

**Assessing resident selection criteria and  
performance outcomes in an orthodontic  
residency – a retrospective study**

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## **Dedication**

I dedicate this publication to my wonderfully supportive and loving husband, Walter Menjivar, and to my family who has always encouraged and believed in me.

## **Abstract**

*Aims:* The purpose of this study was to assess the relationship between resident selection criteria and performance outcomes in an orthodontic residency.

*Methods:* A retrospective, cross-sectional review of applications and residency performance of thirty orthodontists who graduated from 2007 to 2011 was conducted. Subjective and objective resident selection criteria were compared with measurable outcomes of resident performance.

*Results:* Both undergraduate GPA and the quantitative Graduate Record Exam score were inversely associated with the orthodontic residency GPA. The National Board Dental Exam part I microbiology/pathology subscore was negatively associated with financial productivity from two years of patient treatment. Dental school class rank was positively associated with both the first year exam and faculty evaluation at the end of the program. Dental school GPA was positively associated with scores on the outcome case presentation but negatively associated with the mean change in faculty evaluations from the beginning to the end of the program.

*Conclusions:* While some significant associations may exist between objective resident selection criteria and orthodontic resident performance criteria, the predictive value of many of the subjective criteria (i.e. letters of recommendation, personal statements, etc.) was largely undetermined by our small sample.

*Key words:* Orthodontic Residency; Postgraduate admission; Selection criteria; Residency success; Performance Outcomes

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## **Introduction and Literature Review**

Admission to postgraduate dental specialty programs is highly competitive. The number of applications to orthodontic residency programs has soared to more than 10,600, an estimated increase of 8%, while first-year enrollment has remained constant at 355.<sup>1</sup> At the University of Minnesota, Division of Orthodontics, the number of applicants increased approximately 12% between 2005-2008 (Wendy Johnson, personal communication, December 2013). Upon joining the American Dental Education Association's Postdoctoral Application Support Service in 2013, the Division of Orthodontics experienced an 82% jump in the number of applicants compared with the previous year. All the while, the number of resident positions available each year has remained unchanged. With increasing competition, postgraduate dental programs tend to focus more heavily on academic achievements to screen applicants.<sup>2</sup>

Galang et al<sup>3</sup> surveyed postgraduate orthodontic program directors and found that the top three criteria used to evaluate orthodontic applicants include interview ratings, dental school class rank, and dental school clinical grades. Before interviews can be granted, however, the applicant pool is narrowed considerably with high importance placed on academic achievement.

To date, much of the research related to postgraduate dental admissions has focused on which criteria best predict *acceptance* into residency. The intent of this study is to expand past research to evaluate the significance of resident selection criteria on ultimate *performance* in a residency. After all, residency program directors and selection committees invest considerable resources – time, departmental funds, and labor – to

review hundreds of applications and interview top candidates. For instance, in 2012, the University of Minnesota, Division of Orthodontics, invested over thirty-two hours per residency position as part of its admission process (Admissions selection committee, personal communication, December 2012). Beyond attracting the most highly qualified applicants, it is in the best interest of the program to also select residents who are going to succeed in its particular program. This study seeks to identify factors which help predict successful performance in orthodontic residency, in particular, the orthodontic residency program at the University of Minnesota.

Much of the research on the relationship of admissions criteria to subsequent performance in residency has occurred in medicine, for example, in surgical, orthopedic, and anesthesiology residencies. A retrospective study of the Medical University of South Carolina surgical residency program found that medical school grade point average (GPA) and standardized board scores had a negative correlation with clinical performance in residency as measured by faculty ratings in core competency areas.<sup>4</sup> “The ‘best’ students do not always make the ‘best’ residents, and sometimes the ‘average’ students excel as residents”.<sup>5(p.1094)</sup> A study by Fine and Hayward<sup>6</sup> of University of Michigan internal medicine residents found no correlation between the National Board of Medical Examiners (NBME) Part I score and subsequent residency performance as measured by evaluations by attending physicians and a residency committee. In a retrospective study of obstetrics and gynecology residents, objective components of medical student applications such as the United States Medical Licensing

Exam (USMLE) score and grades on clinical rotations had no predictable influence on residency performance.<sup>7</sup>

Therefore, the current evidence which originates mostly from the medical literature, suggests limited association between the criteria used to select residents and resident performance outcomes. “Resident success is a complex outcome, and other unmeasured and unexamined characteristics can provide additional insight into choosing successful residents”.<sup>8(p.654)</sup> Though the comparison of objective data such as GPA, standardized exams, or class ranking would seem to create a level playing field among candidates, they do not necessarily provide selection committees with a complete profile to identify future high-performing residents. “The utility of these data as a means of identifying those medical students who will be successful residents is based on the unproven assumption that performance during medical school is a good predictor of performance during residency”.<sup>9(p.259)</sup>

While *success* in residency may be interpreted differently based on the program or the specialty, there are certainly many shared ideals of resident performance. Patient care, professionalism, knowledge, work ethic, communication skills, leadership, and teachability are presumably valued by medical and dental residencies alike. Apart from the objective criterion of knowledge, many of these attributes are challenging to measure or assess from an application or interview.

Almost certainly character, motivation, affective attitudes, and interpersonal skills have a very significant role in candidates’ success. Equally certain is that these aptitudes and abilities are not well reflected in the admission information as are the cognitive abilities. Although resident interviews are often meant to close the gap, they are hindered by the time commitment required and the differences among faculty in their ability to perceive nonacademic attributes.<sup>10(p.328)</sup>

Without standardized evaluation tools, i.e. rubrics, designed to guide the interview or to calibrate faculty interviewers, it can be difficult to consistently use the interview to make admissions decisions. The utility of the interview process to compare and contrast candidates can be drastically influenced by the mood or affect of the interviewer, the ability of the applicant to make a positively memorable first impression, and of course, each interviewer's personal and professional biases. In addition, faculty interviews provide only a glimpse or snapshot of the applicant. Due to the challenge of adequately assessing the non-cognitive attributes of applicants, more weight is often given to the objective, numerical indicators of achievement – grades, class rank, and board scores.<sup>10(p.328)</sup>

With a strong focus on objective achievement, specialty programs have relied heavily, if not erroneously, for many years, on the National Board Dental Examination (NBDE) to stratify competitive applicants. A major focus in postgraduate dental education is the admissions process and subsequent selection of exceptional candidates to enhance the dental profession. Despite the fact that the “National Board Exam results are not intended to compare individuals...or to show gradients of academic achievement or ability”<sup>11(p.1289)</sup>, the exam scores have continued to be used for such a purpose. In its 2011 newsletter, the Joint Commission on National Dental Examinations asserted that “there is no evidence that there is a significant difference between candidates who receive scores of 89, 90 or 91. The use of National Board scores for any purpose other than as part of the licensure process has not been validated”<sup>12(p.4)</sup>.

The conversion to pass-fail underscores the mission of the board exam and returns it to its fundamental purpose: to determine whether “the candidate has acquired the minimum theoretical knowledge and problem solving skills to practice safely”.<sup>13(p.3)</sup> The NBDE’s change to a pass-fail scoring system in January 2012 eliminates an objective measure traditionally used to screen applicants to orthodontic residency and other dental specialties. For those applicants from dental schools without grades or class ranks, the NBDE may have been the only objective indicator of academic achievement.

In light of the recent change of the NBDE scoring to pass-fail, review of the postgraduate dental admissions process to identify meaningful selection criteria is critical. To the author’s knowledge, there is no published study to date that has considered whether resident selection criteria used in postgraduate orthodontic admissions are predictive of a student’s performance in an orthodontic residency program. Based on previous studies in other fields, the interpretation of residency success in this study was determined by a combination of objective and subjective assessments. Most of these criteria were unique to the orthodontic residency program at the University of Minnesota but are also conceptually similar to assessments used in other residency programs.

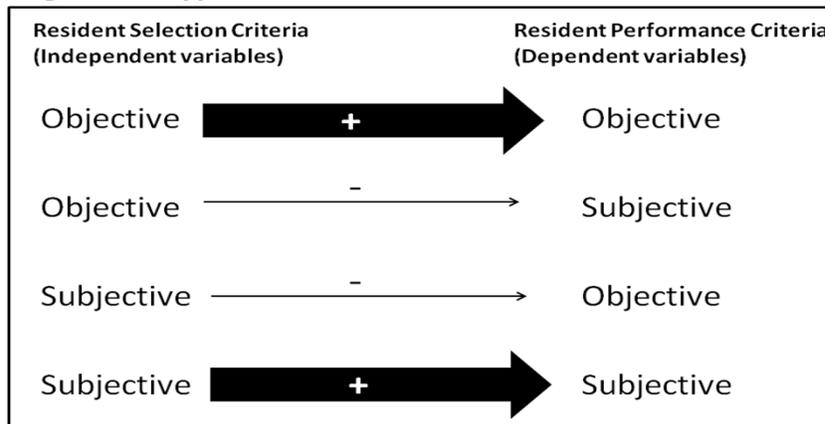
This study retrospectively reported on application data and residency performance outcomes for a limited group of orthodontic residents who graduated from the University of Minnesota, Division of Orthodontics, over a five year period. Its objective was to assess the relationship between objective and subjective resident selection criteria and measureable performance outcomes in an orthodontic residency. In order to achieve this

goal, a program-specific definition of successful performance in orthodontic residency, incorporating both objective and subjective outcomes, was created. In addition, evaluative rubrics to standardize the analysis of qualitative data were customized.

