</tr>
</tbody>
</table>

Table 3. Number of Subjects by Sex and Age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Hypodivergent</th>
<th>Normodivergent</th>
<th>Hyperdivergent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>13-25</td>
<td>2</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>26-38</td>
<td>7</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>39-51</td>
<td>2</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>52-64</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Cephalometric Analysis:

CBCT scans were imported into Dolphin Imaging Premium Version 11.5.04.36 (Dolphin Imaging Sciences, Chatsworth, California) in 3-D DICOM-3 file format. Lateral and posteroanterior cephalograms were generated in Dolphin using the full skull data with orthogonal projection (0% built-in magnification). The lateral cephalogram was constructed from a right side only.
cut to minimize any distortion caused by superimpositions of adjacent structures. The landmarks identified and measured on the constructed lateral cephalograms are described and defined in Table 4. From these points the mandibular plane angle (FMA) formed by the mandibular plane (Go-Me) and Frankfort horizontal (Po-Or) were constructed. (See Figure 1)

Table 4: Definitions of cephalometric points

<table>
<thead>
<tr>
<th>Landmark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonion</td>
<td>A point midway between the points representing the middle of the curvature at the left and right angles of the mandible</td>
</tr>
<tr>
<td>Menton</td>
<td>The lowest point on the symphysis of the mandible</td>
</tr>
<tr>
<td>Orbitale</td>
<td>A point midway between the lowest point on the inferior margin of the two orbits</td>
</tr>
<tr>
<td>Anatomical Porion</td>
<td>The midpoint of the upper contour of the external auditory canal</td>
</tr>
</tbody>
</table>
Coronal cross-sections 5-mm thick were obtained through the maxillary and mandibular first molar crowns on the posteroanterior cephalograms. Five-millimeter slices were used to visualize both the mesiobuccal and palatal roots of the maxillary molar, and so that both the maxillary and mandibular first molar could be visualized on the same section. If a thinner section was used, a portion of the maxillary root might appear and mislead the investigator as to the location of the furcation. (See figure 2)
Our transverse measurements were made using a technique developed by Miner et al. The palatal width was defined as the distance between points on the left and right palatal cortex of the maxilla at a vertical level halfway between the buccal root apex and the CEJ of the maxillary first molar. Lingual width was defined as the distance between points on left and right side of the lingual cortex of the mandible at a vertical level halfway between the CEJ and the apex of the mandibular first molar. Skeletal transverse discrepancy was defined as the maxillomandibular width difference (difference between palatal width and
lingual width). (See figure 3) Dental angulation measurements were made by creating a functional occlusal plane reference between the points of contact of the maxillary and mandibular molars and then drawing a line down the long axis of the tooth. For maxillary molars, the line was drawn between the deepest concavity between the buccal and palatal cusps and the furcation of the roots. For the mandibular molars, the line was drawn between the deepest concavity between the buccal and lingual cusps and the root apex. The angle formed was then recorded as molar angulation. (See figure 4)

Figure 3. Dental and Skeletal Landmarks and Parameters as Defined by Miner, et al. 2012

<table>
<thead>
<tr>
<th>Landmark or parameter</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long axis, maxillary molar</td>
<td>The line drawn between the deepest concavity between the buccal and palatal cusps and the furcation of the roots</td>
</tr>
<tr>
<td>Long axis, mandibular molar</td>
<td>The line drawn between the deepest concavity between the buccal and lingual cusps and the root apex</td>
</tr>
<tr>
<td>Functional occlusal plane</td>
<td>The line drawn between the points of contact between the maxillary and mandibular molars</td>
</tr>
<tr>
<td>Palatal S’ point</td>
<td>The point on the palatal cortex of the maxilla at a vertical level halfway between the buccal alveolar crest and the buccal root apex of the maxillary first molar</td>
</tr>
<tr>
<td>Lingual S’ point</td>
<td>The point on the lingual cortex of the mandible at a vertical level halfway between the buccal alveolar crest and the apex of the mandibular first molar</td>
</tr>
</tbody>
</table>
Figure 4. Transverse linear and angular analysis for molar axial inclinations and maxillomandibular width differential (mm)
STATISTICAL ANALYSIS

To measure operator error, 18 DICOM files were randomly selected using a random number generator (Randomness and Integrity Services Ltd, Dublin, Ireland) to be retraced by the same principal investigator (JW) two months after the first measurements. The intra-examiner reliability of the measurements was assessed using the Intraclass Correlation Coefficient.

