

KNOWLEDGE OF DENTAL STUDENTS WITH RESPECT TO ORTHODONTIC  
DIAGNOSIS AND CLEAR ALIGNER THERAPY

A THESIS IN  
Oral and Craniofacial Sciences

Presented to the Faculty of the University  
of Missouri-Kansas City in partial fulfillment of  
the requirements for the degree

MASTER OF SCIENCE

by  
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2016



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ABSTRACT

The purpose of this project was to investigate how prepared dental students are to diagnose orthodontic problems and provide clear aligner therapy, and whether or not certain demographic characteristics could predict an effect on aligner knowledge or orthodontic knowledge. An IRB-approved 16-item survey was constructed and administered to 163 third and fourth year dental students at UMKC to test if demographics including school year, future practice plans, interest in orthodontics, desire to provide clear aligner therapy, and confidence to provide clear aligner therapy are associated with aligner knowledge and orthodontic knowledge. The survey was introduced to the dental students via an IRB-approved verbal script during a class, and then the students anonymously filled out the surveys. The survey questions were divided into 3 domains. The first 6 questions made up the first domain and assessed demographic information of the students. The next 4 questions investigated aligner knowledge and were grouped together in the second domain to give each student a score for their aligner knowledge. The last 6 questions were grouped together in the third domain to do the same for orthodontic knowledge. Student demographics were then used to evaluate whether or not there was an effect on students' aligner knowledge or orthodontic knowledge. Because there was no significant difference in the aligner knowledge or orthodontic knowledge between the D3 and D4 classes, it was

decided to run all evaluations to include both classes to increase the sample size. Across D3 and D4 classes, students planning to specialize in orthodontics had a significantly higher ( $p < 0.05$ ) orthodontic knowledge compared to students planning to enter general practice. Aligner knowledge was significantly higher ( $p < 0.05$ ) among students planning to refer all orthodontic cases to a specialist. Confidence to treat patients with clear aligners had no bearing on aligner knowledge and orthodontic knowledge. There was no correlation found between aligner knowledge and orthodontic knowledge.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the School of Dentistry, have examined a thesis titled “Knowledge of Dental Students with Respect to Orthodontic Diagnosis and Clear Aligner Therapy,” presented by Steven Shaw, candidate for the Master of Science degree, and certify that in their opinion it is worthy of acceptance.

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## ACKNOWLEDGEMENTS

I would like to express my sincere appreciation and special thanks to:

Dr. Mary Walker, for her guidance, encouragement, and expertise.

Dr. Laura Iwasaki, for her input and support through this process.

Dr. Lynn Friesen, for her knowledge and input.

Dr. Ying Liu, for her statistical knowledge and input.

Erin Liljequist, for her organization and support.

My wife Robin; my children Adam, Austin, and Cardon; and my parents Paul and Julie; for their love and support throughout my education. I could not have reached this point without them.

## CHAPTER 1

### INTRODUCTION

#### **Orthodontics Overview**

Crowded, irregular, and protruding teeth have been a problem for some individuals since antiquity, and attempts to correct this disorder go back at least to 1000 BC (Wahl 2005). Primitive orthodontic appliances have been found in both Greek and Etruscan materials (Corruccini and Pacciani 1989). Today there are a myriad of appliances available for orthodontic therapy and there continues to be innovation in this field. According to the American Association of Orthodontists, orthodontics and dentofacial orthopedics is defined as the area of dentistry which includes the diagnosis, prevention, interception, guidance and correction of malrelationships of the developing or mature orofacial structures (AAO 2012). The goals of orthodontic therapy are to improve the smile and facial appearance (resulting in improvement in an individual's social well-being and quality of life), obtain optimal occlusion, and establish normal oral function (Ackerman 2012).

A majority of orthodontic treatment has traditionally been performed by the orthodontic specialist. However, patients may be treated orthodontically by any licensed dentist. General dentists are often the first dental professionals to determine the orthodontic needs of patients. They have the option to provide orthodontic treatment as long as they can provide care that meets the standard of care provided by orthodontic specialists. Less complex cases may be treated in the general dental office, if clinicians have sufficient training, while the more complex cases should be referred to an orthodontic specialist (Proffit 2013a). If the general dentist feels that his or her clinical skill set is inadequate to treat a certain case or that he or she does not have the room in their practice to do so, they may refer the patient to an orthodontist for treatment.

In the modern era there are a variety of methods available to treat patients orthodontically. Ideally, appliance design is based on effectiveness to meet goals for changing jaw and/or tooth positions. Other factors include patient compliance, craniofacial anatomy, as well as the skills and experience of the operator. For example, a rapid palatal expander can be chosen to increase the transverse dimension of the dentition and its supporting bone when necessary and desirable (Wertz 1970). Functional appliances such as the herbst can be used to posture the mandible forward in an effort to correct the dentition of a growing class II patient with a deficient mandible (Pancherz 1997). There are a myriad of other appliances that a clinician may choose for a specific patient. Ideal appliance selection is dependent on a correct diagnosis of the orthodontic problems, which will in turn lead to ideal outcomes.

### **Clear Aligner Therapy Overview**

One appliance system that has become more widely used in recent years is the clear aligner system (Christensen 2002). Clear aligners were conceptualized as early as 1945 by Dr. H.D. Kesling. He described the use of a flexible tooth positioning appliance as an alternative method to conventional brackets, bands, and wires to treat a case orthodontically. He proposed this method mostly for the final positioning and retention of the teeth after basic treatment had been accomplished and it was intended to be used in conjunction with other appliances (Kesling 1945).

Recently this type of therapy has been combined with modern technology and marketing strategies and is offered as a comprehensive treatment modality without the use of other appliances. For example, in 1998, a clear aligner system for orthodontic treatment began to be advertised which consisted of a set of custom removable polyurethane aligners (Invisalign®, Align Technology, (Joffe 2003)). This system uses computer aided design and computer aided manufacturing (CAD/CAM) stereolithographic technology to forecast

treatment and fabricate custom made aligners from a single impression (Proffit 2013b). Each aligner is set to move a tooth or group of teeth 0.25 to 0.33 mm every 14 days. After 14 days the patient begins wearing the next aligner in the series to continue tooth movement. The aligners are removable but they are to be worn at least 22 hours per day 7 days a week (Kravitz et al. 2009).

The treatment process begins with the provider submitting a set of polyvinylsiloxane impressions or intraoral scan of all the teeth, a centric occlusion registration, radiographs, and photographs to the company (Wong 2002). Once the company obtains the impressions, they are scanned with computed tomography to create a three-dimensional digital model of each arch (Proffit 2013b). Once the scan is complete each tooth is separated on the scan and a technician moves the teeth to simulate a proposed treatment.

Along with the patient's clinical records, the provider submits a prescription for the desired tooth movements. Depending on the complexity of the case the provider may include ancillary treatment to assist with the clear aligners. These ancillary treatments include: interproximal reduction (IPR), attachments, and other auxiliaries. IPR consists of slenderizing teeth by removing enamel at the proximal surfaces in an attempt to create more space to alleviate crowding. Attachments made of clear plastic can be bonded to the facial surfaces of teeth in order to assist with root movement (as in the closure of extraction sites), closure of open bites by extrusion of incisor teeth, and translation of molars (Proffit 2013b). In theory, the aim of an attachment is to provide a point of contact for the trays to apply a force. It cannot be known in these aligner systems, what the resultant forces acting on the teeth and or attachments are because the trays contact many areas. However, there is work being done to try to quantify the forces that are generated by clear aligners (Simon et al. 2014b). The preliminary data show that clear aligners produce forces within the range of commonly used orthodontic forces. The third type of ancillary treatment includes other

auxiliaries such as buttons and elastomeric chains which may be needed to accomplish movements that are not possible with the use of the aligner trays and or bonded attachments only. Portions of the aligners can be cut out at certain teeth to accommodate buttons bonded directly to the teeth. The patient-specific prescription is followed by the technician to position the teeth in the virtual models and use certain auxiliaries according to the provider's preferences (Wong 2002).

The preliminary plan is then made available online for the doctor (e.g. "ClinCheck", Align Technology , (Invisalign 2014a)). The preliminary plan consists of tooth movements, number of trays, if and where there is a need for interproximal reduction, if and where attachments and auxiliaries will be needed, and the final position of the teeth. The planned tooth movement is simulated digitally for review. The provider can request changes to the plan before approval. Once the provider approves the plan, it is sent to a cast production facility. Here, the digital information is converted to physical models by a process known as stereolithography. From the physical models the aligners are fabricated and all aligners that will be needed for treatment are sent to the provider's office (Proffit 2013b).

### **Commercial Aligner Systems**

Currently there are multiple companies offering clear aligners for orthodontic care. Invisalign® was created by Align Technology in 1997 and according to the company's website, has provided aligners to over 2.5 million patients (Align 2014). Many clear aligner companies have originated since Align Technology's inception of Invisalign®, and many lawsuits have been filed by various companies claiming patent infringement (Wickham 2014); however, many companies still remain in the market. These other aligner systems include ClearCorrect™, Simpli5™, Clearguide™, Orthocaps TwinAligner®, MTM® aligners, and Red White and Blue®. Currently there is even an aligner system that bypasses a dental

professional's office and provides clear aligners directly to the consumer from a set of self-taken photos and a self-taken impression (SmileCareClub 2014).

