

DIGITAL INDIRECT BRACKET BONDING  
IN ORTHODONTIC PRACTICE

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Oral and Craniofacial Sciences

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MASTER OF SCIENCE

by  
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ABSTRACT

This study investigated the use of indirect bonding in orthodontic practices, specifically whether the orthodontist demographics and practice characteristics influenced the use of indirect bonding within an office. This study also examined factors that influenced or deterred orthodontists from the use of indirect bonding in practice. A survey was sent to members of the American Association of Orthodontists (AAO) to collect this data. Based on the results of this survey, graduation year was the only significant association between orthodontist demographics and indirect bonding use. There were no significant associations between practice characteristics and indirect bonding use. This study did find, however, that individuals who were trained on indirect bonding use by sales staff or manufacturers and practice colleagues regarding indirect bonding were significantly more likely to utilize indirect bonding in practice. Similarly, orthodontists with no training on indirect bonding use were significantly less likely to use indirect bonding in their practice. The results of this study also suggested that while many orthodontists believe that there are benefits to using indirect bonding in orthodontic settings, many still have not incorporated this technique into their own offices.

## APPROVAL PAGE

The faculty listed below, appointed by the Dean of the School of Dentistry, have examined a thesis titled “Digital Indirect Bracket Bonding in Orthodontic Practice,” presented by Richard Charles Boehm, candidate for the Master of Science degree in Oral and Craniofacial Sciences, and certify that in their opinion it is worthy of acceptance.

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## CHAPTER 1

### INTRODUCTION

Orthodontic bonding procedures play a significant role in the day-to-day workflow of an orthodontic private practice. Traditionally, most orthodontists utilize the direct bonding procedure (direct bracket technique) for bonding cases (Keim et al. 2014). The direct bracket technique requires the clinician to manually place and manipulate each bracket intraorally. There is a second bonding technique known as indirect bonding (indirect bracket technique). This procedure can be performed in two ways, digitally or manually. In both indirect techniques, the clinician places the brackets on a model, adjusts the brackets to the ideal position, and fabricates a transfer tray to then transfer the bracket positions intraorally (Nawrocka and Lukomska-Szymanska 2020). Due to technological advancements throughout the last decade, many orthodontists are beginning to implement the digital workflow into practice. There are many advantages to the digital model in orthodontic practice, the most relevant being more efficient and predictable treatment outcomes, thus over time could lead to a more profitable practice (Cunha et al. 2021).

#### **Conventional Orthodontics**

Orthodontics and dentofacial orthopedics, a dental specialty that uses fixed and removable appliances to properly align the dentition. Conventional orthodontics is a major aspect of orthodontic practice which traditionally involves the use of brackets, wires, and tubes to position teeth and roots in a functional position (De Oliveira et al. 2019). These appliances facilitate the transmission of force through the tooth and root to alter the tooth position relative to the surrounding bone.

## **History of Orthodontic Bonding**

Fixed appliance orthodontics historically involved the placement and cementation of metal bands with soldered brackets, around each tooth which was bound together using gold wire (Green 2014). Over time, the banding technique became obsolete as the application of fixed orthodontic appliances evolved into an enamel bonding system. This system involves an etching process applied to the tooth and the use of resin cement to physically bond the bracket to the tooth surface (Gange 2015). During the 20<sup>th</sup> century, this technique was termed direct bonding, due to the need for the clinician to manually place the bracket on the tooth directly.

Historically, to achieve the desired orthodontic tooth movement, clinicians used intricate wire bends in three planes of space to engage the bracket and direct forces in specific directions. This technique was first introduced to the orthodontic community by Dr. Charles Tweed in the late 1940s, which along with other novel advancements was termed the Tweed technique (Jain et al. 2017). During this time, wire bending was necessary to express the desired results because bracketing systems had not yet been customized. Up until the 1970s, orthodontic brackets were milled with the same dimensions for each tooth. Each bracket was formed at a 90-degree angle to the tooth and each slot was cut at a 90-degree angle (McLaughlin and Bennett 2015).

The straight wire system, first introduced by Dr. Lawrence Andrews in 1970 was developed to limit the need for intricate wire bending. Dr. Andrew's new system accounted for the unique angulation and positioning for each tooth known as crown tip, torque, and rotation. These specific characteristics were then implemented into a universal bracketing system known as Andrew's prescription (1979; McLaughlin and Bennett 2015).

Following the advancements demonstrated by Dr. Andrew's straight wire system, an abundance of bracket prescriptions developed. Each new bracket prescription incorporated minor adjustments to the design and angular dimensions of Andrew's prescription. Today, there are many bracket prescriptions available, most of which are named after the orthodontist who developed them. Aside from Andrew's prescription, two popular prescriptions are the Roth and MBT (McLaughlin, Bennett, and Trevisi) bracketing systems (Cozzani et al. 2019).

### **Bracket Positioning**

To achieve the desired tooth movement within a straight wire system, it is of utmost importance for the clinician to position the bracket in the correct orientation (Andrews 1979). Ideal bracket positioning is a widely controversial topic in orthodontics which ultimately is determined by the bracket prescription being used. In general, the midpoint of each bracket should be positioned on the tooth in an orientation that facilitates the alignment of each bracket on the same plane at the end of treatment (Tariq et al. 2015). To provide clarity throughout this study, positioning will be defined as the final location of the bracket on the dentition to facilitate bonding and the proper prescription of the bracket on tooth movement.

Due to the anatomy of the dentoalveolar complex, orthodontic brackets can be placed, positioned, and bonded on the clinical crown of the tooth, the only aspect of the tooth that is readily accessible clinically to the orthodontist. Therefore, tooth movement must be controlled via forces applied to the crown. The limiting factor in orthodontic movement is the ability of the tooth root to move through the surrounding bone. Orthodontic forces are distributed from the crown down to the root. These forces rely on a physiological response of the surrounding bone to remodel around the root to facilitate movement (Jeon et al. 2021).

Orthodontic force application and the resulting tooth movement rely immensely on bracket positioning. When an orthodontic force is applied to a tooth, the tooth tends to rotate around the center of resistance located within the tooth root, this rotational movement is called a moment. To counteract the moment, a torquing force must also be applied to the bracket-wire interface (Smith and Burstone 1984). If bracket positioning is misaligned with respect to the specific bracket prescription, undesirable tooth movement will result.

Due to the importance of bracket positioning within the straight wire system, a new technique of bracket placement was developed in hopes of limiting human error, the indirect bonding (IDB) technique, which was developed in 1974 by GV Newman. Instead of focusing on the entire bonding procedure, this study will focus on two components of the procedure, bracket placement and positioning.

The indirect bracket technique allows the clinician to place and position the brackets extraorally on either a physical or digital model (Newman 1974). Using models, the clinician can analyze and measure each tooth prior to placing the bracket, while also eliminating other factors that make accurate positioning in the direct bracket technique more difficult (Nojima et al. 2015). In theory, the indirect bracket technique provides a more stable work environment for the clinician thus allowing the clinician to be more precise in bracket positioning (Nawrocka and Lukomska-Szymanska 2020).

