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A Study of the Objective and Subjective Evaluation of Three Different Bracket Prescriptions (Roth vs MBT vs Damon) Used in a Graduate Orthodontic Program

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Objective and Subjective Evaluation of Three Different Bracket Prescriptions (Roth vs MBT vs Damon) Used in a Graduate Orthodontic Program

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TABLE OF CONTENTS

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LIST OF TABLES

LIST OF FIGURES

STEPHANIE CHAMBERS FURLONG. A study of the objective and subjective evaluation of three different bracket prescriptions (Roth vs MBT vs Damon) used in a graduate orthodontic program.. (Under the direction of Dr. Jing Zhou)

Objective: To identify the objective and/or subjective difference between three different bracket prescriptions used in the comprehensive orthodontic treatment of patients at the MUSC residency program. The ABO scoring system was utilized to classify the objective final result of cases treated. In addition, experienced orthodontists provided their expert subjective analysis of the completed cases to examine differences in the final result and determine if orthodontists can reliably determine which bracket prescription was used in each case. Secondary data examined included differences in treatment time, the number of adjustments, and the number/type of arch wires utilized.

Materials and Methods: A retrospective review of 60 patient records in the permanent dentition was performed. Pre-treatment records (radiographs and casts) were used to determine the DI score and identify any exclusion criteria. Final models and panoramic radiographs of the cases selected were used in the objective ABO and subjective scoring. Treatment records were used to determine length of active treatment time, the number of adjustment appointments, and type/number of arch wires used.

Results: Sixty cases non-extraction, non-surgical cases evenly distributed between the three bracket groups consisted of 66% female and 33% male with a majority of Class I malocclusions were included in the study. There was a statistically significant difference in the type but not the number of arch wires utilized in the Damon group. There was a statistically significant difference in the number of adjustment appointments but not the overall treatment time in the Damon group. Overall, there was no statistical difference in the total ABO objective score. However, there was a statistical difference in alignment,

overjet, and root positioning for the cases treated with Damon and for canine occlusion in the cases treated with Roth. The categories that were statistically significant for the subjective evaluation were the lower incisor torque for the MBT group and both upper canine torque for the Damon group. Evaluators incorrectly determined which prescription was utilized in the cases 83% of the time with those treated by Roth and Damon incorrectly identified twice as often then they were correctly identified.

Conclusions: The cases evaluated were all treated to clinically acceptable standards by all three bracket prescriptions. Overall, the cases did not have statistically significant differences in the total objective and subjective scores and orthodontic specialists could not identify which bracket prescription was used in the case. However, when examined closely by category significant differences were found. Most notable, the MBT group controlled lower incisor torque most effectively and the Damon group had on average facially over-torqued canines.

INTRODUCTION

Historical Overview

Today, most comprehensive orthodontic treatment is carried out with fixed appliances. Dr. Edward Angle is credited with developing the standard edgewise appliance (Angle 1928). He experimented with several different system designs before developing the horizontal rectangular slot bracket that provided multi-dimensional control of teeth when engaged with a rectangular wire (Angle 1928). This design remained the appliance of choice through the 1970's. However, these brackets did not incorporate individual tip and torque for each tooth. Therefore, the appliance required meticulous bends to detail final tooth position, which required a vast amount of time and skill.

In the late 1970's, Dr. Lawrence Andrews revolutionized fixed appliance orthodontics by introducing the pre-adjusted edgewise or 'straight-wire' appliance (Andrews 1979). The straight-wire appliance is based on an untreated sample of ideal occlusions to design a built-in prescription that is customized for each individual tooth (Andrews 1979). The customized brackets featured pre-angulated slots for correct mesiodistal tooth angulation/tip, bracket bases inclined for correct inclination or torque, and variable distance from the base of the slot to the base of the bracket for correct in/out position (Andrews 1979). The use of this system significantly reduced the amount

of wire bending required in orthodontic treatment as well as allowed spaces to be closed and groups of teeth to move along an archwire in unison (Andrews 1979).

Over time, different variations and versions of the original Andrews bracket prescription have been developed. Many of these edgewise "straight-wire" variations are aimed at incorporating increased torque prescriptions in the incisors because it was found that some of the torque in the original Andrews prescription were not being fully expressed due to the 'slop' or free space between the bracket slot and the archwire. These changes involve alterations of just a few degrees. Several studies have found that torque expression in particular is not solely based on bracket prescription, it is affected by many factors such as: the amount of play between the archwire and the slot, widening/notching of the bracket slot when larger archwires are placed, the initial inclination of teeth, differences in the tolerance size of manufactured brackets and archwires, the method of ligation, and variations in the shape of the labial surface of teeth (Archambault 2010, Cash 2004, Gioka and Eliades 2004, Badawi 2008). Therefore, in the normal clinical use of the straight-wire appliance, expression of the chosen bracket prescription is multifactorial and thus some adjustments and wire bending to complete final positioning of teeth can occur.

The Roth prescription was designed by Ronald Roth in 1979. This prescription had two main differences in relation to the Andrews pre-adjusted prescription. First, the Roth prescription incorporated extra lingual root torque in the upper teeth as it was found that the torque in most brackets was not fully expressed especially as teeth were retracted in space closure. Second, there was a greater emphasis on functional occlusion, so the canines had more distal root tip to facilitate cuspal guidance and the maxillary molars had

more facial root torque to prevent palatal cusps from creating non-working side interferences (Roth 1979). The values presented in the following table reflects the values of the standard appliance at the time of conception. Specifically, Table 1 reflects the torque and angulation values for the original Roth bracket prescription (Profitt 2007). Variable bracket prescription options have been made available and the specific Roth prescription values used in the cases included in this study are listed in Table 4.

TABLE 1: Original Roth Prescription

ROTH PRESCRIPTION		
TEETH	**TORQUE**	**ANGULATION**
U1's	+12	+5
U2's	+8	+9
U3's	-2	+13
U4/5's	-7	0
U6's	-14	0
U7's	-14	0
L1/2's	-1	+2
L3's	-11	+2
L4's	-17	7
L5's	-22	-1
L6's	-30	-1
L7's	-30	-1

In the 90's, Richard McLaughlin, John Bennett and Hugo Trevisi developed the MBT prescription. This version of the pre-adjusted appliance focused on minimizing proclination of the lower incisors by incorporating facial root torque in addition to the similar increased lingual root torque in the upper teeth that the Roth prescription had. In addition, there was reduced distal tip in the upper arch, especially the upper canines, to reduce anchorage requirements and reduced facial root torque in the lower molar region to prevent lingual rolling of lower molars (McLaughlin & Bennett 1990). The values

presented in the following table reflects the values of the standard appliance at the time of conception. Specifically, Table 2 reflects the torque and angulation values for the original MBT bracket prescription (Profitt 2007). Variable bracket prescription options have been made available and the specific MBT prescription values used in the cases included in this study are listed in Table 5.

TABLE 2: Original MBT Prescription

MBT PRESCRIPTION		
TEETH	**TORQUE**	**ANGULATION**
U1's	+17	+4
U2's	+10	+8
U3's	+7/0/-7	+8
U4/5's	-7	0
U6's	-14	0
U7's	-14	0
L1/2's	-6	0
L3's	+6/0/-6	+3
L4's	-12	+2
L5's	-17	+2
L6's	-20	0
L7's	-10	0

The Damon system was introduced in 1998 as a passive self-ligating bracket. This appliance was based on individual brackets that did not require elastomeric rings to engage the wire in the bracket slot but had metal doors that engaged it instead. The idea behind these brackets is to reduce the amount of friction between the bracket and the wire to allow for faster alignment. Most of the differences in the Damon bracket prescription and Roth and MBT are torque values for upper and lower anterior teeth. The different characteristics of these prescriptions are aimed at achieving a better functional and esthetic outcome. The values presented in the following table reflects the values of the

standard appliance at the time of conception. Specifically, Table 3 reflects the torque and angulation values for the standard passive Damon bracket prescription. There are variable bracket prescription options (low versus super) that can range in torque values. The specific prescription values for the Damon bracket prescriptions used in the cases included in this study are listed in Table 6.

TABLE 3: Original Standard Damon Prescription

DAMON PRESCRIPTION		
TEETH	**TORQUE**	**ANGULATION**
U1's	+15	+5
U2's	+6	+9
U3's	+7	+5
U4/5's	-11	+2
U6's	-18	0
U7's	-27	0
L1's	-3	+2
L2's	-3	+4
L3's	+7	+5
L4's	-12	+4
L5's	-17	+4
L6's	-28	+2
L7's	-10	0

Archwires engaged in individualized brackets are the main variable component of comprehensive orthodontic care. An archwire sequence is tailored to individualized treatment needs, but there is a general sequence that is followed in edge-wise mechanics in order to take advantage of each wire's specific properties in the different stages of treatment (Rinchuse et al 2007). In the initial alignment stage of treatment, several different sizes and shapes of nickel titanium (niti) arch wires are usually used to unravel crowding and correct for rotations. This is because niti wires show the least deflection,

have the lightest forces for the least discomfort, and the flexibility for rotations. A round stainless steel wire can be used for leveling the Curve of Spee or sliding mechanics. Next, rectangular beta titanium (TMA) wires can be used for root paralleling and torque expression. These wires can be used to detail and finish cases as well. If interarch elastics or additional leveling or force is going to be exerted, a large rectangular steel wire provides more arch rigidity. Finishing and settling with elastics can be completed with multiple different wires such as a small round steel or a large rectangular archwires sectioned for settling. The number, type, and duration of use on each arch wire however, can vary greatly on patient treatment needs and operator preferences. However, the fundamental expression of torque in a bracket by an archwire is dependent on the stiffness of the material. Therefore, a Niti and TMA of the same thickness have lower stiffness than a stainless steel wire and thus express less torque (Kusy 1983). Several rules of arch wire usage include not moving to the next wire until the arch wire is passive. If there are large discrepancies, it is preferable to reposition the bracket early as opposed to placing compensating bends. This enables the practitioner to establish and maintain arch forms while maximizing bracket expression in order to exert the customized bracket prescription.

Contemporary Overview

As noted previously, different bracket prescriptions express different amounts of tip and degrees of torque on each tooth. The size of the bracket slots can be 0.018" or 0.022" slots, each having their own advantages and disadvantages. Proffit and Fields 2007 for example advocated for 0.022 slot size because of the advantage for sliding

mechanics where a heavier undersized stainless steel wire could be used. Although the different bracket prescriptions incorporate different amounts of tip and degrees of torque the expression of these differences is somewhat dependent on the wires used.

Thus, bracket selection and wire usage are two of the main essential daily dental supply expenditures required to treat comprehensive orthodontic cases. Different bracket prescriptions and types can vary significantly in price, which can be a factor in selecting what bracket system to utilize. Thus, it is prudent for the orthodontist to pick a bracket prescription that is most cost-effective but will give the best result in the shortest amount of time. Consequently, if a difference between the three bracket prescriptions is determined, a practitioner can take this into account when selecting a bracket prescription. If no difference is found, selecting brackets can be based on other factors the practitioner may deem important.

Outcome measures to establish a standard of care and quality of orthodontic treatment is a mandatory component in determining efficiency and effectiveness of evidence-based clinical practice (Vig et al 2007). Monitoring and maintaining quality of care has a profound effect on the patient treated and the orthodontic practice as a whole (Vig et al 2007). Quality of care has both qualitative and subjective or quantitative and objective measures. Vig et al highlights the discrepancies between patient and clinician perspectives on quality of care noting patient assessment is usually a subjective quality of life assessment while orthodontists may focus more on objective measures of occlusion.

The American Board of Orthodontics investigated indices such as the occlusal index to determine treatment quality (Summers 1971). However, the validity and reliability with some of the indices were not proven and in the case of the occlusal index

the method was tedious and more appropriate for scoring pretreatment rather than post-treatment records. In 1987, the PAR Index (Peer Assessment Rating) (Richmond 1992) was developed with good reliability and validity to assess an occlusion at any stage of development. However, this measuring system was determined to not be precise enough to discriminate between the minor inadequacies of tooth position that are found in ABO case reports. Therefore, in 1994 an ABO committee was formed to begin field testing precise methods of objectively evaluating post-treatment dental casts and panoramic radiographs. The ABO grading system evaluates a total of eight criteria for scoring dental casts and panoramic radiographs which include alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation (ABO 2012). Case management is also considered in the evaluation of cases by the ABO. In this study, only four criteria are assessed in the cases examined, specifics of which are described in Appendix C.

Utilizing certain aspects of the ABO grading system described in Appendix C, in this study the final ABO score of treated cases will be determined for each case treated by the three different bracket prescriptions. This will also be correlated with treatment efficiency. In 1998, the American Board of Orthodontics (ABO) began to develop the Discrepancy Index (DI), which was designed to provide an objective evaluation of case complexity that may lead to a better understanding of case difficulty (Cangiolosi 1998). DI is obtained from routine pre-treatment orthodontic records (dental casts, panoramic and cephalometric radiographs). The ABO Discrepancy Index (DI) will be used to evaluate and standardize the cases analyzed in this study according to pre-treatment case complexity to ensure initial case complexity is within a similar range. This DI score

incorporates twelve factors that include: overjet, overbite, anterior open bite, lateral open bite, crowding, occlusal relationship, lingual posterior crossbite, buccal posterior crossbite, ANB angle, SN-MP angle, lower incisor to MP, and other significant factors (ABO 2014). See Appendix A for specifics on the DI scoring system.