Specific hypotheses for this study (Figure 1) included the following:

1. Objective resident selection criteria (i.e. dental school GPA) are positively associated with objective measures of resident performance (i.e. orthodontic residency GPA).
2. Objective resident selection criteria are negatively associated with subjective measures of resident performance (i.e. faculty evaluations).
3. Subjective resident selection criteria (i.e. letters of recommendation) are negatively associated with objective measures of resident performance.
4. Subjective resident selection criteria are positively associated with subjective measures of resident performance.

**Figure 1. Hypotheses**



**Material and Methods**

Approval for the study was secured by the Institutional Review Board, Human Subjects Committee at the University of Minnesota (project number 1304E32025).

### *Study Design*

A retrospective study of applications and residency performance of thirty (N=30) orthodontic residents who graduated from the University of Minnesota, Division of Orthodontics, from 2007 to 2011 was performed. The applications for admission for thirty orthodontic residents were copied and made available to the investigator in a deidentified format. Additional documents in the residents' files used to assess performance in residency were also duplicated and deidentified. The residents from 2005 until 2011 (i.e. 5 graduating classes, 2007-2011) were given subject identification numbers, and their accompanying photocopied application and residency documents were similarly labeled. Data was entered into a password-protected Microsoft Excel (2007) file. A master list of residents' names linked with subject identifications was securely maintained by a staff member, not affiliated with the study.

A preliminary power analysis using data from a pilot group of an earlier graduating class (2006) estimated the sample size needed to achieve 80% power at 5%. The results estimated that a sample of thirty subjects would achieve 82.7% power while maintaining a type-1 error rate of 5%.

### *Admissions Process*

Late every summer, a new application cycle to orthodontic specialty programs begins. At the University of Minnesota, Division of Orthodontics, the task of reviewing applications is shared by members of an admissions selection committee, consisting of six full-time faculty. Each application is read by two members of the committee which meets to discuss all candidates once applications have been preliminarily reviewed. The

original applicant pool of over one-hundred is narrowed to approximately twenty-five candidates invited to interview in the fall. Following the interview process, members of the committee submit their own individualized rankings of the interviewees, the average of which is used to create a master ranking. Once again, the committee meets to debate the formal ordered ranking. The final rank order list is submitted to the postdoctoral dental matching program (the “Match”) which uses an algorithm to pair candidates with their preferred programs based on the rank order lists. This complex matching system is mutually beneficial for candidates and programs, allowing candidates to attend their most preferred programs while simultaneously matching programs with their top candidates.

*Resident Selection Criteria*

The independent variables in this study included many of components of the original application to orthodontic residency and were a compilation of objective and subjective admission criteria (Table 1).

<b>Table 1. Resident Selection Criteria</b>			
<b>(Independent variables)</b>			
<b>Objective</b>		<b>Subjective</b>	
GPA1	Undergraduate GPA	REC	Letters of recommendation
GPA2	Dental school GPA	PS	Personal statement
CL RANK	Dental school class rank	RANK	Match ranking
NBDE	National Board Dental Exam		
GRE	Graduate Record Exam		

The objective criteria included undergraduate and dental school grade point average (GPA1 and GPA2, respectively), dental school class rank (CL RANK), National

Board Dental Examination (NBDE) Part I score, and finally, the Graduate Record Examination (GRE). Subscores of the NBDE exam including Anatomic Sciences (NBDEa), Biochemistry/Physiology (NBDEb), Microbiology/Pathology (NBDEc), and Dental Anatomy and Occlusion (NBDEd) also considered. Verbal and quantitative sections of the GRE (GREv and GREq, respectively), were also evaluated.

As part of the application to orthodontic residency at the University of Minnesota, three letters of recommendation (REC) and a personal statement (PS) are required. For the purpose of this study, original rubrics were developed to rate both the letters of recommendation and personal statements retrospectively (Appendices A and B, respectively). The concept to design our own tool for analyzing the qualitative aspects of an application stemmed from interview evaluation forms created by the Medical University of South Carolina surgical residency program to assess reference letters and personal characteristics.<sup>4(p.379)</sup> Our letter of recommendation evaluation form assessed the following: applicant characteristics and contribution, originality, support for the applicant, relationship of recommender to applicant, and overall quality of the recommendation. The personal statement evaluation form included the following five equally-weighted categories: directions followed and presentation, quality of the writing, content, individuality, and specific interest in our program. Both evaluation forms utilized a visual analog scale (VAS) to mark the appropriate rating.

For consistency, one member of the research team (N.M.) read and rated all letters of recommendation and applicant personal statements. To test intrarater reliability, letters of recommendations and personal statements were rated a second time by the same

independent rater at least one month after the initial rating. In addition, letters of recommendation and personal statements were read separately from the remainder of the application so as not to introduce bias from other variables such as grades or test scores.

The final subjective criterion was the selection committee’s rank order list of applicants following their interviews (RANK). To rank interviewees, each faculty judged the written application and interview performance of candidates based on his/her own beliefs. The simple average of all faculty rankings resulted in a preliminary rank; faculty met to discuss and debate the final rank order list which was submitted to the Match program.

Additional descriptive characteristics of the sample were collected (Table 2). Resident demographic information including gender, age, ethnicity, date of application submission, and public versus private educational institutions were recorded. Marital status, dentist in the family, and work experience, including private practice or other residency experience, was noted when mentioned in the application.

<b>Table 2. Resident Characteristics</b> (Demographic variables)	
Age	Date of application submission
Gender	Public or private undergrad
Ethnicity	Public or private dental school
Marital status	Dentist in the family
	Work experience

### *Resident Performance*

The dependent variables in this study were the measurable factors of success during residency; they consisted of both objective and subjective criteria (Table 3).

<b>Table 3. Resident Performance Criteria</b> (Dependent variables)			
Objective		Subjective	
EX1	First year exam	PCP	Progress case presentation
GPA3	Ortho residency GPA	OCP	Outcome case presentation
ABOE	American Board Exam	EVAL	Faculty evaluations
FP	Financial productivity	FRANK	Faculty ranking
		FRANK-r	Faculty regrets

Objective factors included a written examination (EX1) taken by residents at the end of their first year to assess orthodontic knowledge acquired and critical thinking skills. Grade point average from the two year orthodontic residency (GPA3) and the American Board of Orthodontics standardized examination (ABOE), which is a component of board certification, were two more objective assessments. Finally, financial productivity (FP) represented the dollar amount generated by each resident for orthodontic services over two years.

The subjective factors describing performance in residency consisted of scores from orthodontic progress case presentations (PCP) and orthodontic outcome case presentations (OCP). These presentations are designed to evaluate residents' diagnostic and treatment planning skills, clinical progress, and the ability to finish a case meeting board certification criteria. Residents presented cases in mid-treatment (PCP) or cases

that had been completed (OCP), highlighting aspects such as diagnosis, treatment options, and overall knowledge of the case. Faculty who attended the PCPs or OCPs graded residents in multiple categories using a 3-point Likert, checking off unacceptable, acceptable, or outstanding based on the quality of the presentation (Appendices C and D, respectively).

Another subjective component of the resident performance criteria included bi-annual evaluations (EVAL) in which faculty used a visual analog scale to assess residents in five core areas (Appendix E). For each evaluation, full-time faculty rated residents on five competencies including preparation and performance in seminars, clinical skills, patient and time management, teaching effectiveness, and research progress. While the original faculty evaluations included an open response section for comments, we chose not to analyze this data.

Finally, four full-time and six part-time faculty from 2005-2011 were asked to provide a subjective ranking (FRANK) of past residents. According to Stohl et al, “faculty ranking of residents is the most commonly used method for assessing ‘success’”<sup>7(p.324)</sup> The faculty had significant interaction with the residents both in clinical and didactic settings and thus were able to use their own personal experiences to make subjective rankings of the residents by class. Through a secure and anonymous online survey (<http://www.surveymonkey.com>), the faculty were asked to provide a rank score from one through six for each class where one was the highest score for a resident and six was the lowest. To reduce the potential for recall bias, photos of residents were placed alongside their names. Similar to the studies of Daly et al and Gunderman and Jackson,

no set criteria were provided as guidelines in the faculty rankings.<sup>8(p.650), 18</sup>

Faculty evaluations of residents were completed every six months during the two-year residency program. During the period from 2005-2011, seven different faculty completed evaluations of residents. On average, between two and three evaluations were completed for each resident at each time period (T1-T4). The first and third evaluations (T1 and T3, respectively) were completed six months into each academic year. Significantly fewer evaluations were completed during T4. Due to the considerable amount of missing data, it was decided to take the mean of the faculty evaluations. Averaging across criteria, faculty evaluators, and time points created a one-dimensional variable for faculty evaluations (EVAL). Here we made the assumption that inter-rater reliability was strong enough. It was found that the data from T3 was the most complete so the mean of faculty evaluations from T3 was considered as a separate dependent variable (EVAL:T3). In addition, we were interested in measuring the significance of the change in faculty evaluation from T1 to T3 which created another variable (EVAL: T3-1).

In addition to ranking past residents, faculty were also asked how they felt about each resident's admittance to the program. Galang et al asked postgraduate program directors "Would you select all of your current and/or former residents from the last 5 years again?"<sup>3(p.827e.4)</sup> We designed a similar question using descriptive categories (Likert scale), permitting faculty to choose: strongly readmit, consider readmitting with hesitation, or regret admitting to describe how they felt about each resident's admittance to the program. This determination represented variable FRANK-r.