### **Direct vs. Indirect Bracket Technique**

Bracket placement in orthodontics is a unique and intricate process. As the field of orthodontics evolved throughout the 20<sup>th</sup> century, bracketing techniques became simpler in their application. One of the major advancements in orthodontics was the implementation of epoxy adhesives to facilitate orthodontic bracket bonding (Newman 1965). This new system

of bracket bonding provided a more simplistic approach to a very complex system. Due to this progression in dental materials, the direct bracket technique originated.

Direct bracket application is a technique widely used for orthodontic tooth movement. In the simplest form, the direct technique includes placing the bracket on the enamel surface and positioning the bracket according to the prescription guidelines. Proper placement and positioning then facilitate the bonding step, light curing the previously placed resin adhesive (Gange 2015). Despite the schematic approach to the direct bracket procedure, many factors are involved in achieving the ideal orthodontic result. The direct bracket technique requires the clinician to position the bracket in the proper orientation while working in a restricted and complicated environment, thus introducing the possibility of human error. To reduce human error, the indirect bracket technique was developed.

The indirect bracket technique was introduced to provide the clinician with a more accessible and controlled environment for bracket positioning. Unlike the direct technique, in the indirect procedure, the clinician uses a dental model of the patient's dentition to position the brackets in an ideal location. A transfer tray is then fabricated to hold the position of the brackets to then be transferred intraorally in the same position and orientation to be bonded to the enamel surface (Newman 1974). Thus, combining the placement and positioning steps into one efficient step, therefore, limiting the possibility of human error (figure 1).

It is important to note that the direct and indirect bracket techniques differ only in how the brackets are physically placed on the teeth (figure 1). The actual bonding of the bracket to the enamel is the same. Both techniques require the clinician to etch the enamel surface, apply a resin adhesive to the bracket base, place, and position the bracket base on the

enamel surface (one or two steps), and light cure the resin-enamel interface to facilitate a physical bond.

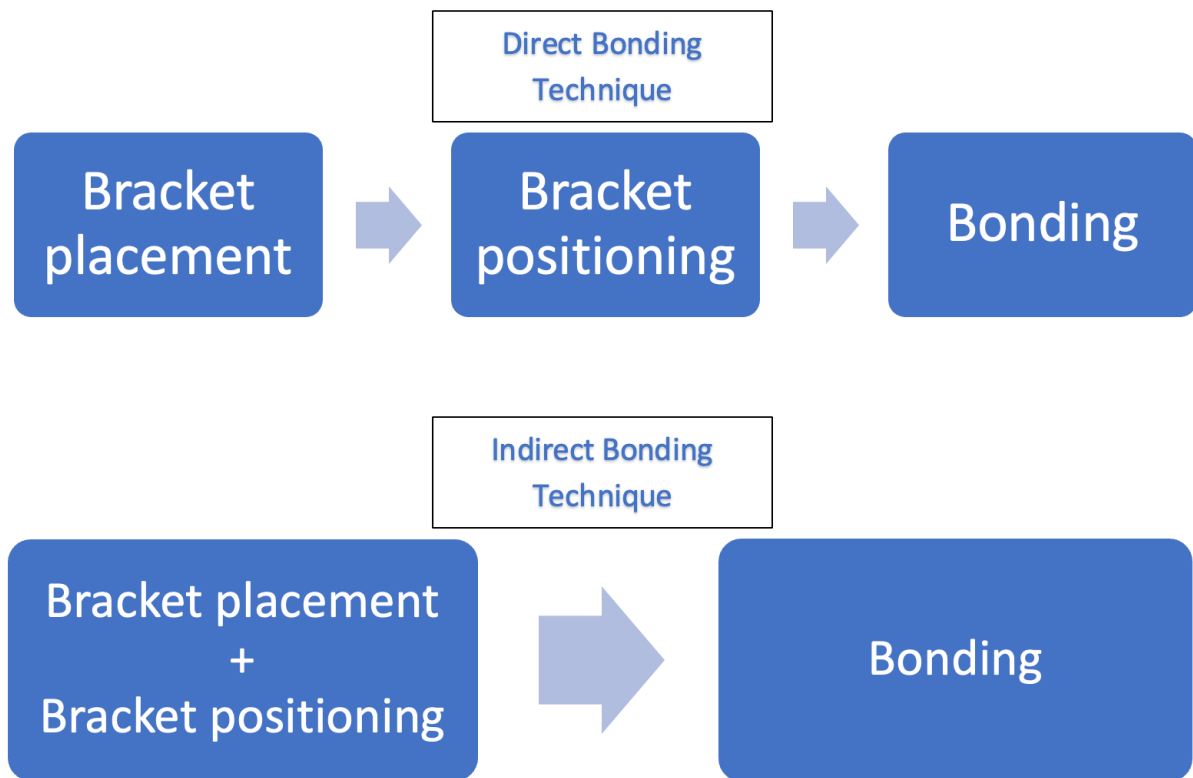


Figure 1. Comparison of clinical steps for direct and indirect bracket bonding.

### **Evolution of the Indirect Bracket Technique**

The indirect bracket technique, like other orthodontic procedures, evolved. Initially, the indirect technique was a manual process that required the use of stone models fabricated from an intraoral impression. The stone model was then analyzed by the clinician and brackets were directly placed on the model in the ideal position. Next, a transfer tray was fabricated using impression material to hold the position of the brackets. Lastly, composite resin was applied to the bracket bases and the enamel prepared for intraoral placement and subsequent bracket bonding (Newman 1974; Xue et al. 2020). One important aspect of the

bonding step to note is that clinicians continue to do this in different ways. It is possible to bond all brackets in an arch simultaneously, with a single transfer tray. However, many clinicians choose to section the transfer trays into sextants, three per arch, six total sections for the entire dentition. Placement and bonding in sextants allow the clinician to evaluate the accuracy of this technique and to identify any errors that may be present prior to bonding the remaining dentition.

Orthodontic practice success relies heavily on the ability of the clinician to manage treatment time, specifically the amount of time spent chairside with each patient and ultimately the total length of comprehensive treatment. The idea is that the shorter the chairside time, the more patients a clinician can see in a day, thus a higher output and therefore increased efficiency. Efficiency is defined by the overall amount of time a clinician attributes to a case, including lab working time, chairside time, and treatment planning time. Bracket placement accuracy, positioning the bracket in the most ideal location (in all three dimensions) for the desired tooth movements while reducing undesired movements, is of utmost importance to reduce overall treatment time and increase efficiency.

The manual indirect technique facilitated a quicker chair time but required a longer working time for the clinician in the lab stage (Yildirim and Saglam-Aydinatay 2018). In other words, a manual indirect technique provided benefits including better chair time efficiency and accuracy when compared to the direct bracket technique (Sondhi 2007; Bozelli et al. 2013; Nojima et al. 2015; Czolgosz et al. 2021). Two obstacles the manual indirect technique struggled to address were first, a more efficient lab working time for the clinician, and second, many of the brackets being used were not pre-pasted nor flash-free

brackets. Therefore, clinicians often struggled to remove excess resin, termed flash, which is expressed from under the bracket base during the placement and positioning step.