Isaacson 2000 discusses an educational and economically driven change in the model of orthodontic residency programs that highlights their influence on maximizing educational experiences in addition to the productivity of orthodontic residency programs. He discusses that the productivity is important to a good education in order to prepare future orthodontic graduates for private practice. Specifically, he hypothesizes residents should make treatment decisions on the basis of the same criteria you would use in a private orthodontic office so that there is not one standard of care for school and a second of care for private offices. This includes making appropriate and ethical individualized treatment decisions that result in the highest quality of care that maximizes treatment efficiency. Through the application of ABO standards in our orthodontic residency program by residents and faculty this is achievable. The primary armamentarium of orthodontic care are brackets. Therefore, assessing and determining bracket selection based on the quality of the results as well as the effectiveness in treatment time should be considered.

Thus, the objective of this study is to determine if, when treated to an acceptable occlusal result, there is a significant difference in the final objective ABO score and/or subjective clinical result determined by a cohort of orthodontic specialists in comprehensive orthodontic cases treated with three different bracket systems used in a graduate orthodontic clinic. In addition, as a secondary assessment, this study will

evaluate if there is a difference between the three different bracket prescriptions in relation to treatment efficiency, specifically the number of adjustments and the total treatment time.

A review of the literature provided only a few studies that examined some of these factors that can relate to bracket prescription. One study by Moesi et al 2011 performed a retrospective study to determine whether the bracket prescription has an effect on the subjective outcome of pre-adjusted edgewise treatment as judged by professionals. Analysis determined there was no effect on the subjective esthetic judgment of cases treated with two different bracket prescriptions and the ability to determine which bracket prescription was used was no better than chance for most clinicians. Another study by Jain et al 2013 assessed the clinical outcomes of Roth versus MBT bracket prescriptions using the ABO objective grading system. They determined while there were several categories of the ABO grading system that showed statistical significance between the two bracket systems, there was no clinical significance in the overall outcome and quality of treatment between the two bracket prescriptions. However, there were no studies that could be identified that examined subjective or objective results of the use of Damon brackets in comparison to Roth or MBT.

The aim of this study is to determine a difference in the objective and/or subjective evaluation of cases treated with three different bracket systems (Roth versus MBT versus Damon). Specifically, the study will attempt to correlate bracket prescription to objective results utilizing aspects of the ABO grading analysis. Also, subjective assessments by a group of specialized orthodontists will provide practical

clinical insight into case finishes utilizing the three bracket prescriptions. The secondary aim of this study is to determine a difference in treatment efficiency of utilizing one of the three bracket systems, ie: the number of adjustment appointments, the total treatment time, and arch wire usage.

The null hypothesis is there is no difference between the final objective or subjective results of cases treated with the three different bracket prescriptions. In addition, there is no difference in the treatment efficiency details (treatment time, number of adjustments, arch wire usage) between the three bracket prescriptions.

The clinical significance of this study is to determine if there is a clinical difference in terms of final result as well as examine treatment efficiency implications in using one of the three selected bracket prescriptions. Therefore, if a significant difference can be determined, the study can help outline possible reasons for practicing orthodontists to select a bracket prescription or perhaps a variation in bracket prescription based on a possible better objective or subjective final treatment result and/or possible increased treatment efficiency.

MATERIALS and METHODS

This was a retrospective study submitted and approved by the Institutional Review Board (IRB) at the Medical University of South Carolina College of Dental Medicine on an expedited status as it involved no more than minimal risk to the participants and met the criteria for an expedited review. The study received institutional research board approval to review patient records which after examination are de-identified. Pre-treatment and post-treatment records including panoramic and cephalometric radiographs as well as initial and final dental models were obtained from the archives of the Department of Orthodontics at the Medical University of South Carolina. The power analysis conducted by the collaborating statistician determined a sample size between 20-30 cases could be reviewed for a significant difference to be determined. The power calculation yielded 95% power at an alpha level of 0.05. Therefore, a target of 20 cases per group for a total of 60 cases were identified and reviewed in this study. This was determined by consideration of the three independent variable groups (Roth vs MBT vs Damon bracket prescription) and the dependent variables (objective ABO analysis and subjective orthodontic specialists analysis) to be examined and a comparison to previous similar studies.

The cases were chosen from the Graduate Orthodontic Clinic at the Medical University of South Carolina. All cases reviewed had treatment completed to a finished standard determined by the pair of treating resident/orthodontic faculty specialist. The

patients were treated by several different pairs of faculty/residents, but the bracket type and archwires used were standardized within the department. Cases were selected from a similar pool of patients in the South-East treated by resident/orthodontist pairs with similar training and treatment principles. The three bracket prescriptions that are evaluated in this study are all 0.022 inch bracket slots with the ROTH prescription (American Orthodontics, Sheboygan Wisconsin), the MBT prescription (Opal, South Jordan Utah), and the Damon prescription bracket (passive self-ligating by ORMCO, Orange California). Reference Table 1, 2, and 3 for variable bracket prescription details utilized in the cases included in this study. Variations from the original prescription are highlighted values.

TABLE 4: Roth Prescription – AO Mini-Master Series

ROTH PRESCRIPTION		
TEETH	**TORQUE**	**ANGULATION**
U1's	+12	+5
U2's	+8	+9
U3's	-2	+7
U4/5's	-7	0
U6's	-10	0
U7's	-10	0
L1/2's	0	0
L3's	-11	+7
L4's	-17	0
L5's	-22	0
L6's	-25	0
L7's	-30	0

TABLE 5: MBT Prescription - OPAL

MBT PRESCRIPTION		
TEETH	**TORQUE**	**ANGULATION**
U1's	+17	+4
U2's	+10	+8
U3's	0	+8
U4/5's	-7	0
U6's	-14	0
U7's	-14	0
L1/2's	-6	0
L3's	0	+3
L4's	-12	+2
L5's	-17	+2
L6's	-20	0
L7's	-10	0

TABLE 6: Damon Prescription - ORMCO

DAMON PRESCRIPTION		
TEETH	**TORQUE**	**ANGULATION**
U1's	+2	+5
U2's	-5	+9
U3's	+11	+5
U4/5's	-11	+2
U6's	-18	0
U7's	-27	0
L1's	-11	+2
L2's	-11	+4
L3's	+13	+5
L4's	-12	+4
L5's	-17	+4
L6's	-28	+2
L7's	-10	0

SUBJECT SELECTION

Confirmation of the bracket prescription was obtained from electronic treatment notes secured in the Axium (Coquitlam, BC) notes documented at the initial bond-up appointment that specified the type of bracket used in each case. Potential cases were identified from former resident patient lists based on the following inclusion criteria:

1. Male or female patient treated with non-extraction comprehensive orthodontics in the graduate orthodontic clinic at MUSC;
2. Patient is equal to or younger than 18 years old
3. All permanent dentition (excluding third molars) are present at the start of treatment;
4. Fixed appliance approach with one of the three bracket prescription types (DAMON, MBT, ROTH); and
5. A DI score of less than or equal to 25.

Patient records were excluded if:

1. The patient had braces removed early due to non-compliance (oral hygiene or elastics);
2. There were excessive (>3) cancellations/emergencies resulting in non-compliance;
3. A functional appliance was used;
4. Orthognathic surgery was required; and
5. Records are incomplete or models inadequate.

Initially, the principle investigator solely evaluated patient lists in order to select eligible cases based on bracket prescription used and the inclusion and exclusion criteria

described above. Once the cases were identified, they were randomized by utilizing a computer generated randomizer tool (https://www.randomizer.org) to assign a case number 1 through 60. A third party assistant identified and labeled the case models per the randomized case number in order to blind the principle investigator and other study examiners to the identity of the cases. The initial and final case models were all uniformly prepared and trimmed to ABO standards.

TREATMENT HISTORY

The demographics about each case obtained from treatment records included patient's age at treatment initiation, race, and gender of the patient. In compliance with IRB protocol, specific dates were not recorded in the raw data material. For age at the onset of treatment, the patient's birthday was inserted into an age calculator (www.calculator.net/age-calculator.html) with the treatment start date. The calculator arrived at a "#years, #months, #days" and the age was rounded to the nearest year for the purpose of this study. Treatment was considered "started" once any active appliance was placed as comprehensive treatment. For total treatment time, the start and end date were inserted into a calculator (www.timeanddate.com/date/duration.html), which produced a total number of days. Number of days, rather than months and days, was determined for ease and accuracy in calculations.

To collect the secondary data, a review of the patient's chart by the principle investigator was completed to also determine the number of adjustment appointments. In addition, the initial treatment occlusion (CI, end-on, CII, CIII), the number and type of arch-wires used during treatment, and other specifics on treatment mechanics were also

determined. The treatment history was reviewed and documented by the principle investigator after the objective analysis was complete to ensure the investigator was not bias prior to grading.

The Discrepancy Index Score of the initial presenting malocclusion was also retroactively determined for each case. The Discrepancy Index (DI), was designed to provide an objective evaluation of initial case complexity that may lead to a better understanding of case difficulty (Cangiolosi 1998). DI was obtained from routine pre-treatment orthodontic records (dental casts, panoramic and cephalometric radiographs). The ABO Discrepancy Index (DI) was used to evaluate and standardize the cases analyzed in this study according to pre-treatment case complexity to ensure initial case complexity is within a similar range (see Appendix A and B for DI scoring information).

OBJECTIVE GRADING

Prior to the objective examination of each case utilizing the American Board of Orthodontics (ABO) grading system, the principal investigator and one other orthodontic specialist were standardized on how to score the cases using the ABO grading system. Only five of the eight categories in the ABO grading system were assessed in this study including: alignment, canine position, overjet, interproximal contact, and root position were evaluated. In addition, only the anterior teeth, specifically upper and lower canine to canine areas were graded. The grading for the categories were adjusted and applied in this manner. Standardization and test cases were completed in order to ensure intra-rater and inter-rater reliability. Specifically, ten random finished cases that were not used in this study were initially evaluated by the principle investigator and one orthodontic

specialist at two different time points separated by one week. Once standardization was ensured and the intra-rater and inter-rater reliability confirmed, the two examiners objectively scored the selected cases, blinded to the identity of the patient and which bracket system was used in each case. The ABO scores for each case was then averaged for the two examiners. Information on the ABO measuring gauge used in the model grading system can be found in Appendix C. The American Board of Orthodontics criteria, rational, and instructions for grading the categories used in this study are described in Appendix D.

1. **Alignment** – scored according to the ABO scoring system as applied to the upper and lower anterior teeth only.
2. **Canine position** – scored according to the ABO scoring system to assess antero-posterior position of the canines only, not the molars.
3. **Overjet** – scored according to the ABO scoring system as applied to the relationship of the upper and lower anterior teeth only.
4. **Interproximal contacts** – scored according to the ABO scoring system as applied to the upper and lower anterior teeth only. No case had lack of contact, therefore, a score of 0 was given in each of the sixty cases.
5. **Root position** – scored according to the ABO scoring system as applied to the upper and lower incisors only because the canine teeth are not scored due to potential distortion at the area of the canines.

After the principle investigator objectively scored the final models of the selected cases, the initial records and treatment records were then assessed in detail as described above. This was done after the final models were scored in order to ensure no bias was established prior to the objective scoring of the cases. The initial and complete treatment records reviewed included the initial models, the panoramic and cephalometric radiographs, and treatment record details. From this information, treatment time, the number of appointments, the details of arch wire usage, and the ABO Discrepancy Index Score were determined.

SUBJECTIVE GRADING

For the subjective analysis portion of the study, seven orthodontic specialists with more than five years of experience completed a subjective analysis of the sixty identified cases. As described above, to ensure no bias and that the cases were blinded to the seven orthodontic specialist examiners a third party located the final models and de-identified the cases by assigning each case a number 1-60. An instruction form (Reference Appendix E for Subjective Scoring Instructions) as well as verbal instructions were provided to the orthodontists that participated in the subjective analysis portion of the study. Specific directions were given to the examiners in terms of noting the torque of upper and lower incisors and upper canines. The examiners were asked to note if they subjectively felt the incisors or canines were excessively facially torqued as there was some ambiguity with the wording of the subjective score form since inadequate or adequate torque can range from the crowns being under-torqued lingually to the crowns being over-torqued facially. For the subjective assessment, a case score sheet consisting

of ten subjective assessment questions was administered to the seven orthodontic specialists about each of the sixty cases (Reference Appendix F for the Subjective Case Score Form). The participating orthodontists were blinded to the identity of the patient, the resident/faculty pair that treated the case, and the bracket system used. The subjective case score sheet was designed based on the questionnaire utilized in a previous study by Moesi et al 2011 with several additional assessment categories at the recommendation of the study advisory committee. The case score sheet was designed to capture the clinician's subjective assessment of several categories of the final case models. The responses for the first eight questions were scored on a 0 to 4 point Likert scale. Specifically, the questions assessed:

- **Questions 1-2:** Upper or lower incisor torque (0-1 points are given for inappropriate torque of 4 or 3 teeth respectively, 2 points for 2 teeth inappropriately torqued or all teeth excessively torqued, 3-4 points for good or best possible crown torque of 3-4 teeth respectively)
- **Questions 3-4:** Upper right and left canine torque (0-1 points are given for severely inadequate or poor torque, 2 points for adequate torque, 3-4 points for good or best possible crown torque)
- **Questions 5-6:** Upper right and left canine mesio-distal tip (0-1 points are given for significant or slight distal tip, 2 points for upright canines, 3 points for significant mesial tip, and 4 points for correct tip)
- **Question 7:** Arch development (0-1 points are given for significant or poor under-developed or over-expanded arches, 2 points for satisfactory arch development, and 3-4 points for good or best possible arch development)

- **Question 8:** Overall case finish (0-1 points are given for significantly poor or poor finish, 2 points for satisfactory finish, and 3-4 points for good or best possible finish)
- **Question 9:** Bracket type the orthodontic examiner used most in their practice
- **Question 10:** Which bracket type the examiner thought the case was treated with

STATISTICAL ANALYSIS

Collaboration with a statistician was essential to analyze the data and determine statistical significance within the data set. It was necessary to compare data from the three independent variables (bracket prescription) and determine statistical significance for the dependent variable. In addition, analysis to determine correlation statistics was also necessary to assess several aspects of the data set.

