PRAC Assessment Grant Final Report

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Background

Orthodontic postgraduate programs are advanced dental education programs that train general dentists to become orthodontists over a 2-3 year period. Postgraduate programs are charged by the Commission of Dental Accreditation (CODA), the accrediting body of Indiana University School of Dentistry and most of its affiliated programs, to ensure that orthodontic graduates have an understanding of "the variety of recognized techniques used in contemporary orthodontic practice (Accreditation Standards for Orthodontic and Dentofacial Orthopedics Programs, Standards 4-4)." Therefore, during an orthodontic residency program, graduate students learn a multitude of didactic and clinical knowledge that will allow them to safely and effectively manage the orthodontic needs of the general public. One of the most essential skills a graduate orthodontic student will learn during their program is how to correctly place orthodontic brackets on teeth. This important skill is taught by one of two methods: 1) direct bracket bonding (DB) or 2) indirect bracket bonding (IDB). Direct bracket bonding was first described approximately 50 years ago (Newman 1965) and has since undergone several modifications (Lee 1974; Newman 1974; Zachrisson 1978). In general however, direct bracket bonding involves an orthodontist placing each individual bracket by hand on a patient's teeth. With the indirect bracket bonding technique, orthodontic brackets are first placed on a dental cast and later transferred to the patient's mouth via a transfer tray (Thomas 1979). While both techniques are taught in orthodontic graduate programs, research comparing the accuracy of direct versus indirect bonding methods has left much to be debated (Aguirre 1982; Shpack 2007; Hickman 1993; Hodge 2004; Koo 1999). Some studies report that the direct technique is superior (Koo 1999), while others claim that indirect bonding results in greater accuracy (Shpack 2007). Still others have shown that the two techniques are equivalent, as both direct and indirect bonding results in clinically satisfactory results (Zachrisson 1978; Hodge 2004). When evaluating the overall accuracy of bracket placement with these two techniques, the orthodontic literature indicates that there is no difference or only a very slight advantage in using the indirect bonding method (Aguirre 1982; Hickman 1993; Koo 1999; Hodge 2004; Shpack 2007).

Accurate bracket placement is important because errors in bracket placement result in positional tooth discrepancies (Suaréz 2009) such as deviations in tooth rotation, tipping, in/out, extrusion/intrusion, and torque (McLaughlin 1995). These problems can result in a number of adverse treatment outcomes including increased total treatment time and suboptimal orthodontic treatment results. Therefore, to reduce the potential for these problems, orthodontist must quickly enhance their ability to identify the proper position for orthodontic brackets.

Most postgraduate orthodontic programs typically provide their students with foundational information on bracket placement via lectures or limited pre-clinical laboratory activities and then have them continue to improve their skills on actual patients. By trial and error, with only subjective feedback from their faculty members, graduate orthodontic students gradually gain more experience and an increased ability to adequately place brackets. Unfortunately, the rate of improvement for each student is extremely variable and it is difficult to ensure that a student has reached a level of clinical competence prior to the end of their formal training. Furthermore, within the dental and orthodontic literature, there are no studies that have investigated the best method for training or assessing graduate orthodontic students in this fundamental clinical skill. To help address this current void in knowledge, the aims of this pilot study are to:

1. Gain information that suggests an optimal method for teaching orthodontic bracket placement to graduate orthodontic students.

2. Develop and evaluate a novel digital method of assessing proper bracket placement and providing objective feedback during student training.

Summary of Intended Outcomes and Project Accomplishments

The "Novel Approach to Assessing Orthodontic Bracket Placement Teaching Techniques: A Pilot Study" project ran from June 1, 2013– May 1, 2014. The project was funded by a Program Review and Assessment Committee (PRAC) grant and an IUSD DDS Student Research Program Fellowship grant. This section provides a summary of the project's intended outcomes and accomplishments.

The project's intended accomplishments include obtaining data that would suggest:

1. Which bracket placement teaching technique (direct vs. indirect) is more effective in enhancing a student's bracket placement abilities,
2. Whether a digital assessment technique can be developed to more objectively evaluate a student's bracket positioning in a simulated clinical situation.

Materials and Methods

Following approval from the Indiana University School of Dentistry Institution Review Board, graduate orthodontic students were recruited for this pilot study. The inclusion criteria for student participation were as follows: 1) must be a current orthodontic graduate student, 2) must have less than 1 year of bracket placement experience, and 3) must be willing to participate in the pilot study. The recruited students were randomly assigned to one of the two groups. Group 1 performed bracket placement training on hand-held stone models, indirect bracket placement technique, while Group 2 performed bracket placement training using stone models mounted in mannequin simulation units, direct bracket placement technique. From this point forward in the report Group1 will be referred to as HHG and Group 2 as MMG.