Clear aligners were marketed directly to orthodontists by Align Technology in 1999. In 2000, Align Technology Inc. launched a \$40 million marketing campaign directly at consumers, creating demand for the product (Schlossberg 2001). Only board certified orthodontists were able to provide the service until a class-action lawsuit was filed by general dentists requesting to be able to use the product (Schlossberg 2001). It has currently been estimated that a majority of new patients treated with Invisalign® are treated by general dentists (Marques et al. 2011). Dental students have most likely been exposed to clear aligner systems even before entering dental school, through shadowing dentists who use an aligner system, through the advertising efforts of private companies or through their own personal treatment. To the lay person, including dental students without any experience, the technology of clear aligners may seem to make tooth movement a simple and straightforward treatment. The degree to which dental students adequately assess the difficulty of certain tooth movements with clear aligners and their attitude toward incorporating this type of treatment in their future practices are unknown.

For most aligner systems, in order for a dental professional to provide the aligners in his or her office he or she must become a provider certified by the company. The type of training offered by the aligner companies ranges from a free of charge one-hour online course to attending a ~\$2000 one-day training course. However, there are some companies that will provide aligners without any required training (Ormco 2014). In the case of Align Technology for example, the certification course covers the following aspects of treatment: case selection and treatment goal planning; case submission; treatment planning process; treatment initiation; case monitoring; finishing and retention; support tools to assist with the system; selection of more predictable cases from treatment based on relevant clinical

experience; and, how to gain the necessary knowledge to integrate the system into practice immediately (Invisalign 2014b). Theoretically, the more experience a clinician has the better the treatment plan they can create with the system. According to material provided by the company, the computer system can make any tooth movement, but an experienced clinician is required to determine the feasibility of such movement and its consequences (Invisalign 2014a).

The claims that different clear aligner companies make differ in regards to the type and amount of possible tooth movement. ClearCorrect™ and Invisalign® make claims of possible tooth movement on their websites (ClearCorrect 2014; Invisalign 2014a). According to Align Technology's claims, clear aligners are a good option for patients with mild to moderate crowding (1-6 mm), mild to moderate spacing (1-6 mm), constricted dental arches, and patients who have experienced relapse after fixed appliance therapy (Boyd RL 2001; Kuncio et al. 2007). Additionally, clear aligners were originally intended for use in adults or adolescents who have a fully erupted dentition and for highly compliant patients as the appliances need to be worn for a minimum of 20 hours per day (Christensen 2002). Despite the previous references, Align Technology reports that 90% of orthodontic patients are candidates for clear aligners (Kuncio et al. 2007). Upon reviewing the Align Technology website, there is currently no set of indications or contraindications to clear aligner treatment, and there are links to articles claiming that every case can be treated with clear aligners (Invisalign 2014c). However, the company does list different types of movements that are more difficult in nature and may require a more experienced clinician.

ClearCorrect™ does list the following contraindications on their website:

Any type, method, or movement indicated as difficult (Table 1)

Centric-relation and centric-occlusion discrepancies

Teeth with short clinical crowns

Arches with multiple missing teeth

Patients whose second molars have not yet erupted

Patients with poor oral hygiene

Patients with active periodontal disease

Patients with dental prosthetics or implants

Both ClearCorrect™ and Invisalign® companies will indicate the amount of clinical skill required for each tooth's movement as easy, moderate, or advanced difficulty (Table 1).

Moderate movements may require the following ancillary treatments: interproximal reduction (IPR) or monitoring interproximal contacts for IPR, attachments bonded temporarily to teeth, use of detailing pliers to bend a portion of the aligner to a different position, buttons and elastics, or interarch elastics with precision cuts in the aligners.

Advanced movements may require the above ancillary treatments and possibly any of the following: sectional fixed braces, full fixed braces, pre-aligner correction, or orthognathic surgery (Invisalign 2014a). Table 1 describes guidelines for tooth movement from two different companies.

Align Technology places responsibility for evaluating whether or not clear aligners are appropriate for use in each patient's case solely with the doctor and waives any claims against Align Technology relating to the treatment or outcome of treatment (Invisalign 2014a). The values in Table 1 of possible tooth movement do not reflect the literature regarding the accuracy of extrusion of anterior teeth or rotation of canines and premolars achieved by aligner systems, as will be described in the next section.

TABLE 1

## COMPANY CLAIMS OF POSSIBLE TOOTH MOVEMENT WITH CLEAR ALIGNERS

Type of Tooth Movement	Easy		Moderate		Advanced	
Company*	A*	B*	A*	B*	A*	B*
Anterior extrusion (mm)	0 - 2.5	NA	2.5 - 3.5	0 -.5	3.5 - 6+	>.5
Posterior extrusion (mm)	0 - 0.5	NA	.5 - 1	0 -.5	1 - 6+	>.5
Anterior intrusion (mm)	0 - 2.5	0 - 1	2.5 - 3	1 - 2	3 - 6+	>2
Posterior intrusion (mm)	0 - 2.5	0 -.5	2.5 - 3	.5 - 1	3 - 6+	>1
Root movement (mm)	0 - 4	NA	4 - 6	NA	6+	NA
Anterior-posterior correction (mm per quadrant)	0 - 2	0 - 2	2 - 4	2 - 4	4 - 6+	>4
Rotation of upper central & lower incisors (°)	0 - 40	0 - 30	40 - 50	30 - 45	50 - 60+	>45
Rotation of upper lateral incisors (°)	0 - 30	0 - 30	30 - 40	30 - 45	40 - 60+	>45
Rotation of canines & premolars (°)	0 - 45	0 - 20	45 - 55	20 - 30	55 - 60+	>30
Rotation of molars (°)	0 - 20	0 - 10	20 - 30	10 - 15	30 - 60+	>15

\*Company A=Invisalign® (Invisalign 2014a), Company B=ClearCorrect™ (ClearCorrect 2014)

### Tooth Movement with Aligner Systems

Although the commercial systems described above have been around for nearly 15 years, there is not much literature based on strong evidence to support good outcomes with this treatment approach. Most of the published literature regarding clear aligner therapy consists of case reports which rank very low on the hierarchy of evidence. In 2005, one of the first systematic reviews was published regarding the treatment results of clear aligners,

but no conclusions about the indications, limitations and outcomes of use could be made because no studies were found that quantified treatment effects or accomplishment of treatment goals using clear aligners (Lagravere and Flores-Mir 2005). The review concluded that due to the lack of evidence, clinicians so far have to rely on their clinical experience, the opinion of experts, and the limited literature available when using removable aligners (Lagravere and Flores-Mir 2005).

While companies claim to be able to treat nearly all patients with clear aligners, there is little evidence to support that specific types of tooth movement can be achieved to the same degree of success as with conventional braces. From the current literature there are certain tooth movements that have been identified as being more predictable with aligners than others. Recently, Kravitz and colleagues (2009) investigated the accuracy of the predicted tooth movement on the final predicted end of treatment model and the actual outcome for certain anterior tooth movements. The sample comprised 37 participants (14 men, 23 women), whose mean age was 31 years. The mean number of aligners per treatment was 10 maxillary and 12 mandibular. The mean amounts of anterior IPR were 1.3 mm in the maxilla and 1.6 mm in the mandible. The frequency of anterior IPR was 180 of 401 teeth (45%). Tooth attachments varied in shape, size, and position according to the doctor's prescription. The frequency of use of anterior tooth attachments was 68 of 401 teeth (17%). The virtual model of the predicted outcome was superimposed over the virtual model of the actual final tooth position. The percentage of the actual tooth movement was calculated based on the predicted amount using the following equation: percentage of accuracy =  $\left[ \frac{|\text{predicted} - \text{achieved}|}{|\text{predicted}|} \right] \times 100$ . The study determined that on average for all teeth lingual constriction was the most accurate movement achieved (47.1%), and the least accurate on average was extrusion (29.6%) (Kravitz et al. 2009). This means that if a plan included a predicted 3 mm of extrusion, the actual extrusion achieved on average was

0.9 mm. This is consistent with the results of the Krieger and colleagues' study (2011) where the accuracy of the final predicted model was assessed through clinical measurements of overbite, overjet, arch length, and midline deviation. This study looked at 50 patients with mild to moderate crowding based on Little's Irregularity Index with a mean irregularity of 5.3 mm in the maxilla and 5.9 mm in the mandible. At the end of treatment the mean irregularity was 1.5 mm for the maxilla and 0.8 mm in the mandible. Overbite, which measures a vertical component of the malocclusion, resulted in the largest deviations between the final predicted model and the actual treatment outcome. There was a 0.71 mm (SD=0.87) mean difference between the predicted and actual models (Krieger et al. 2011). While not in complete agreement as to the amount of discrepancy among actual and predicted outcomes, the results of Krieger et al. and Kravitz et al. both showed that in the anterior region vertical tooth movements were more difficult to achieve with clear aligners than transverse or sagittal tooth movements. Another study recently verified that the predicted outcomes of clear aligner therapy do not reflect the actual occlusion at the end of treatment (Buschang et al. 2015). Using the American Board of Orthodontics (ABO) Objective Grading System (OGS) it was found that post-treatment models showed significantly ( $P = 0.016$ ) more overall point deductions (24 vs 15) when compared to the predicted treatment outcome (Buschang et al. 2015). In order for a case to pass the ABO certification exam, the case must score 20 points or less (ABO 2012).