Treatment History Analysis

A one-way ANOVA model analysis with post-hoc comparisons with a Tukey adjustment was utilized to analyze the following dependent variables: initial Discrepancy Index (DI) Score, number of arch wires used, treatment time, and number of appointments.

Objective Analysis Statistics

In order to examine inter-rater and intra-rater reliability of the objective ABO scoring, statistical analysis of test cases scored by the principle investigator (R1) and another orthodontic specialist (R2) was completed. Cohen's kappa was utilitized to determine agreement between the raters as well as between the two separate scoring of each rater. In addition, once objective scoring was completed

by R1 and R2 for the sixty cases included in this study, the values were compared using the Wilcoxon sign rank test to evaluate the consistency of the objective scores of R1 and R2. The objective scores from R1 and R2 were then averaged between the two raters to obtain the average objective score for each case. Considering prior studies have shown Discrepancy Index (DI) Score is an indication of potential case difficulty, evaluating the relationship of DI and the final objective score was analyzed. A correlation coefficient was utilized to measure the strength and direction of the linear relationship between the DI score and final objective score. The final average objective scores for each bracket prescription group as well as the subcategories in the objective analysis were examined utilizing a one-way ANOVA model analysis with post-hoc comparisons with a Tukey adjustment.

Subjective Analysis Statistics

The final average subjective scores for each bracket prescription group as well as the subcategories in the subjective analysis were examined utilizing a one-way ANOVA model analysis with post-hoc comparisons with a Tukey adjustment. A chi-square test was used to evaluate the percent that correctly guessed and those that did not correctly guess which bracket prescription was utilized in each case. Cohen's kappa was also utilitzed to assess inter-rater reliability between the subjective guess and the correct prescription utilized.

RESULTS

A total of 60 cases were evaluated in this study both objectively and subjectively. Of the sixty cases selected based on the inclusion and exclusion criteria, two-thirds of the patients were female with a total of 40 females and 20 males being included. In each bracket prescription group, the distribution of females and males was similar. The female to male ratio in each of the Roth, MBT, and Damon groups was about 3:2. The age of the patients ranged from 10 to 18 years old with a total average age of 13.03 years old and were similar between each group Roth (13.05), MBT (13.2), and Damon (12.85). Ninety-three percent of the patients were of Caucasian ethnicity with only three patients being Hispanic and one being African American. Overall, the patient demographics between the three bracket prescription groups studied were comparable (see Table 7 for Patient Demographics).

TABLE 7: Patient Demographics

Bracket Prescription	# / % Females	# / % Males	Age (avg years)	Caucasian	Hispanic	African American
ROTH	13 (65%)	7 (35%)	13.05	19 (95%)	1 (5%)	0
MBT	12 (60%)	8 (40%)	13.20	20 (100%)	0	0
DAMON	15 (75%)	5 (25%)	12.85	17 (85%)	2 (10%)	1 (5%)
TOTAL	40 (66.67%)	20 (33.33%)	13.03	56 (93.33%)	3 (5%)	1 (1.67%)

The initial records were examined to determine the original presenting malocclusion of each case. While there are many sub-classifications for occlusal relationships, for this study the cases were solely grouped as Class I, II, or III. The majority of the cases were Class I at 70% with the next group being Class II at 23.33% and Class III at only 6.67%. The distribution of the types of malocclusions of the cases examined in this study was even except all of the four Class III malocclusions were in the Damon bracket group (see Table 8 for Initial Case Malocclusion).

TABLE 8: Initial Case Malocclusion

Bracket Prescription	Class I	Class II	Class III
ROTH	14 (70%)	6 (30%)	0
MBT	14 (70%)	6 (30%)	0
DAMON	14 (70%)	2 (10%)	4 (20%)
TOTAL	40 (70%)	14 (23.33%)	4 (6.67%)

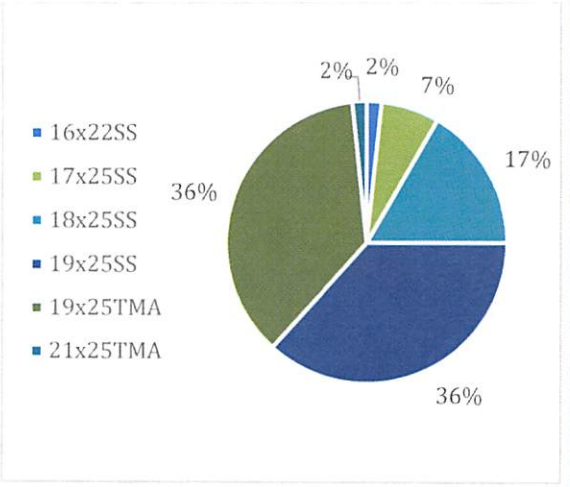
The Discrepancy Index (DI), was designed to provide an objective evaluation of initial case complexity that may lead to a better understanding of case difficulty (Cangiolosi 1998). In order to ensure initial case complexity was similar amongst the bracket prescription groups, the Discrepancy Index was calculated as described in Appendix A. As an inclusion criterion, the calculated discrepancy index had to be less than or equal to 25 for each of the cases used in this study. The average DI between all of the cases was 10.72 with a minimum of 3 and maximum of 25. Of the three bracket prescription groups, the Damon group had the highest average DI score at 12.2 followed by 11.5 in the Roth group and 8.45 in the MBT group. It was determined there was a statistically significant difference between the groups ($p=0.0034$). Specifically, the MBT

group had a statistically significantly different average discrepancy index score compared to the Roth (p=0.0251) and Damon group (p=0.0043). There was no statistical difference between Roth and Damon (p=0.8167). Reference Table 9 for Discrepancy Index Scores.

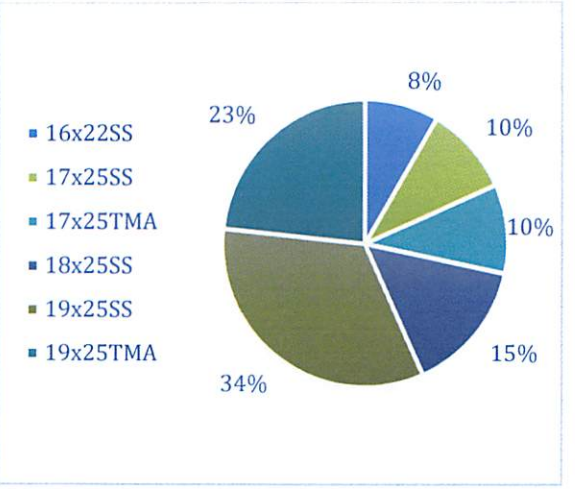
TABLE 9: Discrepancy Index (DI) Scores (p=0.0034)
(Roth vs MBT p=0.0251, MBT vs Damon p=0.0043, Damon vs Roth p=0.8167)

Bracket Prescription	Minimum DI	Maximum DI	Average DI
ROTH	5	22	**11.5**
MBT	3	19	**8.45**
DAMON	5	25	**12.2**
TOTAL	3	25	**10.72**

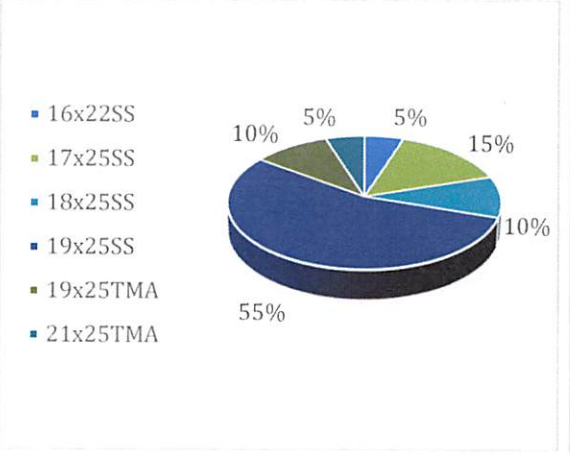
Treatment records were reviewed to also determine the type and number of archwires used in each case. The largest arch wire that was utilized for at least one month on the upper or lower arch was recorded. For the majority of the cases in the upper and lower arch a 19x25 stainless steel (36.67% UA, 33.33% LA) or TMA (36.67% UA, 23.33% LA) wire was used. The second most commonly used was an 18x25SS (16.67% UA, 15% LA). The largest diameter wire utilized was a 21x25 TMA in the Roth group and the smallest was a 16x22SS in the Roth group. An overwhelming majority of the Damon cases, a 19x25TMA wire was used (100% UA, 60% LA). Reference Figure 1 for percentage breakdowns of the Total, Roth, MBT, Damon upper and lower arch wire types that were utilized.



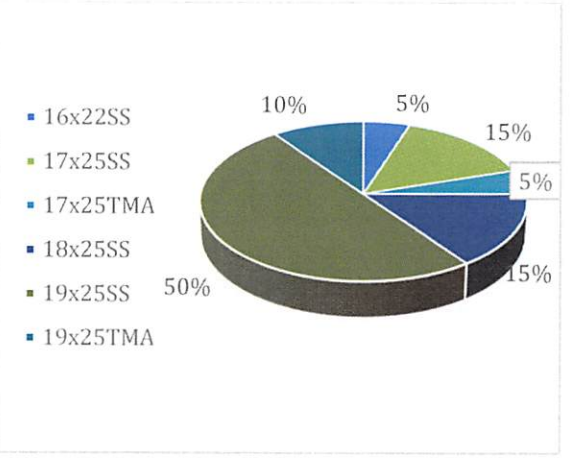
A. Total UAW



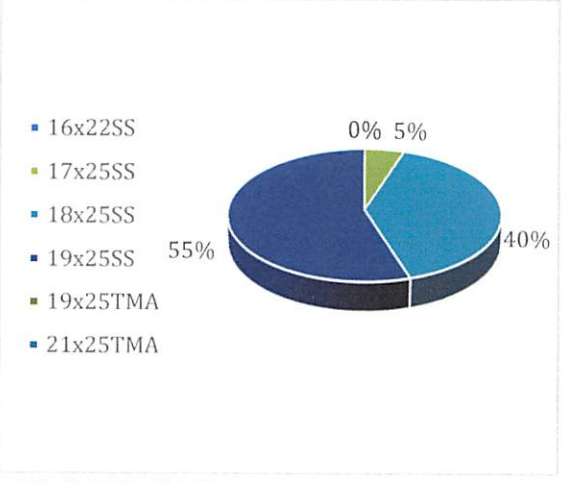
B. Total LAW



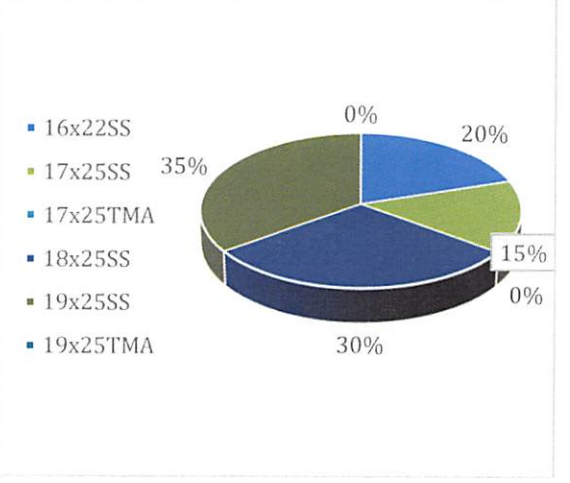
C. Roth UAW



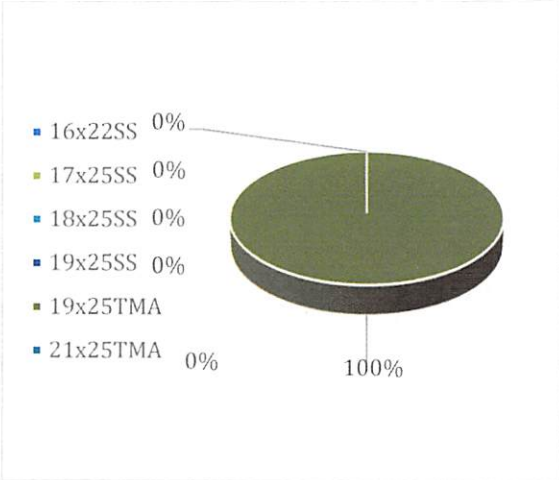
D. Roth LAW

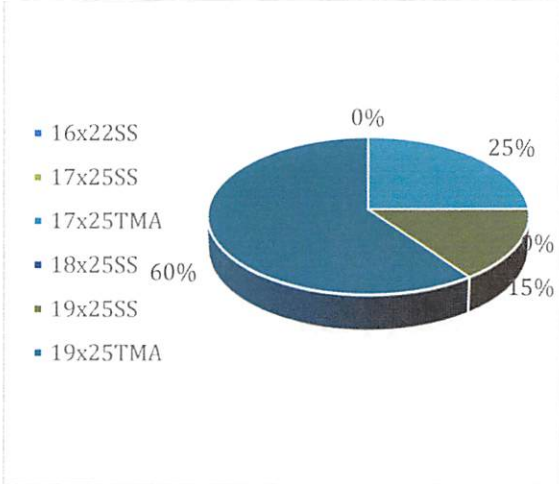


E. MBT UAW



F. MBT LAW





G. Damon UAW **H. Damon LAW**

FIGURE 1: Upper and Lower Arch Wire Type. The total upper and lower arch wires are represented in (A) and (B), the Roth upper and lower arch wires are represented in (C) and (D), the MBT upper and lower arch wires are represented in (E) and (F), and the Damon upper and lower arch wires are represented in (G) and (H).