### *Statistics*

Several measures, both independent and dependent, were averaged together to simplify the overall analysis. For the resident selection criteria, the subscales for each recommendation and personal statement and personal statement were averaged together. As such, there is an overall rating for each recommendation (three total recommendations) and personal statement. The three recommendations were averaged together to assess the average quality of an applicant's recommendations. A similar approach was taken for faculty evaluations (EVAL), faculty rankings (FRANK), and progress/outcome presentations (PCP/OCP).

Averaging together multiple ratings to obtain a "composite" score is a simple idea that is easy to implement. However, it implicitly assumes that the missing data is missing completely at random. For example, if poor faculty evaluations were, on average, more likely to be missing, then the assumption of missing completely at random is violated. If this assumption, which cannot be tested, is violated, then the resulting analyses are biased.

Bland-Altman plots were constructed to show variability in repeated measurements. Simple linear regression models were used to estimate the relations between independent and dependent variables with the exception of the variable FRANK-r.

A generalized estimating equation (GEE)<sup>14</sup> was utilized to evaluate FRANK-r. In statistics, GEE is a method that accounts for the correlated nature of the outcome, which is robust against structure of the working correlation. In our case, we used exchangeable working correlation and investigated the effects of objective independent variables on

FRANK-r. A p-value value of less than 0.05 was considered statistically significant.

**Results**

Descriptive statistics for the thirty residents, including demographics, continuous variables, and performance characteristics are included in Tables 4, 5, and 6, respectively. Fifty-seven percent were men (n=17). The mean age of the orthodontic residents upon enrollment was 27 years (range: 24-43). Most residents attended public institutions for undergraduate (n=21) and dental school (n=22). Mean GPAs for undergraduate and dental school were 3.7 and 3.8, respectively. The sample mean for the NBDE part I score was 92 while the mean for the GRE was 1259 out of 1600. Class rank was listed as a percentile (1- (rank/# of students)).

**Table 4. Resident Demographics, 2005-2011**

Variable	Category	N	Percent
Gender	Male	17	57%
	Female	13	43%
Race	White	21	70%
	Asian	7	23%
	Black	2	7%
Undergrad	Public	21	70%
	Private	9	30%
Dental School	Public	22	76%
	Private	7	24%

**Table 5. Resident Continuous Characteristics, 2005-2011**

Variable	N	Mean	SD	Min	Max
Age	24	27	3.7	24	43
GPA1	30	3.7	0.26	3.0	4.0
GPA2	24	3.8	0.15	3.5	4.0
CL RANK*	23	0.92	0.07	0.76	0.99
NBDE	29	92	3.3	82	98
GRE	30	1259	117	950	1490
REC	30	9.9	0.56	8.8	11.0
PS	30	9.8	1.3	6.6	11.5
RANK	30	7.1	4.6	1.0	18.0

\*CL RANK, class rank listed as a percentile  
GPA1, Undergraduate grade point average; GPA2, Dental school grade point average;  
NBDE, National Board Dental Examination part I; GRE, Graduate Record Examination;  
REC, Letters of recommendation; PS, Personal statement; RANK, Match ranking

Personal statements and letters of recommendation were rated independently by one member of the research team (N.M.). The intraclass correlation coefficient is a commonly used measure of intra-rater reliability.

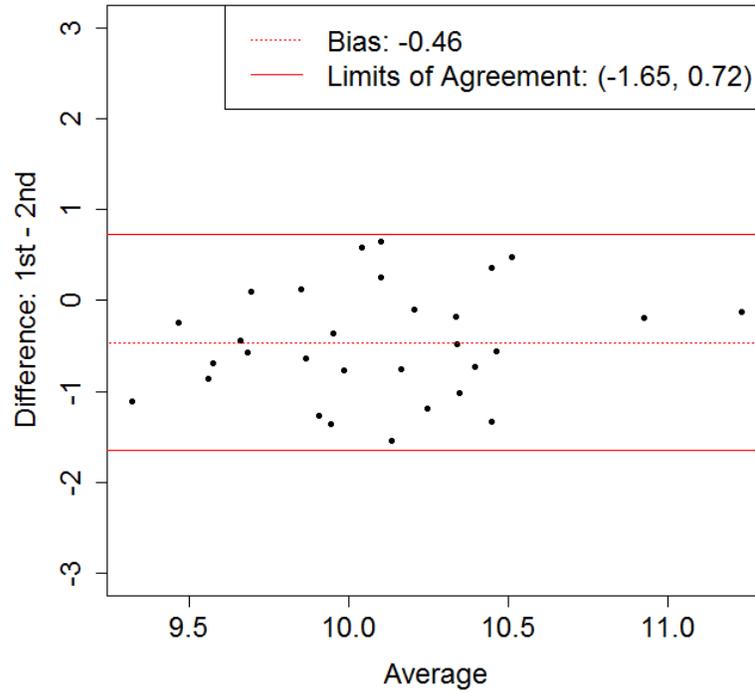
<b>Table 6. Resident Performance Characteristics, 2005-2011</b>					
<b>Variable</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>
EX1	18	0.88	0.04	0.79	0.95
GPA3	26	3.9	0.07	3.8	4.0
ABOE	18	6.7	0.33	6.1	7.5
FP (\$)	30	220,000	19,000	185,000	258,000
PCP	16	1.4	0.30	1.1	2.0
OCP	28	1.4	0.23	1.0	1.8
EVAL	24	8.9	0.87	7.1	9.9
FRANK	30	3.5	1.1	1.3	5.8

*EX1, First year exam; GPA3, orthodontic residency GPA; ABOE, American Board of Orthodontics exam; FP, Financial productivity (rounded to the nearest thousand); PCP, Progress case presentation; OCP, Outcome case presentation; EVAL, Faculty evaluation; FRANK, Faculty ranking*

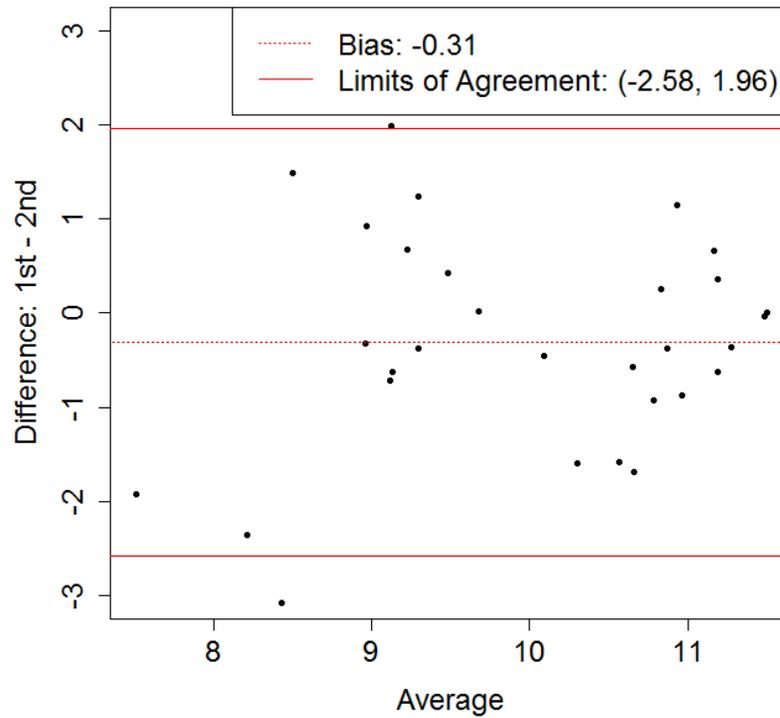
Intraclass correlation

coefficients (ICC) were 0.56 for the personal statement and 0.51 for the letters of recommendation. Intra-rater reliability for judging personal statements and letters of recommendation was interpreted as being low. Bland-Altman plots were also constructed to visually display the repeatability of test-retest data for letters of recommendation and personal statements (Figures 2 and 3 respectively). Solid red horizontal lines indicate the upper and lower 95% agreement limits while the dashed red line in the middle represents the bias, or average difference between first and second measurements. A bias of zero would indicate no difference between first and second measurements on average. In the case of rating letters of recommendation and personal statements, a negative bias represents a higher rating given on average during the retest. For Bland-Altman plots, 95% of the test-retest differences are expected to fall into the limits of agreement. As such, narrow limits of agreement suggest good within-rater reliability, while wide limits of agreement suggest poor within-rater reliability.

**Figure 2. Bland-Altman plot: Average of Recommendation Letters**



**Figure 3. Bland-Altman plot: Personal Statement**



*Hypothesis #1: Objective Resident Selection Criteria and Resident Performance*

Simple linear regression models were constructed to analyze the relationship between objective resident selection criteria and objective resident performance outcomes (Table 7). The first year exam (EX1), American Board of Orthodontics exam (ABOE), orthodontic residency grade point average (GPA3), and financial productivity (FP) were considered as the dependent variables. Financial productivity was normalized to reflect the values for 2009-2010 cost of comprehensive orthodontic treatment.

Shown below are the mean changes, confidence intervals, and p-values for the effects of objective resident selection criteria on EX1, ABOE, GPA3, and FP.