Kravitz et al. (2009) also found that the accuracy of rotation correction decreases as the amount of desired rotation increases above  $15^\circ$ . For maxillary canine rotations under  $15^\circ$  were achieved with 35% accuracy. As the amount of desired rotation increased above  $15^\circ$  the accuracy of the tooth movement decreased significantly to 18% (Kravitz et al. 2009). Weaknesses of this study include that it only investigated anterior tooth movements, and it used aligners only and did not include potential auxiliaries. However, Simon et al. (2014)

found very similar results even when looking at posterior teeth and utilizing auxiliary attachments. For premolar derotation less than 15°, 43.3% of the planned tooth movement occurred. Whereas, for premolar derotations greater than 15°, only 23.6% of the predicted tooth movement occurred (Simon et al. 2014a). Others have written about the weakness of the aligners to perform this movement and have suggested that overcorrection of rotation movements be planned into the treatment to achieve the desired tooth position (Boyd 2005). Alignment is usually a fundamental objective of any orthodontic treatment plan. Therefore, it seems reasonable that any assessment of the quality of orthodontic result must contain an assessment of tooth alignment (ABO 2012). The American Board of Orthodontists (ABO) grades the outcomes of treatment based on a variety of factors, of which alignment is a major factor. A rotation that is not fully corrected even by a few degrees adversely affects the score received by the Board.

For other tooth movements the literature has varying results. Some authors have concluded that clear aligners are not appropriate for treating complicated malocclusions such as anteroposterior corrections greater than 2 mm (McNamara 2001; Djeu et al. 2005). However, a more recent study concluded that distalization of maxillary molars greater than 1.5 mm could be achieved with high accuracy (Simon et al. 2014a). The mean accuracy was calculated from predicted models superimposed over the actual treatment outcome model for 20 patients. The average amount of distalization among the sample was 2.6 mm. Of the predicted amount of distalization, 88.4% (SD = 0.2) was achieved. However, this study may be inconclusive because it did not account for any anchorage loss after the anterior teeth were retracted, and did not specify if the teeth were tipped or if true bodily movement was achieved.

A recent systematic review summarized the available literature for tooth movement with clear aligners, but the heterogeneity of the studies still warrants caution when drawing

conclusions (Rossini et al. 2014). After searching multiple databases the review selected eleven relevant articles (two randomized clinical trials, five prospective non-randomized trials, and four retrospective non-randomized trials). The amount of mean intrusion attempted was 0.72 mm with 46% mean accuracy for the proposed movement. Extrusion was the most difficult movement to achieve, where mean amount attempted was 0.56 mm with 30% accuracy for the proposed movement. Rotation was the next most difficult movement to achieve. Upper molar distalization revealed the highest predictability (88% accuracy) when a bodily movement of at least 1.5 mm was prescribed. It was concluded that clear aligner therapy aligns and levels the arches; it is effective in controlling anterior intrusion but not anterior extrusion; it is effective in controlling posterior buccolingual inclination but not anterior vestibulolingual inclination; it is effective in controlling upper molar bodily movements of about 1.5 mm; and it is not effective in controlling rotation of rounded teeth in particular (Rossini et al. 2014).

### **Other Studies Regarding Clear Aligner Therapy**

While there are studies being conducted about the clear aligner systems, there are very few comparing their effectiveness to traditional braces. One cohort study found that patients treated with clear aligners had a greater rate of relapse than those treated with conventional fixed appliances (Kuncio et al. 2007). Djeu et al. compared similar cases based on complexity treated with clear aligners and braces. Upon comparing the two it was found that overall, the final treatment outcome, as measured by the ABO Objective Grading System (OGS), was significantly better for cases treated with braces (Djeu et al. 2005). The OGS is a very stringent measure; however, it still demonstrated a significant difference between the percentage of cases that failed when treated with braces (52%) versus clear aligners (79%). These findings are similar to another study by Kassas et al. that investigated outcomes of treatment with the OGS. For mildly to moderately difficult cases, based on the

ABO Discrepancy Index scores between 10 and 20, of the 119 cases in the study only 3% of cases treated with aligners received a passing score, 71% failed, and 26% were considered borderline using the ABO OGS (Kassas et al. 2013). An interesting finding of the Kassas et al. study was that clear aligner treatment when used in mild to moderate malocclusions was effective in correcting tooth alignment and buccolingual inclination; however, it had a negative effect on posterior occlusal contacts and occlusal relationships. Of interest to the current study is whether or not dental students know that braces have been shown to have a better result. It is important for clinicians to be able to present the advantages/disadvantages of a treatment and alternative treatments so that the patient can make a well informed decision.

Buschang et al. compared the time efficiency of clear aligners versus conventional braces and found that for simple Class I cases with minor crowding, clear aligners have significantly less average chair time per case (93 vs 186 minutes, respectively) as well as shorter average treatment duration (11.5 vs 17 months, respectively) than conventional braces . However, the cost of materials for Class I cases with minor crowding is significantly higher for clear aligners versus conventional braces (\$1569 vs \$95, respectively) (Buschang et al. 2014). These costs include the lab fee paid for the manufacture of aligners and the polyvinylsiloxane impressions for clear aligners; while the cost for braces includes brackets, wires, and a few additional care items including wax (Buschang et al. 2014). Whether or not the greater time efficiency of clear aligners offsets the greater material costs compared to conventional braces is a decision for each individual practitioner and his or her practice. More studies like this one are needed to compare the costs incurred for different types of orthodontic treatment.

Other variables influencing tooth movement with clear aligners include the timing of aligner changes, stiffness of the material, and amount of movement produced by one

aligner. Preliminary studies looking at the strain in clear aligner systems found it to be very important that the patient wear the aligners as close to 24 hours per day as possible during the first 2 days of treatment (Vardimon and Brosh 2010). It was also recommended that final aligners should be thicker or worn for a longer period of time, such as three weeks rather than the normal 14 day interval (Vardimon AD 2010). Another study concluded that material fatigue does not make a difference in tooth movement with clear aligners but points out the need for further evaluation of patient characteristics, such as age, bone quality, and tooth morphometrics that could impact aligner treatment planning (Drake et al. 2012).

Considering all the literature available for tooth movement with clear aligners is limited to date, in the future it is necessary to generate randomized controlled trials with rigorous methodology and proper sample sizes in order to increase the power of the studies for estimating the effects of tooth movement with clear aligners. Only with this knowledge will it be possible to develop defined clear aligner treatment protocols for daily clinical practice (Rossini et al. 2014). The current study aims to investigate whether or not dental students are familiar with the capabilities of clear aligner treatment and the need for further research of high quality to investigate more fully the effectiveness of this treatment modality.

### **General Dentists' Use of Clear Aligners**

General dentists do not receive much training while in dental school regarding orthodontic treatment, but some pursue additional orthodontic knowledge through continuing education courses. Multiple studies have shown that historically around 18-20% of general dentists will provide comprehensive orthodontic treatment (Koroluk 1988; Wolsky and McNamara 1996); however, with the advent of clear aligners and the marketing of these systems to dentists and the public, this incidence may be higher than what was previously cited. During the 12 months prior to publication in May 2010, Vicens and Russo found that more Invisalign® cases were started by general dentists than were started by orthodontists

(Vicens and Russo 2010). In a survey sent to 1000 general dentists by Borello in 2009, 27% of 153 responding general dentists provided orthodontics with aligner therapy (Borello 2010). It will be interesting to find out if a similar percentage of current dental students planning on entering general practice (GP) desire to provide orthodontic therapy with clear aligners.

### **State and Regional Boards**

The practice of dentistry is regulated by national, state, and regional organizations. In order to obtain a license to practice dentistry, dentists must first pass Part I and II of the National Board Examination, a standardized examination administered by the American Dental Association. Additionally, dentists are required to pass successfully either state or regional board examinations that are aimed at ensuring clinical competency. Most of the board examinations have a written portion and a clinical portion. However, none of the state or regional boards require clinical assessment of competency in orthodontics for licensure (Smith 1987). Additionally, the boards do not emphasize assessing orthodontic theory (Moyers 1990). However, this does not preclude general dentists from providing orthodontic care in their general practices. Legally, any licensed practitioner may treat orthodontic problems (Smith 1987).

### **Standard of Care**

Although general dentists may provide orthodontic care to their patients, they are legally held to the same standards as the orthodontic specialist. In an article on the standard of care in dentistry, Graskemper asserts that general dentists cannot perform below the minimum level of care to which patients are entitled (Graskemper 2004). A study by Abei et al. evaluated the treatment outcomes provided by orthodontists and general dentists using a scoring system designed by the ABO for determining whether or not a finished case met the ABO's standards for alignment of teeth. In this study, it was found

that the cases treated by orthodontists scored significantly fewer deductions according to the ABO's Objective Grading System (26 vs 30) (Abei et al. 2004). A more recent study by Marques et al. found that orthodontic cases treated by orthodontists when compared to orthodontic cases treated by general dentists had shorter treatment durations ( $2.1 \pm 0.9$  vs  $2.6 \pm 0.8$  years) and achieved better quality outcomes (96.7% vs 50% passed ABO criteria) (Marques et al. 2011). It may be hard to make conclusions from the data because the goals of treatment and the initial complexities of the malocclusions were not described for either study.

### **Predoctoral Orthodontics Education**

Currently, the American Dental Association's Commission on Dental Accreditation (CODA) standards for malocclusion and space management state:

Graduates should be able to evaluate, assess, and apply current and emerging science and technology. Graduates should possess the basic knowledge, skills, and values to practice dentistry, independently, at the time of graduation. The school identifies the competencies that will be included in the curriculum based on the school's goals, resources, accepted general practitioner responsibilities and other influencing factors. The comprehensive care experiences provided for patients by students should be adequate to ensure competency in all components of general dentistry practice. Programs should assess overall competency, not simply individual competencies in order to measure the graduate's readiness to enter the practice of general dentistry (CODA 2013).