Bracket Placement Training & Assessments

A prospective, longitudinal, cohort study design was utilized for this study. All recruited students participated in a total of 5 sessions during the study (Figure 1), an initial assessment session, three training sessions, and a final assessment session.

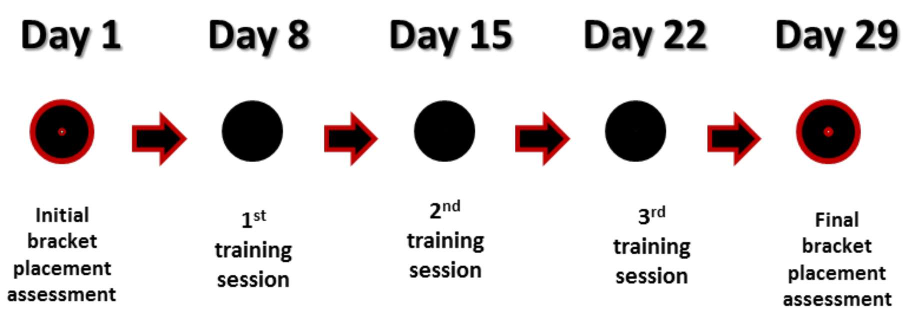

Figure 1. Depiction of study design

During the initial and final assessments, both groups were given 1 hour to place 10 ceramic brackets (3M Unitek, CA) (Figure 2A), from second premolar to second premolar, on a maxillary stone model in mannequin simulation units. The stone models (Figure 2B) were composed of orthodontic plaster (Whipmix, KY) and customized to include a small magnetic base (Figure 2C) that allowed the model to adhere to the simulation unit.