<b>Dependent</b>	<b>Independent</b>	<b>Mean Change</b>	<b>Confidence Interval</b>	<b>P value</b>
First year exam (EX1)	GPA1 (0.25)	0	(-0.01, 0.02)	0.723
	GPA2 (0.25)	0.03	(-0.01, 0.07)	0.125
	NBDE	0	(0, 0.01)	0.761
	NBDEa	0	(0, 0.01)	0.546
	NBDEb	0	(0, 0.01)	0.589
	NBDEc	0	(-0.01, 0.01)	0.907
	NBDEd	0	(0, 0.01)	0.363
	GRE (50)	-0.01	(-0.02, 0)	0.055
	GREq (25)	0	(-0.01, 0)	0.364
	GREv (25)	-0.01	(-0.01, 0)	0.08
	CL RANK (%) (0.05)	0.02	(0.01, 0.03)	0.008*
Orthodontic residency GPA (GPA3)	GPA1 (0.25)	-0.03	(-0.05, -0.01)	0.023*
	GPA2 (0.25)	-0.01	(-0.06, 0.04)	0.613
	NBDE	0	(-0.01, 0.01)	0.843
	NBDEa	0	(-0.01, 0)	0.666
	NBDEb	0	(-0.01, 0.01)	0.875
	NBDEc	0	(-0.01, 0)	0.666
	NBDEd	0	(-0.01, 0.01)	0.79
	GRE (50)	-0.01	(-0.02, 0)	0.092
	GREq (25)	-0.01	(-0.02, 0)	0.029*
	GREv (25)	0	(-0.01, 0.01)	0.68
	CL RANK (%) (0.05)	0	(-0.02, 0.03)	0.732
American Board of Orthodontics Exam (ABOE)	GPA1 (0.25)	0.02	(-0.19, 0.23)	0.883
	GPA2 (0.25)	0.13	(-0.24, 0.5)	0.502
	NBDE	0.02	(-0.02, 0.06)	0.452
	NBDEa	0	(-0.03, 0.03)	0.974

<b>Dependent</b>	<b>Independent</b>	<b>Mean Change</b>	<b>Confidence Interval</b>	<b>P value</b>
American Board of Orthodontics Exam (ABOE)	NBDEb	-0.01	(-0.04, 0.03)	0.731
	NBDEc	-0.01	(-0.04, 0.01)	0.286
	NBDEd	0.02	(-0.01, 0.05)	0.198
	GRE (50)	-0.01	(-0.07, 0.05)	0.798
	GREq (25)	0.02	(-0.04, 0.07)	0.551
	GREv (25)	-0.02	(-0.07, 0.02)	0.367
	CL RANK (%) (0.05)	0.1	(-0.07, 0.28)	0.268
Financial productivity (FP)	GPA1 (0.25)	162.52	(-5036.21, 5361.25)	0.952
	GPA2 (0.25)	-2843.54	(-13924.9, 8237.81)	0.62
	NBDE	-637.41	(-2245.14, 970.32)	0.444
	NBDEa	-665.29	(-1669.68, 339.1)	0.206
	NBDEb	-902.41	(-2108.64, 303.81)	0.155
	NBDEc	-1050.8	(-1992.35, -109.24)	0.038*
	NBDEd	-728.66	(-1956.05, 498.73)	0.255
	GRE (50)	1518.71	(-756.73, 3794.15)	0.201
	GREq (25)	619.88	(-1178.91, 2418.68)	0.505
	GREv (25)	1004.37	(-613.72, 2622.47)	0.234
	CL RANK (%) (0.05)	-2429.41	(-6662.91, 1804.08)	0.273

\*  $p < 0.05$

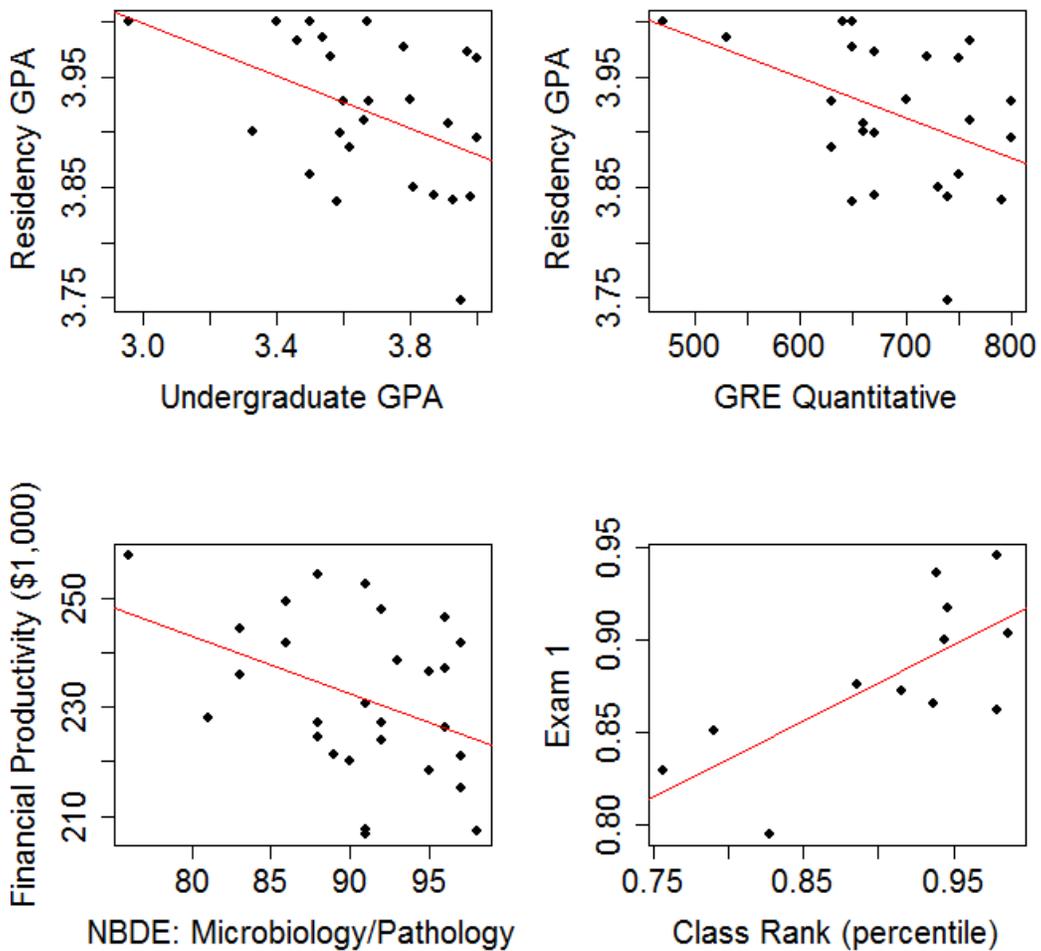
Parentheses ( ) reflect the scale of the independent variable.

GPA1, Undergraduate GPA; GPA2, Dental school GPA; NBDE, National Board Dental Exam; NBDEa, Anatomic Science; NBDEb, Biochemistry/Physiology; NBDEc, Microbiology/Pathology; NBDEd, Dental Anatomy and Occlusion; GRE, Graduate Record Exam; GREq, quantitative; GREv, verbal; CL RANK, Class Rank (as a percentile)

Significant *negative* associations were found between the resident selection criteria GPA1 and GREq and the dependent variable GPA3 (Figure 4). Therefore, the better the GPA in undergrad and the better the quantitative score on the GRE, the worse the GPA from the two year orthodontic residency. In addition, a statistically significant *negative* association was found between NBDEc and FP. This means that those who scored higher on the microbiology and pathology subsection of the NBDE did not produce as much revenue for the department. While it was estimated that there would be a positive association between objective resident selection criteria and objective resident performance criteria, this directionality did not occur in three out of the four significant

associations. The only significantly *positive* association was found between CL RANK and EX1. This demonstrated the tendency for those top students in dental school to continue performing well when taking the written examination at the end of their first year.

**Figure 4. Linear regression plots, Objective Resident Selection Criteria and Resident Performance**



*Hypothesis #2: Objective Resident Selection Criteria and Subjective Resident Performance*

Simple linear regression was used to analyze the relationship between objective resident selection criteria and subjective resident performance outcomes, namely the case presentations (PCP and OCP), faculty evaluations (EVAL), and faculty ranking (FRANK).

Table 8 shows the mean change, confidence intervals, and p-values for the simple linear regressions where the independent variables were objective resident selection criteria and the dependent variables were subjective resident performance criteria.