These guidelines are vague concerning the desired competency of graduating dental students when it comes to orthodontic care. This allows for a wide array of interpretations and has most likely lead to a wide variety of pre-doctoral orthodontic curricula across the United States. One study investigated the relative amount of time devoted to orthodontic

education in predoctoral dental curricula. The authors surveyed 97 University of Florida and 101 non-University of Florida graduates practicing in Florida. Among those surveyed at that time, the average number of hours of instruction in predoctoral education was, which for most schools was less than 4% of the total instruction time in clinical sciences (McDuffie and Kalpins 1985). A more recent survey suggests that the amount of predoctoral instruction may be even less in today's dental schools (Alexander 2007). A permanent increase in the predoctoral class size at one institution occurred in 1996 without an increase in faculty support, contributing to a decline in orthodontic appliance insertions by students from 1999 to 2003. During this same time period the overall clinical experience at the predoctoral level in orthodontic procedures declined in this particular institution (Alexander 2007). According to a survey among pre-doctoral orthodontic directors less than half of dental school programs offer students the opportunity to treat orthodontic patients in some way during the dental school curriculum (Kwo and Orellana 2011). Other findings from this survey include that the majority of schools offered most of their orthodontic coursework in the third year (D3), and a majority of the orthodontic education received in dental school is didactic with supplementary clinical experiences in various forms including: laboratory classes, observing residents, and assisting residents.

The variations in the exposure of dental students to orthodontic training may potentially impact patient care when it comes to malocclusion. One study found that didactic knowledge of orthodontics increased over the four year curriculum; however, clinical skills and application of didactic knowledge of orthodontics had marginal improvement (Brightman et al. 1999).

The 2013 American Dental Education Association (ADEA) survey of graduating U.S. dental students stated that 32.6% of respondents (over 4300 total respondents) perceived that the time devoted to orthodontic training in the dental school curriculum was

“Inadequate” (the highest percentage for any clinical discipline), while 63.2% perceived the time devoted to orthodontics training to be appropriate (ADEA 2013). What the survey failed to explain was why the majority of respondents felt that the time dedicated to orthodontics was “appropriate.” Was it judged as appropriate because they felt competent in their abilities to diagnose and treat orthodontic patients, because they do not plan to treat orthodontic problems, or because they perceive that aligner system companies will make it easy for them to provide orthodontic care with the help of continued education? The same survey also reported that a majority of graduating dental students (62%) felt “under-prepared” or “somewhat under-prepared” for practice in orthodontics (ADEA 2013). Of note, the 2013 ADEA survey compared to the 2009 ADEA survey showed a trend that more students in 2013 perceive the time dedicated to orthodontics in the curriculum was appropriate yet more students felt under-prepared or somewhat under-prepared to practice orthodontics. In 2009, 39% of graduating dental students felt that the time devoted to orthodontics was “Inadequate”, while 55% felt it was “appropriate”, and 58% felt “under-prepared” or “somewhat under-prepared” (ADEA 2009). This study will seek to find out if dental students desire more time in the curriculum for clear aligner therapy training.

A study prior to the mass marketing of clear aligners explored the self-confidence of general dentists in diagnosing malocclusion and referring patients to orthodontists (Ngan and Amini 1998). The study found that more than 70% of the general dentists thought that they received enough training to recognize malocclusions and to assess when a referral to a specialist was necessary. Nevertheless, 9% thought they received enough orthodontic training to perform comprehensive orthodontic treatments, and 19% felt confident to provide limited treatment (Ngan and Amini 1998). This study was done prior to the mass marketing of clear aligners. It would be of interest to know if dental students today have similar confidence levels in providing orthodontic treatment with clear aligners.

## **Problem Statement**

From the first day after licensure a newly graduated dentist can provide a wide array of dental treatment including orthodontics. After minimal or even no training, general dentists are able to provide clear aligner therapy with commercial systems. Providing the best patient care requires clinical experience with orthodontic diagnosis, treatment approaches, and assessment of outcome. To date there are no studies investigating how well prepared dental students are to diagnose orthodontic problems and provide orthodontic treatment with clear aligners. The purposes of this study are to investigate the knowledge of dental students with respect to orthodontic diagnosis and clear aligner orthodontic treatment.

## **Hypotheses**

1. Student demographics such as:
  - a. class (D3 or D4),
  - b. future practice plans,
  - c. interest in clear aligners and/or orthodontics,
  - d. confidence in providing clear aligner therapyhave an effect on aligner knowledge and orthodontic knowledge.
2. There is a correlation between students' aligner knowledge and orthodontic knowledge.

## CHAPTER 2

### METHODS

#### **Survey Development and Description**

In order to investigate the knowledge of dental students with respect to orthodontics and clear aligners, a sixteen item questionnaire was constructed. The questionnaire included questions aimed at eliciting information on students' desire to provide clear aligner therapy, their knowledge of clear aligners, and their knowledge of orthodontics.

The sixteen-item questionnaire was divided into three domains: (1) Student demographics, (2) Student knowledge of clear aligners (AK), and (3) Student knowledge of orthodontics (OK). The first domain, student demographics, elicited demographic information regarding the student's year of graduation, their future practice plans regarding general or specialty practice, and their future plans regarding providing clear aligner therapy. There is also an item in the first domain that elicited the students' perceived confidence regarding providing clear aligner therapy. Another item in the first domain elicited information regarding the adequacy of the training they have received in order to provide clear aligner therapy.

The second domain, student knowledge of clear aligners, aimed at answering the first hypothesis by evaluating the AK of the students. The four items in the second domain elicited their knowledge of the evidence of the application of clear aligner therapy. The four items were constructed based on the clear aligner studies that were previously cited in chapter one.

The third domain, student knowledge of orthodontics, was comprised of six items that tested the OK of the students. Two items tested their knowledge of growth and development. Two items elicited their self-perceived confidence in diagnosing dental and skeletal malocclusions. The last two items included clinical photos that were required to

answer the questions. The elicited information from the third domain allowed the second hypothesis to be tested by correlating how well students performed on the OK questions with their responses in the second domain regarding AK.

Prior to administration of the survey a focus group consisting of graduating fourth year (D4) dental students (Class of 2015) reviewed the survey from dental students' perspectives and discussed any previously unforeseen problems with the questions. Two D4 students participated in the focus group, one who was planning on entering an orthodontic residency and one who was not.

After making updates to the survey based on the focus group's feedback the survey was given to four full time orthodontic faculty members who have experience in teaching pre-doctoral students. The faculty members completed the survey and then the questions were discussed as a group. The questions were updated to reflect their feedback and suggestions for the questions. All of the faculty members answered the OK questions correctly. All of the faculty members answered the AK questions correctly except one faculty member answered question number 10 with answer choice 'C', which receives partial credit according to the rubric in Appendix 4.

After updates were made to the survey based on the faculty members' feedback, the survey was given to a group of eight orthodontic residents. They answered the questions on the survey and then the survey as a whole was discussed amongst the group. Changes were made according to their feedback and the survey was finalized.

The final version of the survey is included in Appendix 1.

### **Survey Distribution and Data Collection**

A convenience sample of UMKC D3 and D4 dental students (Classes of 2017 and 2016 respectively) were invited to complete the survey. All members of the D3 class (106) and D4 (106) were potential participants. Permission was obtained in advance from the

instructor of the pre-doctoral orthodontics course for D3 dental students and the instructor of a seminar class for D4 dental students to recruit students to complete the 5-10 minute survey at the beginning of the selected class sessions.

The survey was administered during a pre-doctoral orthodontic class for D3 dental students and a seminar class for D4 dental students during fall semester 2015. The survey and response forms were distributed to D3 and D4 class members at the beginning of the respective class sessions. A Master's student in the Oral and Craniofacial Sciences graduate program passed out surveys and read instructions (see verbal script –Appendix 2) for the survey to D3 and D4 dental students. The students were informed that participation was entirely voluntary and would only require 5-10 minutes of their time. The students who participated placed their answers to the survey on response forms. Students placed the completed or incomplete questionnaire and response form in a slot in the top of a large collection box at the back of the classroom, so that anonymity would be maintained. Since it was voluntary the students were given the option to turn in the survey and response form whether completed or not into the slot in the box to further assure anonymity. The survey answers were completed on a Scantron® response form and run through the Scantron® machine at the School of Dentistry. The collected data were transferred to an excel spreadsheet for statistical analysis. UMKC Policy states the completed surveys will be kept for 7 years after the study is complete.

This survey and the associated protocol were approved by the University of Missouri-Kansas City (UMKC) Institutional Review Board (IRB Protocol 15-186). The IRB approval letter is included in Appendix 3.

### **Experimental Design**

This study utilized a one-factor, non-experimental design. The dependent variables assessed were (1) student AK and (2) student OK. Student demographics was the global-

independent variable, with four specific demographic features. Table 2 outlines the experimental design with dependent and independent variable specifics. The sample size was based on the number of respondents from the potential maximums of 106 D3 students and 106 D4 students.

TABLE 2

EXPERIMENTAL DESIGN: INDEPENDENT AND DEPENDENT VARIABLE SPECIFICS

Independent variable	Specific details of Student demographics	Dependent variable
Student demographics	Dental school classification (D3 or D4)	Aligner knowledge (Composite score of 5 questions)
	Future practice plans (GP, orthodontic specialty, or other specialty practice)	
	Future plans to provide orthodontic care and clear aligner therapy	Orthodontic knowledge (Composite score of 6 questions)
	Confidence in providing clear aligner therapy	

### Data Analysis

A composite score was generated for the second and third domains, AK and OK, to allow the same types of questions to be compared as a group instead of comparing individual questions, thereby allowing for a broader perspective of the data. A rubric was created to describe the composite scoring for each domain and is included in Appendix 4.