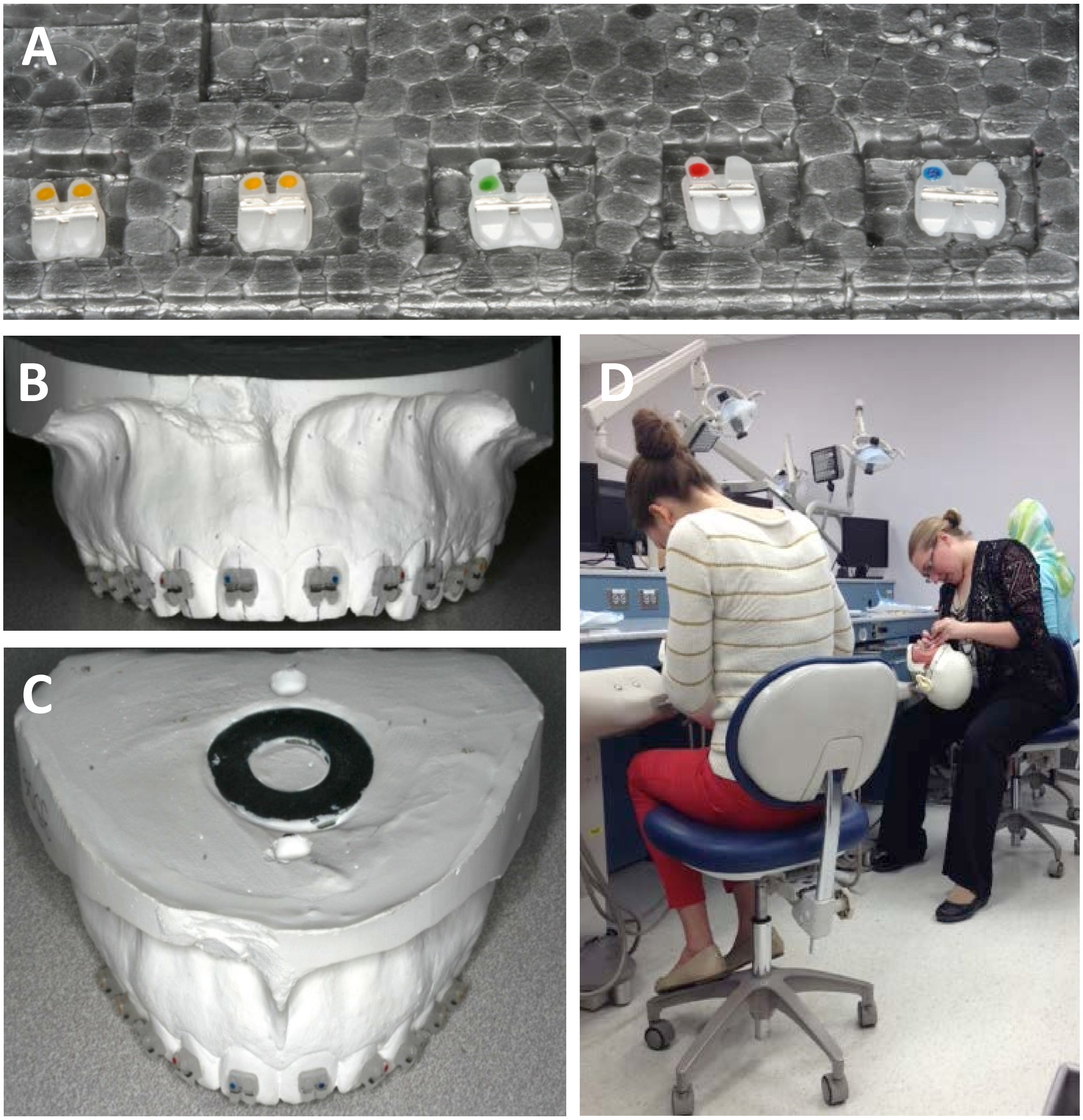

Figure 2. A. 3M ceramic brackets used in the study, B. Master plaster model with ceramic brackets in place, C. Customized orthodontic stone model used to mount in simulation units, D. Photograph of students using simulation units during the initial bracket placement assessment.

The simulation unit/ stone model complex was used to simulate bracket placement on a patient in a true clinical setting. Identical stone models were utilized for both the initial and final assessment sessions to allow for the longitudinal evaluation of the students' performance. Students used a color-changing composite resin (Transbond Plus, 3M Unitek, CA) to bond the brackets to the stone models. Composite resin curing lights (Ortholux, 3M Unitek, CA) were used to polymerize the composite resin and firmly attach the brackets to the stone model. The following instructions were given to the students during the assessments:

1) Place each bracket on the correct tooth,
2) Position each bracket in the middle of the designated teeth horizontally (mesiodistally) and vertically (occlusogingivally),
3) Remove all excess composite resin prior to polymerizing the composite resin,
4) No additional guidance or feedback on bracket positioning would be given during the assessments.

Training Sessions

Between the initial and final bracket placement assessment sessions, each group met for additional bracket placement training sessions over a three-week period (Days 8, 15, and 22). The two groups met once per week, for 1 hour, and practiced bracket placement using the teaching modality designated for their group (hand-held models or models in simulation unit). Three different stone models were used during the three-week training period, with the degree of bracket placement difficulty increasing from one week to the next. Due to the high cost of orthodontic ceramic brackets ($2.50-20.00 per bracket), the students used metal brackets (Advant-Edge I Bracket, TP Orthodontics, IN) during the training sessions. Overall, the students followed the same procedural instructions as previously noted. The only instructional variations were that students could seek guidance/feedback on their bracket positioning during the training sessions and there was no time limitations placed on the students during the training sessions.

Data Collection and Bracket Accuracy Evaluation Methods

After the experiment, a single investigator (K.S) scanned all the models from the initial and final assessment sessions using an Itero IOC scanner (Cadent, CA) (Figure 2A). This process created digital versions of the models in a Standard Tessellation Language (.STL) format that could be used to conduct the bracket accuracy portion of the pilot study. The digital files were then imported into the 3dMD Vultus superimposition software (3dMD, GA). Bracket discrepancies between models were evaluated using a surface tomography feature in the Vultus software. Since the same stone models were used for the initial and final assessment, the teeth and palate of the models served as reference points/areas and allowed for the superimposition, or exact overlapping, of the models. By superimposing the models, the difference in bracket position between the two time points could be assessed (Figure 3). Once the superimposition was completed, the total degree of bracket discrepancy, for the 10 brackets, was quantified and a total numerical surface discrepancy was automatically calculated. Along with assessing the discrepancy in bracket placement from one time point to another, each student's initial and final stone models were compared to a master model. The master model served as the "gold standard" in this project. A highly trained orthodontist, with years of clinical experience, positioned the brackets on the master model.