In addition to the arch wire type, the number of arch wires that were used was also calculated. The overall minimum number of arch wires used in both the upper and lower arches was 4 and the maximum for the upper was 16 and lower was 14. The overall average of total arch wires used in all sixty cases were 8.25 for the upper arch and 7.18 for the lower arch. The Roth prescription group used the most upper and lower arch wires whereas the Damon prescription group used the least (see Figure 2 for Arch Wire Usage). Statistical analysis revealed that the difference in the number of arch wires used was not statistically significant between the groups (upper arch $p=0.3122$ / lower arch $p=0.0932$).

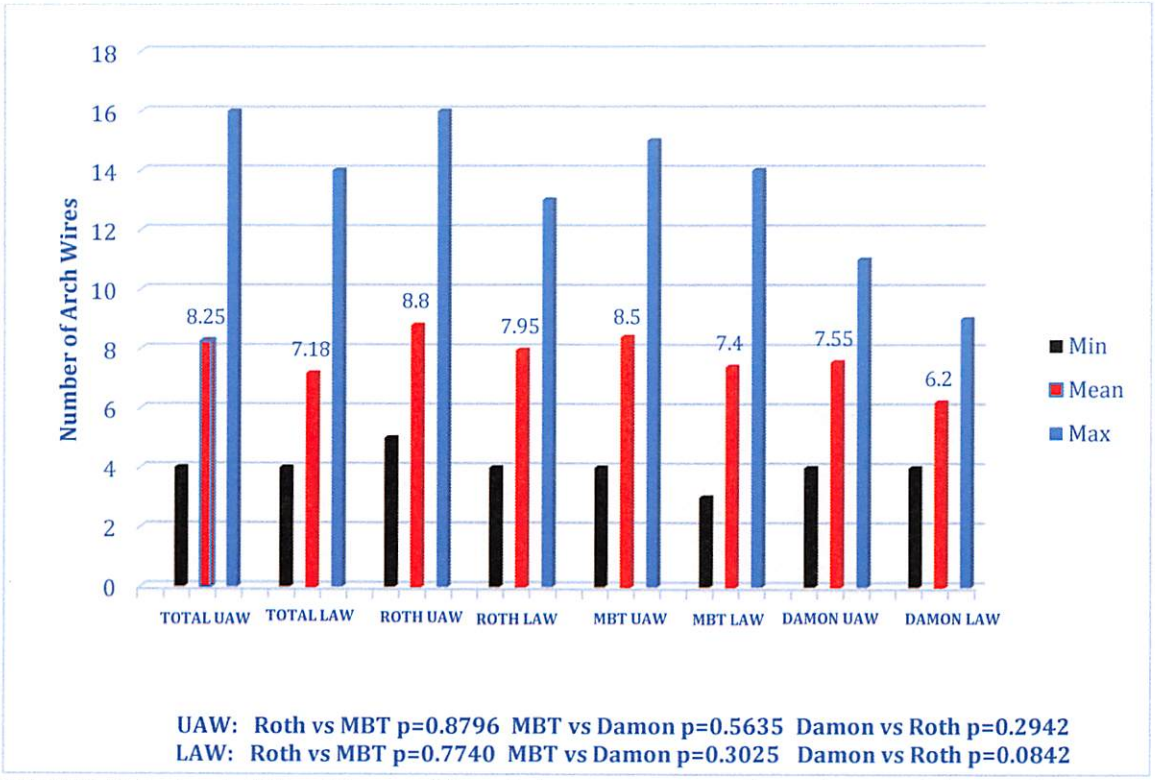


FIGURE 2: Arch Wire Usage. The minimum, mean, and maximum of the total upper and lower arch wires as well as the number of arch wires used in each separate group with no statistically significant difference (UAW p=0.3122 and LAW p=0.0932).

The treatment time and number of appointments was also obtained from treatment records and examined. The overall average treatment time for all sixty cases was 688.05 days (22.5 months). Separated into bracket prescription group, Damon had the longest average treatment time at 712.4 days followed closely by Roth at 710.7 days and MBT at the shortest average treatment time of 641.05 days. The Roth prescription group had the largest range of treatment times with the least being 309 days and the most 1093 days. Although MBT had the shortest average treatment time, there was no statistically significant difference between the three groups (p=0.2285) (see Figure 3 for Average Treatment Time).

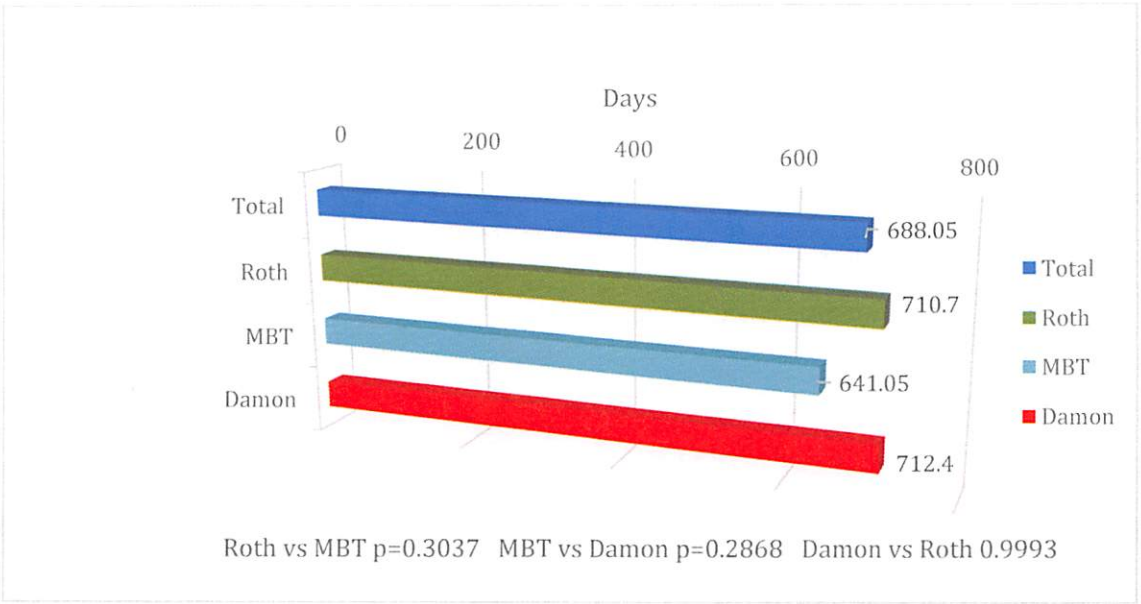


Figure 3: Average Treatment Time. The average treatment time in days for the total of all of the cases as well as each bracket prescription group with no statistically significant difference (p=0.2285).

The average number of appointments for each case was also obtained for the total and three bracket prescription groups. The total average number of appointments was 19.3 with the Roth prescription having the highest average number of appointments at 21.05, followed by the MBT group at 19.7 and the lowest number of appointments in the Damon group at 17.15. The Roth prescription group again had the largest range of number of appointments with a minimum of 10 and maximum of 31 (see Figure 4 for the Average Number of Appointments). A statistically significant difference was found between the number of appointments (p=0.0272). Specifically, there was a statistically significant difference between the Damon and the Roth group (p=0.0226). There was no statistically significant difference between Damon and MBT (p=0.1839) or MBT and Roth p=0.6144).

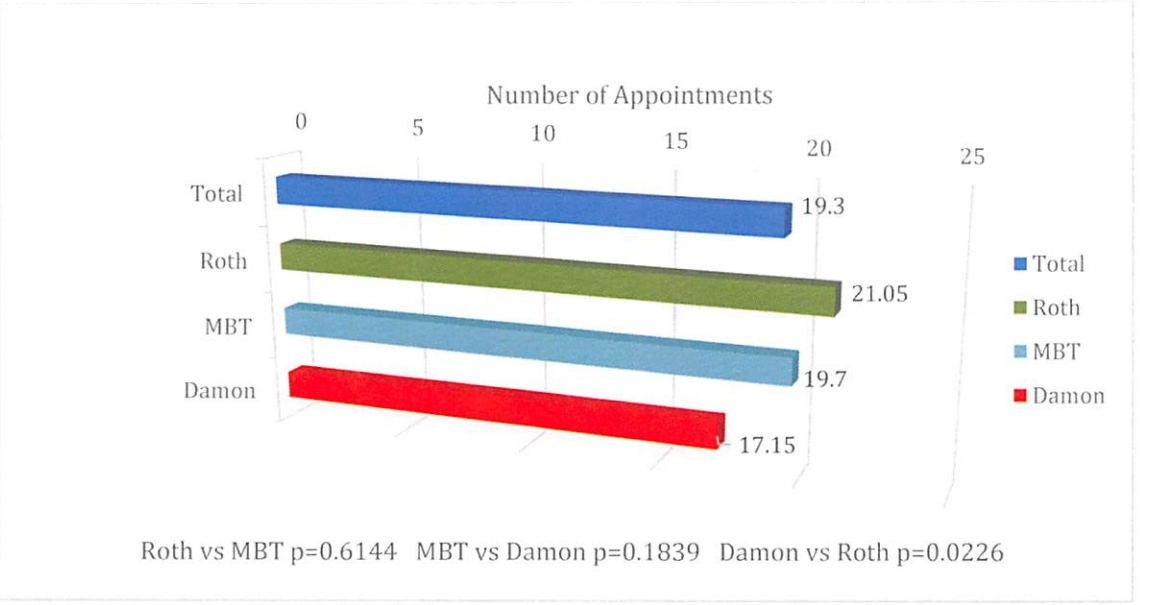


Figure 4: Average Number of Appointments. The average number of appointments for all cases as well as per each prescription group with a statistically significant difference (p=0.0272).

In order to ensure intra-rater and inter-rater reliability of the objective grading portion of this study, ten test cases were scored twice by the principle investigator (R1) and another orthodontic specialist (R2) using the objective grading system described above. Statistical analysis indicated substantial agreement between R1 and R2. In addition, for intra-rater reliability there was fair agreement between the total of two gradings of R1 and R2.

Once inter and intra-rater reliability was confirmed, the sixty cases selected for this study were objectively scored by both raters (R1 and R2). The five variables assessed using the objective ABO scoring system included alignment, canine occlusion, overjet, interproximal contacts, and root positioning to give an overall total. A higher score correlates with elements of the final case that deviate from ABO ideal standards. Overall, MBT (6.73) had the lowest total average scores followed by Roth (7.6) and then

Damon (8.38) with the highest. Statistical asssessment of the total average objective scores between the three bracket systems showed there was no statistically significant difference between the three groups (MBT vs Damon p=0.1244, MBT vs Roth p=0.5506, Damon vs Roth p=0.6257).

However, once examined more closely within the subcategories of the objective grading system, statistical differences were found. The rankings of ABO scores from highest score to lowest included: alignment (Damon>MBT>Roth), canine occlusion (Roth>Damon>MBT), overjet (Damon>MBT>Roth), and root position (Roth>MBT>Damon). A statistically significant difference was found for each of the groups (see Table 10 for Average Objective Scores P-Values). Specifically, for alignment (p=0.0483) indicating a statistical difference; specifically, there is a statistically significant difference between Damon and Roth (p=0.0494). There was no statistical difference between MBT versus Damon (p=0.1617) and MBT versus Roth (0.8514). For canine occlusion (p=0.0018) there was a statistically significant difference; specifically, a statistically significant difference was determined betwee Roth and MBT (p= 0.0014) but there was no statistical difference between MBT versus Damon (p=0.4406) and Damon versus Roth (0.0513). For overjet (p=0.0122) there was also a stastically significant difference; specifically, there was a statistical difference with Damon versus MBT (p=0.0316) and Roth (p=0.0228) but there was no statistical difference between MBT versus Roth (p=0.9916). There were no cases that had space and thus all of the cases had a score of zero for interproximal contacts, so no analysis was performed on this variable. Finally, for root positioning (p=0.0013) a statistically significant difference was also determined; specifically, there was a statistically

significant difference between Damon versus Roth (p=0.0030) and MBT (p=0.0063) but there was no difference between MBT vs Roth (p=0.9709). Refer to Figure 5 for the Average Objective ABO Scores for a breakdown of each objective category analyzed.