<b>Table 8. Simple Linear Regression Summary, Objective Resident Selection and Subjective Resident Performance Criteria</b>				
<b>Dependent</b>	<b>Independent</b>	<b>Mean Change</b>	<b>Confidence Interval</b>	<b>P value</b>
Progress Case Presentation (PCP)	GPA1 (0.25)	0	(-0.13, 0.13)	0.995
	GPA2 (0.25)	0.18	(-0.09, 0.45)	0.226
	NBDE	0.03	(-0.04, 0.09)	0.427
	NBDEa	0.01	(-0.03, 0.05)	0.679
	NBDEb	0.01	(-0.04, 0.06)	0.627
	NBDEc	0.02	(-0.03, 0.07)	0.438
	NBDEd	0.02	(-0.03, 0.07)	0.498
	GRE (50)	-0.01	(-0.07, 0.05)	0.74
	GREq (25)	-0.01	(-0.06, 0.03)	0.571
	GREv (25)	0	(-0.04, 0.05)	0.932
	CL RANK (%) (0.05)	0.03	(-0.07, 0.14)	0.542
Outcome Case Presentation (OCP)	GPA1 (0.25)	0.03	(-0.05, 0.12)	0.433
	GPA2 (0.25)	0.2	(0.04, 0.36)	0.024*
	NBDE	0.02	(-0.01, 0.04)	0.215
	NBDEa	0	(-0.02, 0.02)	0.898
	NBDEb	0.01	(-0.02, 0.03)	0.642
	NBDEc	0	(-0.02, 0.01)	0.771
	NBDEd	0.02	(0, 0.04)	0.099
	GRE (50)	-0.01	(-0.05, 0.03)	0.673
	GREq (25)	0.02	(-0.01, 0.05)	0.216
	GREv (25)	-0.02	(-0.05, 0)	0.094

**Table 8. Simple Linear Regression Summary, Objective Resident Selection and Subjective Resident Performance Criteria**  
(continued)

Dependent	Independent	Mean Change	Confidence Interval	P value
OCP	CL RANK (%) (0.05)	0.06	(-0.01, 0.13)	0.118
Faculty Evaluation (EVAL)	GPA1 (0.25)	-0.09	(-0.34, 0.16)	0.508
	GPA2 (0.25)	0.41	(-0.39, 1.2)	0.39
	NBDE	0.1	(-0.05, 0.25)	0.258
	NBDEa	0.09	(-0.04, 0.22)	0.254
	NBDEb	0.09	(-0.04, 0.22)	0.278
	NBDEc	0.1	(-0.01, 0.2)	0.166
	NBDEd	0	(-0.18, 0.17)	0.971
	GRE (50)	0.05	(-0.22, 0.33)	0.725
	GREq (25)	-0.05	(-0.15, 0.04)	0.329
	GREv (25)	0.07	(-0.02, 0.17)	0.175
	CL RANK (%) (0.05)	0.17	(-0.1, 0.44)	0.315
Faculty Evaluation time 3 (EVAL:T3)	GPA1 (0.25)	-0.16	(-0.46, 0.15)	0.319
	GPA2 (0.25)	0.25	(-0.35, 0.86)	0.421
	NBDE	-0.05	(-0.18, 0.08)	0.435
	NBDEa	-0.05	(-0.11, 0.02)	0.178
	NBDEb	-0.04	(-0.13, 0.04)	0.313
	NBDEc	-0.06	(-0.14, 0.02)	0.163
	NBDEd	0.04	(-0.06, 0.15)	0.462
	GRE (50)	-0.13	(-0.27, 0)	0.069
	GREq (25)	-0.05	(-0.15, 0.06)	0.378
	GREv (25)	-0.09	(-0.19, 0.01)	0.082
	CL RANK (%) (0.05)	0.24	(0.07, 0.41)	0.013*
Faculty Evaluation change time 1-3 (EVAL:T3-1)	GPA1 (0.25)	-0.05	(-0.25, 0.15)	0.634
	GPA2 (0.25)	-0.5	(-0.88, -0.12)	0.02*
	NBDE	-0.04	(-0.12, 0.04)	0.338
	NBDEa	-0.01	(-0.05, 0.03)	0.545
	NBDEb	-0.02	(-0.07, 0.03)	0.467
	NBDEc	0	(-0.05, 0.05)	0.915
	NBDEd	-0.01	(-0.07, 0.05)	0.703
	GRE (50)	-0.02	(-0.12, 0.08)	0.679
	GREq (25)	0	(-0.07, 0.07)	0.97
	GREv (25)	-0.02	(-0.09, 0.05)	0.52
	CL RANK (%) (0.05)	-0.04	(-0.22, 0.14)	0.671
Faculty Ranking (FRANK)	GPA1 (0.25)	-0.17	(-0.56, 0.23)	0.416
	GPA2 (0.25)	-0.47	(-1.25, 0.32)	0.26
	NBDE	0.04	(-0.09, 0.17)	0.56

**Table 8. Simple Linear Regression Summary, Objective Resident Selection and Subjective Resident Performance Criteria**  
(continued)

Dependent	Independent	Mean Change	Confidence Interval	P value
Faculty Ranking (FRANK)	NBDEa	-0.02	(-0.1, 0.06)	0.602
	NBDEb	-0.03	(-0.12, 0.07)	0.622
	NBDEc	0.04	(-0.04, 0.12)	0.393
	NBDEd	-0.01	(-0.11, 0.09)	0.862
	GRE (50)	0.12	(-0.06, 0.29)	0.204
	GREq (25)	0.04	(-0.1, 0.17)	0.606
	GREv (25)	0.09	(-0.04, 0.21)	0.185
	CL RANK (%) (0.05)	0.17	(-0.1, 0.44)	0.315

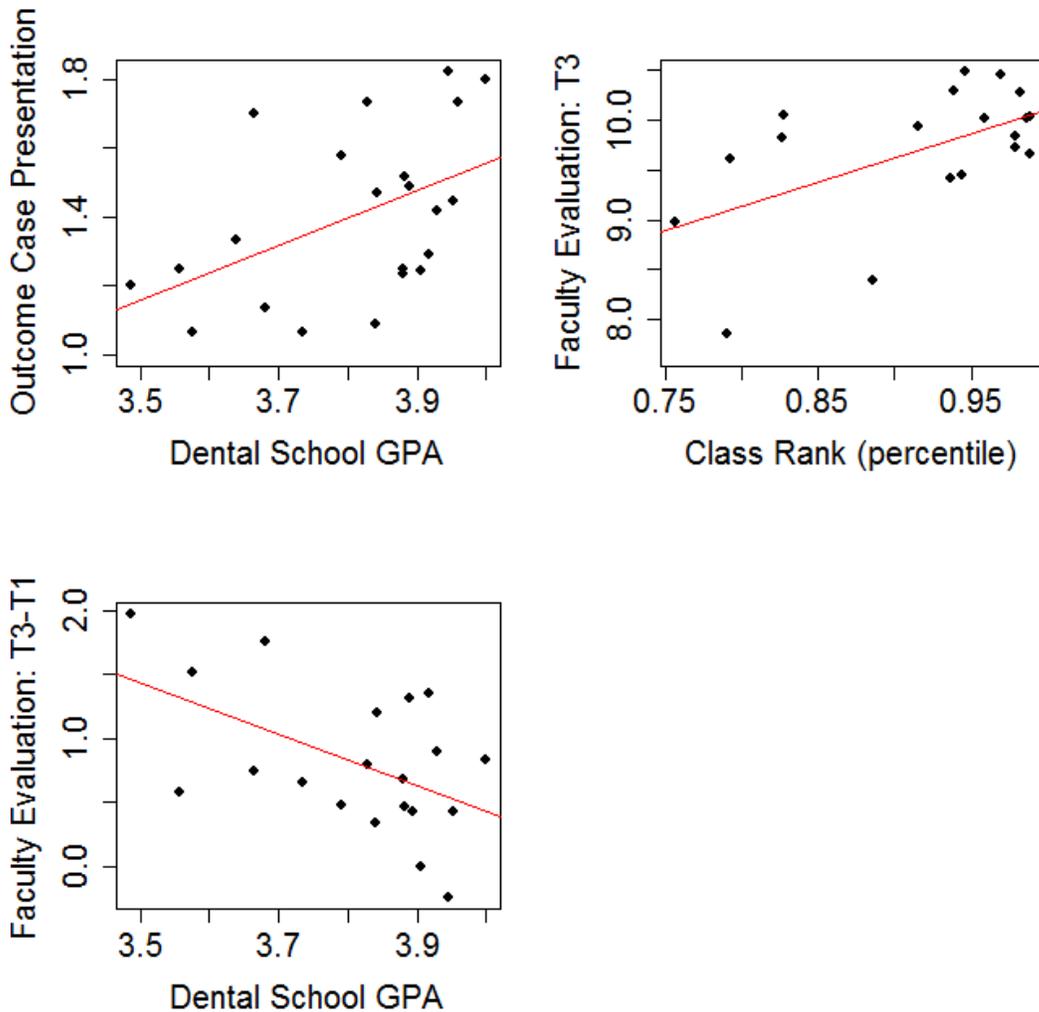
\*  $p < 0.05$

Parentheses ( ) reflect the scale of the independent variable.

GPA1, Undergraduate GPA; GPA2, Dental school GPA; NBDE, National Board Dental Exam; NBDEa, Anatomic Science; NBDEb, Biochemistry/Physiology; NBDEc, Microbiology/Pathology; NBDEd, Dental Anatomy and Occlusion; GRE, Graduate Record Exam; GREq, quantitative; GREv, verbal; CL RANK, Class Rank (as a percentile)

Dental school grade point average (GPA2) was found to be significantly *positively* correlated with OCP but *negatively* correlated with EVAL: T3-T1. Therefore, GPA in dental school was a positive predictor of a resident's ability to finish a case and demonstrate a thorough understanding of the treatment delivered. However, higher dental school GPAs were associated with a smaller mean increase in faculty evaluations from T1 to T3. Class rank (CL RANK) was significantly *positively* associated with EVAL: T3. Those students highly ranked in their dental school class tended to receive the best evaluations by orthodontic faculty in their second year. While the second hypothesis predicted a negative association between the objective resident selection criteria and subjective resident performance criteria, only one out of three significant associations was negative (Figure 5).