### **Digital Indirect Bracket Technique**

As a result of the obstacles clinicians faced using the manual indirect technique, a transition was made from the manual indirect technique to the digital indirect technique. Given the incorporation of intraoral scanners and CAD-CAM technology as the new standard for generating orthodontic records, a virtual setup for the indirect technique was imminent. The origin of the virtual setup came in 2006 using digital scanning of physical models which could then be analyzed digitally for bracket placement and positioning (Deahl et al. 2007). The first step in the digital indirect technique is to take an intraoral scan of the patient's dentition that is imported as a digital model into one of many software packages available (table 1). The digital model can be analyzed and segmented tooth by tooth either by the clinician or via an external vendor. Segmentation allows the operator to identify the ideal bracket position using software-based measurement tools. The operator can then select the preferred bracket prescription set and virtually place the brackets on the tooth model. The software, depending on the package, provides the operator with multiple options to assist in bracket positioning using pre-determined measurements.

TABLE 1

CURRENT INDIRECT BONDING  
SOFTWARE PROGRAMS

Brand	Manufacturer
ARCAD	ARCAD
DIBS AI®	OrthoSelect
LightPlan	LightForce™
OnyxCeph <sup>3</sup> ™	OnyxCeph™
OrthoAnalyzer	3Shape
OrthoStudio	Maestro 3D
Unitek™	3M™

The digital approach continued to evolve as stereolithography was introduced in 2011 to generate stereolithographic (STL) files of digital models that are commonly used throughout dentistry. The STL files are generated via intraoral scanning of a patient’s dentition. This file can then be exported from the scanner into any of the software packages available. The stereolithographic technique (figure 2) established pre-determined bracket positions on the virtual model, thus eliminating the need for the clinician to identify the ideal bracket position prior to altering bracket angulation (Son et al. 2011; Nawrocka and Lukomska-Szymanska 2020). Using this stereolithographic technique, newer software allows for treatment simulation after bracket placement is complete. Based on the simulation outcome, the operator can manually adjust the bracket position, if desired (Christensen and Cope 2018).

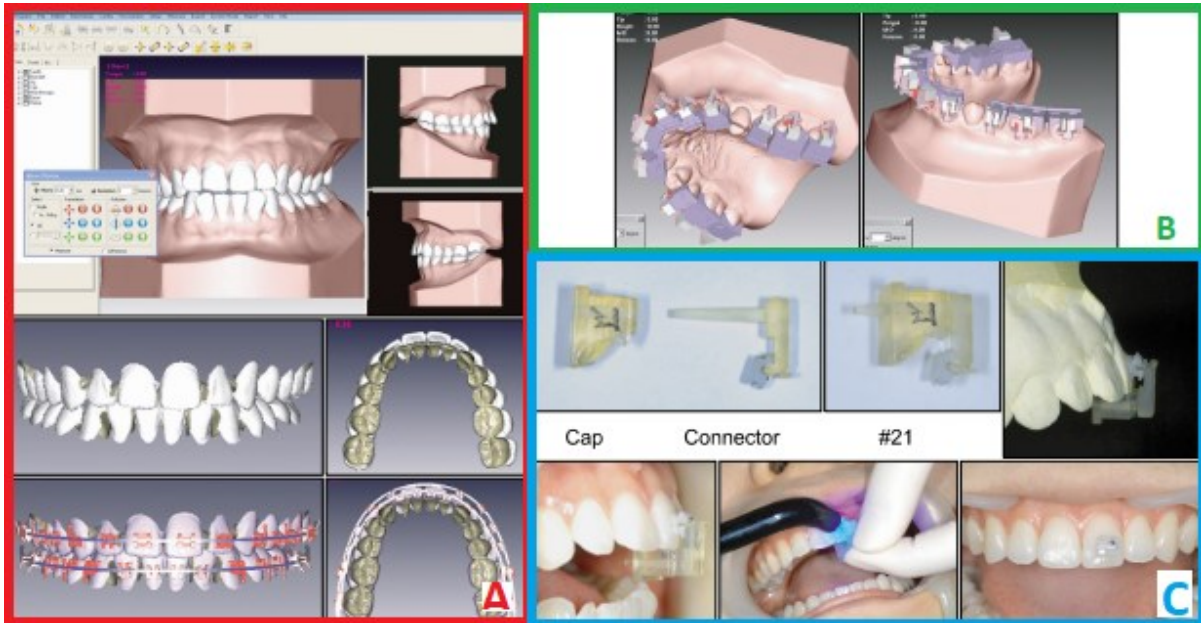


Figure 2. Digital indirect bonding workflow: A. Digital model analysis and bracket positioning, B. Transfer tray design, and C. Printed transfer tray with clinical indirect bonding. Adapted from Son et al. 2011.

After positioning has been finalized, the clinician has a couple of options for the fabrication of a transfer tray. First, using 3-D printing, the operator can print a model with the brackets integrated into the printed model and fabricate a transfer tray using lab material such as impression material or as an Essix retainer (Sondhi 2007). The second option makes use of CAD-CAM technology to directly print the transfer tray from a clear flexible resin, eliminating the need for a physical dental model (Nawrocka and Lukomska-Szymanska 2020). When comparing the accuracy of bracket positioning with the digital indirect to the direct technique, Oliveira et al. noted a statistically significant increase in vertical bracket position accuracy with the digital technique (2019).

An additional advantage of the digital indirect technique was the development and implementation of pre-pasted, flash-free brackets. Using these flash-free brackets, the

clinician is simply able to place and position the brackets using the 3-D printed clear, flexible resin transfer tray without the need to clean and remove excess resin material from around the bracket base. Not only did pre-pasted brackets make this process much more efficient, but they also aided in the elimination of hygienic concerns, which were often seen in the manual indirect technique (Foersch et al. 2016).

### **Digital Indirect Bracket Technique with Artificial Intelligence**

In recent years, the digital indirect technique evolved even further, integrating the use of artificial intelligence (AI) to speed up the process of tooth segmentation, bracket placement, and positioning. Many indirect bonding software companies have incorporated AI assistance into their programming. It is important to note that the integration of AI technology in the indirect technique only aids the clinician in the digital bracket placement and positioning step. The clinical bonding step is identical to that being used in both direct bonding and manual indirect bonding procedures.

Artificial intelligence is based on algorithms with parameters set by human programming. Each software program is developed individually by the company's software engineers. These AI programs use a unique "machine learning" model in which the software acquires data points from pre-set information defined by the individual companies. The software continuously inputs the datasets into the database as cases are completed by the users. This database grows continually, thus allowing the software to become smarter and more precise (Akdeniz and Tosun 2021). It is important to note that the data collected belongs to the company that created the software. Each company builds a unique database solely based on the cases completed using that specific software program, this is not a

universal database. It is also important to understand that these companies collect data in different ways.

Incorporating AI-based software into bracket positioning is an extremely complex process. In its simplest form, the software uses data accumulated over time to first segment the individual teeth to then identify the exact location of the facial axis point and the facial axis of the clinical crown point (Aldabbagh et al. 2019). The software program then works backward, first creating an ideal occlusion (figure 3). Once the ideal occlusion is defined, the software then positions the individual brackets to express the desired movement to achieve the ideal final tooth position and alignment (Retrouvey et al. 2021).