Table 10: Average Objective Scores P-Values

Category	Overall	MBT vs Damon	Roth vs MBT	Damon vs Roth
Total		P=0.1244	P=0.5506	P=0.6257
Alignment	***P=0.0483***	P=0.1617	P=0.8514	***P=0.0494***
Canine Occlusion	***P=0.0018***	P=0.4406	***P=0.0014***	P=0.0513
Overjet	***P=0.0122***	***P=0.0316***	P=0.9916	***P=0.0228***
Root Position	***P=0.0013***	***P=0.0063***	P=0.9709	***P=0.0030***

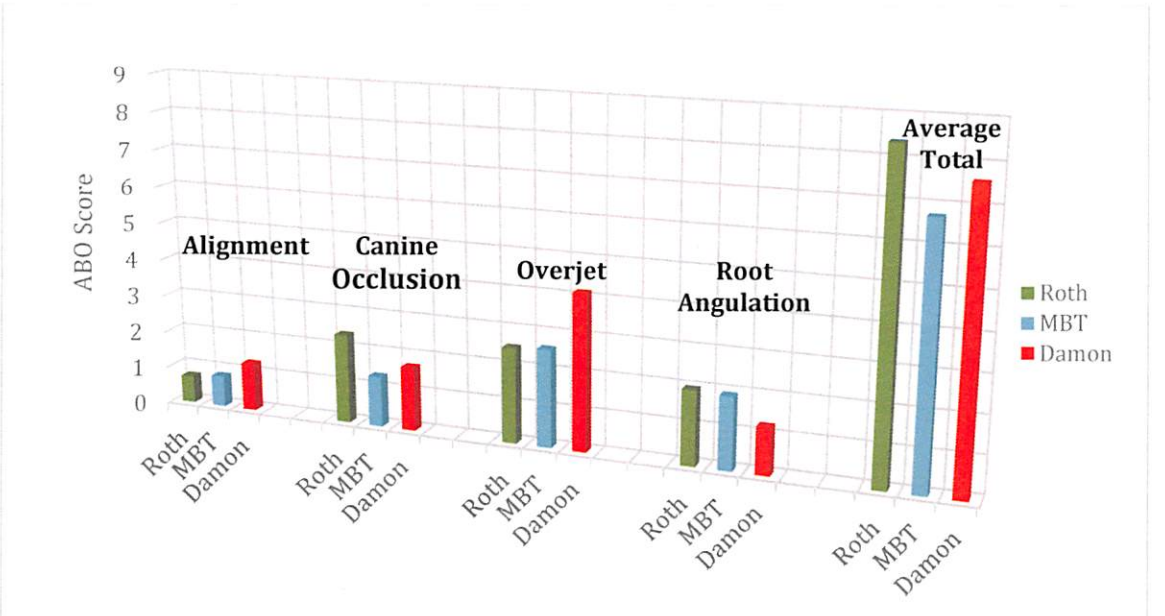


Figure 5: Average Objective ABO Scores. The average scores per grading category as well as the total average for each of the three bracket prescription groups.

The initial case difficulty which should be reflected with a higher DI score was also examined in correlation with the objective ABO score. There was a significant difference between the average initial discrpancy index score (DI) (p=0.0034). Specifically , MBT had a statistically significantly different DI score than Damon (p=0.0043) and Roth (0.0251) but there was no difference between Damon versus Roth (p=0.8167). The average DI scores ranked Damon>Roth>MBT which actually correlated with ranked final objective ABO scoring (Damon>Roth>MBT). Upon analysis, the DI score and the Objective Score showed a moderate to strong positive linear relationship. In addition, when comparing the scoring of raters (R1 vs R2), no significant difference was found between the two raters on average score per group (Roth p=0.0990, MBT p=0.1907, and Damon p=0.2268) indicating consistency in objective scoring.

SUBJECTIVE ASSESSMENT RESULTS

The subjective portion of the study involved seven orthodontic specialists blinded to the identity of the patient, the treating orthodontist/resident pair, and bracket prescription used. The orthodontic specialists were asked to answer a set of ten subjective questions regarding final cases treated non-extraction with one of the three bracket prescriptions. Based on the final models of the cases, the seven specialists were asked to give their subjective opinion on several aspects of the treated cases, these included: the torque of the upper incisors/lower incisors/upper canines, the mesio-distal tip of the upper canines, the arch development, and the overall case finish. Unlike the objective scoring portion of this study, a higher subjective score indicates a better subjective analysis for the case indicating a better result. Overall, for the subjective

analysis, the group treated using the MBT prescription had higher scores, indicating a better subjective evaluation for proper upper incisor torque, proper lower incisor torque, and proper torque of the upper left canine. The Roth prescription group had the highest scores for proper torque of the upper right canines, mesio-distal tip of the upper right canine, and arch development. The only category the Damon group had the highest score was for the mesio-distal tip of the upper left canine. For overall best case finish, MBT had the highest score followed by Damon and Roth whose overall case finish score was essentially the same. However, a statistically significant difference between the three bracket prescriptions in only the lower incisor torque (p=0.0129), upper right canine torque (p=0.0012), and upper left canine torque (p=0.0001) was found (see Table 11 for Subjective Questions P-Values and Figure 6 for Subjective Survey Average Scores).

Table 11: Subjective Questions P-Values

Question	P-Values
1 – Upper incisor torque	P=0.3814
2 – Lower incisor torque	***P=0.0129***
3 – Upper right canine torque	***P=0.0012***
4 – Upper left canine torque	***P=0.0001***
5 – Upper right canine tip	P=0.5987
6 – Upper left canine tip	P=0.3330
7 – Arch development	P=0.0724
8 – Case finish	P=0.0877

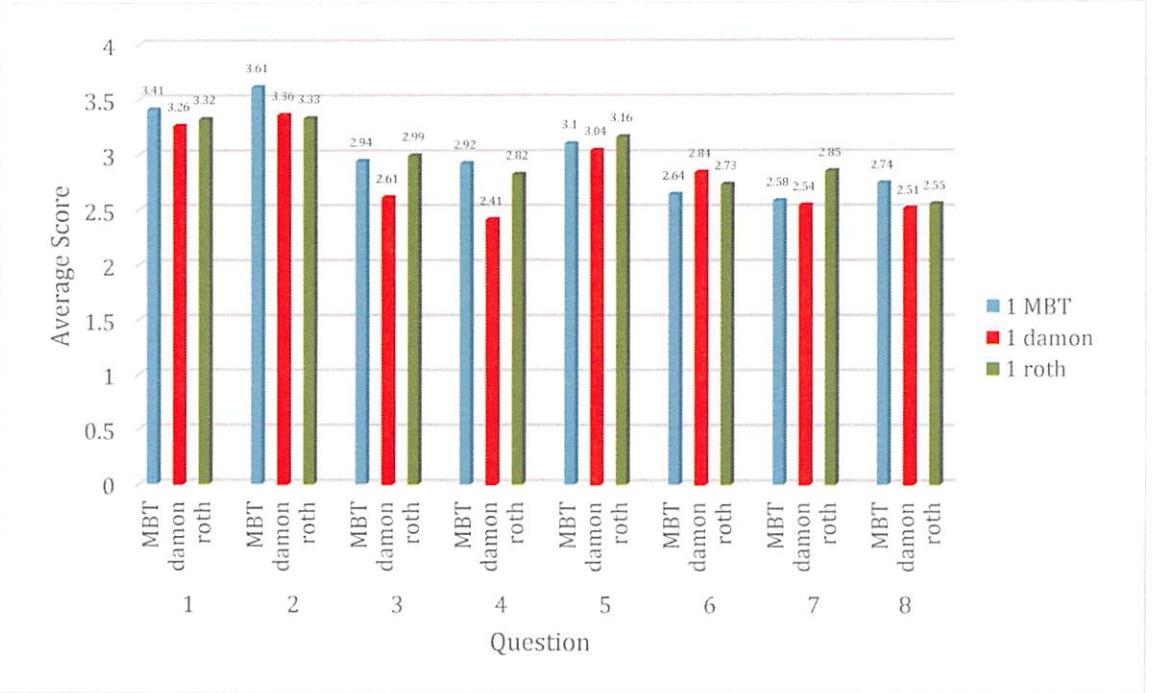


Figure 6: Subjective Survey Average Scores. The eight subjective questions scored on a 0-4 Likert Scale are averaged and listed per bracket prescription group. The three categories that resulted in statistically differences are questions 2 (p=0.0129), 3 (p=0.0012), and 4 (p=0.0001).

The orthodontic specialists that evaluated the cases were also instructed to note if they deemed any of the cases to be over-torqued or over-proclined. When this was noted on the form, an average score of two was applied to that particular section and the number of upper incisors, lower incisors, or canines that were noted to have over-proclination or too much torque were tallied if one or more specialists deemed the case to have too much labial crown torque in the upper or lower incisors or upper canines (see Table 12 for Number of Cases with Excessively Torqued Incisors or Canines). In terms of upper incisor torque, at least one orthodontist deemed the upper incisors were proclined in about half of each bracket prescription group. In terms of the lower incisors torque, 70% of the Roth cases were deemed to have over-torqued lower incisors by at least one orthodontic specialist. Damon follwed at 60% and MBT had the least over-

proclined lower incisors at 45%. In terms of the canines, a significant number of Damon cases (90%) were deemed to have too much labial crown torque with only two cases having good upper canine torque.

Table 12: Number of Cases with Excessively Toruqed Incisors or Canines

Bracket Prescription	Over-torqued Upper Incisors	Over-torqued Lower Incisors	Over-torqued Canines
ROTH	11 (55%)	14 (70%)	6 (30%)
MBT	10 (50%)	9 (45%)	6 (30%)
Damon	10 (50%)	12 (60%)	18 (90%)

In addition, the specialists were asked to guess which bracket prescription they thought was used in the case. When examining how often each of the seven orthodontic specialists were correct in guessing the actual bracket prscription used, it was found that they were incorrect 83% of the time. There was a significant difference between the percent that correctly guessed and those that did not correctly guess. Inter-rater reliability was very low suggesting limited to no agreement between the guess and the correct prescription utilized. All of the orthodontic specialists that participated in the study had experience in using only either the Roth or MBT prescription. Of those that used MBT in their own practice, they guessed the case was treated with MBT 25% of the time and those who used Roth guessed the case was treated with a Roth prescription 36.67% of the time. Overall, the majority of the orthodontic specialists subjectively guessed the case was treated by Roth (189), second by MBT (133), and the least by Damon (98). The higher guessing percentage of cases potentially treated with a Roth prescription may be correlated to the familiarity of the orthodontic specialists with this prescription as three of the seven currently use this prescription and all of the seven have experience using the

Roth prescription whereas this is not the case with the MBT or Damon group (refer to Table 10 for Bracket Prescription Guess versus Actual Group and Figure 7 for Correct versus Incorrect Guess per Bracket Prescription Group).

Table 13: Bracket Presciption Guess versus Actual Group

	Correct Guess	**Incorrect Guess**	
Response	73 (17.38%)	347 (82.62%)	
	ACTUAL GROUP		
	Damon	**MBT**	**Roth**
Damon Guess	***41 (41.84%)***	28 (28.57%)	29 (29.59%)
MBT Guess	53 (28.04%)	***73 (38.62%)***	63 (33.33%)
Roth Guess	46 (34.59%)	39 (29.32%)	***48 (36.09%)***

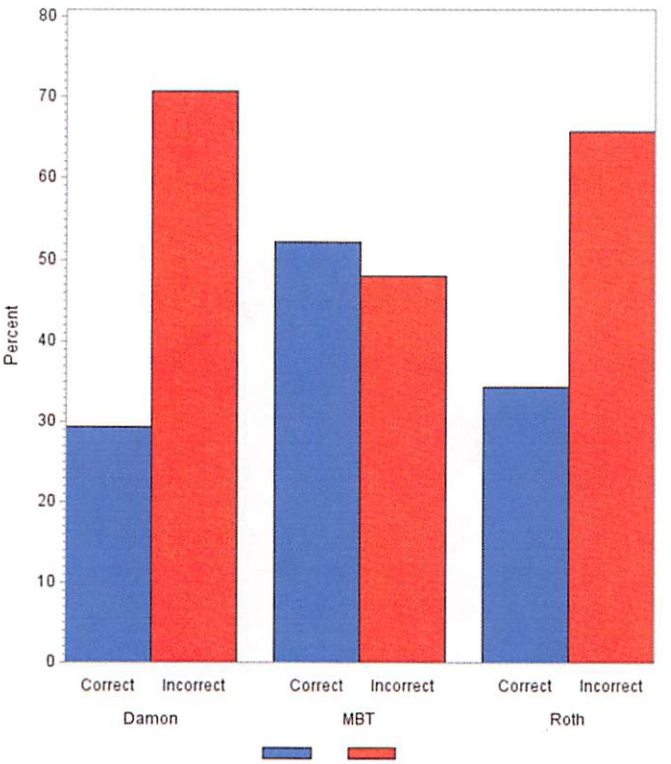


FIGURE 7: Correct versus Incorrect Guess per Bracket Prescription Group. The Damon and Roth groups were incorrectly guessed twice as many times as they were correctly identified and MBT was guessed correctly and incorrectly half the time.

DISCUSSION

Standardization between the cases in the three bracket groups was designed in this retrospective study utilizing the inclusion and exclusion criteria. The patients selected were all less than 18 years old, did not require an orthodontic extraction technique, surgery or growth modification was not implicated, patients that were not compliant were excluded, and the discrepancy index score had to be less than 25. Upon examination, homogeny of many case variables was confirmed between the three bracket prescription groups. Each of the three groups of the twenty cases had a similar female:male ratios, average age, ethnicity, and presenting malocclusion. As a retrospective study, it is difficult to standardize and reduce variables that can introduce error and that could potentially affect study results. However, in this study these variables were eliminated as potential influential characteristics that could affect study results when trying to solely examine bracket prescription.

No former studies could be identified in the examination of arch wire type or amount used between bracket prescription groups. In this study, it was found that in the majority of the Roth (65% UAW, 65% LAW) and MBT (95% UAW, 65% LAW) cases, either a 18x25 or 19x25 stainless steel was the largest and stiffest wire utilized in the case. However, in the majority of those in the Damon category a 19x25TMA (100% UAW, 60% LAW) wire was the largest and stiffest wire used. In each of the three bracket prescription groups the dimension of the largest arch wire used was similar and therefore could potentially express a similar percentage of the bracket prescription.