Data collected from the items in the survey were coded and entered into a statistics software program<sup>1</sup>. Appropriate descriptive statistics including frequency distributions and central tendencies was computed. Non-parametric Kruskal-Wallis and Mann-Whitney U

<sup>1</sup> IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY 10504

tests were used to evaluate the effect of student demographics, such as class, interest, and confidence, on AK and OK. Correlations between AK and OK were run with the Spearman correlation test. Significance for all testing was set at  $\alpha = 0.05$ .

## CHAPTER 3

### RESULTS

Of the 106 D3 students 75 completed a survey, and of the 106 D4 students 88 completed the survey for a total response rate of 76.9%. The major reason for non-response was not being present in class when the survey was administered. Of those present in class only seven students total between the two classes did not complete a survey. The data were tested for an effect of each of the independent variables as a complete data set, split for D3 only, split for D4 only, and split for only those planning to practice general dentistry.

#### **Effect of Dental School Classification**

Dental school class had no effect on AK and OK (Figure 1). AK describes the Domain 2 score and OK describes the Domain 3 score. There was no significant difference for either dependent variable, which does not support hypothesis 1a. While there was no significant difference between the medians for either dependent variable the D4 class had a higher percentage of students who obtained the highest scores possible for both AK and OK. Out of a possible score of 8 for AK (Domain 2 score) 14.6% of the D4 class scored a 7 or 8, compared to 5.5% of the D3 class. Out of a possible score of 12 for OK (Domain 3 score) 12.3% of the D4 class scored an 11 or 12, compared to 8.2% of the D3 class.

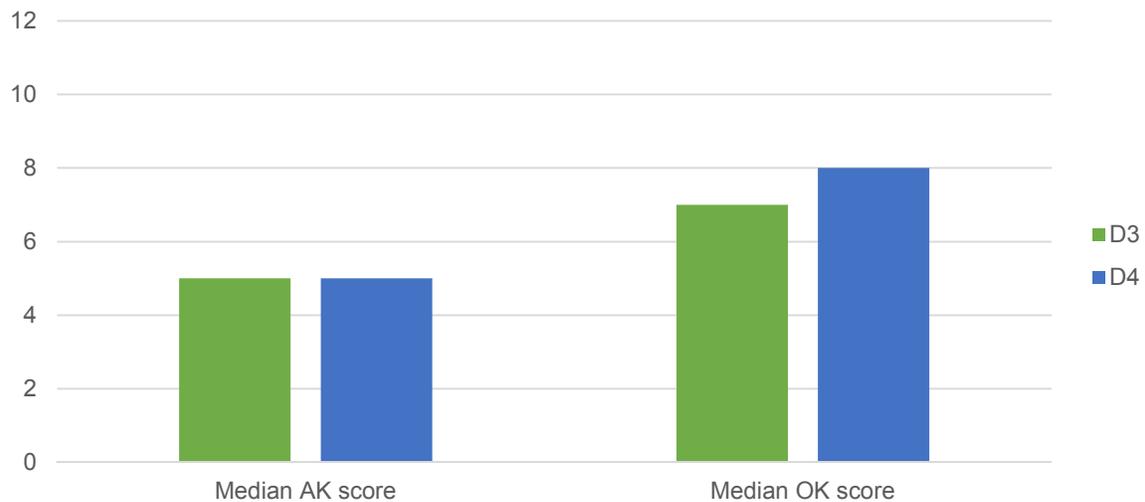


Figure 1. Class effect on aligner knowledge (AK) and orthodontic knowledge (OK). The median AK scores (maximum score=8) and OK scores (maximum score=12) for the D3 and D4 classes. No significant difference was found for the AK score ( $p \geq 0.05$ ) or for the OK score ( $p \geq 0.05$ ) between the two classes.

### Future Practice Plans

Out of the 163 total respondents, 136 or 83.4% were planning on entering GP which included those who were planning on entering a general dentistry residency program. Seven or 4.3% of the 163 respondents were planning on specializing in orthodontics (referred to as Ortho in Figure 2), while 20 or 12.3% were planning on specializing in a field other than orthodontics (referred to as Other specialty in fig. 2).

Future practice plans had a significant effect on OK but not on AK (Figure 2.) The post-hoc test revealed that those planning on entering orthodontic specialty practice were more likely to have a higher Domain 3 score suggesting a higher OK. Students planning on entering orthodontic specialty practice had a higher OK than those planning on entering GP ( $p \leq 0.05$ ), as well as those planning on entering another specialty ( $p \leq 0.05$ ). There was no significant difference between those planning on entering GP and those planning on entering another specialty besides orthodontics ( $p \geq 0.05$ ). Out of the possible 12 points for

the OK score (Domain 3 score) 57.2% of those planning on specializing in orthodontics scored an 11 or 12 compared to only 8.8% of those planning on practicing GP and 5.0% for those planning on specializing in something other than orthodontics. These results address hypothesis 1b regarding a difference between the groups in OK, but not in AK.

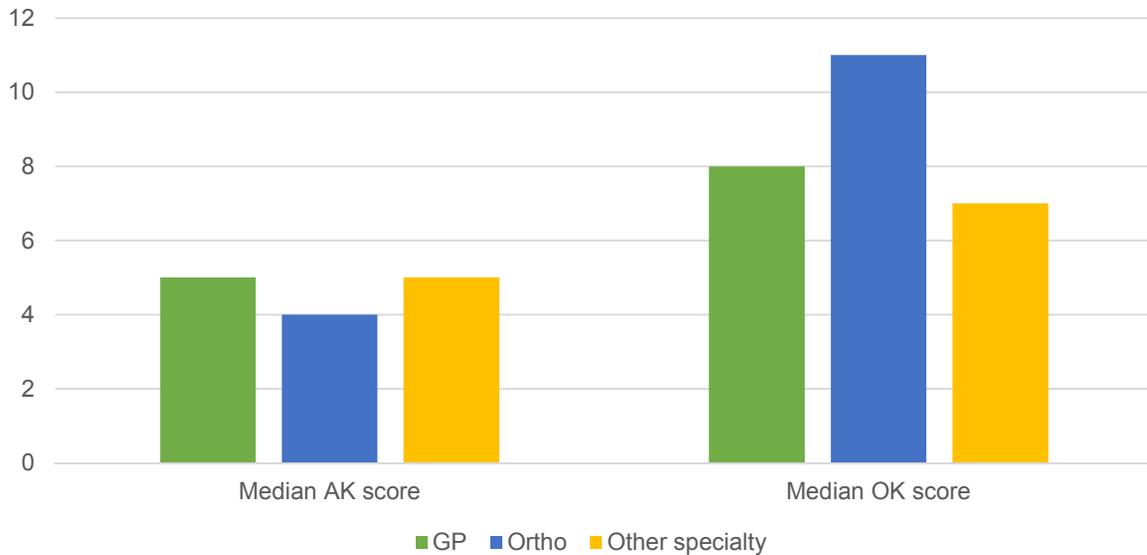


Figure 2. The effect of future practice plans on aligner knowledge (AK) and orthodontic knowledge (OK). The median aligner knowledge (AK) scores (maximum score=8) and orthodontic knowledge (OK) scores (maximum score=12) for students planning on entering general practice (GP), orthodontic specialty practice, and another specialty practice. A significant difference was found between the OK score of students planning on specializing in orthodontics versus those planning on entering GP ( $p \leq 0.05$ ) and those planning on entering another specialty ( $p \leq 0.05$ ). There was no difference among the 3 groups for AK scores ( $p \geq 0.05$ ).

### Future Plans to Provide Orthodontics

Out of the 163 total respondents, 58 or 35.6% plan on referring all patients with orthodontic needs to an orthodontist. Ninety-one or 55.8% of respondents plan on treating some of their patients with orthodontic needs, and 14 or 8.6% plan on treating all of their patients with orthodontic needs.

When looking at just those students who plan on entering GP, 45 of the 136 respondents or 33.1% plan on referring all of their patients with orthodontic needs to an

orthodontist. Eighty-five or 62.5% plan on treating some of their patients with orthodontic needs, and 6 or 4.4% plan on treating most of their patients with orthodontic needs.

Students planning on entering GP who responded that they planned on treating “some” and those who planned on treating “most” patients with orthodontic needs were combined for question 3 of the survey and compared with those who responded that they planned to refer all patients with orthodontic needs (Figure 3). There was a significant difference ( $p \leq 0.05$ ) in the median AK scores for students entering GP who planned to refer all patients for orthodontic treatment (5.0) and those who planned to treat some (4.0). There was not a significant difference between the two groups for OK ( $p \geq 0.05$ ). These results address hypothesis 1c where those who planned to refer all patients with orthodontic needs when compared to those who planned to treat at least some patients with orthodontic needs had a significantly higher AK but had no significant differences in OK.