**Figure 5. Linear regression plots, Objective Resident Selection Criteria and Subjective Resident Performance**



The response rate for the anonymous online survey asking full-time and part-time faculty to rank past residents was 90% (n=9). In addition to having faculty rank past residents 1 through 6 by class, the faculty were also asked about regrets with regards to resident admittance. The faculty regrets question offered three categories: strongly readmit, consider readmitting with hesitation, and regret admitting. This data was transformed into a binary variable (FRANK-r) in which two different schemes were

considered: 1) strongly readmit versus the other two categories (FRANK-r1) and 2) other two categories versus regret admitting (FRANK-r2). Based on the belief that a resident who got a “strongly readmit” from one faculty was more likely to garner a similar conclusion from another faculty and similarly for “regret admitting”, we decided to use GEE to evaluate the variable FRANK-r. The results are summarized in Table 9 as odds ratios.

<b>Table 9. Summary of Odds Ratios for Faculty Regrets Variable and Objective Resident Selection Criteria</b>				
<b>Dependent</b>	<b>Independent</b>	<b>Odds Ratio</b>	<b>Confidence Interval</b>	<b>P-value</b>
FRANK-r1 (Strongly readmit vs. other 2 categories)	GPA1 (0.25)	1.16	(0.73, 1.47)	0.407
	GPA2 (0.25)	1.56	(0.53, 2.33)	0.238
	NBDE	0.97	(0.84, 1.11)	0.624
	NBDEa	1.03	(0.93, 1.15)	0.556
	NBDEb	1.03	(0.91, 1.17)	0.597
	NBDEc	0.99	(0.88, 1.11)	0.832
	NBDEd	1.04	(0.92, 1.16)	0.541
	GRE (50)	0.91	(0.74, 1.13)	0.395
	GREq (25)	0.98	(0.87, 1.1)	0.691
	GREv (25)	0.93	(0.81, 1.07)	0.329
	CL RANK (%) (0.05)	1.19	(0.89, 1.6)	0.233
FRANK-r2 (Other two categories vs. regret admitting)	GPA1 (0.25)	0.83	(0.49, 1.85)	0.589
	GPA2 (0.25)	1.77	(0.36, 3.66)	0.334
	NBDE	0.96	(0.79, 1.16)	0.679
	NBDEa	1	(0.87, 1.14)	0.982
	NBDEb	0.98	(0.82, 1.17)	0.82
	NBDEc	0.95	(0.82, 1.1)	0.494
	NBDEd	1.08	(0.94, 1.23)	0.273
	GRE (50)	0.83	(0.6, 1.16)	0.274
	GREq (25)	0.94	(0.78, 1.14)	0.54
	GREv (25)	0.88	(0.7, 1.09)	0.244
	CL RANK (%) (0.05)	1.41	(1.08, 1.83)	0.01*
* $p < 0.05$				
<i>Parentheses () reflect the scale of the independent variable.</i>				
<i>Odds ratio, OR &gt; 1 always indicates a positive outcome</i>				
<i>GPA1, Undergraduate GPA; GPA2, Dental school GPA; NBDE, National Board Dental Exam; NBDEa, Anatomic Science; NBDEb, Biochemistry/Physiology; NBDEc, Microbiology/Pathology; NBDEd, Dental Anatomy and Occlusion; GRE, Graduate Record Exam; GREq, quantitative; GREv, verbal; CL RANK, Class Rank (as a percentile)</i>				

As can be seen in Table 9, a significant association was found between CL RANK and FRANK-r2 suggesting that a higher class percentile is associated with higher odds of getting “readmit or consider readmitting with hesitation” from faculty.

*Hypothesis #3: Subjective Resident Selection Criteria and Objective Resident Performance*

A simple linear regression model was used to investigate the relationship between subjective resident selection criteria and objective resident performance criteria. Based on the results (Table 10), the association between subjective resident selection criteria and objective resident performance criteria was marginal. It was hypothesized that there would potentially be a small *negative* association between the subjective resident selection criteria and objective resident performance criteria, but this could not be determined.

<b>Table 10. Simple Linear Regression Summary, Subjective Resident Selection and Objective Resident Performance Criteria</b>				
<b>Dependent</b>	<b>Independent</b>	<b>Mean Increase</b>	<b>Confidence Interval</b>	<b>P value</b>
First year exam (EX1)	REC	0.01	(-0.03, 0.04)	0.716
	PS	-0.01	(-0.02, 0.01)	0.353
	RANK	0	(-0.01, 0)	0.217
Orthodontic residency GPA (GPA3)	REC	0	(-0.05, 0.05)	0.98
	PS	-0.01	(-0.03, 0.01)	0.531
	RANK	0	(-0.01, 0.01)	0.857
American Board of Orthodontics Exam (ABOE)	REC	0.03	(-0.27, 0.33)	0.868
	PS	0.02	(-0.08, 0.13)	0.698
	RANK	0.03	(-0.02, 0.08)	0.246
Financial productivity (FP)	REC	4255.19	(-5562.9, 14073.28)	0.403
	PS	2595.73	(-1500.6, 6692.05)	0.225
	RANK	306.19	(-908.48, 1520.87)	0.625

*REC, Letters of recommendation; PS, Personal statement; RANK, Match ranking*

*Hypothesis #4: Subjective Resident Selection Criteria and Resident Performance*

A combination of simple linear regression and GEE was used to analyze the relationship between subjective resident selection criteria and subjective resident performance outcomes. The hypothesis predicted there would be a strong *positive* relationship between the subjective independent and dependent criteria. There was no statistically significant relationship found between the independent and dependent variables in this hypothesis (Tables 11 and 12).

<b>Dependent</b>	<b>Independent</b>	<b>Mean Increase</b>	<b>Confidence Interval</b>	<b>P value</b>
Progress Case Presentation (PCP)	REC	0.08	(-0.21, 0.36)	0.609
	PS	-0.02	(-0.13, 0.09)	0.697
	RANK	0	(-0.03, 0.02)	0.781
Outcome Case Presentation (OCP)	REC	-0.07	(-0.22, 0.08)	0.388
	PS	0.04	(-0.02, 0.11)	0.203
	RANK	0	(-0.02, 0.02)	0.861
Faculty Evaluation (EVAL)	REC	0.51	(0.11, 0.91)	0.054
	PS	0	(-0.42, 0.43)	0.991
	RANK	-0.04	(-0.1, 0.01)	0.175
Faculty Evaluation time 3 (EVAL:T3)	REC	-0.17	(-0.78, 0.44)	0.594
	PS	-0.11	(-0.35, 0.12)	0.356
	RANK	-0.03	(-0.1, 0.03)	0.337
Faculty Evaluation change time 1-3 (EVAL:T3-1)	REC	-0.19	(-0.59, 0.21)	0.358
	PS	-0.05	(-0.21, 0.11)	0.541
	RANK	0.02	(-0.02, 0.07)	0.293
Faculty Ranking (FRANK)	REC	0.12	(-0.63, 0.87)	0.759
	PS	-0.24	(-0.55, 0.06)	0.129
	RANK	0.02	(-0.07, 0.12)	0.619

*REC, Letters of recommendation; PS, Personal statement; RANK, Match ranking*

<b>Table 12. Summary of Odds Ratios for Faculty Regrets Variable and Subjective Resident Selection Criteria</b>				
<b>Dependent</b>	<b>Independent</b>	<b>Odds Ratio</b>	<b>Confidence Interval</b>	<b>P value</b>
FRANK-r1	REC	0.97	(0.43, 2.18)	0.947
FRANK-r1	PS	1.19	(0.82, 1.71)	0.366
FRANK-r1	RANK	0.98	(0.89, 1.08)	0.67
FRANK-r2	REC	0.9	(0.23, 3.58)	0.882
FRANK-r2	PS	1.16	(0.79, 1.7)	0.446
FRANK-r2	RANK	0.97	(0.85, 1.11)	0.672
<i>Odds ratio, OR&gt;1 always indicates a positive outcome</i>				
<i>FRANK-r1, Strongly readmit and all else; FRANK-r2, Regret Admitting and all else; REC, Letters of recommendation; PS, Personal statement; RANK, Match ranking</i>				

## **Discussion**

This study found marginal associations between resident selection criteria and resident performance outcomes in an orthodontic residency. Statistical significance was demonstrated between eight unique pairs of objective resident selection criteria and objective/subjective resident performance outcomes. No statistically significant associations were identified which supported the third and fourth hypotheses involving subjective resident selection criteria.

Both undergraduate grade point average (GPA1) and the Graduate Record Exam quantitative score (GREq) were significantly *negatively* correlated with the orthodontic residency grade point average (GPA3). This was a surprising finding since many past studies have demonstrated the value of academic variables in predicting future cognitive success.<sup>4(p.382),6(p.837),15(p.593),16(p.529-530),17</sup> However, there have also been other studies which found no significant value between pre-residency academic variables and objective measures of residency performance.<sup>15(p.593),18</sup> Warrick and Crumrine<sup>15(p.593)</sup> found a significant negative correlation when they compared NBME Part I scores with the results of the Anesthesiology In-Training Examination taken by their residents. Although most

objective resident selection criteria were not positively associated with objective resident performance outcomes in this study, the findings could be understood in light of the fact that high achieving students have reached the peak of their education. Perhaps the incentive for maintaining the highest grades does not exist simply because there is no additional educational program which would require the residency GPA for admission. Finally, statistical significance is harder to reach with a small sample size which could have also been an explanation for unexpected results.