Standard descriptive statistics, including means, and standard deviations, were calculated for each measurement. One-way ANOVA, post-hoc Tukey HSD tests, and linear regression analysis were used for statistical analysis to determine if any significant differences existed between the divergence groups in the above-mentioned measurements. A p-value less than 0.05 were deemed to be statistically significant. All statistical analysis were performed with Microsoft Office Excel (Version 2013; Microsoft)
RESULTS

The mean maxillary width of the hypodivergent group was found to be 1.6 mm wider than that of the hyperdivergent group. This was the only statistically significant result from our ANOVA with a p value = 0.05 (See table 5). We also found that the mandible in the hypodivergent group was on average 2.51 mm wider than that of the hyperdivergent group. However, the p value was only 0.06 for this comparison.

The regression analysis of the maxillary molar angles showed that the right maxillary first molar (MaxR) was related only to age and not divergency.

The regression equation was:

Predicted MaxR = 86.07 + age35*(0.17). Thus at age 35, the predicted MaxR is 86.07. This model resulted in a p value = 0.000023 and a $R^2 = 0.165$.

The angulation of the left maxillary first molar (MaxL), however, was related to age and divergency. The equations for the different divergency groups are below:

The equation for the hypodivergent group:

Predicted MaxL = 85.82 – 1.29 + age35*(0.19 – 0.31) = 84.53 – 0.12*age35.

Thus at age 35 the predicted MaxL is 84.53
The equation for the normodivergent group:

Predicted MaxL = 85.82 + age35*(0.19 ) = 85.82 + 0.19*age35

Thus at age 35 the predicted MaxL is 85.82

The equation for the hyperdivergent group:

Predicted MaxL = 85.82 + 0.22 + age35*(0.19 - 0.06) = 86.04 + 0.13 *age35

Thus at age 35 the predicted MaxL is 86.04

*Age 35 was used as the baseline. Essentially age 35 = 0. A subject that is age 18 would enter -17 for age since age 35-18 = 17 years difference, and 0-17 = -17.

Thus in summary for the left maxillary molars, when age and divergency are looked at together we saw a p-value = 0.003, and an R² value = 0.136. (See figure 5, and table 6)

The Intraclass Correlation Coefficient showed that intra-examiner agreement was reliable (Mean, 94.4%; Range, 91%-98%) for the angular and linear measurements chosen. Power analysis revealed that based on our sample size, the power of our study was confirmed at 0.8.
Table 5. Angular measurements across the different divergency groups