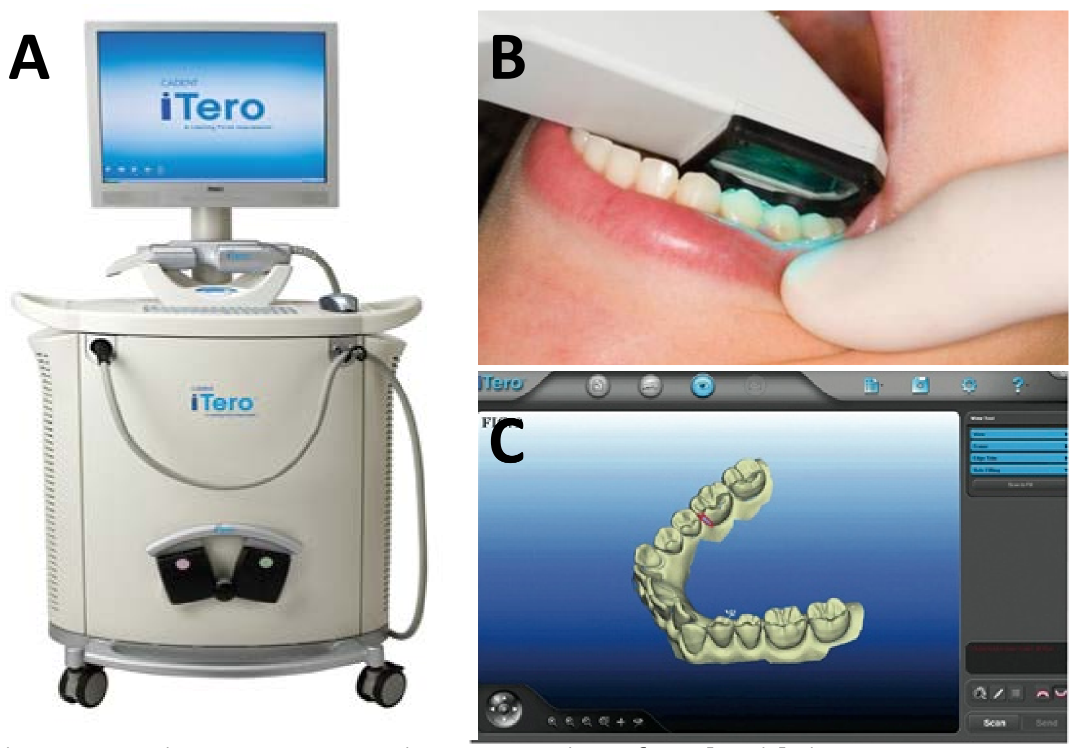

Figure 2. A. iTero scanner unit, B. Scanning of teeth with iTero scanner, C. Image of .STL file produced from scanning using the iTero scanner.

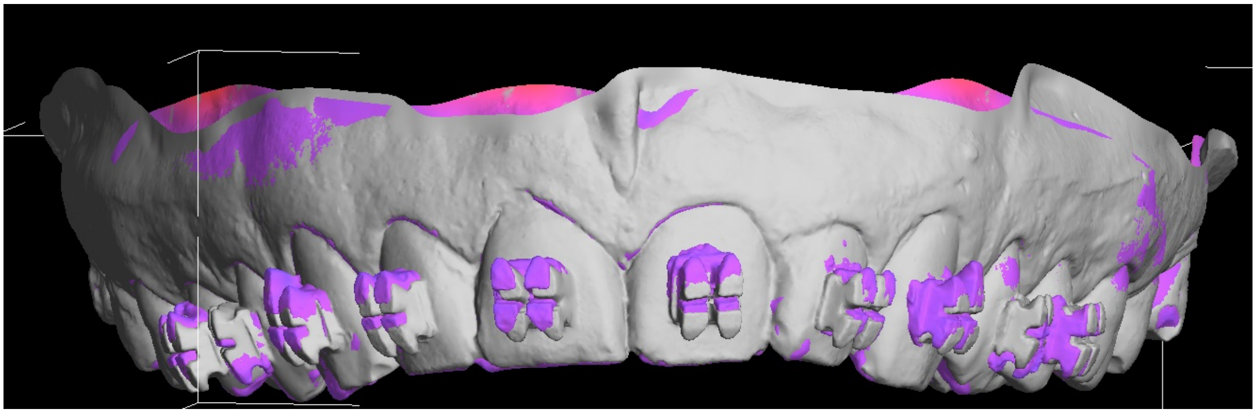

Figure 3. Bracket placement evaluated by digitally superimposing the two bonded models and using the 3dMD Vultus software to compute the difference in spatial positioning.