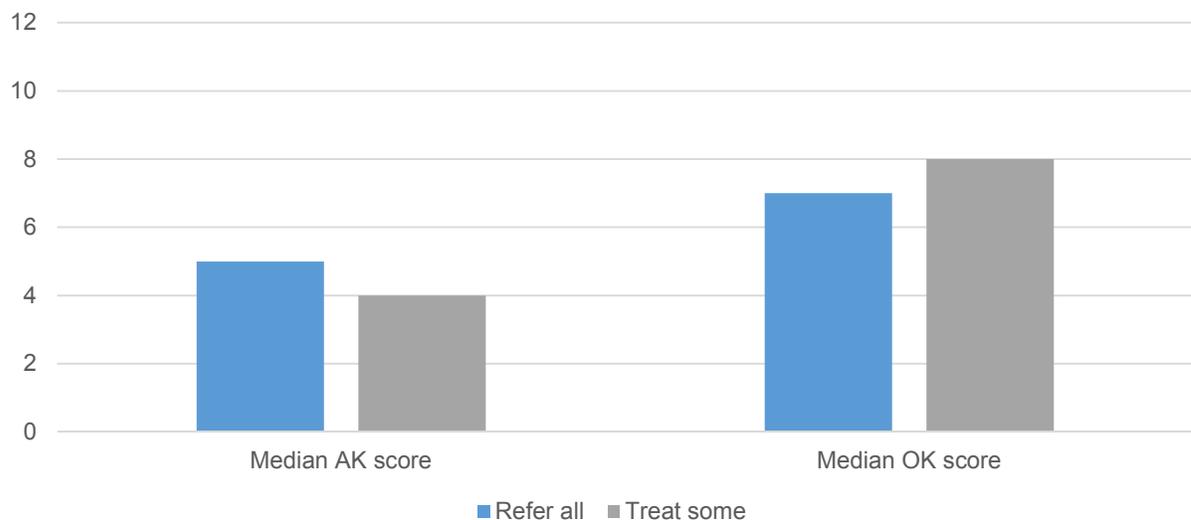


Figure 3. Future treatment plans effect on aligner knowledge (AK) and orthodontic knowledge (OK) for those planning on entering general practice. The median AK scores (maximum score=8) and OK scores (maximum score=12) for those who planned to refer all orthodontic patients versus those who plan to treat some themselves. There was a significant difference in the median AK scores for students entering general practice (GP) who planned to refer all patients for orthodontic treatment and those who planned to treat some ( $p \leq 0.05$ ). There was no significant difference between the two groups for OK score ( $p \geq 0.05$ ).

### **Future Plans to Use Clear Aligners**

When asked “What appliances you plan on using”, 50 or 30.7% of the 163 total respondents said that they would not use any appliance because they plan to refer all patients with orthodontic needs. Fifty-five of 163 or 33.7% plan on using only clear aligners to treat their patients with orthodontic needs, only 3 of 163 or 1.8% plan on using only fixed appliances to treat their patients with orthodontic needs, and 55 of 163 or 33.7% plan on using both clear aligners and fixed appliances to treat their patients with orthodontic needs.

When looking at only those who planned on entering GP, 37 of 136 or 27% said that they would not use any appliance because they planned to refer all patients with orthodontic needs. Fifty-two of 136 or 38% planned on using clear aligners only to treat patients with orthodontic needs. Only 3 of 136 or 2% planned on using only fixed appliances, and 44 of 136 or 32% planned on using both clear aligners and fixed appliances to treat patients with orthodontic needs. There was a total of 96 of 136 or 70% of respondents who planned on entering GP that planned on using clear aligners.

Students who planned on entering GP who answered ‘A’ or ‘C’ (which indicate a plan to use clear aligners) on question 4 of the survey were compared to those who answered ‘B’ or ‘D’ (which indicates no plan to use clear aligners) in order to compare those who planned to use clear aligners to those who did not (Figure 4). Those who planned on using clear aligners had a significantly lower AK (4.0) compared to those who did not plan to use clear aligners (5.0,  $p \leq 0.05$ ). These results address hypothesis 1c where those who planned to use clear aligners had a significantly lower AK but no significant differences in OK compared to those who did not plan on using clear aligners.

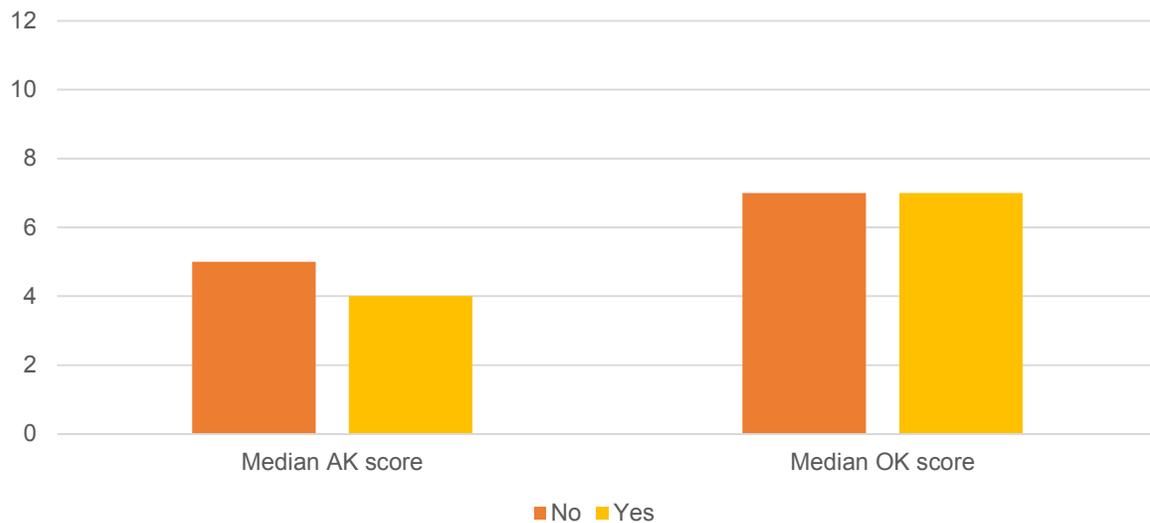


Figure 4. Future plan to use clear aligners effect on aligner knowledge (AK) and orthodontic knowledge (OK) for those entering general practice. The median scores for AK (maximum score=8) and OK (maximum score=12) are depicted above comparing those who plan on using clear aligners (Yes) and those who do not (No). Those planning on using clear aligners had a significantly lower AK score than those who did not ( $p \leq 0.05$ ). There was no significant difference between the two groups for OK ( $p \geq 0.05$ ).

### Confidence in Providing Clear Aligner Therapy

When asked “My dental school education has given me an adequate amount of education and training in orthodontics to confidently provide treatment with clear aligners in my future practice”, 29 or 17.8% of respondents replied ‘Strongly Disagree’, 92 or 56.4% replied ‘Disagree’, 38 or 23.3% replied ‘Agree’, and 4 or 2.5% replied ‘Strongly Agree’.

Those who answered ‘Disagree’ or ‘Strongly Disagree’ on question 5 of the survey were compared to those who answered ‘Agree’ or ‘Strongly Agree’ (Figure 5). There was no significant difference found between the groups for either dependent variable ( $p \geq 0.05$ ).

There was also no significant difference between any of the groups when looking at the four possible responses separately ( $p \geq 0.05$ ). This addresses but does not support hypothesis 1d because there was no difference in AK or OK between students who had confidence to treat orthodontic cases with clear aligners and those who did not.

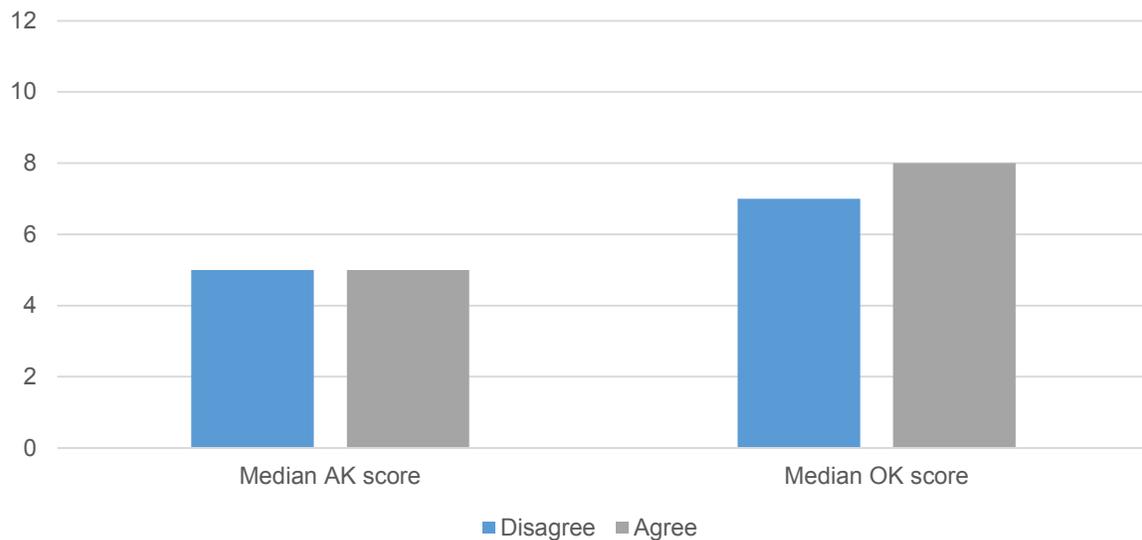


Figure 5. Confidence in providing clear aligner therapy effect on aligner knowledge (AK) and orthodontic knowledge (OK). The median scores for AK (maximum score=8) and OK (maximum score=12) scores are depicted above comparing those who had confidence in providing clear aligner therapy (Agree) and those who did not (Disagree.) There was no significant difference between the two groups for AK ( $p \geq 0.05$ ) and OK ( $p \geq 0.05$ ).

### **Correlation between Domain 2 and Domain 3**

A Spearman's correlation determined the relationship between the Domain 2 scores and the Domain 3 scores which looked at AK and OK respectively. There was no significant correlation found between the two scores ( $r_s=0.04$ ,  $p \geq 0.05$ ). This addresses but does not support hypothesis 2 because there was not a correlation between students' AK and OK.