However, there is a possibility since the Damon group used TMA wires instead of steel wires that the torque expression could differ. Prior studies by Kusy et al 1983, found the fundamental expression of torque in a bracket by an archwire is dependent on the stiffness and size of the arch wire. Specifically, a Niti and TMA of the same thickness actually have lower stiffness than a stainless steel wire and thus may express less torque (Kusy 1983). There are several effects of final case treatment that can potentially be related to this difference in arch wire type assessed in the objective and subjective categories that relate to torque and arch development.

The difference in wire type usage among the two groups have implications in terms of clinical significance with overhead. There is a substantial difference in price for stainless steel versus TMA archwires. When analyzing prices from DENTSPLY GAC a pack of 10 wires for 19x25SS was $24.84 whereas a pack of 19x25TMA was $127.60. From these values, TMA wires are almost five times more expensive than stainless steel wires. The number of archwires used should also be considered. Certain arch wires, like more flexible TMA wires, may be utilized longer to finish cases than more rigid wires like stainless steel. In this study, it was found that the Roth and MBT prescription utilized more archwires on average and Damon utilized the least, however, the difference was not statistically significantly different. Therefore, a more significant impact on treatment in terms of treatment effects and overhead is the arch wire type utilized not necessarily the number of arch wires. A limitation to this study is that although operators were standardized to similar treatment philosophies, there were multiple operators within each bracket prescription group whose personal treatment sequence can influence specifics of arch wire types and usage. In future studies, to eliminate operator

preferences, one operator utilizing the three bracket prescription groups during the same time frame could reduce this error.

Early on in orthodontics, treatment intervals were shorter with two to three weeks between adjustments being the norm. However, in 1965, an orthodontist, Alger began to question the short treatment intervals and conducted a study to evaluate a minimum of six week adjustment intervals. The results showed that this did not lengthen overall treatment duration and 50% more active patients could also be seen. Proffitt 2007 cites the rationale of appointment interval time is biologically based. Specifically, tooth movement takes approximately 10 days to complete but the repair time of the periodontal ligament to regenerate is equal to or longer than the time required to move the tooth. Therefore, if patients are seen too soon, damage can occur to the teeth. Therefore, a treatment interval of at least 4-6 weeks is recommended. Maximizing treatment intervals while minimizing treatment time is an important part of orthodontic treatment from a patient satisfaction standpoint as well as from a practice management standpoint. Therefore, in the assessment of potential benefits to bracket prescriptions, determining a potential difference in the treatment time and number of appointments is essential. Most of the literature that assesses treatment time and adjustment intervals are comparing self-ligating versus conventional brackets. The literature provides conflicting findings with regard to self-ligating Damon systems in comparisons to conventional systems. Several studies have shown overall shorter treatment time with the Damon system (Rinchuse 2007). However, other studies such as those by Yorita 2007 and Pandis 2007 have shown no difference in total treatment time. In this study, bracket prescription was the main focus of the study, however, the difference in ligation technique between the

systems should be noted as it is a fundamental difference between the bracket prescription groups.

When comparing the three different bracket prescriptions in this study in relationship to the number of adjustment appointments, a statistically significant difference was found between the Damon and MBT and Damon and Roth. The data reveals that the Damon bracket prescription group had on average a significantly less number of adjustment appointments than both the Roth and MBT groups. There was no statistically significant difference in the number of adjustment appointments between Roth and MBT. However, there was no statistically significant difference in treatment time between any of the three bracket prescription groups. The Damon system actually had a slightly longer average treatment time than Roth and MBT. In addition, although MBT had on average a treatment time of about sixty days less than Roth and Damon, this difference was not statistically significant. This is a difference of about two months which may be a clinically significant advantage of the MBT. When assessing the initial DI, which is an assessment of initial case complexity, the MBT group did have a statistically significantly lower average DI than the Roth and Damon group. Prior findings such as those of Vu et al 2008 and Parrish et al 2011 showed that DI score is correlated with increased treatment duration. Therefore, the lower initial case difficulty difference could contribute to the difference in treatment time with MBT having a shorter treatment time, it is not necessarily an advantage of using the bracket prescription. In addition, as noted previously, there were multiple operators within each bracket prescription group whose personal treatment philosophies could affect the treatment time and adjustment appointment numbers. Also, appointment availability differences

between the operators as some were present in clinic more than others, could potentially effect treatment time and adjustment numbers which is an additional limitation to this study.

The American Board of Orthodontic Index has gained increased recognition in the orthodontic profession as a valid measure of excellence in orthodontic finishing (Cangialosi 2004 and Casco 1998). Lower ABO scores correlates with a better overall finish of the case. In this study, the objective ABO evaluation of each bracket prescription group showed a difference with MBT having the lowest total average scores followed by Roth and then Damon with the highest, however, these differences were not to the level of statistical significance. These results support prior findings such as those by Jain et al 2013 that found a lower ABO score for the MBT bracket prescription when compared to the Roth prescription. The potential differences in overall ABO score could possibly be related to the initial differences in the discrepancy index scores of each case. Statistical analysis showed a strong correlation between the initial DI score and the final objective ABO score showing the MBT group with lower DI scores and lower final ABO scores and Damon with higher initial DI scores and higher final ABO scores. However, when each case was more closely analyzed and the objective scores broken down into subcategories, statistically significant differences were found between the bracket prescription groups.

Specifically, there is a statistically significant difference between Damon versus MBT and Roth in terms of both alignment and overjet. A potential contributing factor in the Damon having higher alignment scores and thus poorer alignement results could be the smaller mesiodistal bracket width design of the Damon brackets that can potentially

lead to less mesio-distal control of the tooth. In addition, poorer alignment results could be related to the bracket prescription differences as well. First (in-out), second (mesio-distal tip), and third (torque) order dimensional positions may all be interpreted as an alignment issues due to improper positioning of incisal edges. Thus, torque and angulation differences in bracket prescriptions can potentially have an impact on alignment. This is more of a possibility in these cases, because although alignment scores in the anterior were higher on average for Damon, this group actually had the lowest score in root positioning errors. Therefore, torque rather than mesio-distal tip may have resulted in alignment deviations. Specifically, the Damon prescription used in cases in this study had different angulation values for lower incisors at +2 at the centrals and +4 at the laterals compared to Roth and MBT where all four incisors were at 0. In addition, there was a larger variance in torque between the upper lateral incisors and upper canines in the Damon bracket group. There was 16 degrees of torque difference between the upper lateral incisors and canines in the Damon group and only a 10 degrees variation in the MBT and Roth group. The higher overjet scores found in the Damon group could also potentially be related to the higher torque values incorporated into the Damon bracket prescription group. Specifically, in comparison to Roth (upper canines -2 and lower canines -11) and MBT (upper canines 0, lower canines 0), the canines torque in the Damon group is higher with more labial crown torque incorporated into the bracket system (upper canines +11, lower canines +13). In addition, the lower incisor torque in the Damon group is much lower at -11 lingual crown torque compared to the MBT (-6) and Roth (0) groups. Expressing these torque values could result in potentially more overjet in the Damon cases with upper canines torqued more labially and lower incisors

torqued more lingually. However, to note, torque expression itself is not soley based on bracket prescription. Former studies such as those by Gioka and Eliades 2004 note many factors play a role in torque expression, for example, the method of ligation or the use of different arch wire sizes and types which were both factors in this study. The statistical difference between the Damon group versus the Roth and MBT group in terms of alignment or torque could also be attributed to other factors that have been identified to affect torque expression such as individual orthodontists finishing techniques, bracket placement errors, and tooth morphology (Van Loenen 2005).

There was a statistically significant difference in the Roth group versus MBT and Damon when evaluating canine occlusion. Roth had higher scores in terms of canine occlusion, indicating poorer antero-posterior relationships of the canine teeth. Historically, the Roth prescription was designed with more distal root tip in the canines to facilitate cuspal guidance. However, the brackets used in this study were slightly variable to the original prescription at the upper canine angulation with less distal tip incorporated into the bracket. The angulation of the Roth group upper canines used in this study was +7 which is between MBT at +8 and Damon at +5. Although there is a slight 2 degree angulation difference in the lower canines in the Roth group compared to the Damon and MBT, there is no clear trend observed in the data relating influence of bracket prescription that one could attribute. The canine occlusion relationship is most likely more related to antero-posterior correction achieved with inter-arch coordination rather than bracket prescription.

From the subjective portion of the study, several aspects of the overall case finish were assessed by seven experienced orthodontic specialists. They were asked to

subjectively evaluate the torque of the upper and lower incisors, the torque and mesio-distal tip of the upper canines, the arch development, and the overall case finish. A higher numerical subjective score correlates with better final results of the case. Results for the overall subjective analysis revealed that orthodontists gave on average higher scores to cases treated with the MBT prescription. In the study by Moesi et al 2011, the MBT group also had the most highly scoring subjective totals which was also found in this study. Specifically, MBT had a better subjective evaluation for proper upper incisor torque and proper lower incisor torque. In addition, the MBT group had the best scores for overall case finish. MBT has a higher built in torque value at central incisors +17 and +10 for upper lateral incisors compared to Roth at +12/+8 and Damon +2/-5. In addition, MBT has a negative lower incisor torque of -6 compared to Roth at 0 and but this torque is less negative than the Damon prescription that has -11. The subjective values for lower incisors torque could be the result of acceptable negative torque expressed in the MBT group because large stainless steel wires were utiliized. When comparing those noted as over-torqued or proclined all three groups had an equal number of cases that were deemed potentially over-torqued facially or slightly proclined in the upper incisors. To note, however, the MBT group had the least number of those marked to have facially over-torqued or proclined lower incisors and there was a statistically significant difference between MBT versus Roth and Damon in terms of the lower incisor torque. Considering these cases were all non-extraction, this may be the result of crowding resolution using proclination rather than a result of bracket prescription itself, however, even if this is the case the MBT group subjectively appeared to control lower incisor proclination most effectively.

The most statistically significant difference was the results of the subjective analysis of canine torque. For both of the upper canines, the Damon group had significantly lower scores and thus poorer torque control on both of the upper canines. When assessing built-in canine torque in the Damon prescription group, Damon has +11 built in torque compared to Roth at -2 and MBT at 0. In addition, when subjectively evaluated by the orthodontic specialists, in 18 of the 20 cases in the Damon group evaluators noted the upper canines were over-torqued facially or proclined. This correlates with the objective evaluation that showed the Damon group had poorer scores in the overjet category, most likely due to the facially torqued canines that did not contact with the lower incisors or canines.

When it came to the clinicians utilizing their experience to subjectively assess which bracket prescription was used in each case, 83% of the time practicioners could not correctly identify the bracket prescription utilized in the case. The Roth and Damon groups were incorectly identified twice as often than they were correctly identified. With the MBT group there was no more than a 52% chance of correct identification which is barely better than chance. These findings support the prior study by Moesi et al 2011 that also found when comparing Roth versus MBT prescriptions in the majority of cases the ability of the clinicians to determine which bracket prescription was used was no better than chance. These findings highlights the fact that the small difference in bracket prescription is rarely detectable on a clinical subjective level.

There are several limitations to this study. First, multiple operator preferences and scheduling availability can affect factors such as arch wire usage and treatment time. In addition, bracket placement preferences and finishing techniques of different operators

can affect torque and alignment results as a slight change to optimal bracket placement or finishing bends can result in different expression of prescription. Also, different ligation technique between the Damon and Roth/MBT bracket prescriptions can affect torque expression. A possible future prospective study to assess bracket prescription effects would be to select cases with very similar initial malocclusions and discrepancy index scores and have one clinician treat the patient using the different bracket prescriptions using the same appointment protocols and arch wires. Another option of a potential future study would be to utilize a computer based model to assess the different prescription effects utilizing the different bracket prescriptions on the same case in a computer generated model system.

CONCLUSIONS

Several conclusions can be drawn from this study:

- There was no statistically significant difference for the overall averaged objective scores of the five ABO categories utilized to evaluate upper and lower anterior teeth in each bracket prescription group, although MBT on average had the lowest total scores indicating less deviations from ABO standards than the Damon and Roth.
- When the objective scores were evaluated by subcategory, a significant difference was found in each group. Specifically, the Damon group had more deviations from ideal in terms of alignment and overjet but less root positioning errors. Cases in the Roth group had higher canine occlusion scores.
- From the subjective assessment by seven orthodontic specialists, the cases treated with MBT were scored the best overall.
- Subjectively the statistically significant categories were the cases in the MBT group had better lower incisor positioning and the cases in the Damon group had excessively facially torqued canines.
- However, when assessed clinically, the clinicians deemed all of the cases were treated to an acceptable finish and they were unable to detect 83% of the time what bracket prescription was utilized in each group.

- Cases treated with Roth or MBT finished in large rectangular stainless steel wires whereas cases treated with Damon finished in rectangular TMA wires.
- There was no statistically significant difference in the total number of arch wires used per bracket prescription group.
- Cases treated with Damon had less adjustment appointments than cases treated using the Roth or MBT bracket prescription.
- There was no statistically significant difference in treatment time between the three groups, although cases treated with MBT on average finished treatment two months earlier than Roth and MBT.

APPENDIX A - ABO Discrepancy Index Instructions

Occlusion for plaster models is determined by placing the separated, properly trimmed study casts (Mx/Mn) on a flat surface and then bringing them together into maximum intercuspation. All measurements must be made from this position.

OVERJET: Overjet is a measurement between two antagonistic anterior teeth (lateral or central incisors) comprising the greatest overjet and is measured from the facial surface of the most lingual mandibular tooth to the middle of the incisal edge of the more facially positioned maxillary tooth.