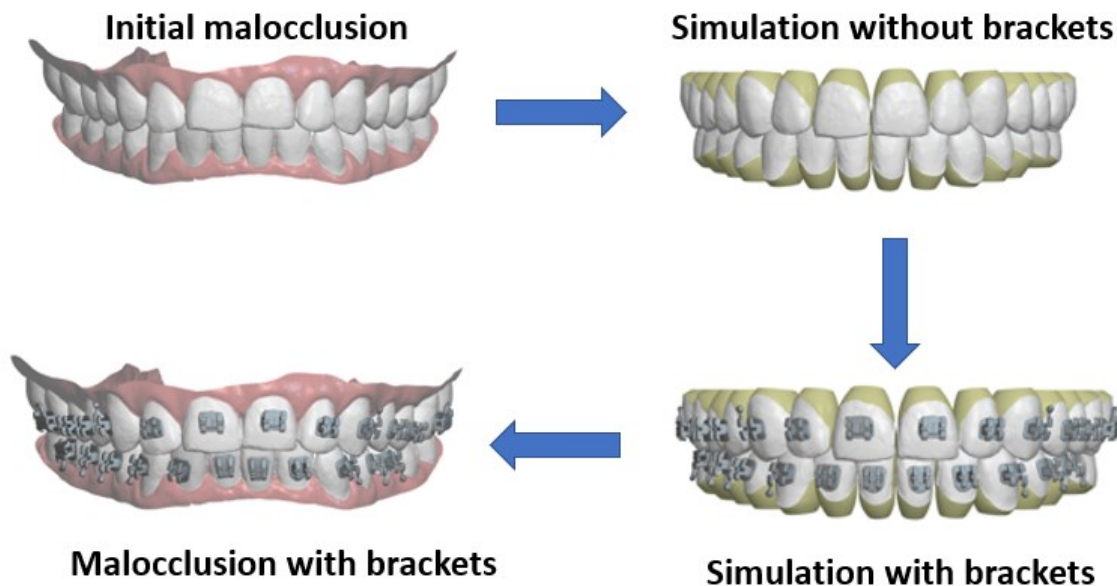


Figure 3. Digital indirect bonding AI simulation via DIBS AI.

Despite the wealth of data available within these software programs, the use of AI for bracket placement and positioning is still not perfect. Much of the research currently being completed is focusing mainly on the accuracy of tooth segmentation. One in vitro study has

been done assessing the accuracy of tooth segmentation using AI technology to identify the accuracy and precision of different segmentation techniques in defining the mesial-distal (M-D) widths of all teeth (Im et al. 2022). It was concluded that using the automatic tooth segmentation method, there was a 97% success rate in accurately identifying the M-D widths of the teeth and that dentition tooth segmentation was efficiently completed in 57.23 seconds.

Though the previous study only focused on M-D width assessment, it supports that the use of AI in digital orthodontics provides an efficient and accurate analysis for virtual treatment planning (Im et al. 2022). As technology continues to advance and new ways of implementing the virtual setup evolve, digital orthodontics will continue to become more user-friendly. Despite this understanding, little information exists about the practical use of this technology in clinical settings. To date, no literature exists as to the use and accuracy of the indirect bracket technique with AI in clinical practice.

### **Factors Impacting the Clinical Use of Indirect Digital Bracket Techniques**

The Digital indirect bracket technique in orthodontics is continuing to evolve as the implementation in clinical practice is quickly gaining popularity. Only one study has been conducted to assess the percentage of orthodontists implementing indirect bracket bonding into clinical practice. This study showed that 44% of respondents were currently using indirect bracket bonding in practice (Keim et al. 2014). However, many issues may need to be addressed before the indirect technique becomes the standard of care. The first factor impacting the integration of the virtual setup in most practices is the need for specialized training of both the orthodontist and the clinical staff. Aside from the need to learn and comprehend the workflow of new software, training also requires clinic downtime as well as

a likely short-term drop-off in clinical productivity due to the learning process (Camardella et al. 2016; Cousley 2020). The second important factor limiting the use of the virtual setup is the high cost to implement this technology into practice (Camardella et al. 2016). In the current state of clinical orthodontics, most practices have already implemented the intraoral scanner for daily use. However, the integration of the digital indirect bracket technique requires the purchase of an indirect bonding software (table 1), and in some cases a 3-D printer to print models or fabricate transfer trays. In addition to the purchase of software, many companies also require a subscription for services ranging from model printing, transfer tray fabrication, and bracket insertion into the transfer tray. There may be other reasons this technology is not being introduced. For example, it is possible that the age of the orthodontist, the number of years in practice, the region of practice of the orthodontist, the amount of experience with digital orthodontics in residency, and possibly even the size of the practice could impact the implementation of this new digital technique into clinical practice.

### **Purpose Statement**

To date, very limited information exists evaluating the implementation of the digital indirect bracket technique in clinical orthodontic practice while considering practice and provider characteristics. Despite the wealth of knowledge about the indirect technique, no studies have assessed how many orthodontists are using the digital indirect bracket technique in practice. To gain a better understanding of this topic, this pilot study will aim to identify who is using the indirect technique in clinical practice and to identify trends, if any, regarding practice and provider characteristics.

## **Hypotheses**

1. Orthodontist demographics including region of orthodontic training, graduation year of orthodontist, gender, age of orthodontist, and race/ethnicity will impact the utilization of digital indirect bracket procedures in the practice.
2. Practice characteristics such as practice setting (ownership status in the practice), number of office locations, patient demographics (population served), region of practice, number of active patients, and practice model (percent of patients for which conventional fixed braces are used) will impact the utilization of digital indirect bracket procedures in the practice.

## CHAPTER 2

### METHODS

#### **Construction and Aim of Survey**

A survey consisting of 18 questions was developed to gather information regarding indirect bonding use in private and corporate-owned orthodontic practices in the United States. The frequency of utilization of indirect bonding and digital indirect bonding software was examined within the survey. The orthodontists' preferred procedures for indirect bonding and the perceived benefits of indirect bonding were also assessed.

The proposed survey had three domains. The first was the orthodontic practice characteristics, which involved questions regarding the number of office locations, regional location of the primary orthodontic office, and the number of active patients treated. This section also contained a screening question that prompted the survey to terminate if the participant was not currently an orthodontist in a private or corporate-owned practice. The second domain included questions about indirect bonding use, training, the perceived benefits, and factors that may prevent the utilization of indirect bonding. The third domain of the study was the orthodontist demographics, including questions regarding age, gender, race/ethnicity, and year of orthodontic residency graduation.

Following a review of the survey during an Oral and Craniofacial Sciences (OCS) Master of Science (MS) committee meeting, some survey updates were made in response to committee suggestions. The updated survey was then reviewed by two faculty members in the University of Missouri-Kansas City (UMKC) Advanced Orthodontics and Dentofacial Orthopedics program to evaluate the content, order, and clarity of the survey questions. These evaluators were given an electronic copy of the survey that included space for

feedback for each question. The feedback evaluation request is located in Appendix A. The comments from the survey evaluation were utilized when revising the survey for final distribution. The final survey was constructed and securely stored in Research Electronic Data Capture (REDCap) software, which is hosted by The Center for Health Insights of UMKC (Harris et al. 2009; Harris et al. 2019).

After the survey was initially entered into REDCap, several committee members were asked to take the survey to test for any errors. It was decided to distribute the survey in an electronic format via email mainly due to convenience and cost. The electronic survey allowed termination of the survey immediately if exclusion criteria were met. This format also provides the option for branching questions, which aided in the avoidance of survey fatigue for respondents. A copy of the final survey can be found in Appendix B.