To reduce possible measurement bias and ensure participant anonymity, each participating student received a unique identification code number and all participant data were logged using that number. A single, blinded, co-investigator (T.L) conducted all of the digital measurements within the Vultus software.

Prior to completing the measurements for the main study, the co-investigator completed reliability testing with the Vultus software. Five digital models were randomly selected from the sample and the superimposition/quantification process was completed. The same co-investigator repeated the process after a 1-week break.

Statistical Analysis

Intraclass Correlation Coefficient (ICC) was used to evaluate the co-investigator's reliability during the reliability assessment. The co-investigator was deemed reliable if an ICC value of >0.9 was obtained for all measurements. In the event a particular parameter received an ICC value of <0.9, the co-investigator would repeat the reliability assessment for that parameter until a value of 0.9 or higher was achieved.

Descriptive statistical analysis was conducted for the entire test sample. Mixed model ANOVA statistical tests were used to assess differences in bracket placement between the three groups (initial, final, gold standard). A significance level of $p < 0.05$ was established for this study.

Results

A total of 7 orthodontic graduate students were identified and recruited for participation in the study. Four students were assigned to the HHG (hand-held model group) and 3 to the MMG (mounted-model group). All students had approximately 9 months of bracket placing experience. Each of the students completed the two assessment sessions (initial and final); however, one participant from the MMG missed the first training session. No other irregularities occurred during the study.

Reliability Assessment

The results from the reliability study demonstrated that the co-investigator was reliable with using superimposition technique, all ICC values found to be 0.9 or higher. Thus, the investigative team felt comfortable proceeding with the main analysis of the study.

Bracket Placement Method Assessment

All students finished the assessments within the allotted time. The HHG took approximately 30 minutes to complete the exercise, while it took the MMG 35 minutes. During the final assessment, both groups significantly reduced the amount of time required to complete the exercise with the HHG taking 19.3 minutes and MMG 23.3 minutes.

The mean difference in bracket position placement in the two groups from initial to final was statistically significant. The mean difference for the HHG was 9.49±3.07mm and 11.73±7.88mm for the MMG (Figure 4).

When comparing the two groups to the master model, no statistically significant difference was noted during the initial assessment session. However, a statistically significant difference was observed between the two groups from the final assessment when compared to the master model. The HHG had a mean difference of 12.17±7.86mm, while the MMG had a difference of 8.13±4.23mm.