### **Desire for More Training in Clear Aligners**

When asked if you think the dental school curriculum should incorporate more training in clear aligner therapy, 142 or 87% of respondents said "yes." Eleven or 6.7% responded: "no, because I do not plan to use clear aligners as a practicing clinician." Ten or 6.1% responded: "no, because I feel I can learn it best after graduation." The percentage of those responding "yes" was slightly higher (90%) among those planning on entering GP compared to the respondents as a whole.

## CHAPTER 4

### DISCUSSION

This study is the first of its kind to investigate dental student knowledge regarding aligner knowledge and orthodontic knowledge. The annual ADEA survey administered to graduating dental students is the most well-known survey that provides information to educators and other dental professionals regarding the views and perceptions of dental students towards the dental school curriculum. The ADEA survey asks dental students about how much time was devoted to orthodontics in the curriculum and how well prepared they feel to provide orthodontic care (ADEA 2013). However, the ADEA survey does not look into actual student knowledge and does not survey students regarding their interest or confidence in providing clear aligner therapy. In the current literature there are no studies to which the results of this study can be compared; however, speculations can be made regarding the results.

The survey results suggest that those planning on entering orthodontic specialty practice demonstrated a greater orthodontic knowledge than those planning on entering general dentistry or another specialty. Students who have already identified that they want to enter orthodontic specialty practice may take more of an interest in learning about orthodontics in the predoctoral curriculum which may lead to them gaining a greater knowledge of orthodontics. However, simply having an interest in providing orthodontic treatment is not a predictor of orthodontic knowledge, since there was no significant difference in orthodontic knowledge found between those who plan on treating patients with orthodontic needs versus those who plan to refer all patients to an orthodontic specialist. Typically, students who are interested in specializing, irrespective of the discipline, are typically driven students interested in maintaining a high GPA, so they can competitively apply to programs by being relatively highly qualified applicants. However, wanting to

specialize in disciplines other than orthodontics was not linked to higher orthodontic knowledge.

In this study sample, a much higher percentage of dental students plan on providing at least some orthodontic treatment as general dentists, 62.5%, than the 18-20% general dentist interest in the 1980s and 1990s (Koroluk 1988; Wolsky and McNamara 1996), which was prior to aligner therapy availability. It is difficult to determine what proportion of this difference is due to the students not having any practice experience or the advent of clear aligners being marketed directly to general dentists. It would be interesting to follow this group of dental students a few years into practice to see if the desire to treat patients with orthodontic needs as a general dentist remains as high as it is now.

In this study there was a slight discrepancy between the results of two questions that gauged student plans to refer orthodontic cases. Question 3 asked directly what future plans the students had for treating orthodontic cases, and question 4 had an answer choice that allowed them to say that they didn't plan on using any orthodontic appliances because they plan on referring all patients with orthodontic needs. When responding to question 3, 35.6% responded that they plan to refer all patients; and when responding to question 4, 30.7% responded that they don't plan to use any orthodontic appliances because they plan to refer all orthodontic cases. There were 8 students that responded in question 3 that they plan to refer all orthodontic cases, but responded in question 4 that they plan to use a certain type of orthodontic appliance. Those students may only plan to use an orthodontic appliance on a very limited basis and thus their answer choice in question 3 was the most accurate response for their situation.

Another important observation from the current results is that students with a higher aligner knowledge were more likely to refer orthodontic cases to a specialist and not use clear aligners. This may indicate that because they understood more about aligners (and

possibly its limitations) they are more likely to refer orthodontic patients instead of trying to treat them themselves. It may be worthwhile for dental schools to review their curricula to incorporate more education in orthodontics and aligners. More education for dental students may help them better assess whether or not they want to include this therapy option in their private practice.

### **Curriculum Implications**

More education in orthodontics may help give dental students a better idea of the experience required to treat orthodontic cases. General dentists are certainly bombarded in private practice with aligner companies encouraging them to offer orthodontic services; thus, more education in dental school may help general dentists make a more informed decision about whether or not to provide the service as a general dentist and to whom they can and or should offer the service.

There was no statistically significant improvement in orthodontic knowledge from the third to fourth year of dental school, but this is in line with previous studies that have looked at the competency of dental students in regards to their knowledge of orthodontics. There are no current studies; but in 1999, the Brightman study reported that clinical skills and application of didactic knowledge of orthodontics had marginal improvement from D3 to D4 (Brightman et al. 1999). If looking to provide more orthodontics content in the curriculum, dental schools should heavily favor providing more opportunities to apply didactic knowledge of orthodontics and increase clinical skills.

Perceived confidence in providing clear aligner therapy had no bearing on knowledge of aligners and orthodontic knowledge. Those who felt they could confidently provide aligner therapy did not have any higher aligner knowledge or orthodontic knowledge than those who were not confident to do so. It's also interesting to note that more students in this study, 26%, felt that they could confidently provide orthodontic care to their patients

based on their dental school education than has been historically reported (9% for comprehensive cases and 19% for limited treatment) (Ngan and Amini 1998). However, the lower confidence level in the 1980s and 1990s was prior to aligner therapy availability, so confidence was related to performing traditional orthodontic treatment. In the 1980s and 1990s, when a lower percentage of students reported confidence in providing comprehensive orthodontic care to their patients compared to this study, 9-19% vs 26%, there was a greater amount of orthodontic instruction in the curriculum nationally compared to the amount students received in this study, approximately 110 total hours (McDuffie and Kalpins 1985) vs 72 total hours. Also during the 1980s and 1990s, there was a greater amount of orthodontic appliance insertions by dental students compared to more recent studies (Alexander 2007). The total curriculum hours reported include didactic courses and clinical courses and are reported as a total over the 4 years of the dental school curriculum. In 2015 the UMKC graduating class received 45 hours of orthodontic didactic courses, 21 hours of orthodontic laboratory courses, and 6 hours of clinical orthodontic courses. Forty-nine out of 106 students in the 2015 graduating class from UMKC were able to treat a patient with orthodontic needs with fixed appliances and only 6 students were able to treat a patient with clear aligners. The higher confidence levels reported in this study may be due to the lower amount of orthodontic instruction students received in this study compared to the amount of orthodontic instruction received by students in the 1980s and 1990s. The lower amount of orthodontic instruction may be just enough to build some confidence to treat cases, but not enough to provide sufficient experience to demonstrate the treatment complexities that can occur. More instruction in aligners and orthodontics in general could help those with perceived high confidence gain a more realistic understanding of what aligners can do and the training that is required to adequately treat orthodontic cases.

Another reason for dental schools to incorporate more education of orthodontics and aligners in the curriculum is based on the feedback for the D3 and D4 class in this study. Of those planning on entering general practice, 90% desired more time in the dental school curriculum for clear aligner therapy. An additional 6% wanted more training in clear aligner therapy, but felt that the training would be best done after graduation. The 2013 ADEA survey of graduating U.S. dental students reported that 32.6% of respondents stated that the time devoted to orthodontic training in the dental school curriculum was “Inadequate” and 62% felt “under-prepared” or “somewhat under-prepared” for practice in orthodontics (ADEA 2013). The students in this study were specifically asked about their desire to add time in the curriculum for clear aligner therapy, but the percentage of students in this study desiring more time in the curriculum for orthodontics compared to the 2013 ADEA survey was much higher.

### **Limitations of Current Study**

The main limitation of this study is that it was limited to one dental school. If more dental schools from more regions of the country were included, the results may be more generalizable to represent the country as a whole and not just UMKC dental students.

The survey needed to be kept short in order to have a large enough completion rate during the short time the survey could be administered. However, a more lengthy survey would have enabled a more comprehensive look into the aligner knowledge and orthodontic knowledge of the students who participated in the study.

Another limitation was that it was limited to third and fourth year dental students. If first and second year dental students were included, the study would be able to consider the effects of other influences before the dental students at UMKC have had formal courses in orthodontics. This could possibly be an improved basis for comparing results from other dental schools who have varying curricula and timing of introducing orthodontics.

## **Future Directions**

Expanding the population of students to which the survey is distributed would be a logical next step. It would be interesting if the viewpoints and knowledge of the dental students at this dental school reflect the viewpoints and knowledge of dental students across the country. The ADEA survey in past years has not asked specifically about clear aligners and whether or not dental students desire more time in the curriculum to learn more about them. The ADEA may find that a higher percentage of students feel that the curriculum in regards to orthodontics is inadequate when the question specifically asks about clear aligner therapy.

Another logical next step could be following the students in this study a few years into practice. Because of the higher percentage of students who desire to provide orthodontic care to their patients than the historical percentages of general dentists that actually do, it would be interesting to follow the students to see if that desire to provide treatment remains the same or changes. It would also be interesting to see if their knowledge of aligners and orthodontics stays the same or changes a few years into practice and see what effects this has on their choice to provide orthodontic care to their patients.

CHAPTER 5  
CONCLUSIONS

1. Certain student demographics have an effect on student knowledge of clear aligners and their ability to diagnose orthodontic problems.
  - a. There were no significant differences in the orthodontic knowledge and the aligner knowledge between the D3 and D4 classes.
  - b. Those planning on specializing in orthodontics had a significantly higher orthodontic knowledge than those planning on entering general practice or another specialty.
  - c. Those with a higher aligner knowledge were more likely to refer orthodontic cases to a specialist and not use clear aligners.
  - d. Confidence to treat patients with clear aligners had no bearing on aligner knowledge and orthodontic knowledge.
2. There was no correlation found between aligner knowledge and orthodontic knowledge.