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

A link to the final survey was distributed electronically through the American Association of Orthodontists (AAO) Partners in Research program following completion of an agreement and payment of a \$275 fee. The survey was intended for practicing orthodontists in private or corporate-owned practices who were currently members of the AAO (N= 8,430 orthodontists) (AAO 2023). The survey link was sent via email to approximately 2,300 U.S. orthodontists, who were randomly selected by the AAO. The email with the survey request is located in Appendix C. Approximately three weeks after the initial email was sent, the same email was sent to the same recipients asking them to complete the survey if they have not already done so. No further communication occurred with the recipients of the survey. Before distributing the survey, the Institutional Review

Board (IRB) at UMKC reviewed and approved the protocol and associated documents as exempt (IRB #2097420). The IRB approval form is included in Appendix D.

### **Experimental Design**

This study was a cross-sectional, non-experimental design based on an 18-question survey. There were two independent variables, orthodontic practice characteristics and orthodontist demographics and one dependent variable, utilization of indirect bonding. Within the survey, questions 1-6 were related to the domain of orthodontic practice characteristics and questions 14-18 were related to orthodontist demographics, while question 8 was related to indirect bonding utilization. Questions 7 and 9-13 were opinion-based questions related to the use of indirect bonding in clinical practice. Associations between utilization of indirect bonding and orthodontic practice characteristics and orthodontist demographics were also examined. The study design is outlined in table 2.

### **Data Analysis**

For all variables from the survey data, descriptive statistics including percentages and counts were calculated. To evaluate the hypotheses of the study, Chi-square and Fisher's Exact tests were utilized within a statistical software program<sup>1</sup>. Significance for all testing was set at  $p \leq 0.05$ .

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<sup>1</sup> SPSS Statistics for Windows, Version 26.0. IBM Corp., Armonk, NY 10504

TABLE 2  
EXPERIMENTAL DESIGN

Independent variables	Specific questions	Dependent variables
Orthodontic practice characteristics	<ul style="list-style-type: none"> <li>• Current practice setting (Q1)</li> <li>• Number of office locations (Q2)</li> <li>• Population type of area being served (Q3)</li> <li>• Office location by region (Q4)</li> <li>• Number of current active patients (Q5)</li> <li>• Percentage of active patients receiving conventional orthodontics (Q6)</li> </ul>	Utilization of indirect bonding in the orthodontic practice (Q8)
Orthodontist demographics	<ul style="list-style-type: none"> <li>• Region of orthodontic training (Q14)</li> <li>• Year of graduation from orthodontic residency (Q15)</li> <li>• Self-identified gender (Q16)</li> <li>• Age (Q17)</li> <li>• Race/ethnicity (Q18)</li> </ul>	
<p>Sample size (n) = 79 orthodontists responding to survey</p> <p>*Questions 7,9-13 are opinions on the use of indirect bonding in practice*</p>		

## CHAPTER 3

### RESULTS

#### **Orthodontist Demographics**

Only 79 orthodontists of approximately 2,300 to whom the survey was sent completed the survey, for a response rate of approximately 3%. The sample of survey respondents, as well as their utilization of indirect bonding, is summarized (table 3). The majority of respondents were male (80%), aged 60 and older (33%), identified as White/Caucasian (88%), graduated prior to 2000 (53%), and had orthodontic training in the Midwest region (38%). Graduation year was the only orthodontist demographic significantly associated with IDB utilization. Graduates from orthodontic residency between the years 2000 and 2009 were more likely to utilize indirect bonding compared to those who graduated prior to 2000 or 2010 and after.

TABLE 3

ORTHODONTIST DEMOGRAPHIC VARIABLES ASSOCIATED  
WITH DIGITAL INDIRECT BONDING USE

	Sample N = 79 N (Col. %)	IDB use		p-value*
		Yes N (Row %)	No N (Row %)	
Gender (N=76)***				0.18
Male	61 (80.3%)	21 (34.4%)	40 (65.6%)	
Female	15 (19.7%)	8 (53.3%)	7 (46.7%)	
Age (N=78)				0.07**
Younger than 40	11 (14.1%)	3 (27.3%)	8 (72.7%)	
40-49	18 (23.1%)	11 (61.1%)	7 (38.9%)	
50-59	23 (29.5%)	10 (43.1%)	13 (56.5%)	
60 or older	26 (33.3%)	6 (23.1%)	20 (76.9%)	
Race/Ethnicity (N=77)				0.72**
White/Caucasian	68 (88.3%)	25 (36.8%)	43 (63.2%)	
Other/Multiple	9 (11.7%)	4 (44.4%)	5 (55.6%)	
Graduation Year (N=76)				0.02
Prior to 2000	40 (52.6%)	10 (25.0%)	30 (75.0%)	
2000-2009	17 (22.4%)	11 (64.7%)	6 (35.3%)	
2010 or after	19 (25.0%)	8 (42.1%)	11 (57.9%)	
Region of Orthodontic Training (N=78)				0.82
Pacific/Rocky Mtn/Southwest/Noncontig	16 (20.5%)	5 (31.3%)	11 (68.8%)	
Midwest	30 (38.5%)	11 (36.7%)	19 (63.3%)	
Southeast	15 (19.2%)	6 (40.0%)	9 (60.0%)	
Northeast	17 (21.8%)	8 (47.1%)	9 (52.9%)	

\*Calculated using a Chi-square test or \*\*Fisher's Exact Test

\*\*\*Missing data excluded from tests of association

**Orthodontic Practice Characteristics and Training  
Associated with Digital Indirect Bonding Use**

The orthodontic practice characteristics associated with IDB use of the orthodontists who responded to the survey are summarized (table 4). The majority of respondents were owners/associates of private practice orthodontic offices (87%), worked at only one office location (52%), and served suburban populations (68%). The respondents were fairly evenly

dispersed among the U.S. geographic regions. Most respondents had between 501-750 active patients (42%) and used conventional fixed braces in >75% of cases (52%). There were no statistically significant associations between orthodontic practice characteristics and IDB use.

TABLE 4

PRACTICE CHARACTERISTICS ASSOCIATED  
WITH DIGITAL INDIRECT BONDING USE

	Sample N = 79 N (Col. %)	IDB Use Yes N (Row %)	No N (Row %)	p-value*
Practice Setting				0.17**
Owner/Associate of private practice	69 (87.3%)	24 (34.8%)	45 (65.2%)	
Employee in corporate practice/Other	10 (12.7%)	6 (60.0%)	4 (40.0%)	
Office Locations				0.86
1	41 (51.9%)	15 (36.6%)	26 (63.4%)	
2	21 (26.6%)	9 (42.9%)	12 (57.1%)	
3 or greater	17 (21.5%)	6 (35.3%)	11 (64.7%)	
Population Served (N=77)				0.17**
Rural	16 (20.8%)	9 (56.3%)	7 (43.8%)	
Suburban	52 (67.5%)	16 (30.8%)	36 (69.2%)	
Urban	9 (11.7%)	4 (44.4%)	5 (55.6%)	
Region of Practice				0.60
Pacific	14 (17.7%)	7 (50.0%)	7 (50.0%)	
Rocky Mtn/Southwest/Noncontig	14 (17.7%)	4 (28.6%)	10 (71.4%)	
Midwest	19 (24.1%)	6 (31.6%)	13 (68.4%)	
Southeast	18 (22.8%)	6 (33.3%)	12 (66.7%)	
Northeast	14 (17.7%)	7 (50.0%)	7 (50.0%)	
Active Patients (N=71)				0.53**
500 or less	28 (39.4%)	8 (28.6%)	20 (71.4%)	
501-750	30 (42.3%)	13 (43.3%)	17 (56.7%)	
Greater than 750	13 (18.3%)	5 (38.5%)	8 (61.5%)	
Conventional Fixed Braces				0.59**
< 50%	8 (10.1%)	2 (25.0%)	6 (75.0%)	
≥ 50% but < 75%	30 (38.0%)	13 (43.3%)	17 (56.7%)	
> 75%	41 (51.9%)	15 (36.6%)	26 (63.4%)	