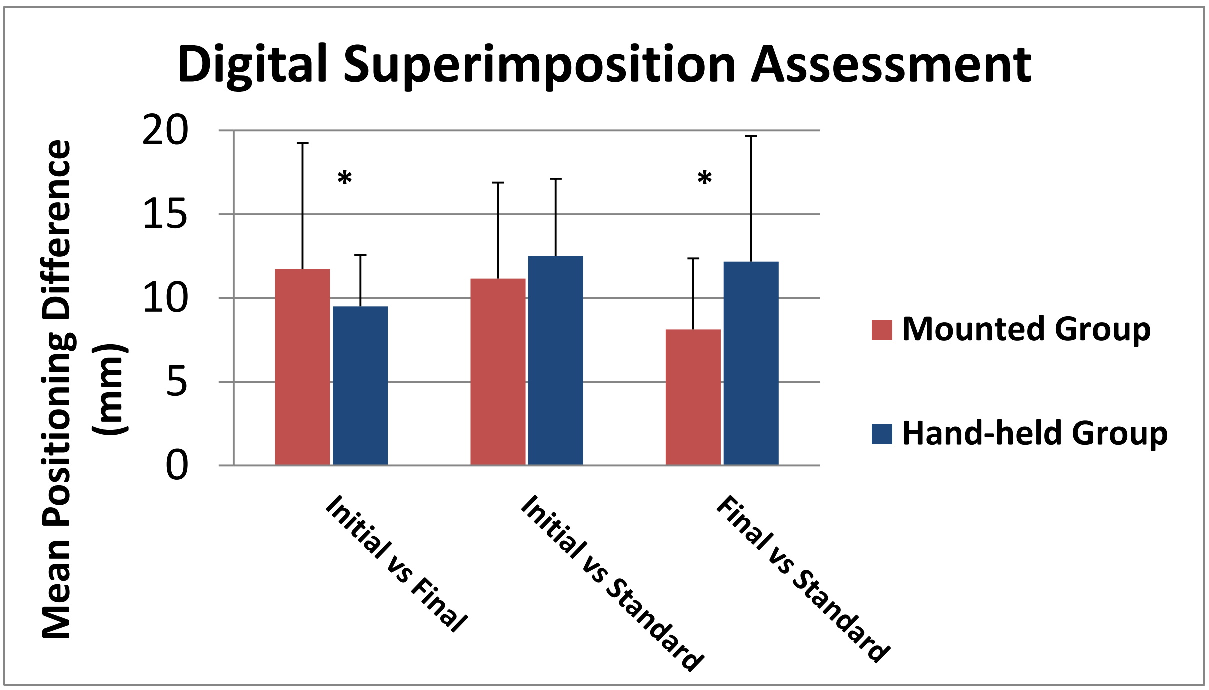

Figure 4. Bracket position assessment: Mean position difference in millimeters between Initial & Final, Initial & Gold Standard, Final & Gold Standard.

(*denotes significance at the P<0.05 level*)

Discussion

As with many tactile skills in the dental profession, proper bracket placement improves with time and experience. Though some literature supports the notion that brackets are slightly more accurately placed when done in an indirect manner (Aguirre 1982; Hickman 1993; Koo 1999; Hodge 2004; Shpack 2007), there is no literature that supports an optimal method of teaching bracket placement to novice orthodontic clinicians. By selecting orthodontic graduate students with limited clinical experience, a prospective study could be designed to evaluate an optimal pedagogical approach in this area. While the study had a low sample size, the initial skill level of the participants was approximately equivalent as shown by the initial mean bracket position differences between the two groups and the master model.

During the training phase of the study, both groups engaged in activities that increased their ability to identify the proper position of the brackets. The results indicated that both groups became more accurate during the study. As one might expect, the group engaged in bracket placement in a simulated clinical environment showed a greater improvement. This enhanced improvement was most likely the result of the participants' elevated ability to assess bracket position through both direct and indirect vision, as well as an improved appreciation of operator positioning during the procedure. In dentistry, direct vision refers to the capacity of a clinician to see the treatment area with their eyes alone. Indirect vision refers to the capacity of a clinician to see the treatment areas by using an oral cavity mirror. During bracket placement, clinicians must effectively utilize both direct and indirect vision to properly place brackets. The use of models in simulation units provided an opportunity for the development of both direct and indirect vision, while hand-held models only promoted the improvement of direct vision.

Another important aspect of correct bracket placement is the proper positioning of the patient and clinician during the procedure. When either the patient or clinician is poorly positioned, the proper placement and/or assessment of a bracket is dramatically reduced. Proper clinician positioning also has a significant impact with respect to ergonomics, the science relating humans to their work, including the factors affecting the efficient use of human energy. When properly positioned, clinicians can effectively complete clinical procedures with little impact on the quality of their work or their physiology. However, when a clinician and/or patient is poorly positioned, it can severely impact the quality of the treatment being provided and result in significant and long-lasting problems for the clinician including problems with their wrists, neck, and back. With the additional three weeks of simulated patient treatment, the mounted-model group had more time to identify the proper positions for the clinician and simulated patient to place and review the bracket placement, which also helped increase the groups' bracket placement when compared to the gold standard.

The use of simulation units to improve bracket placement techniques seems to be a more ideal method of preparing students to perform effectively in clinical situations than hand held models. As more dental schools continue to create simulation laboratories with simulation units to prepare students to perform other clinical procedures, this technique could become a more commonly accepted and utilized method of teaching bracket placement.

Along with obtaining information to support an optimal teaching modality, this pilot study was able to utilize the superimposition feature of the Vultus software to provide a quantitative assessment of the students' bracket position. This technique has been employed in other areas of medicine/dentistry including the assessment of surgical procedures, upper airway modification, and orthodontic tooth movement. It represents a vast improvement to the subjective qualitative feedback that orthodontic educators have historically used during the training of their students. This method also seems more reliable and efficient than other digital methods, including linear measurements made from the brackets to certain reference structures on the digital model (Figure 5). With further technological improvements, this superimposition technique could be able to provide the accurate and immediate quantitative feedback that would allow orthodontic programs to ensure that all of their students graduate with a high proficiency in bracket placement.