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>Hypo</th>
<th>Normo</th>
<th>Hyper</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MaxR (right maxillary molar angulation)</td>
<td>84.55</td>
<td>85.91</td>
<td>87.81</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>+/- 4.92</td>
<td>+/- 6.17</td>
<td>+/- 6.39</td>
<td></td>
</tr>
<tr>
<td>MaxL (left maxillary molar angulation)</td>
<td>84.51</td>
<td>85.54</td>
<td>86.25</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>+/- 5.06</td>
<td>+/- 5.75</td>
<td>+/- 5.39</td>
<td></td>
</tr>
<tr>
<td>ManR (right mandibular molar angulation)</td>
<td>97.94</td>
<td>98.27</td>
<td>96.00</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>+/- 5.37</td>
<td>+/- 4.45</td>
<td>+/- 5.18</td>
<td></td>
</tr>
<tr>
<td>ManL (left mandibular molar angulation)</td>
<td>101.84</td>
<td>101.88</td>
<td>99.78</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>+/- 7.42</td>
<td>+/- 7.73</td>
<td>+/- 7.39</td>
<td></td>
</tr>
<tr>
<td>Palatal Width</td>
<td>30.44</td>
<td>29.71</td>
<td>28.82</td>
<td>0.05*</td>
</tr>
<tr>
<td></td>
<td>+/- 2.79</td>
<td>+/- 2.80</td>
<td>+/- 2.25</td>
<td></td>
</tr>
<tr>
<td>Lingual Width</td>
<td>27.98</td>
<td>27.17</td>
<td>25.46</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>+/- 4.24</td>
<td>+/- 4.24</td>
<td>+/- 4.39</td>
<td></td>
</tr>
<tr>
<td>MM Difference</td>
<td>2.45</td>
<td>2.65</td>
<td>3.36</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>+/- 4.35</td>
<td>+/- 4.08</td>
<td>+/- 4.32</td>
<td></td>
</tr>
</tbody>
</table>

* statistically significant at p ≤ 0.05
Figure 5: Regression analysis of the left maxillary first molar angulation taking into account age and divergency.

Table 6: Description of MaxL Values from figure 5

<table>
<thead>
<tr>
<th>MaxL Value at age 35</th>
<th>Slope (one year change in age)</th>
<th>Standard error of slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypo = 84.53</td>
<td>~0.13</td>
<td>0.072</td>
</tr>
<tr>
<td>Normo = 85.82</td>
<td>0.19</td>
<td>0.061</td>
</tr>
<tr>
<td>Hyper = 86.04</td>
<td>0.13</td>
<td>0.057</td>
</tr>
</tbody>
</table>
DISCUSSION

The findings of this study confirm what was previously found by Isaacson et al. in 1971 that as the width of the palate through the molar area is increased the MP:SN angle decreased.\textsuperscript{38} We found that there was a mean difference of 1.6 mm between the palatal width of the hypodivergent group and the hyperdivergent group with a statistically significant p-value of 0.05. Wagner and Chung found that at age 6, children with high MPA angles had narrower maxillary and mandibular widths than their low angle peers.\textsuperscript{37} We found that there was a 2.51 mm mean difference in lingual width between the hypodivergent and hyperdivergent groups with a tendency towards statistically significance (p = 0.06).

However, what was most interesting in our study was that we found a correlation between age, divergency, and molar angulation in the maxilla. The angulation of the left maxillary first molars was significantly related with both age and divergency with an $R^2$ value of 0.136 ($p = 0.003$). In the hyperdivergent, normodivergent, and hypodivergent groups we saw correlations of 0.13, 0.19, and -0.13 respectively. We hypothesize that in the hyperdivergent and normodivergent groups, their left maxillary molars tilt lingually due to the stretched masseter muscle.\textsuperscript{38} On the contrary in the hypodivergent group the left maxillary molars possibly tip buccally to maintain occlusion with the wider
mandible. This $R^2$ value means that 13.6% of the variation in molar angulation can be attributed to age and divergency.

The angulation of the right maxillary molar was only mildly related to age with a correlation of 0.17 and a $R^2$ value of 0.165 ($p = 0.000023$). Their relationship with divergency was not statistically significant. This $R^2$ value means that 16.5% of the variation in molar angulation can be attributed to age alone. With $R^2$ values of 0.136 and 0.165 there are certainly other factors involved, however we can possibly predict a trend.

It can be hypothesized that a steep mandibular plane (which is really the essence of hyperdivergency) is heterogeneous and can occur with a variety of upper facial heights, thus taking into account the PFH/AFH ratio might have been a good idea as well.