The microbiology/pathology subsection of the National Board Dental Exam (NBDEc) was also significantly negatively correlated with financial productivity (FP). According to Wood et al, “NBME scores...were intended to measure performance on content taught in medical school; they were never intended to be used to assess preparation for residency”.<sup>19(p.858)</sup> To the author’s knowledge, this is the only study of its kind to employ the variable financial productivity. While it could be argued that the dollar-amount generated by each resident is dependent on patient distribution and subsequent differing costs of treatment, the use of this variable assumes that cases and costs will be balanced across residents. Financial productivity, therefore, can be interpreted in this study as representing both clinical efficiency and effective time and patient management.

The only positive association to support the first hypothesis was the association between class rank (CL RANK) and the first year exam (EX1). Class rank in dental school was also significantly positively correlated with faculty evaluation in the second year (EVAL:T3). Although class rank was not significantly associated with subjective

faculty rankings (FRANK), a trend in increasing class rank percentile that parallels higher faculty rankings is evident in Table 13.

<b>Table 13. Investigating the Relationship between Faculty Ranking and Objective Resident Selection Criteria</b>						
<b>FRANK (1-6)</b>	<b>N</b>	<b>GPA1</b>	<b>GPA2</b>	<b>CL RANK</b>	<b>NBDE</b>	<b>GRE</b>
Rank ≤ 2	2	3.84	3.78	0.96	91.33	1275
2 < Rank ≤ 3	10	3.65	3.86	0.94	91.50	1240
3 < Rank ≤ 4	8	3.69	3.81	0.92	93.14	1232
4 < Rank ≤ 5	8	3.58	3.75	0.91	92.50	1265
5 < Rank ≤ 6	2	3.78	3.84	0.83	90.33	1425
<i>GPA1, Undergraduate GPA; GPA2, Dental school GPA; NBDE, National Board Dental Exam; GRE, Graduate Record Exam; CL RANK, Class rank (as a percentile)</i>						

The second hypothesis predicted an inverse relationship between the objective resident selection criteria and the subjective resident performance outcomes. The only significant negative association existed between the dental school GPA (GPA2) and the mean faculty evaluation change (EVAL:T3-1). This suggests that as dental school GPA increased, the mean change in faculty evaluations from T1-T3 decreased. Grade point average from dental school (GPA2) was significantly positively associated with the subjective resident performance variable OCP.

Also of interest is the fact that residents with the *highest* GRE scores, more than 150 points higher than the next GRE average, had the *lowest* average faculty rankings. Similarly, Carmichael et al<sup>16(p.532)</sup> found that orthopedic residents with the highest scores on the United States Medical Licensing Examination (USMLE) tended to be ranked 3<sup>rd</sup> by faculty out of a graduating class of four. In their study, an unexpected finding was that the residents selected by their faculty as the best residents in their class were the only ones to fail the American Board of Orthopedic Surgery Part I exam.

In a prospective study of radiology residents, Wood et al<sup>19(p.856)</sup> used an evaluation

form called a Behavioral Observation Scale (BOS) to assess behaviors considered by radiologists to be vital in residency for competent performance. The results showed negative correlations between the NBME and interpersonal skills and confidence measured by the BOS. Conversely, Dirschl et al<sup>20</sup> found no difference in faculty ratings of resident performance based on academic score. In their study, academic score was comprised of medical school grades, USMLE score, membership in the honor society Alpha Omega Alpha, number of publications and research projects, in addition to medical school notoriety.

The third hypothesis which predicted a negative relationship between subjective resident selection criteria and objective resident performance criteria was not supported by the data. Similarly, the fourth hypothesis was not supported by statistical evidence linking subjective resident selection criteria with subjective outcomes of resident performance.

Brothers et al<sup>4(p.382)</sup> found a significant positive relationship between reference letter evaluation scores and clinical performance of surgical residents. An original rubric was designed to rate reference letters in multiple categories such as technical skill of the applicant, quality of the medical school, work ethic, and honesty, among others. At the completion of each clinical rotation, residents were evaluated on core competencies by surgical faculty. Their study also found a positive correlation between the final rank list, similar to the RANK variable in our study, and clinical performance in residency. Furthermore, a study of residents in an obstetrics and gynecology program found a positive correlation between the National Resident Matching Program rank list percentile

and first year clinical performance evaluation score.<sup>21</sup>

This study did not find any significant associations involving the subjective resident selection criteria, a finding that is likely attributable to a small sample size and low intrarater reliability. Rather than conclude that letters of recommendation and personal statements are not important in resident selection, I would rather stress that a more robust study is needed to fully understand the impact of these variables on the selection and ultimate performance of orthodontic residents. Perhaps other programs have instituted rubrics to evaluate the subjective components of the residency application and interview. If the validity of these instruments could be tested and made available, then the process of postgraduate dental resident selection could be improved. With the elimination of the NBDE numerical score and prevalence of pass-fail dental curriculums, there is an even greater need to explore the significance of the subjective components of a candidate's application.

As of December 2012, twelve-percent of dental schools maintain a pass-fail curriculum where it has been suggested that the benefits of learning in a pass-fail environment outweigh the costs. Robbins et al<sup>22</sup> found that the absence of grades or class rank fosters collaboration and reduces unnecessary competition. A study by Rohe et al<sup>23</sup> showed that students in a pass-fail environment had less perceived stress and demonstrated increased group cohesion. Learning is perpetuated by one's intellectual drive and curiosity rather than being influenced by the external motivation of higher grades.<sup>24</sup> But for those students planning to pursue advanced training in a dental specialty, grades, class standing, and the NBDE are essential for admissions.

A survey of postgraduate orthodontic program directors found that the top five factors of importance included integrity, interpersonal communication skills, maturity, critical thinking skills, and assuming responsibility.<sup>25</sup> Apart from the interview, there has not been another way to assess these traits in the admission process until recently. In 2009, the Educational Testing Service (ETS), which administers a host of standardized exams such as the GRE, created a new tool called the personal potential index (PPI).<sup>26</sup> The American Dental Education Association implemented the PPI in 2013 into its postgraduate dental application. Now with this standardized tool that assesses personal attributes of applicants, there is another avenue for measuring an applicant's noncognitive abilities. The PPI has recommenders comment on six core areas including knowledge and creativity, resilience, communication skills, planning and organization, teamwork, and ethics and integrity. The ETS purports that the PPI can be used to make objective comparisons among candidates and predict their potential for success.<sup>27</sup> In the future, it would be very interesting to evaluate the predictive nature of the PPI in identifying successful residents in orthodontics.

### *Limitations*

Significant limitations of the study included a small sample size and a considerable amount of missing data. A small sample size could explain the statistical outcomes found in this study; in addition, the observational nature of the study was a major limitation. In addition, the sample could be described as a high-achieving homogenous sample. To have a greater possibility of achieving significance and increasing our confidence in the results, a larger sample size would be needed. Although a multi-program study would

increase the sample size, it would be very difficult to standardize since objective assessments and performance outcomes differ widely across residency programs. In addition, a program that has remained consistent with respect to leadership and program assessments would also be necessary to limit missing data. Some variables in our study had 40-50% missing data (i.e. EX1, ABOE, and PCP).

Since this was an observational, retrospective study with a small sample size, we were unable to adequately control for potential confounding effects. For faculty evaluations (EVAL) for example, we implicitly assumed that faculty members were similar between the years despite faculty turnover. Therefore, the faculty evaluation analysis was subject to potential, untestable bias. In addition, the faculty did not receive formal training to evaluate residents and clearly brought different biases and judgments to these evaluations. A handout of general guidelines describing the evaluation categories, however, was provided each faculty member at the time of evaluation (Appendix F).

Using multiple linear regression models could help control for potential confounders at the analysis stage. Admission to residency programs is holistic, and there are students who offset their deficiencies in one criterion (i.e. dental school GPA, letters of recommendation, etc.) by having good records on other criteria (i.e. NBDE scores, personal statement). Thus, one possible way to examine the effect of one admission criterion on residency performance would be to control for confounders using multiple linear regression models. This method was not used in this study due to the spread of missing data and low sample size.

With regards to the faculty rankings (FRANK), attempts were made to limit recall

bias by providing photos alongside resident names. No specific guidelines with respect to the basis for the ranking were provided. Instead, it was expected that faculty would have their own subjective criteria when ranking each resident. It was impossible, however, to control for experiences the faculty may have had with residents since their graduation. While all residents became orthodontic colleagues of the faculty, some even went on to become associates in their practices or join the department as part-time faculty. Had this been a prospective study, the ranking would have ideally occurred on or close to the time of graduation.

Due to study constraints, only one rater read, rated, and rerated all personal statements and letters of recommendation. The low intrarater reliability found in this study exemplifies the difficulty in attempting to measure qualitative data or even use it constructively to make an admissions decision. Even after blinding observers to applicant, author, and institution identity, Dirschl et al<sup>20(p.45)</sup> found an extremely low interobserver variability after faculty read and evaluated one-hundred seventy four letters of recommendation. It is suspected that the weak intrarater reliability could occur with any human rater, certainly members of an admissions committee. One might consider exploring the use of qualitative data analysis software to achieve exact and reproducible content analysis from letters of recommendation and personal statements.