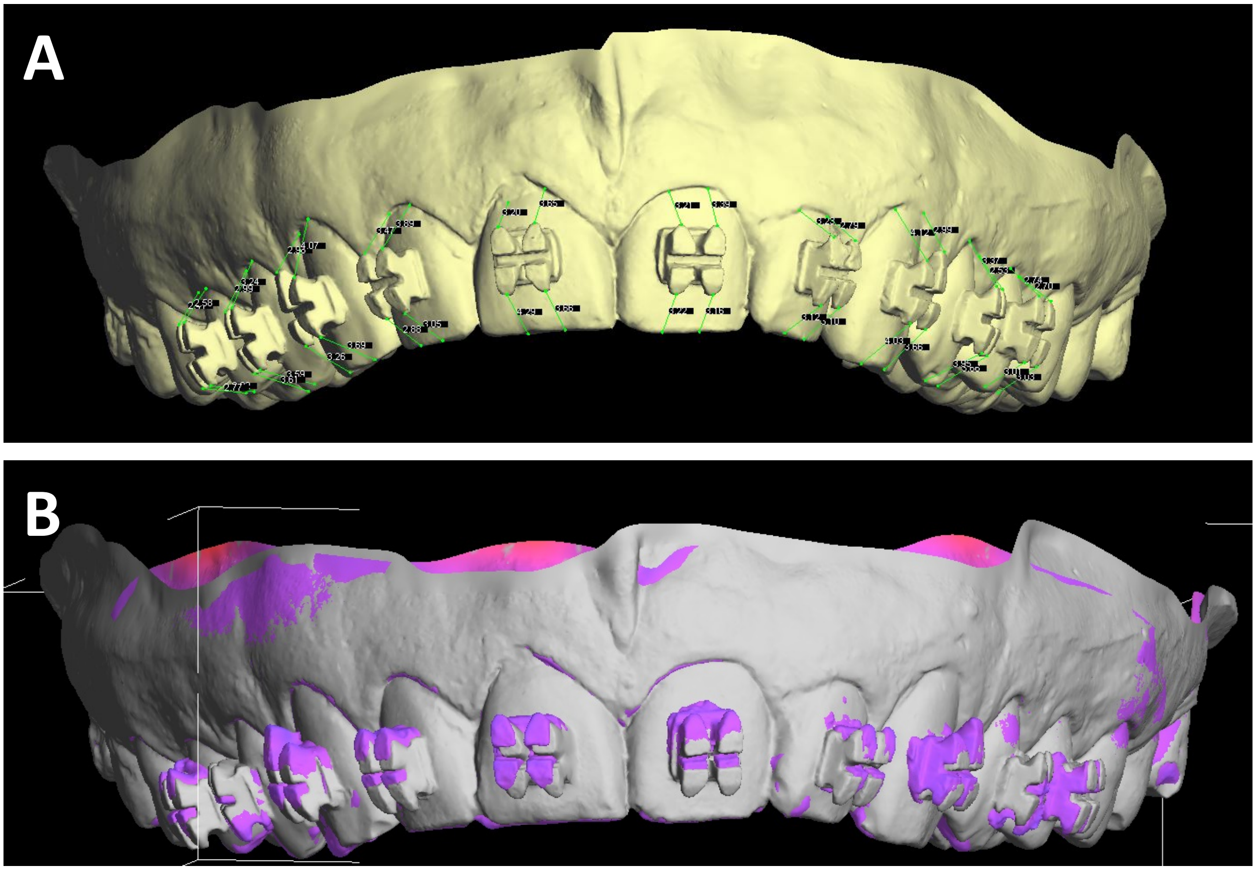

Figure 5. A. Digital bracket assessment method using linear measurements technique from reference points; B. Digital bracket assessment method using superimposition technique.

Study Limitations

As is the nature of pilot studies, the main limitation of this study was the small sample size (n=7). The trends observed in this study suggest that using simulation units in the training of orthodontic bracket placement is a more effective method of teaching this skill. Further investigation with a larger sample size would be useful to confirm this initial observation and help establish an ideal method for both bracket placement and bracket position assessment.

A second limitation of the study was the inability to provide immediate feedback to the students. While more objective feedback could potentially reduce the time it takes for a student to become proficient at bracket placement, the feedback must be immediate. The current assessment method took weeks to generate the quantitative feedback. This delayed response would dramatically reduce the efficiency of the learning process and make it less useful for orthodontic educators and other users in the orthodontic community.

A final limitation was the inability to limit or regulate the amount of external bracket placement training by the students. During the project, each of the 7 students were still engaged with the comprehensive management of patients in the graduate orthodontic clinic. Throughout the study, it was possible that some of the students participated in more bracket placement, which would have impacted their clinical abilities. Since each of the students had the same clinical opportunities, this observation was assumed to be a systematic bias that affected both groups in the study. This possibility will be noted and considered during future projects.