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APPENDIX 1

SURVEY

**Please place your answers on the Scantron® form**  
**Do NOT put your name or student ID on the Scantron® form**

- 1) What year in dental school are you currently in?
  - a) Third year (Class of 2017)
  - b) Fourth year (Class of 2016)
- 2) What are your future practice plans?
  - a) General dentistry (including practice, GPR, AEGD)
  - b) Orthodontics specialty practice
  - c) Other specialty practice
- 3) Choose the option below that best describes your future plans for treating patients with orthodontic needs. I plan to:
  - a) Refer all patients with orthodontic needs to an orthodontist.
  - b) Treat some of my patients with orthodontic needs.
  - c) Treat most of my patients with orthodontic needs.
- 4) What appliances do you plan on using in your future practice to treat orthodontic patients?
  - a) None, I plan on referring all patients with orthodontic needs to an orthodontist.
  - b) Only clear aligners.
  - c) Only fixed appliances (brackets and wires).
  - d) Clear aligners and fixed appliances.
- 5) My dental school education has given me an adequate amount of education and training in orthodontics to confidently provide treatment with clear aligners in my future practice.

Strongly disagree	Disagree	Agree	Strongly agree
(A).....	(B) .....	(C) .....	(D)
- 6) Do you think the dental school curriculum should incorporate more training in clear aligner therapy?
  - a) Yes
  - b) No, because I do NOT plan to be a clear aligner provider as a practicing clinician
  - c) No, because I feel I can learn it best after graduation
- 7) Which of the following tooth movements is likely the most difficult movement to achieve with clear aligners? (ONLY CHOOSE 1)
  - a) Tipping
  - b) Intrusion
  - c) Rotation
- 8) There is NO difference between the final alignment of teeth treated with traditional braces compared to the final alignment of teeth treated with clear aligners.
  - a) True
  - b) False
- 9) Traditional braces have been shown to produce better occlusal contacts than clear aligners.
  - a) True
  - b) False
- 10) How much of the prescribed tooth movement in clear aligner therapy actually occurs clinically for most types of tooth movement?
  - a) Greater than 90%
  - b) 70-90%
  - c) 50-70%
  - d) Less than 50%

- 11) For a patient with a mixed dentition, which of the following features will most likely improve on its own without treatment?
- Anterior crowding
  - Rotation
  - Diastema
  - Overbite
- 12) Do you feel confident in your ability to accurately diagnose **dental** malocclusions?
- No, I am not confident                      Yes, I am somewhat confident                      Yes, I am very confident
- (A).....(B) .....(C)
- 13) Do you feel confident in your ability to accurately diagnose **skeletal** malocclusions?
- No, I am not confident                      Yes, I am somewhat confident                      Yes, I am very confident
- (A).....(B) .....(C)
- 14) The best time to begin comprehensive orthodontic treatment is when peak growth velocity is occurring. What is the ideal age range for females to begin treatment?
- 8-10
  - 10-12
  - 12-14
  - 14-16
- 15) Based on Case 1 (see below), what is the correct canine classification?
- Class I
  - Class II
  - Class III

**Case 1**



- 16) Based on the photos of Case 2 (see below), in your professional opinion, which of the following features is the greatest orthodontic problem?
- Transverse relations of the posterior teeth
  - Anteroposterior relations of the posterior teeth
  - Anteroposterior relations of the anterior teeth
  - Midline diastema

**Case 2**



## APPENDIX 2

### VERBAL SCRIPT FOR SURVEY INSTRUCTIONS

The purpose of this research study is to evaluate the attitudes and knowledge of dental students in regards to orthodontic clear aligner therapy.

We are asking dental students from the Classes of 2016 and 2017 to volunteer to complete a short survey regarding their future plans for using clear aligner therapy and their current knowledge of orthodontics and clear aligner therapy.

This survey will take approximately 5 - 10 minutes or less. All responses will be completely anonymous. The surveys will not have any identifiers to link your responses back to you or any other participants. We are only interested in evaluating the data for the entire group.

There are neither risks nor benefits to participating in this research study. Your decision to participate or not participate will not have any influence on your grade in any class or on your rights as a student. Your participation in this research study is optional.

All surveys will be collected by placing them in a slot in the top of the box located in the back of the room. If you do not wish to complete the survey, you may also place the incomplete survey in the slot in the top of the box located in the back of the room. Your assistance is greatly appreciated.

Please do not place your ID on the Scantron®.

If you have any question regarding the research please contact Dr. Mary Walker at 816-235-2825.

If you have any questions regarding your rights as a research subject, please contact the IRB Administrator of UMKC's Social Sciences Institutional Review Board at 816-235-5927.

APPENDIX 3

IRB APPROVAL LETTER



UMKC  
5319 Rockhill Road  
Kansas City Missouri  
TEL: 816 235-5927  
FAX: 816 235-5602

## NOTICE OF EXEMPT DETERMINATION

Principal Investigator: Mary Walker  
00251 DS Oral Bio  
Kansas City, MO 64109

Protocol Number: 15-186  
Protocol Title: Survey to Assess Dental Students Knowledge of Orthodontic Diagnosis and Clear Aligner Therapy  
Type of Review: Exempt

Date of Determination: 05/15/2015

Dear Dr. Walker,

The above referenced study was reviewed and determined to be exempt from IRB review and approval in accordance with the Federal Regulations 45 CFR Part 46.101(b).

Exempt Category 1. EDUCATIONAL PRACTICES: Research conducted in established or commonly accepted educational settings, involving normal educational practices such as:

- i) research on regular and special education instructional strategies; OR
- ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Exempt Category 2. EDUCATIONAL TESTS (COGNITIVE, DIAGNOSTIC, APTITUDE, ACHIEVEMENT), SURVEY PROCEDURES, INTERVIEW PROCEDURES, OR OBSERVATION OF PUBLIC BEHAVIOR: Research involving these procedures is exempt, IF:

- i) the information obtained is recorded in such a manner that subjects CANNOT be identified, directly or through identifiers linked to the subjects; AND
- ii) any disclosure of the subject's responses outside of the research could NOT reasonably place the subject at risk of criminal or civil liability or be damaging to the subject's financial standing, employability, or reputation

This determination includes the following documents:

**Attachments**

Verbal\_Script\_Dated\_05-15-2015  
Survey Questions v 1.0 Dated 05-11-15

You are required to submit an amendment request for all changes to the study, to prevent withdrawal of the exempt determination for your study. When the study is complete, you are required to submit a Final Report.

Please contact the Research Compliance Office (email: [umkcirb@umkc.edu](mailto:umkcirb@umkc.edu); phone: (816)235-5927) if you have questions or require further information.

Thank you,

Simon MacNeill  
UMKC IRB

APPENDIX 4

SURVEY RUBRIC



**Domain 3: diagnostic ability composite score (Total possible score= 12)**

- 11) For a patient with a mixed dentition, which of the following features will most likely improve on its own without treatment?
- a. Anterior crowding SCORE=0
  - b. Rotation SCORE=0
  - c. Diastema SCORE=2
  - d. Overbite SCORE=0
- 12) Do you feel confident in your ability to accurately diagnose **dental** malocclusions?
- No, I am not confident SCORE=0    Yes, I am somewhat confident SCORE=1    Yes, I am very confident SCORE=2
- (A).....(B) .....(C)
- 13) Do you feel confident in your ability to accurately diagnose **skeletal** malocclusions?
- No, I am not confident SCORE=0    Yes, I am somewhat confident SCORE=1    Yes, I am very confident SCORE=2
- (A).....(B) .....(C)
- 14) The best time to begin comprehensive orthodontic treatment is when peak growth velocity is occurring. What is the ideal age range for females to begin treatment?
- a. 8-10 SCORE=0
  - b. 10-12 SCORE=2
  - c. 12-14 SCORE=0
  - d. 14-16 SCORE=0
- 15) Based on Case 1 (see below), what is the correct canine classification?
- a. Class I SCORE=0
  - b. Class II SCORE=2
  - c. Class III SCORE=0
- 16) Based on the photos of Case 2 (see below), in your professional opinion, which of the following features is the greatest orthodontic problem?
- a) Transverse relations of the posterior teeth SCORE=0
  - b) Anteroposterior relations of the posterior teeth SCORE=0
  - c) Anteroposterior relations of the anterior teeth SCORE=2
  - d) Midline diastema SCORE=0

## VITA

NAME: Steven Shaw

DATE AND PLACE OF BIRTH: September 9, 1984; Provo, UT

### EDUCATION:

6/2003	Diploma	McKinney High School McKinney, TX
5/2010	BS/Exercise Science	Brigham Young University Provo, UT
5/2014	D.D.S.	Texas A&M University Baylor College of Dentistry Dallas, TX
12/2016	M.S. Oral & Craniofacial Sciences	University of Missouri-Kansas City School of Dentistry Kansas City, MO

### RESIDENCY:

2014-2016	Orthodontics & Dentofacial Orthopedics	University of Missouri-Kansas City School of Dentistry Kansas City, MO
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### PUBLICATIONS:

Buschang PH, Ross M, Shaw SG, Crosby D, Campbell PM. Predicted and actual end-of-treatment occlusion produced with aligner therapy. Angle Orthod 2015; 85:723-7.

Buschang PH, Shaw SG, Ross M, Crosby D, Campbell PM. Comparative time efficiency of aligner therapy and conventional edgewise braces. Angle Orthod 2014; 84:391-6.

### PROFESSIONAL ORGANIZATIONS:

2014-Present American Association of Orthodontists  
2010-Present American Dental Association  
2010-2014 American Student Dental Association

### HONORS:

2014 Omicron Kappa Upsilon Clinical Achievement Award  
2012 Odontological Honor Society  
2011-2014 Baylor College of Dentistry Dean's List  
2006-2009 Brigham Young University Academic Scholarship  
2001 Eagle Scout