One potential source of error was that molar angulations that appeared to be outliers were excluded. This is compared to Miner et al\textsuperscript{64} who defined a control group as first molars within 1 SD above or below the mean of the non-crossbite group.
CONCLUSIONS

Our study agreed with what has previously been published in the literature that hyperdivergent patients have palatal widths that are narrower than in hypodivergent patients. However, we did find an interesting trend in the maxillary first molars. We saw a positive correlation between age and molar angulations for all ages and divergences except in the left maxillary first molar of the hypodivergent patients where we saw a negative correlation. This finding suggests that as a patient ages, the maxillary molars reach an equilibrium with the wider hypodivergent mandibles. It is unclear why divergency was significantly related to molar angulation on the left side only. However, it would be valuable to continue the project and look into:

- Repeating the current methodology for Cl II, and Cl III malocclusions
- If using the PFH/AFH ratio as a measure of divergency may change the results
- Whether tongue size is a factor and how this might change with age
- Whether bite force plays a role
- The right vs left maxillary angulations in a larger sample size, which may clarify why we had asymmetrical findings.

Although further study is indicated, clinicians may want to change their treatment plans based on the patient’s age and sagittal skeletal divergency. For
example if we know that in a normodivergent patient the maxillary molars will
tend to tip lingually with age, we may want to slightly overexpand them during
treatment to compensate for this trend.
BIBLIOGRAPHY


17. Sassouni, V. *The face in five dimensions*. (West Virgina University Press).


55. Ricketts, R. M. *Orthodontic Diagnosis and Planning: -- Their Roles in Preventive and Rehabilitative Dentistry*. (Rocky Mountain/Orthodontics, 1982).


59. Proffit, W. R. *Contemporary Orthodontics*.


77. Uysal, T., Sisman, Y., Kurt, G. & Ramoglu, S. I. Condylar and ramal vertical asymmetry in unilateral and bilateral posterior crossbite patients and a normal


CURRICULUM VITAE

Jonathan Werbitt
353 Olivier Ave.
Westmount, Quebec
Canada H3Z 2C8

EDUCATION
MSD/CAGS from Boston University Department of Orthodontics and Dentofacial Orthopedics, Boston, Massachusetts   2013-Present

DMD from McGill University Faculty of Dentistry, Montreal, Quebec   2009-2013

B.Sc. from McGill University Faculty of Science, Montreal, Quebec
Major Biology with Minor in Environment
Graduated with Great Distinction

D.E.C Health Sciences, Dawson College, Montreal, Quebec   2004-2006

AWARDS/ACCREDITATIONS

Deans Athletic Honor List from Dawson College   2006

CPR certified   2009-Present

PUBLICATIONS

Collaborated with Dr. Hans Larsson (Canada Research Chair in Vertebrate Paleontology) on “The Evolution of Streptostyly.” A paper discussing the jaw joint functionality of Tyrannosaurus rex. Submitted for review in June 2009

TEACHING EXPERIENCE

Teaching assistant to Professor Dr. Louis Hermo in Anatomy 214 2008
“Systemic Human Anatomy” at McGill University.
Also graded student’s exams

WORKING EXPERIENCE

M&M Stables: Chief landscaper
2000-2013
Bodies: The Exposition: Docent  
2010

**VOLUNTEER EXPERIENCE**

Meals on Wheels: Delivering meals to shut-ins and people with disabilities  
2002-2004

McGill Dental Outreach program: Providing dental care to the underprivileged  
2009-2013

Montreal Children’s Hospital (Psychiatric ward)  
2004-2006

Fundraising Chair for McGill Dental Outreach dinner  
Raised $24,000 for the under privileged  
2011

Special Olympics Special Smiles  
2014

**AFFILIATIONS**

Class representative for McGill University chapter of Alpha Omega Dental Fraternity  
2009-2011

Vice President of McGill University chapter of Alpha Omega Dental Fraternity  
2012

Vice President of McGill University’s DMD Class of 2013  
2012-2013

ORT Young Leadership Committee  
2011-Present

**INTERESTS**

Golf: (Have maintained an 8 handicap since 2005)

Basketball, Rugby, Softball, Volleyball: (Have played competitively since high school)

**LANGUAGES**

English – Native language

French – Speak fluently and read/write with high proficiency