\*Calculated using a Chi-square test or \*\*Fisher's Exact Test

Most respondents had been trained on IDB use (89%) (table 5). The majority of respondents reported that they received training for IDB within orthodontic residency (57%) and via sales staff or the manufacturer (43%). Respondents who reported receiving training for IDB use by a sales staff or manufacturer and training by a practice colleague were significantly more likely to use than not use IDB ( $p=0.02$  and  $p<0.01$ , respectively). Additionally, respondents who noted they were not trained on IDB use were significantly less likely to use than not use IDB in their practice (0% vs 18%,  $p=0.01$ ).

TABLE 5  
TRAINING FOR INDIRECT BONDING

	Sample N = 79 N (%)	IDB Use Yes N (%)	No N (%)	p-value*
Have You Been Trained on IDB Use?***				
Yes within dental school training	3 (3.8%)	1 (3.3%)	2 (4.1%)	0.99**
Yes within orthodontic residency training	45 (57.0%)	15 (50.0%)	30 (61.2%)	0.33
Yes within a continuing education course	21 (26.6%)	11 (36.7%)	10 (20.4%)	0.11
Yes via sales staff or manufacturer	34 (43.0%)	18 (60.0%)	16 (32.7%)	0.02
Yes via practice colleague	16 (20.3%)	11 (36.7%)	5 (10.2%)	<0.01
No	9 (11.4%)	0 (0.0%)	9 (18.4%)	0.01**

\*Calculated using Chi-square tests or \*\*Fisher's Exact Test

\*\*\*Multiple answers can be selected, so will not sum to 100%.

### Respondents Who Utilize Indirect Bonding

Of the 30 respondents who reported using IDB, the majority used the digital indirect technique (83%) (table 6). Most respondents reported using IDB in greater than 75% of fixed cases (50%) followed by those who use IDB for less than 25% of fixed cases (37%). The majority of these respondents reported that the transfer tray fabrication for IDB use is done using commercial labs (76%).

TABLE 6

IDB USE CHARACTERISTICS FOR RESPONDENTS  
WHO USED IDB (N=30)

Type of IDB Used	N (%)
Manual Indirect Technique	5 (16.7%)
Digital Indirect Technique	25 (83.3%)
How Often is IDB Used in all Fixed Cases	
Less than 25%	11 (36.7%)
25% or more but less than 75%	4 (10.3%)
Greater than 75%	15 (50.0%)
How Transfer Tray is Fabricated	
In-house fabrication	7 (23.3%)
Commercial lab fabrication	23 (76.7%)
Both	0 (0%)

The main reported perceived benefit of IDB use was the ability to delegate procedures to staff (90%) followed by more efficient bonding procedures (83%) and more accurate bracket positioning (70%).

TABLE 7

BENEFITS OF IDB USE FOR RESPONDENTS  
WHO USE IDB (N=30)

Benefits of IDB Use in Practice*	N (%)
Ability to delegate procedures to staff	27 (90.0%)
More efficient bonding procedures	25 (83.3%)
More accurate bracket positioning	21 (70.0%)
Enhanced overall case completion efficiency	18 (60.0%)
Increased patient satisfaction	16 (53.3%)
Improved orthodontic treatment results	14 (46.7%)
Other	3 (10.0%)
The are no benefits of indirect bonding use in orthodontic practice	0 (0%)

\*Multiple answers can be selected, so will not sum to 100%.

### Respondents Who Do Not Utilize Indirect Bonding

Of the 49 respondents who did not use IDB, the main barriers to using IDB were cost, the belief that indirect bonding will not increase efficiency, and other factors (49%, 37%, and 37% respectively).

TABLE 8

WHAT PREVENTS IDB USE FOR RESPONDENTS  
WHO DO NOT USE IDB (N=49)

Reasons for Not Using IDB in Practice	N (%)
Cost	24 (49.0%)
Indirect bonding will not increase efficiency	18 (36.7%)
Other	18 (36.7%)
Indirect bonding is not a reliable alternative to direct bonding	11 (22.4%)
Lack of training on indirect bonding	8 (16.3%)
Lack of indirect bonding software training	6 (12.2%)

\*Multiple answers can be selected, so will not sum to 100%.

## CHAPTER 4

### DISCUSSION

A total of 79 orthodontists participated in this survey. Of those respondents, 38% stated that they use IDB within their practice. Compared to a 2014 study, 18% of polled orthodontists reported using IDB routinely and 15% used IDB occasionally (Keim et al. 2014). It is reasonable to assume that during the last ten years since that study, usage of IDB would have become more common in orthodontic practices as providers have adopted more technologies into their practices.

The majority of orthodontist demographics were not associated with IDB use in this study. The majority (80%) of the respondents to this survey were male. This is not surprising, as approximately 63% of active orthodontists who are members of the AAO are men (AAO 2024). Also, unsurprising was that 88% of respondents identified as White/Caucasian, which aligns with the fact that 68% of dentists in the United States are White/Caucasian (ADA 2023). However, graduation year was significantly associated with IDB use. This study found that 75% of respondents who graduated prior to the year 2000 did not use IDB but 64% of those who graduated between 2000-2009 were using IDB in practice. One possible explanation for this discrepancy may be stability within the career of the orthodontist. Additionally, of the group who graduated 2010 and after, 58% reported they are not using IDB. It would seem likely that younger orthodontists or those who graduated more recently from residency may have more interest or more exposure to newer technologies such as digital IDB software and would be more likely to implement IDB use in practice. This, however, was not the case for those of the most recent graduation group,

possibly due to the position they hold within the practice and the inability to incorporate new techniques due to lack of autonomy.

Practice characteristics did not have a significant impact on the use and implementation of IDB in practice. The majority of respondents were owners or associates of a private practice and worked in single-office locations in suburban settings. It was predicted that orthodontists who practice in urban settings would be more likely to utilize IDB and newer technologies as a way to set their practices apart and be more competitive. Additionally, it was expected that orthodontists with a larger number of active patients and those using fixed braces in a higher percentage of cases would be more likely to utilize IDB. However, none of these associations were seen in this study.

It was hypothesized that orthodontists who received training on IDB use in residency or dental school would be more likely to use IDB in practice. This trend was not supported in this survey. There was however a significant association between orthodontists who were trained on IDB use either by a sales staff or manufacturer or via a practice colleague and the use IDB in practice. It is reasonable to assume that a significant association for IDB use and training by a sales staff or manufacturer is likely a result of the orthodontist purchasing or considering purchasing the software and supplies necessary for IDB use in practice. Another possible explanation for the association between training via a practice colleague and IDB use is that orthodontists who are joining a practice already using IDB are much more likely to use this technique if it is already part of the practice system. Last, there was a significant association between those who have not been trained in IDB use and the decision to not utilize IDB in practice. This should come as no surprise because respondents who have not received training for IDB likely will not be utilizing this system in practice.