- For ≥0 to <1 mm, score 1 pt
- For ≥1 to ≤3mm, score 0pts
- For>3to ≤5mm, score 2pts
- For>5to ≤7mm, score 3pts
- For>7to ≤9mm, score 4pts
- For >9 mm, score 5 pts
- In addition, if there are anterior teeth with negative overjet (canine to canine in anterior crossbite >0 mm), measure from the facial surface of the maxillary tooth to the middle of the incisal edge of the mandibular tooth.
- Round any fractional remainder to the next full mm, then score 1 pt per mm per anterior tooth in crossbite.

OVERBITE: Overbite is a measurement between two antagonistic anterior teeth (lateral or central incisors) comprising the greatest overbite.

- For>0to ≤3mm, score 0pts
- For>3to ≤5mm, score 2pts
- For>5to ≤7mm, score 3pts
- If any of the lower incisors are impinging on the palatal tissues(≤0.5m) or there is 100% overbite (a complete vertical overlap of antagonistic incisors), score 5 pts.

ANTERIOR OPEN BITE: For each anterior tooth (canine to canine) in an open bite relationship with an opposing tooth, measure from the incisal edge of the Mx tooth to the incisal edge of the Mn tooth.

- For each anterior tooth in edge-to-edge relationship (0 mm), score 1 pt per tooth.
- For each anterior tooth in open bite (> 0 mm), round any fractional remainder to the next full mm, then add 1 pt per mm per tooth in open bite.
- No points are scored for any anterior tooth that is blocked-out of the arch due to space deficiency or not fully erupt

LATERAL OPEN BITE: For each maxillary posterior tooth (from the 1st premolar to the 2nd molar) in an open bite relationship ≥0.5 mm from its opposing tooth, measure cusp to cusp.

- Round any fractional remainder to next full mm
- Then score 2 pts per mm of open bite for each tooth.
- No points are scored for any tooth that is blocked-out of the arch due to space deficiency or not fully erupted.

CROWDING: Measure the most crowded arch (only one arch) from the mesial contact point of the right first molar to the mesial contact point of the left first molar. If there are conditions such as missing, fractured or decayed teeth, then measure crowding consistent with your treatment objectives and be prepared to defend the score at your oral exam.

- For ≥0 to ≤1 mm, score 0pts
- For >1 to ≤3 mm, score 1pt
- For >3 to ≤5 mm, score 2pts
- For >5 to ≤7 mm, score 4pts
- For >7mm, score 7pts

OCCLUSALRELATIONSHIP: Models must exhibit the patient's maximum intercuspation. The Angle molar classification is used.

- If the mesiobuccal cusp of the maxillary first molar occludes with the buccal groove of the mandibular first molar or anywhere between the buccal groove and the mesiobuccal or distobuccal cusps (Class I to End On) - Score 0 pts.
- If the mesiobuccal cusp of the maxillary first molar occludes with the mesiobuccal (Class II end-to-end) or distobuccal (Class III end-to-end) cusps of the mandibular first molar – Score 2 pts per side.
- If the relationship is a full Class II or III - Score 4 pts per side.
- If the relationship is beyond Class II or III, measure the additional distance, round any fractional remainder to next full mm–Score 4pts plus 1 addl. pt per mm a side.

LINGUAL POSTERIOR CROSSBITE: For each maxillary posterior tooth (from the 1st premolar to the 2nd molar) where the maxillary buccal cusp is > 0 mm lingual to the buccal cusp tip of the opposing tooth - Score 1 pt per tooth.

BUCCAL POSTERIOR CROSSBITE: For each maxillary posterior tooth (from the 1st premolar to the 2nd molar) where the maxillary palatal cusp is > 0 mm buccal to the buccal cusp of the opposing tooth - Score 2 pts per tooth.

CEPHALOMETRICS:

- If the ANB angle is ≥6° OR ≤2, score 4pts
- If the SN-MP angle is between 27° and 37°
- If the SN-MP angle is ≥38°, score 2 pts
  If the SN-MP angle is ≤26°, score 1 pt
- If the Lower Incisor to MP angle is ≥99°, score 1 pt
- **OTHER**: (List number of occurrences and total points.)
- then, add 1pt for each full degree >6° OR <-2°. score 0 pt
- then, add 2 pts for each full degree > 38°
- then, add 1 pt for each full degree < 26°
- then, add 1 pt for each full degree greater than 99°

Supernumerary teeth – Score 1 pt for each extra tooth.

Ankylosis of permanent teeth – Score 2 pts per tooth.

Anomalous morphology of tooth size & shape (e.g. natural and/or iatrogenic) - Score 2 pts per tooth.

Impaction of teeth (except 3rd molars) – Score 2 pts per tooth.

Midline discrepancy – The midline for each arch equals the mid-point between the Mx central incisors and the Mn central incisors demonstrated by two vertical reference lines. The discrepancy is the difference between the two vertical reference lines measured in the horizontal plane – Score 2 pts for ≥3 mm.

Missing teeth (except 3rd molars) - Non-congenital – Score 1pt per tooth. Congenital–Score 2pts per tooth.

Spacing – For generalized spacing per arch in which there is ≥0.5 mm of space on both sides of any 4 teeth or more - Score 2 pts per arch. For Mx central diastema of ≥2mm –Score 2pts.

Tooth transposition – Score 2 pts for each event.

Skeletal asymmetry (treated nonsurgically) – Score 3 pts (appropriate diagnostic information recommended)

Additional treatment complexities - Score 2 pts each and identify.

APPENDIX B: ABO Discrepancy Index Score Sheet

EXAM YEAR _____ **ABO DISCREPANCY INDEX**

ABO ID # _____ **CASE#** _____ **PATIENT** _____

TOTAL D.I. SCORE ☐

For mm measures, round up to the next full mm.
Examiners will verify measurements in each category.

OVERJET

≥ 0 to < 1 mm (edge-to-edge)	= 1 pt	
≥ 1 to ≤ 3 mm	= 0 pts	
> 3 to ≤ 5 mm	= 2 pts	
> 5 to ≤ 7 mm	= 3 pts	
> 7 to ≤ 9 mm	= 4 pts	
> 9 mm	= 5 pts	
Negative Overjet (x-bite): 1 pt per mm per tooth	= ___pts	
	Total	☐

OVERBITE

> 1 to ≤ 3 mm	= 0 pts	
> 3 to ≤ 5 mm	= 2 pts	
> 5 to ≤ 7 mm	= 3 pts	
Impinging (100%)	= 5 pts	
	Total	☐

ANTERIOR OPEN BITE

0 mm (edge-to-edge), 1 pt per tooth	= ___pts	
then 1 pt per mm per tooth	= ___pts	
	Total	☐

LATERAL OPEN BITE

≥ 0.5 mm, 2 pts per mm per tooth

Total ☐

CROWDING (only one arch)

≥ 0 to ≤1 mm	= 0 pts	
> 1 to ≤ 3 mm	= 1 pts	
> 3 to ≤ 5 mm	= 2 pts	
> 5 to ≤ 7 mm	= 4 pts	
> 7 mm	= 7 pts	
	Total	☐

OCCLUSAL RELATIONSHIP

Class I to End On	= 0 pts	
End-to-End Class II or III	= 2 pts per side	___pts
Full Class II or III	= 4 pts per side	___pts
Beyond Class II or III	= 1 pt per mm additional	___pts
	Total	☐

30130315

LINGUAL POSTERIOR X-BITE

> 0 mm, 1 pt per tooth Total ☐

BUCCAL POSTERIOR X-BITE

> 0 mm, 2 pts per tooth Total ☐

CEPHALOMETRICS (See Instructions)

ANB ≥ 6° or ≤ -2°	@4pts	= ___
Each full degree > 6°	___x 1 pt	= ___
Each full degree < -2°	___x 1 pt	= ___
SN-MP		
≥ 38°	@2pts	= ___
Each full degree > 38°	___x 2 pts	= ___
≤ 26°	@1pt	= ___
Each full degree < 26°	___x 1 pt	= ___
1 to MP ≥ 99°	@1pt	= ___
Each full degree > 99°	___x 1 pt	= ___
	Total	☐

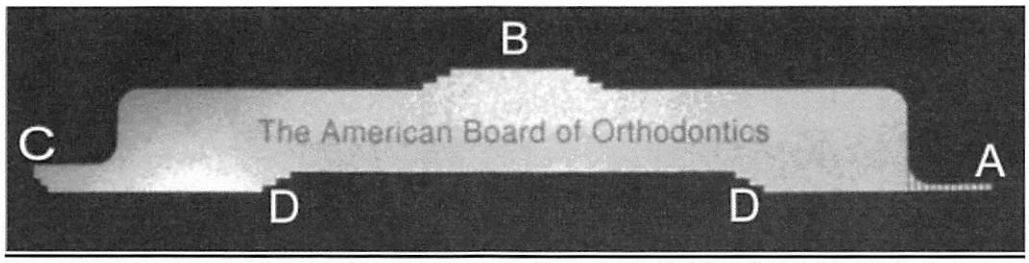
OTHER (See Instructions)

Supernumerary teeth	___x 1 pt	= ___
Ankylosis of permanent teeth	___x 2 pts	= ___
Anomalous morphology	___x 2 pts	= ___
Impaction (except 3rd molars)	___x 2 pts	= ___
Midline discrepancy (≥3 mm)	@ 2 pts	= ___
Missing teeth (except 3rd molars)	___x 1 pt	= ___
Missing teeth, congenital	___x 2 pts	= ___
Spacing (4 or more, per arch)	___x 2 pts	= ___
Spacing (mx cent diastema ≥ 2 mm)	@ 2 pts	= ___
Tooth transposition	___x 2 pts	= ___
Skeletal asymmetry(nonsurgical tx)	@ 3 pts	= ___
Addl. treatment complexities	___x 2 pts	= ___

Identify:

Total Other ☐

APPENDIX C – ABO Measuring Gauge



A This portion of the gauge is in 1 mm increments and is used to measure discrepancies in alignment, overjet, occlusal contact, interproximal contact, and occlusal relationships. The width of the gauge is 0.5 mm.

B This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in mandibular posterior buccolingual inclination.

C This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in marginal ridges.

D This portion of the gauge has steps measuring 1 mm in height and is used to determine discrepancies in maxillary posterior buccolingual inclination.

APPENDIX D – ABO Objective Scoring System

ALIGNMENT

Alignment is usually a fundamental objective of any orthodontic treatment plan. Therefore, it seems reasonable that any assessment of quality of orthodontic result must contain an assessment of tooth alignment. In the anterior region, the incisal edges and lingual surfaces of the maxillary anterior teeth and the incisal edges and labial-incisal surfaces of the mandibular anterior teeth were chosen as the guide to assess anterior alignment. These are not only the functioning areas of these teeth, but they also influence esthetics if they are not arranged in proper relationship. The results of four field tests show that the most commonly malaligned teeth were the maxillary and mandibular lateral incisors and second molars, which accounted for nearly 80% of the mistakes. In the maxillary and mandibular anterior regions, proper alignment is characterized by coordination of alignment of the incisal edges and lingual incisal surfaces of the maxillary incisors and canines (Figure 1), and the incisal edges and labial incisal surfaces of the mandibular incisors and canines (Figure 2).

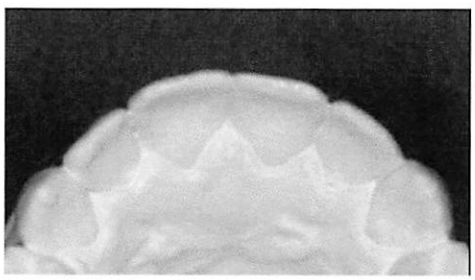


Figure 1

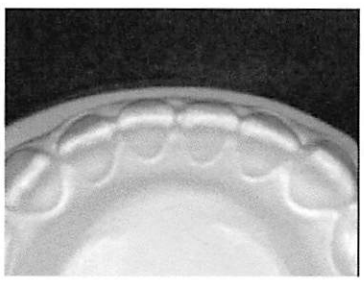


Figure 2

If the mesial or distal alignment at any of the contact points is 0.50 mm to 1 mm deviated from proper alignment (Figure 3), 1 point shall be scored for the tooth that is

out of alignment. If adjacent teeth are out of alignment, then 1 point should be scored for each tooth. If the discrepancy in alignment of a tooth at the contact point is greater than 1 mm, then 2 points shall be scored for that tooth (Figure 4). No more than 2 points shall be scored for any tooth.

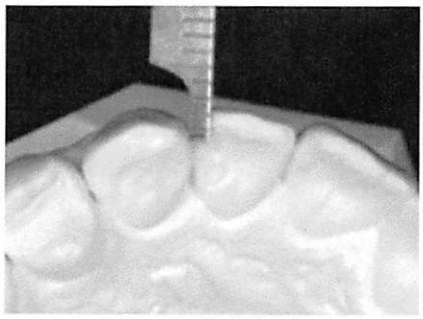


Figure 3

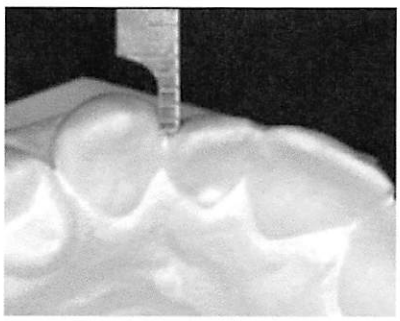


Figure 4

OCCLUSAL RELATIONSHIP

Occlusal relationship is used to assess the relative anteroposterior position of the teeth. In order to achieve accuracy and reliability in measuring this relationship, results of previous field tests have shown that the most verifiable method of scoring this criterion is to use Angle's relationship. Therefore, the buccal cusps of the maxillary canines must align within 1 mm of the interproximal embrasures of the mandibular teeth. Ideally, the maxillary canine cusp tip should align with (or within 1 mm of) the embrasure or contact between the mandibular canine and adjacent premolar (Figure 5). If the maxillary buccal cusps deviate between 1 and 2 mm from the aforementioned positions (Figure 6), then 1 point shall be scored for that maxillary tooth. If the buccal cusps of the teeth deviate by more than 2 mm from ideal position (Figure 7), then 2 points shall be scored for each maxillary tooth that deviates. No more than 2 points shall be scored for each maxillary tooth.