## **Conclusions**

Despite program directors reporting a high level of satisfaction with the admissions process, there has been a, surprisingly, low percentage who would select all current and recent residents again.<sup>3(p.824),28</sup> This investigation serves as one of the only studies that

relates resident selection criteria to resident performance outcomes in an orthodontic residency. The study created a program-specific definition of success in residency which incorporated both objective and subjective outcomes and analyzed qualitative data using original, evaluative rubrics. This study was designed with the ultimate goal of enhancing current models of postgraduate orthodontic admissions as well as potentiating the development of standardized protocols for admission and resident evaluation. The research in the area of postgraduate orthodontic admissions is lacking, and more studies are needed to investigate the predictive value of selection criteria used to identify candidates who will become successful residents. Residency programs may choose to restructure their admissions process if future studies elucidate more reliable indicators of success than many of the selection criteria currently employed.

For the sample analyzed, the conclusions were as follows:

1. Undergraduate GPA: the undergraduate GPA was negatively associated with the average GPA in the orthodontic residency program
2. Dental school GPA: an increasing dental school GPA was positively associated with the average outcome case presentation. An increase in dental school GPA, however, was also associated with having a lower average faculty evaluation in the second year as compared with ratings from the first evaluation.
3. GREq: the higher the quantitative score on the GRE, the lower the average GPA in the orthodontic residency program
4. NBDEc: the higher the microbiology/pathology subscore of the National Board Dental Exam part I, the less revenue generated by the orthodontic resident from

their two years of patient treatment

5. Class rank: the higher the class ranking in dental school, the higher the average performance on the first year written exam; top ranked students also were more likely to have higher average faculty evaluations in the second year; finally, top ranked students had higher odds of not having faculty regret admitting them.

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**Appendix A**

**Letter of Recommendation Evaluation Form**

Please evaluate letter of recommendation as objectively as possible by making an appropriate mark on the scales below.

**1. Applicant characteristics & contribution**

Very little mention of positive characteristics; does not suggest that applicant will contribute to program or orthodontic profession



Letter exemplifies applicant's work ethic, honesty/integrity, communication, leadership skills, etc.; will be an asset to residency program

**2. Originality**

Generic letter that could be used for any applicant; based only on applicant's CV



Content is specific and tailored to applicant; gives insight into applicant's strengths

**3. Support for applicant**

Recommender displays some reservations about applicant



Recommender gives highest commendations and praise for applicant

**4. Relationship to applicant**

Limited interaction with applicant; clear that recommender does not "know" applicant well



Long-term relationship, many opportunities to observe and engage applicant

**5. Overall quality of recommendation**

Poorly written letter



Extremely well-written letter of support

## **Appendix B**

### **Personal Statement Evaluation Form**

#### **Guidelines to applicant:**

What are your immediate and long-range professional goals?

Why have you chosen to apply to this orthodontic specialty program?

Please limit statement to one page.

Please evaluate personal statement as objectively as possible by making an appropriate mark on the scales below.

#### **1. Directions followed & Presentation**

Statement does not address questions; is not limited to one page; is handwritten, font or margins too small or too large; evidence of having written this as a first draft



Statement answers the questions and is limited to one page; typed page is neat with ideal margins, font

#### **2. Quality of writing**

Grammatical errors, misspellings, typos, one block prose



Grammatically sound, crisp writing; paragraph rules followed

#### **3. Content**

Vague, abstract or generic; superfluous or "filler" information



Pertinent, focused with meaningful personal information; specific details, direct language

#### **4. Individuality**

Boring, insipid examples, statement lacks a voice, easily forgettable



Memorable, colorful, refreshing; statement has personality with descriptive examples

#### **5. Specific interest in our program**

Generic statement could be submitted to any program



Applicant has demonstrated interest in and knowledge of the program, highlights reasons for why Minnesota

**Appendix C**

**University of Minnesota Progress Case Presentation Evaluation Form**

Resident Name: \_\_\_\_\_

Date: \_\_\_\_\_

**Presentation**

Please evaluate the resident's case presentation by circling one of the assessments (Unacceptable, Acceptable, Outstanding) for each category below. Four or more "Unacceptable" ratings within one evaluation form will require the student to repeat their presentation, at another scheduled time, until an "Acceptable" grade is obtained.

# of cases presented:   4  

**1. Quality of Diagnostic Records:**

Quality of models, photographs, radiographs. Completeness of records presented to outline case.

Unacceptable

Acceptable

Outstanding

**2. Organization and Sequence of Presentation:**

Logical sequence presented. Presented appropriate case assessments e.g. conclusions, superimpositions, profile changes, incisor/anchorage changes, surgical change etc.

Unacceptable

Acceptable

Outstanding

**3. Familiarity with Case:**

Understanding of case events. Preparedness and attitude toward case presentation.

Unacceptable

Acceptable

Outstanding

**4. Quality of Discussion and Responses to Questions:**

Ability to understand and respond appropriately to questions.

Unacceptable

Acceptable

Outstanding

**5. Followed instructions:**

On time, set up equipment, use of records, presented correct number of cases.

Unacceptable

Acceptable

Outstanding

**6. Overall Case Progress:**

Unacceptable

Acceptable

Outstanding

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**7. Total each category:**

       Unacceptable

       Acceptable

       Outstanding

**Appendix D**

**University of Minnesota: Outcome Case Presentation Evaluation Form**

Resident Name: \_\_\_\_\_

Date: \_\_\_\_\_

**A. Case Assessment**

**1. Objective Scores:**

Case #	D.I. initial case	ABO final score
1.		
2.		
3.		

**2. Subjective Overall Case Results:**

Unacceptable

Acceptable

Outstanding

**B. Presentation**

Please evaluate the resident case presentation by circling (Unacceptable, Acceptable, Outstanding) for each category. Two or more “Unacceptable” ratings within one evaluation form will require the student to repeat their presentation, at another scheduled time, until an “Acceptable” grade is obtained.

**1. Quality of Diagnostic Records:**

Quality of models, photographs, radiographs. Completeness of records.

Unacceptable

Acceptable

Outstanding

**2. Organization and Sequence of Presentation:**

Logical sequence presented. Articulation and flow.

Unacceptable

Acceptable

Outstanding

**3. Familiarity with Case:**

Understanding of case events. Preparation and attitude toward case presentation.

Unacceptable

Acceptable

Outstanding

**4. Quality of Discussion and Responses to Questions:**

Ability to understand and respond appropriately to questions.

Unacceptable

Acceptable

Outstanding

**5. Followed instructions:**

On time, set up of equipment, completed DI and ABO scores, presented superimpositions.

Unacceptable

Acceptable

Outstanding

**6. Summary:** Please indicate the total # in each category:

\_\_\_\_ Unacceptable

\_\_\_\_ Acceptable

\_\_\_\_ Outstanding

**Appendix E**

**Semi-Annual Resident Evaluation Form (By Faculty)**

Faculty: \_\_\_\_\_

Resident Name: \_\_\_\_\_

Date of Evaluation: \_\_\_\_\_

Please evaluate resident performance as objectively as possible by making an appropriate mark on the scales below. Your ratings will be compiled with other faculty ratings and reviewed with the resident during their individual conference.

**1. Preparation and Performance in Seminars**

Poorly prepared and rarely participates ●—————● Always prepared Participates willingly

**2. Clinical Skills**

Unable to complete most clinical procedures without help ●—————● Consistently able to complete clinical procedures without assistance

**3. Patient and Time Management**

Does not communicate well with patients and parents, frequently behind schedule ●—————● Communicates well with patients and parents, good time manager

**4. Teaching Effectiveness**

Demonstrates little preparation or enthusiasm for teaching duties ●—————● Is prepared and enthusiastic about teaching duties

**5. Research Progress**

No progress towards research completion ●—————● Well ahead of expected research progress

## **Appendix F**

### **Resident Evaluation Criteria**

#### **Preparation and Performance in Seminar**

- a. Consistently on time for seminars
- b. Consistently comes to seminars well prepared with obvious understanding of preparatory material
- c. Voluntarily contributes in a meaningful way to the seminar discussion
- d. When serving as a seminar presenter, spends appropriate time in preparation and provides a meaningful seminar for all those participating

#### **Clinical Skills**

- a. Makes diagnosis and treatment planning decisions consistent with current stage of training
- b. Assures proper oversight of clinical cases by the attending faculty
- c. Provides proper oversight of delegated tasks
- d. Makes arch wire changes at appropriate time with proper arch form, offsets, and coordination
- e. Makes appropriate arch wire adjustments to achieve the desired tooth movements
- f. Documents treatment comprehensively in the record, including expectations for the next appointment

#### **Patient and Time Management**

- a. Has a "patient comes first" attitude
- b. Discusses treatment procedures fully with patient and/or parent
- c. Manages clinical time well with a global view of clinic operation
- d. Routinely is on time with clinic schedule
- e. Schedules appropriate time for procedures
- f. Delegates appropriately for stage of training

#### **Teaching Effectiveness**

- a. Is prepared for teaching duties
- b. Is enthusiastic when acting in the teaching role
- c. Presents a positive role model for students

#### **Research Progress**

- a. Has met target research schedule
- b. Has shown diligence in solving problems and creating solutions relative to the research problem
- c. Consistently dedicates at least 1 day per week to research activities

#### **Progress towards Goals**

- a. Has made consistent effort to meet the goals set at last review
- b. Has accomplished the majority of the goals