Given the technological advancement in a majority of orthodontic practices, it was hypothesized that a majority of respondents would use the digital indirect technique, use IDB for the vast majority of their fixed cases, and utilize a commercial lab for fabrication of transfer trays. This was in fact the trend that was seen within this study.

When asked about potential benefits of IDB use, 90% of orthodontists who use IDB stated that the ability to delegate bonding procedures to staff was a perceived benefit. Additionally, 83% of those using IDB stated that they believe IDB provides more efficient bonding procedures. This finding is similar to other studies which show that IDB improves chair time efficiency for the orthodontist (Sondhi 2007; Bozelli et al. 2013; Nojima et al. 2015; Czolgosz et al. 2021). Other perceived benefits include more accurate bracket positioning and enhanced overall case completion efficiency. A study completed by Oliveira et al. also showed similar findings regarding more accurate bracket positioning with IDB (2019).

On the contrary, when asked about factors that prevent the use of IDB, orthodontists who do not utilize IDB stated that cost is the major limiting factor for implementing this technique in practice. This finding is similar to a previous study by Camardella et al. which showed that cost of IDB limits its use in most practices (2016). Another factor limiting the use of IDB is the belief that IDB will not increase efficiency in office systems. This finding indirectly supports that of a previous study which showed a major limiting factor in IDB implementation is the need for clinical downtime and a short-term drop-off in clinical productivity due to a learning curve required for IDB to become an efficient procedure clinically (Camardella et al. 2016; Cousley 2020). Respondents were given the opportunity to provide opinions on other limitations to the implementation of IDB. These limitations

included the time required to train and implement this technique, additional armamentarium needed, additional staff time, the inability to fit into the clinical workflow, more bracket breakage, and the flash removal required after bonding.

### **Clinical Implications**

The current study demonstrated that only 38% of orthodontists surveyed utilized IDB in their practices. However, it appears that most orthodontists believe that there are benefits to using IDB for fixed braces in orthodontics patients. Indirect bonding procedures can be used for fixed cases to improve clinical efficiency through quicker bonding procedures and the ability to delegate these procedures to clinical staff. Additionally, IDB can provide more accurate bracket positioning which in-turn decreases treatment time, improves treatment results, and increases overall patient satisfaction. Therefore, the use of IDB benefits both the orthodontist and the patient for which orthodontic treatment is being provided. If more focus can be directed toward training orthodontic specialists and staff members on the use of IDB, perhaps more orthodontists would utilize this technology in their practices.

### **Study Limitations**

The main limitation of this study was the small sample size. Despite being sent to approximately 2,300 orthodontists, only 79 orthodontists responded to the survey. It is possible then that the results of this survey may not reflect the views of the entire orthodontic practitioner population. Nonresponse bias may also be a factor in that those who are not interested in indirect bonding use may have been less likely to participate in the study, while orthodontists who are more involved with indirect bonding use may have been more willing to respond. If this were the case, the results of the study could be biased. Finally, recall bias could play a role. Several of the items in the survey asked the participant to reflect on the

frequency of indirect bonding use, the percentage of fixed cases using indirect bonding, and other questions that would require the respondent to remember accurately numerical values from their practice. If these estimations were not correctly reported, the data could be a misrepresentation of what is truly happening in these practices.

### **Future Investigations**

Utilizing the AAO Partners in Research program alone for survey distribution did not result in a substantial number of responses. However, it is possible that adding an incentive, such as an entry into a raffle for a prize or gift card, could increase the survey response rate. It could also be beneficial to examine certain aspects of this survey in more depth. For example, this study showed a statistically significant association between training and IDB use in practice. However, a cause-and-effect relationship between training and IDB use cannot be determined from this survey. A future study, therefore, could involve a prospective study on training vs. IDB use. A survey of current orthodontic residents could also be beneficial to further examine the current curriculum on IDB within orthodontic residency programs.

## CHAPTER 5

### CONCLUSIONS

1. In general, graduation year was the only statistically significant association between orthodontist demographics and indirect bonding use. All other demographic factors were not significantly associated with indirect bonding use in practice. Additionally, there was a statistically significant association between training on indirect bonding use from sales staff, the manufacturer, or practice colleagues, and indirect bonding use in practice. Similarly, a lack of training on indirect bonding use was also significantly associated with a respondent being less likely to utilize indirect bonding in practice.
2. The practice characteristics were not associated with whether the provider used indirect bonding in their office.

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APPENDIX A

SURVEY EVALUATION FEEDBACK REQUEST

Dear Dr. (XXXXXX),

Thank you for agreeing to take time to review my survey. Please **evaluate the attached survey for clarity and content.**

This survey is part of my UMKC thesis project to evaluate the use of indirect bonding within private and corporate-owned orthodontic practices. The survey is intended for practicing orthodontists who are members of the American Association of Orthodontists. The final survey will be distributed electronically.

Please note that in the paper format I have provided to you, some questions will have prompts in parentheses such as, “(Skip if answered “yes” to Q8).” Therefore, the survey will be shorter for some participants based on their specific responses.

You do not need to complete the survey. Instead, please examine each question critically, and select ‘Yes’ or ‘No’ to indicate if you feel the question is OK. Also, please leave comments in the area below each question as needed. Your comments will help me improve the survey prior to its final distribution to AAO members throughout the United States.

Thank you again for your assistance and feedback. I appreciate your time and willingness to help with my project.

Respectfully,

Charlie Boehm, DDS, MS  
UMKC School of Dentistry  
Resident, Dept. of Orthodontics & Dentofacial Orthopedics  
MS Candidate, Dept. of Oral and Craniofacial Sciences

APPENDIX B

SURVEY

### Practice Characteristics

1. What is your current primary practice setting? (Survey will end if answers D, E, or F are selected)
  - a. Owner of a private practice
  - b. Associate in a private practice
  - c. Employee of a corporate-owned practice
  - d. Orthodontic staff member
  - e. Employed in a full-time academic position
  - f. Not practicing or retired
  - g. Other: please specify
2. How many office locations belong to the practice in which you work (your practice network)?
  - a. 1
  - b. 2
  - c. 3 or greater
3. How would you describe the population of the area that your primary office is serving?
  - a. Rural
  - b. Suburban
  - c. Urban

4. Based on the map, in which region is your primary office located?



- Pacific
  - Rocky Mountains
  - Southwest
  - Midwest
  - Southeast
  - Northeast
  - Noncontiguous
5. Approximately how many active patients are currently being treated at your primary office? This includes all comprehensive, limited, and phase I patients but does NOT include patients in retention.
- 250 or less
  - 251-500
  - 501-750
  - 751-1000
  - Greater than 1000

6. Approximately what percentage of your active patients are treated with conventional fixed orthodontic appliances at your primary office? (Conventional fixed orthodontic appliances include bonded brackets engaged by an orthodontic archwire)
  - a. Less than 25%
  - b. 25% or more but less than 50%
  - c. 50% or more but less than 75%
  - d. Greater than 75%

### **Indirect Bonding**

**For the following questions, indirect bonding is defined as using a transfer tray for bracket positioning intraorally.**