Figure 5

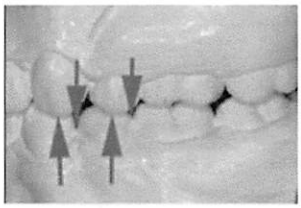


Figure 6

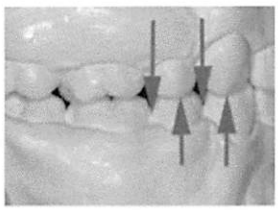


Figure 7

OVERJET

Overjet is used to assess the relative transverse relationship of the anteroposterior relationship of the anterior teeth. In the anterior region, the mandibular incisal edges should be in contact with the lingual surfaces of the maxillary anterior teeth. In past field tests, the common mistakes in overjet have occurred between the maxillary and mandibular incisors and second molars. This section of the evaluation determines whether the occlusion has been finished in an Angle Class I relationship. The overjet is evaluated by articulating the models and viewing the labiolingual relationship of the maxillary arch relative to the mandibular arch. In order to determine the proper relationship of the casts, the examiner must rely on the trimming of the backs of the bases of the models. The models are set flat on their backs, in order to determine this assessment (Figure 8).

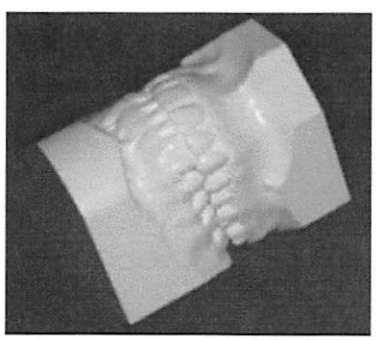


Figure 8

If the models are mounted on an articulator, then the articulated mounting shall determine the proper maxillary and mandibular model relationship. If the proper overjet has been established, in the anterior region, the mandibular canines and incisors will contact the lingual surfaces of the maxillary canines and incisors (Figure 9). If this relationship exists, no points are scored. In the anterior region, if the mandibular canines or incisors are not contacting lingual surfaces of the maxillary canines and incisors, and the distance is 1 mm or less (Figure 10), then 1 point is scored for each maxillary tooth. If the discrepancy is greater than 1 mm (Figure 11), then 2 points are scored for each maxillary tooth. Note that although overjet is typically scored by assessing contact between opposing teeth, this score is subject to examiner modification. For example, cases in which incisors display extremely acute inter-incisal angles and/or significant overlap of incisal edges may be scored an additional point.

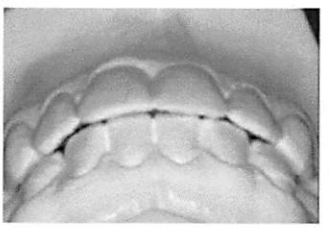


Figure 9

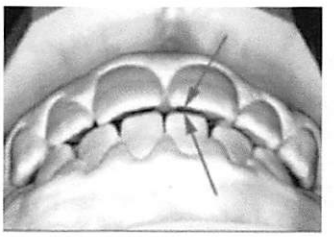


Figure 10

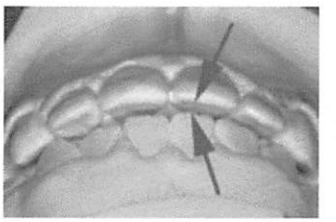


Figure 11

INTERPROXIMAL CONTACTS

Interproximal contacts are used to determine if all spaces within the dental arch have been closed. Persistent spaces between teeth after orthodontic therapy are not only unaesthetic, but can lead to food impaction. In past field tests, spacing is generally not a major problem with ABO cases. This assessment is made by viewing the maxillary and mandibular dental casts from an occlusal perspective. The mesial

and distal surfaces of the teeth should be in contact with one another (Figure 12). If 0.50 mm or less interproximal space exists, then no points are scored. If greater than 0.50 to 1 mm of interproximal space exists between two adjacent teeth (Figure 13), then 1 point is scored for that interproximal contact. If more than 1 mm of space is present between two teeth, then 2 points are scored for that interproximal contact. No more than 2 points are scored for any contact that deviates from ideal. In all of the cases selected for this study, there was no space present. Therefore, for all of the cases, this category was scored a zero.

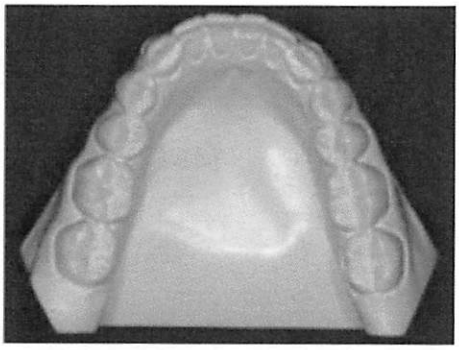


Figure 12

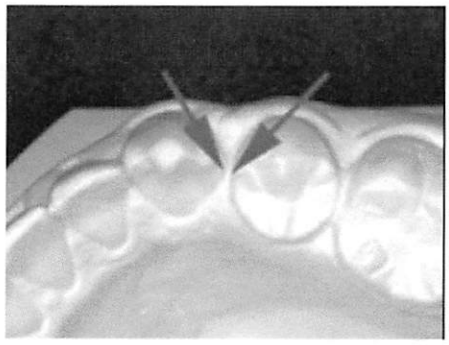


Figure 13

ROOT ANGULATION

Root angulation is used to assess how well the roots of the teeth have been positioned relative to one another. Other than periodical radiographs or three-dimensional imaging, the panoramic radiograph is probably the best practical means for making this assessment. It is incumbent upon the examinee to present imaging evidence to document post-treatment root position. If roots are properly angulated, then sufficient bone will be present between adjacent roots, which could be important if the patient were susceptible to periodontal bone loss at some point in time. If roots are dilacerated, then they are not graded. In past field tests, the common mistakes in

root angulation occurred in the maxillary lateral incisors, canines, second premolars, and mandibular first premolars. The relative angulation of the roots of the maxillary and mandibular teeth is assessed on the panoramic radiograph. Although this is not ideal, it gives a reasonably good assessment of root position. Generally, the roots of the maxillary and mandibular teeth should be parallel to one another and oriented perpendicular to the occlusal plane (Figure 14). If this situation exists, then no points are scored. The ABO acknowledges the distortion that frequently occurs within panoramic radiographs. The Board has recommended the following: Omit scoring the canine relationship with adjacent tooth root when using a final panoramic radiograph. If a root is angled to the mesial or distal (not parallel) and is close to, but not touching, the adjacent tooth root, then 1 point is scored for each discrepancy (Figure 15). If the root is angled to the mesial or distal and is contacting the adjacent tooth root, then 2 points are scored for that tooth.

Figure 14

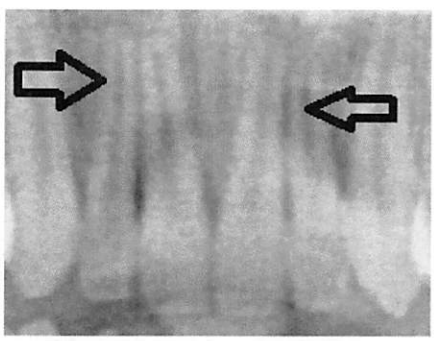


Figure 15

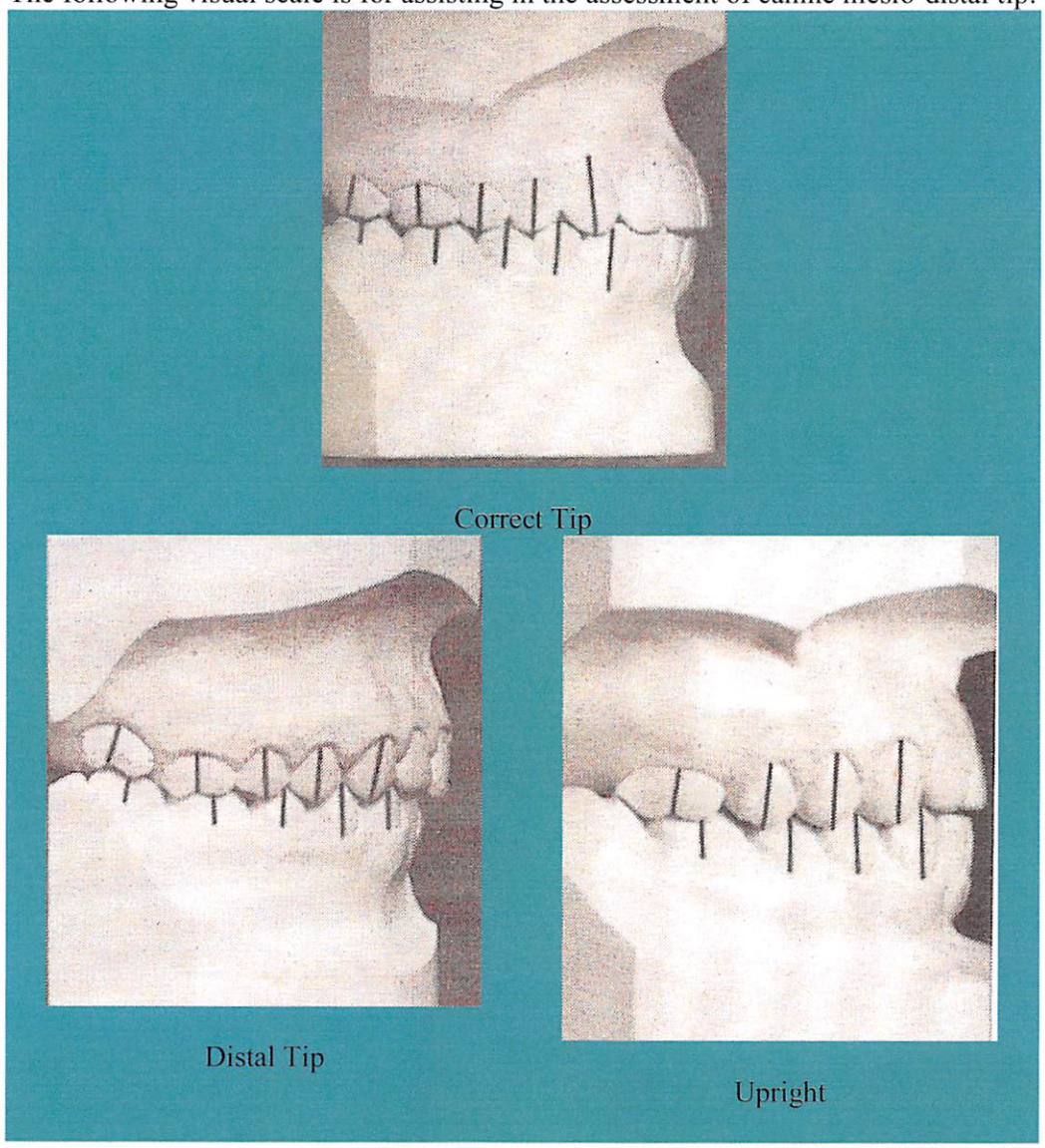
APPENDIX E – Subjective Case Score Instructions

Does bracket prescription have an effect on the outcome of fixed orthodontic treatment?

By assessing the torque of the upper and lower incisors (labio-lingual/palatal), the torque and tip (mesio-distal) of the upper canines, the arch development, and the overall case finish, we wonder whether you are able to predict if a case was treated using the Roth, MBT, or Damon prescription better than chance.

You are asked to assess 8 aspects of each finished case and then to predict if it was treated with Roth, MBT, or Damon bracket prescriptions.

The following visual scale is for assisting in the assessment of canine mesio-distal tip:



Please assess the following 60 cases.

APPENDIX F - Subjective Case Score Form

1. Torque of the upper incisors (UR2 to UL2)

All 4 teeth inadequately torqued	3 teeth inadequately torqued	2 teeth inadequately torqued	1 tooth inadequately torqued	All 4 teeth adequately torqued

2. Torque of the lower incisors (LR2 to LL2)

All 4 teeth inadequately torqued	3 teeth inadequately torqued	2 teeth inadequately torqued	1 tooth inadequately torqued	All 4 teeth adequately torqued

3. Torque of upper right canine (UR3)

Severely under-torqued	Poor torque	Satisfactory torque	Good torque	Best possible torque

4. Torque of upper left canine (UL3)

Severely under-torqued	Poor torque	Satisfactory torque	Good torque	Best possible torque

5. Mesio-distal tip of upper right canine (UR3)

Significant distal tip	Mild distal tip	Upright	Significant mesial tip	Correct tip

6. Mesio-distal tip of upper left canine (UL3)

Significant distal tip	Mild distal tip	Upright	Significant mesial tip	Correct tip

7. Arch development/expansion

Significantly underdeveloped or overexpanded arch	Poor arch development or somewhat overexpanded	Satisfactory arch development	Good arch development	Best possible arch development

8. Case finish

Significantly poor finish	Poor finish	Satisfactory finish	Good finish	Best possible finish

9. Which bracket prescription do you use?

ROTH		MBT		DAMON		OTHER	

10. Which bracket prescription do you think was used in this case?

ROTH		MBT		DAMON	

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