Conclusion

The results from this pilot study suggest that:

1. Bracket placement training on simulator units appears to be a more effective method of teaching bracket placement than the hand-held model technique,

2. The digital superimposition technique appears be a viable assessment method for providing more objective feedback during bracket placement training.

Further evaluation of both the teaching and evaluative techniques should be conducted to gain more support for a definitive conclusion.

Study References

Advanced Specialty in Orthodontic and Dentofacial Orthopedics Accreditation Document (2014)

Aguirre MJ, King GJ, Waldron JM. Assessment of bracket placement and bond strength when comparing direct bonding to indirect bonding techniques. *Am J Orthod 1982; 82*(4), 269-276.

Armstrong, D, Shen G, Petocz P, Darendeliler M. A comparison of accuracy in bracket positioning between two techniques – localizing the centre of the clinical crown and measuring the distance from the incisal edge. *Eur J Orthod 2007; 29*(5), 430-436.

Armstrong D, Shen G, Petocz P, Darendeliler M. Accuracy of bracket placement by orthodontists and inexperience dental students. *Aust Orthod 2007; 23*(2), 96-103.

Chen M, Horrocks E, Evans R. Video versus lecture: effective alternatives for orthodontic auxiliary training. *Br J Orthod 1998; 25*(3), 191-195.

Gargallo J, Rubio E, Perez J, Lagares D, Vazquez C. New dental simulator for microsurgical training preliminary overview. *Med Oral Patol Oral Cir Bucal 2007; 12*(8), 582-584.

Hickman J. Predictable indirect bonding. *J Clinical Ortho 1993; 27,* 215-217.

Hodge T, Dhopatkar A, Rock W, Spary D. A randomized clinical trial comparing the accuracy of direct versus indirect bracket placement. *J Orthod* 2004*; 31*(2), 132-137.

Israel M, Kusnoto B, Evans C, Begole E. A comparison of traditional and computer-aided bracket placement methods. *Angle Orthod 2011; 81*(5). 828-835.

Koo B, Chung C, and Vanarsdall R. Comparison of the accuracy of bracket placement between direct and indirect bonding techniques. *Am J Orthod Dentofacial Orthop 1999; 116*(3), 346-351.

Lee H, Orlowski J, Enabe E, Rogers B. (1974). In vitro and in vivo evaluation of direct-bonding orthodontic bracket systems. *J Clin Orthod 1974; 8*(4), 227-238.

McLaughlin RP, Bennett JC. Finishing and detailing with a preadjusted appliance system. *J Clinical Orthod 1991; 25*, 251-264.

Mohammadi, A., and Moslemzadeh, S. Comparison of the accuracy of bracket placement with height bracket positioning gauge and boone gauge. *J Dent Res Dent Clin Dent Prospects 2011; 5*(4), 111-118.

Newman GV. (1965) Epoxy adhesives for orthodontic attachments, *Am J Orthod 1956; 51,* 901.

Newman G. Direct and indirect bonding of brackets. *J Clin Orthod 1974; 8*(5), 264-272.

Oliver R, Volp CA. Bonding typodont. *Br J Orthod 1991; 18*(4), 323-327.

Sondhi A. Precise bracket placement: effective and efficient indirect bonding. In: Graber TM, Vanarsdall RL, Vig KWL. *Orthodontics Current Principles and Techniques,* 4th ed. St. Louis: Elsevier Mosby; 2005:661.

Shpack N, Geron S, Floris I, Davidovitch M, Brosh T, and Vardimon A. Bracket placement in lingual vs labial systems and direct vs indirect bonding. *Angle Orthod 2007; 77*(3), 509-517.

Suarez C, Vilar T. The effect of constant height bracket placement on marginal ridge leveling using digitized models. *Eur J Orthod 2010; 32*(1), 100-105.

Thomas R. Indirect bonding: simplicity in action. *J Clin Orthod 1979; 13*(2), 93-106.

Zachrisson B, Brobakken B. Clinical comparison of direct versus indirect bonding with different bracket types and adhesives. Am J Orthod 1978; 74(1): 62-78.

Appendix I: Acronyms

CODA – Commission on Dental Accreditation

DB – Direct bonding

DDS – Doctor of Dental Surgery

HHG – Hand-held group

IDB – Indirect Bonding

IUPUI – Indiana University – Purdue University Indianapolis

IUSD – Indiana University School of Dentistry

MMG – Mounted-model group

PRAC – IUPUI Program Review and Assessment Committee

STL – Standard Tessellation Language

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