7. Have you ever been trained on indirect bonding? Select all that apply.
  - a. Yes, within dental school training
  - b. Yes, within orthodontic residency training
  - c. Yes, within a continuing education course
  - d. Yes, via instruction from sales staff or manufacturer (printed, audio-visual materials or hands-on training)
  - e. Yes, via instruction from a practice colleague
  - f. No, I have not been trained on indirect bonding use

**If no to question #8, questions #9-12 will not be asked, question #13 will be asked instead.**

8. For those patients treated with conventional fixed orthodontic appliances, do you utilize indirect bonding within your primary office?
  - a. Yes
  - b. No
9. (If yes to question 8) What type of indirect bonding do you utilize in your primary office? Select all that apply:
  - a. Manual indirect bonding (bracket positioning on physical models)
  - b. Digital indirect bonding (using a software program for bracket positioning)

10. (If yes to question 8) For patients treated with conventional fixed orthodontics, what percentage of these cases is indirect bonding utilized in your primary office?
- Less than 25%
  - 25% or more but less than 50%
  - 50% or more but less than 75%
  - Greater than 75%
11. (If yes to question 8) Do you fabricate transfer trays in-house or do you order from a lab?
- In-house fabrication
  - Commercial lab fabrication
  - Both
12. (If yes to question 8) Which of the following do you feel are benefits of indirect bonding use in your primary practice? Select all that apply.
- More efficient bonding procedures
  - More accurate bracket positioning
  - Ability to delegate procedures to staff
  - Enhanced overall case completion efficiency
  - Improved orthodontic treatment results
  - Increased patient satisfaction
  - Increased revenue within the orthodontic practice
  - Other: please specify
  - There are no benefits of indirect bonding use in an orthodontic practice
13. (If no to question 8) What prevents you from utilizing indirect bonding in your primary practice? Select all that apply.
- Indirect bonding is not a reliable alternative to direct bonding
  - Indirect bonding will not increase efficiency
  - Lack of training on indirect bonding
  - Lack of indirect bonding software training
  - Cost
  - Other: please specify

## Orthodontist Demographics

14. Based on the map, in what region did you complete your orthodontic training (residency)?



- a. Pacific
- b. Rocky Mountains
- c. Southwest
- d. Midwest
- e. Southeast
- f. Northeast
- g. Noncontiguous

15. What year did you graduate from orthodontic residency?

- a. Prior to 2000
- b. 2000-2009
- c. 2010-2019
- d. 2020 or after

16. With what gender do you self-identify?
- a. Male
  - b. Female
  - c. Other/prefer to self-describe: please specify
17. What is your age?
- a. Younger than 30
  - b. 30-39
  - c. 40-49
  - d. 50-59
  - e. 60 or older
18. What is your race/ethnicity? Select all that apply.
- a. White/Caucasian
  - b. Black/African American
  - c. Hispanic/Latino
  - d. Native American Indian or Alaska Native
  - e. Asian
  - f. Native Hawaiian/Pacific Islander
  - g. Other/prefer to self-describe: please specify

APPENDIX C

AAO SURVEY INITIAL EMAIL AND REMINDER EMAIL

Dear AAO Member,

My name is Charlie Boehm, and I am an orthodontic resident and Master of Science candidate in the Oral and Craniofacial Sciences program at the University of Missouri-Kansas City School of Dentistry. I am working on a thesis project focused on educational research related to the use of indirect bonding in orthodontics. Specifically, the goal of my project is to better understand how the use of indirect bonding in a private or corporate-owned practice might be influenced by orthodontist demographics and practice characteristics. To accomplish my research goals, I am requesting that you complete a short survey, which can be accessed via the link provided below.

This 18-question survey should take approximately 5-10 minutes to complete. All survey responses are anonymous with no identifying markers linked to your responses.

Please complete this survey within 10 days of receiving it from the AAO.

Any survey responses you provide will be a valued contribution to this project, and I thank you in advance for your time.

If you have any questions regarding your rights as a research participant, you may contact the UMKC IRB at 816-235-5927.

Sincerely,

Charlie Boehm, DDS, MS  
UMKC School of Dentistry  
Resident, Dept. of Orthodontics & Dentofacial Orthopedics  
MS Candidate, Dept. of Oral and Craniofacial Sciences

APPENDIX D

IRB APPROVAL LETTER



**Institutional Review Board**  
University of Missouri-Kansas City

5319 Rockhill Road  
Kansas City, MO 64110  
816-235-5927  
umkcirb@umkc.edu

July 03, 2023

Principal Investigator: JoAnna Scott  
Department: Dean, School of Dentistry

Your IRB Application to project entitled "Digital Indirect Bracket Bonding In Orthodontic Practice -- Scott/Boehm" was reviewed and determined to qualify for IRB exemption according to the terms and conditions described below:

IRB Project Number	2097420
IRB Review Number	395387
Initial Application Approval Date	July 03, 2023
IRB Expiration Date	N/A
Project Status	Active - Exempt
Exempt Categories	45 CFR 46.104(d)(2)
Risk Level	Minimal Risk

Approved Documents

- IRB #2097420 Boehm AAO Email Information Script 06-30-23 V1.0
- IRB #2097420 Boehm Survey 06-30-23 V1.0
- IRB #2097420 Boehm Survey Bases Research Proposal 06-30-23 V1.0
- IRB #2097420 Boehm Thesis Example Data Collection Form 06-30-23 V1.0

The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the determination:

1. No subjects may be involved in any study procedure prior to the determination date.
2. Changes that may affect the exempt determination must be submitted for confirmation prior to implementation utilizing the Exempt Amendment Form.
3. Maintain all research records for a period of seven years from the project completion date.

If you are offering subject payments and would like more information about research participant payments, please click here to view the UM system Policy on Research Subject Payments: [https://www.umsystem.edu/oei/sharedservices/apss/nonpo\\_vouchers/research\\_subject\\_payments](https://www.umsystem.edu/oei/sharedservices/apss/nonpo_vouchers/research_subject_payments)

If you have any questions, please contact the IRB at 816-235-5927 or [umkcirb@umkc.edu](mailto:umkcirb@umkc.edu).

Thank you,  
UMKC Institutional Review Board

## VITA

NAME: Richard Charles Boehm

DATE AND PLACE OF BIRTH: February 1, 1994; Saint Louis, Missouri

### EDUCATION:

5/2012	Diploma	DeSmet Jesuit High School Saint Louis, MO
5/2016	B.S. Biology	Rockhurst University Kansas City, MO
6/2018	M.S. Biomedical Sciences	Kansas City University of Medicine and Biosciences Kansas City, MO
5/2022	D.D.S.	University of Missouri-Kansas City School of Dentistry Kansas City, MO
12/2024 In Process	M.S. Oral and Craniofacial Sciences	University of Missouri-Kansas City School of Dentistry Kansas City, MO
12/2024 In Process	Orthodontics and Dentofacial Orthopedics	University of Missouri-Kansas City School of Dentistry Kansas City, MO

### PROFESSIONAL ORGANIZATIONS:

2018-Present American Dental Association  
2018-Present Missouri Dental Association  
2022-Present American Association of Orthodontists

### HONORS:

2021 Omicron Kappa Upsilon Honor Society Scholarship  
2021 UMKC SOD Orthodontic Honors Program  
2022 Quintessence Award for Research Achievement